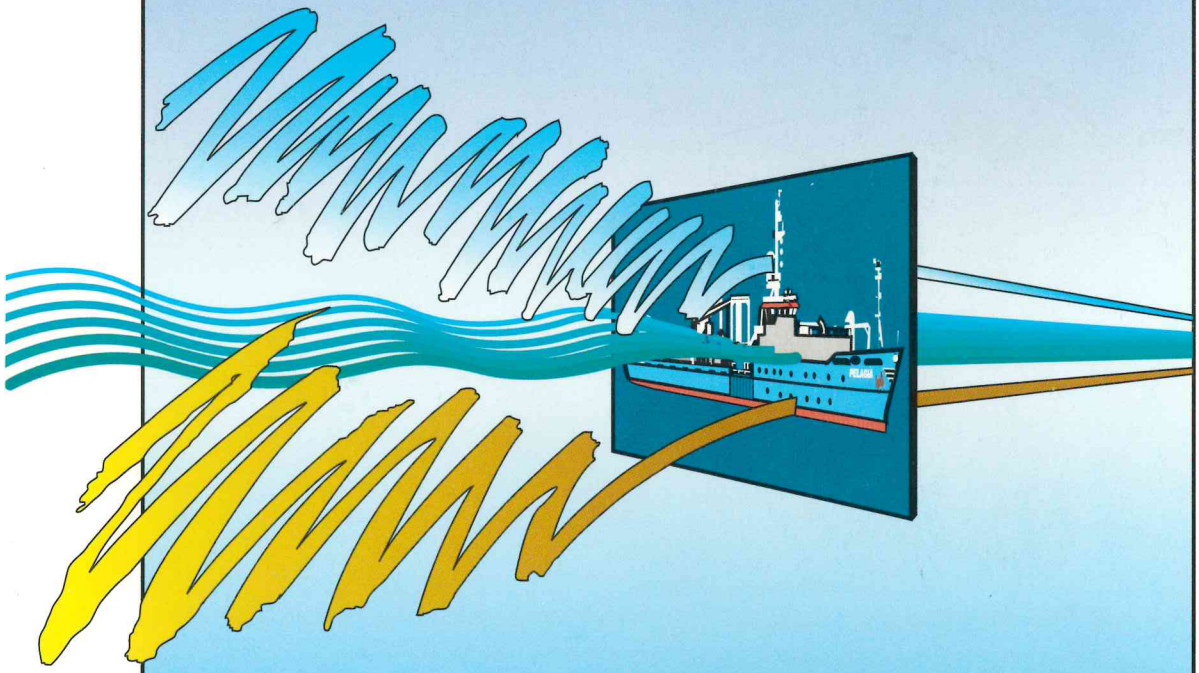
ANNUAL Report 1994



NETHERLANDS INSTITUTE FOR SEA RESEARCH (NIOZ)

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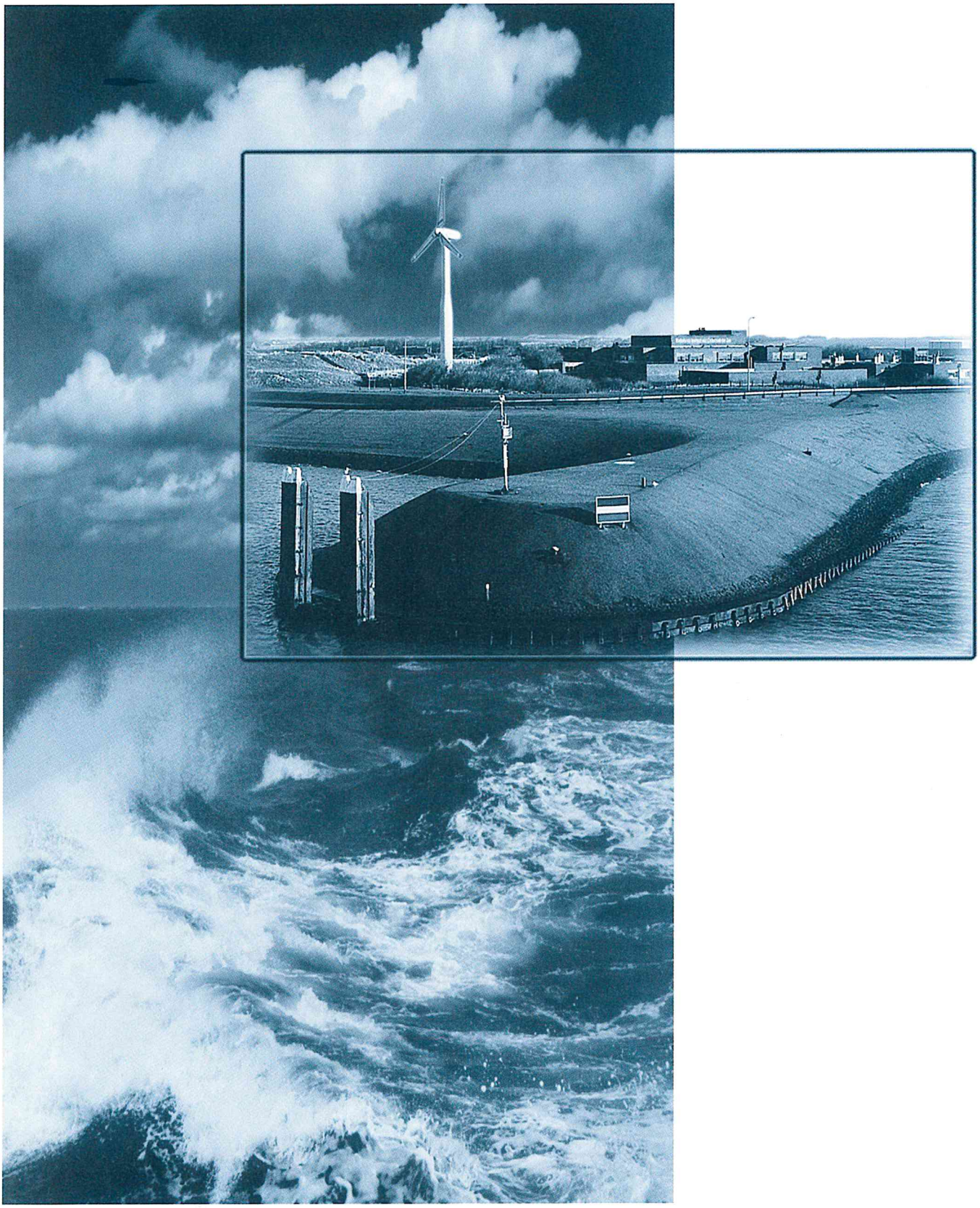
ANNUAL REPORT 1994



NETHERLANDS INSTITUTE FOR SEA RESEARCH (NIOZ)

CONTENTS

INTRODUCTION

1994 was another year of high-quality research conducted in a scientifically healthy and stimulating atmosphere, but the shortcomings of the structural organization, already signalled in last year's Annual Report, have only become more obvious. The 1993 Peer Review had indeed concluded that, although in itself excellent, the research at NIOZ needed restructuring. This opinion, also shared by many NIOZ scientists, was a reason for the NWO Council of the Biological, Oceanographic and Earth Sciences (BOA) to urge NIOZ to review the structure and organization of its science management.

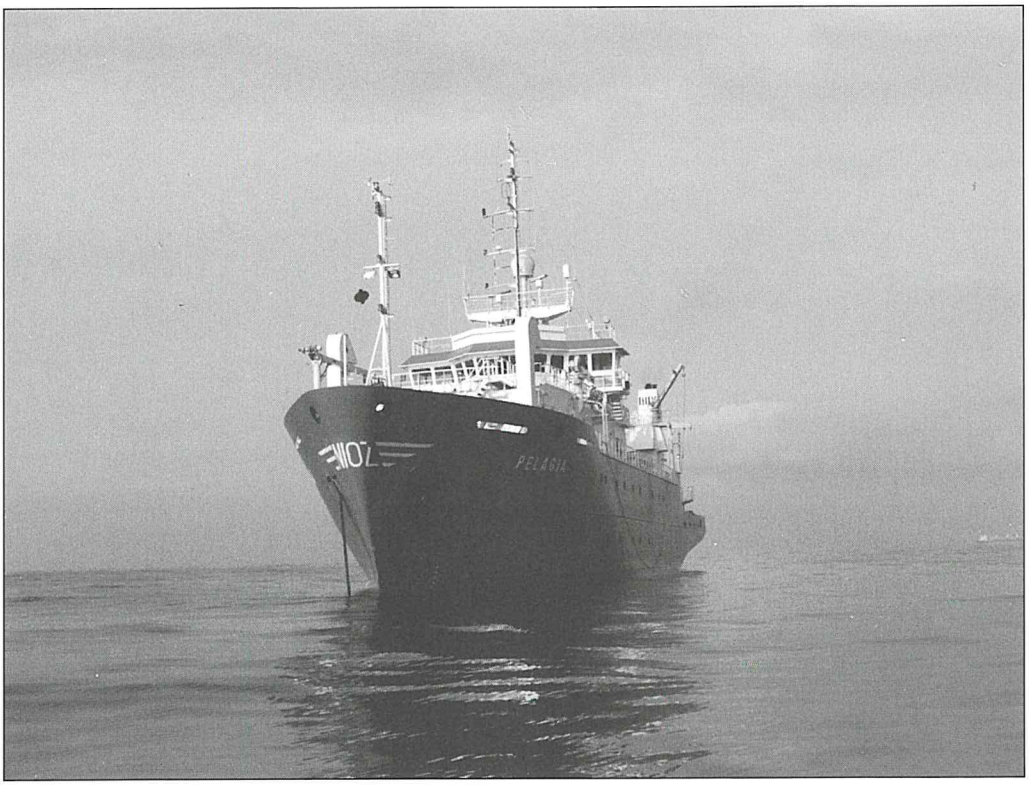
In June 1994 the NIOZ Board decided to have an external consultancy, Andersson, Elffers and Felix (& AEF) in Utrecht, review the internal structure of the Institute, not just the present structure and organization of the scientific research and its division into Scientific Departments, but also the structure of the Directorate and other Services. During the autumn interviews were held with, in principle, all employees, later reported on in a session with the entire NIOZ personnel. Although the Board decided on some essential points in 1994, the full elaboration and implementation of the new plan will take place during 1995.

Also in another respect, 1994 was a year of reorganization. As of 1 January, NWO dissolved the Marine Science Foundation (SOZ). The scientific activities were taken over by the newly founded Geosciences Foundation (GOA), which also embraces the former Earth Sciences Foundation (AWON). The operational task was taken over by NIOZ as the Netherlands Marine Research Facilities, and the co-ordinator is stationed at NIOZ. In future, the planning, preparation and execution of sea-going research will therefore take place at NIOZ.

In spite of wide protest from the oceanographic community within the Netherlands, NWO carried out its decision of December 1993 to sell its ocean research vessel 'Tyro'. The ship was renamed and in March left the NIOZ harbour for good.

Although the research which follows from our participation in the Global Change research programme of NWO (Verstoring van Aardsystemen), in the National Research Programme Global Air Pollution and Climatic Change (NOP), and in the Marine Science and Technology Programme of the European Union (MAST II) is still in progress, NIOZ has already started preparing for the continuation of these programmes, *viz.* NOP II and MAST III, in close collaboration with colleagues from marine institutes abroad.

This year RV 'Pelagia' again proved to be pre-eminently suited for research in the North Sea, in the Bay of Biscay and the Irish Sea. For the execution of the OMEX programme in the Bay of Biscay the RV 'Charles Darwin' of the British National Environment Research Council (NERC) had to be chartered. Although it had too little capacity to accommodate enough scientists to execute the programme as originally planned, the vessel and its crew performed excellently.



RV 'Pelagia'
Photo: A. van Koutrik.

Co-operation was established with two Research Schools, *viz.* that of Atmospheric and Marine Sciences (University of Utrecht and Agricultural University Wageningen) and that of Sedimentary Geology (Free University Amsterdam and University of Utrecht). The position of NIOZ is that of associate, with a representative serving as advisor. Furthermore, there is now close co-operation with the Research School of Environmental Chemistry and Toxicology (Agricultural University Wageningen and University of Utrecht), and discussions are being held on participation in the Research School of Functional Ecology (University of Groningen and others). In this way NIOZ can contribute to the involvement of marine research in the research school community of the Dutch universities, after attempts to establish a separate marine research school failed.

The Core Project Office of the IGBP programme LOICZ, which is housed at NIOZ, received additional staffing during the year, especially through secretarial assistance. In December a project scientist joined the office to introduce Geographical Information Systems. During a number of visits, the International Scientific Steering Committee developed the Implementation Plan, which was later approved by the IGBP in Australia.

NIOZ experienced the second year of the slow but steady decline in its long-term financial relationship with BEON, the Government agency for applied marine research. The fear has indeed been confirmed that the policy-linked research now concentrates more on short-term projects, which require and allow less profundity in research. However, the BEWON Department has proved quite able to achieve sufficient externally funded contracts, besides the BEON monies.

The Board of the NIOZ Foundation underwent a great number of changes. Prof. Dr. H.J.Th. Goos and Prof. Dr. R.A. Prins were succeeded by Prof. Dr. R.H. Drent, Prof. Ir. H.P. van Heel and Prof. Dr. K. Verhoeff, the latter of whom is expected to succeed Prof. Dr. Ir. J.A. Battjes as chairman in early 1995.

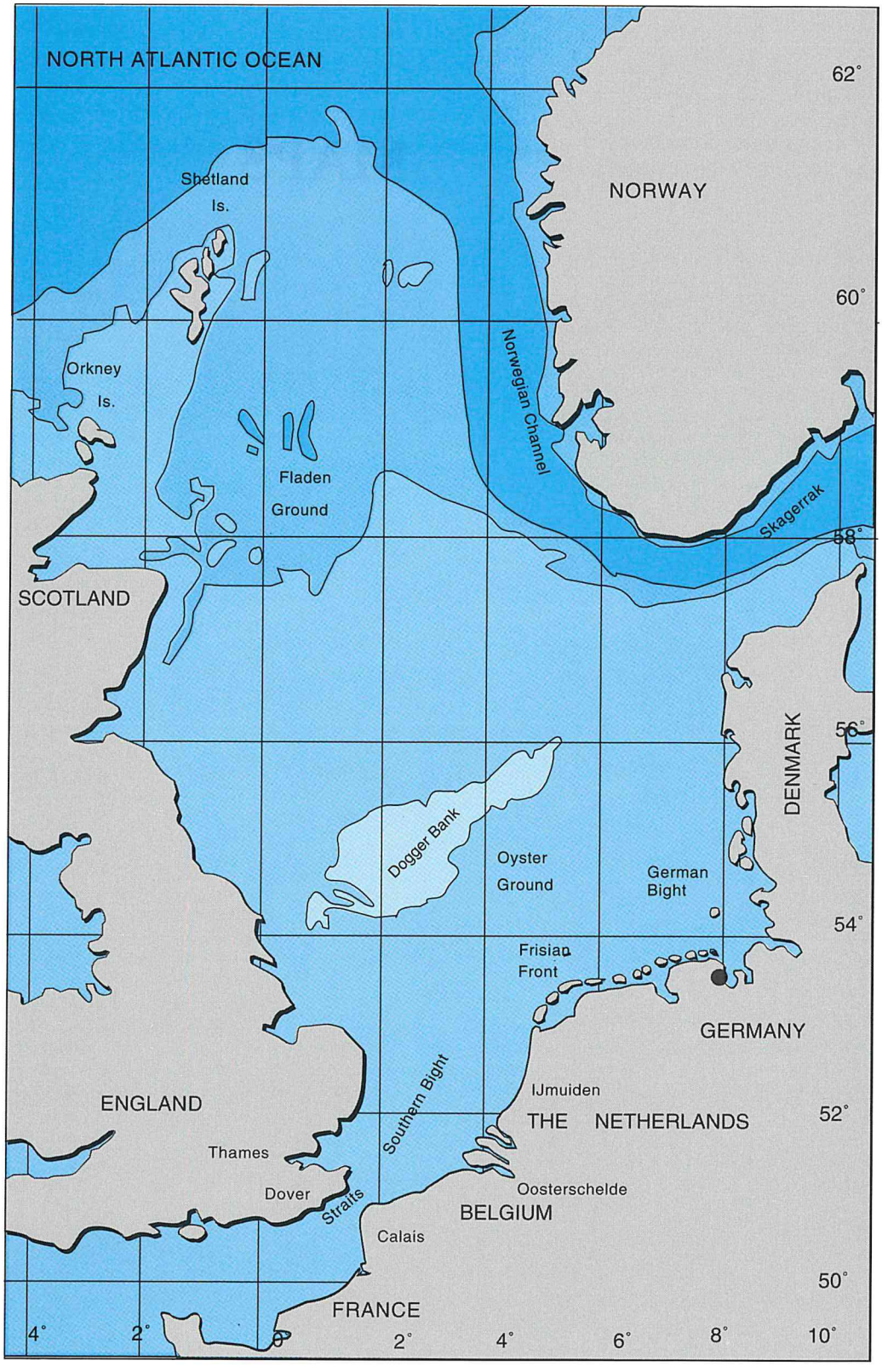
The number of scientific meetings held at NIOZ rose again in 1994. For the first time, a new course entitled Introduction of Marine Sciences was organized. The course is intended for all NIOZ Ph.D. students but is also accessible to students of the Research Schools. It is a two-year course which in 1994 covered all disciplines in an integrated treatment of shallow seas; in 1995 the deep sea and benthic processes are to be treated. Moreover, a large number of conferences, workshops and scientific meetings were held. In this way the excellent facilities and human support available at NIOZ are utilized to the full.

A great number of Ph.D. students took their degrees this year, among them Theunis Piersma, who was awarded the 'Nederlandse Zoologie Prijs 1994' of the 'Nederlandse Dierkundige Vereniging' for his excellent research on the organismal level.

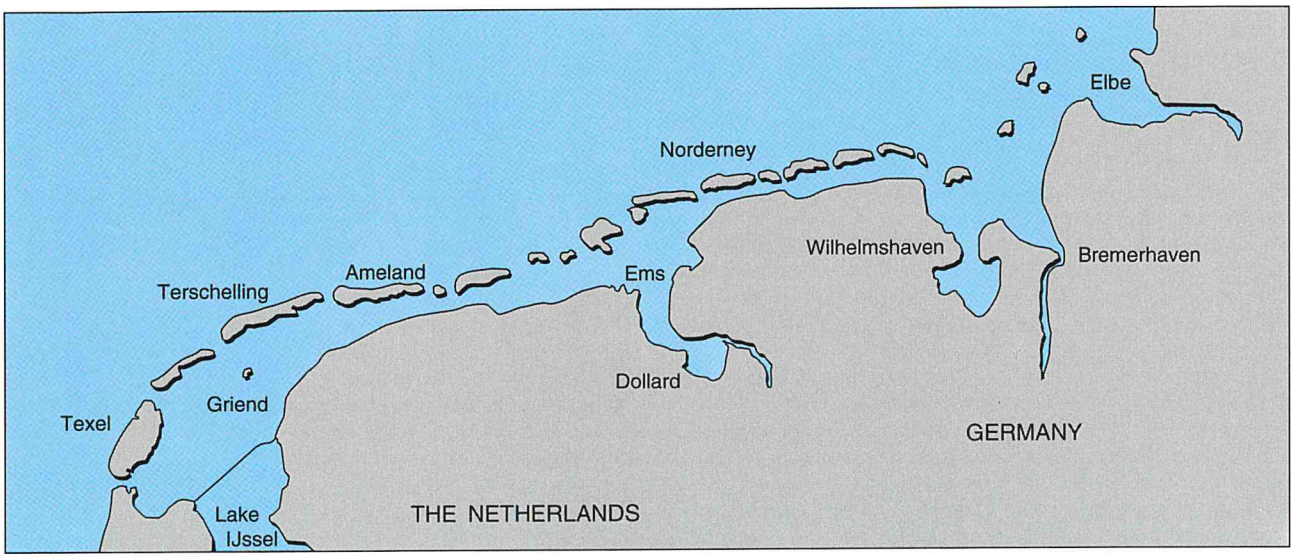
It is inevitable that in 1995 the reorganization of the Institute will take up much of our time and energy. However, we would not undertake these efforts if we were not convinced that they are beneficial to the Institute and especially to our sea research and the many people who feel responsible for this task.

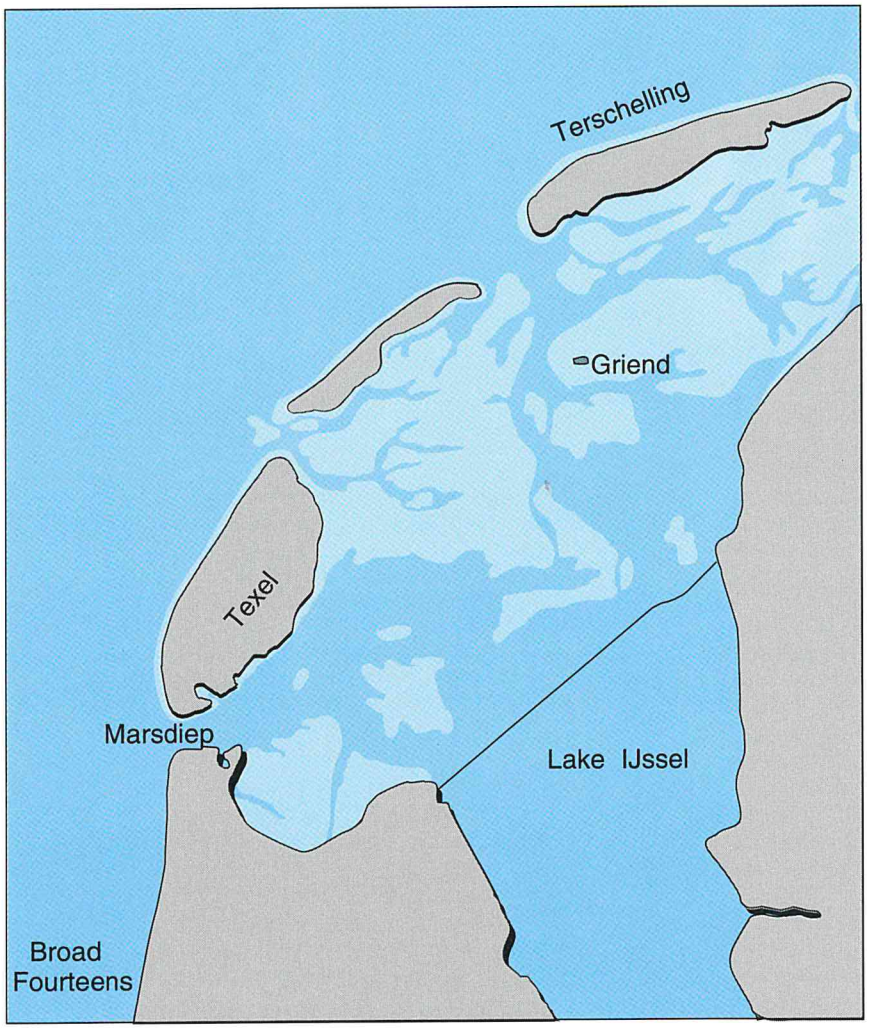
W.G. Mook

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: J. Nieuwenhuis

DEPARTMENT OF PHYSICAL OCEANOGRAPHY

The theoretical study of dynamical processes in ocean circulation and tidal currents was continued in 1994. The study of nonlinear dispersive internal tides was completed with a thesis.

The WOCE-related research in the Iceland Basin (the DUTCH-WARP programme) was continued with data analysis of the deep water masses and of the tracks of ARGOS surface drifters. The region of interest has shifted towards the Bay of Biscay and a study has been planned on the eastern boundary current. A cruise, financially supported by GOA, in which a number of current meter moorings will be deployed is planned for 1995.

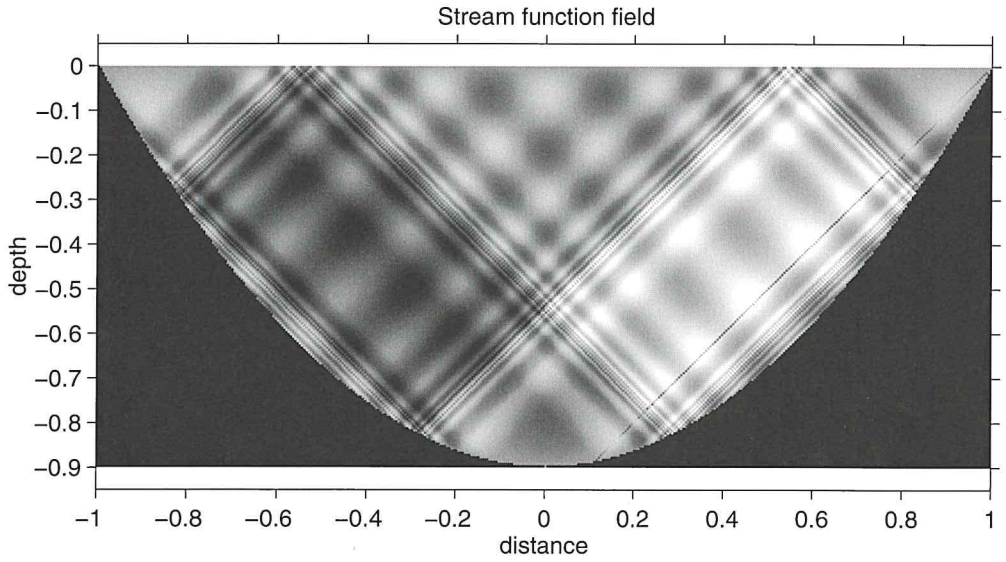
Multidisciplinary projects in which the department was involved were the study of physical and biodynamical behaviour of cohesive sediments, the INP-mooring project, and the JGOFS/Southern Ocean project. For the INP-mooring, 1994 was the last year of data collection. The mooring has been in continuous operation for more than one year.

Optical Remote Sensing techniques have been applied in multidisciplinary projects. Infrared Remote Sensing was applied within the framework of the DUTCH-WARP programme.

There is no formal connection between the four main activities of the department. The theoretical dynamical oceanography has developed in a different direction from that of the sea-going ocean research. The future of the sea-going ocean research is under strong pressure. Due to the reduction in personnel towards the end of 1994, it is not possible both to perform our sea-going physical oceanography project in the North Atlantic and to participate in multidisciplinary projects such as JGOFS.

1. DYNAMICS OF (NON)LINEAR MARINE PROCESSES

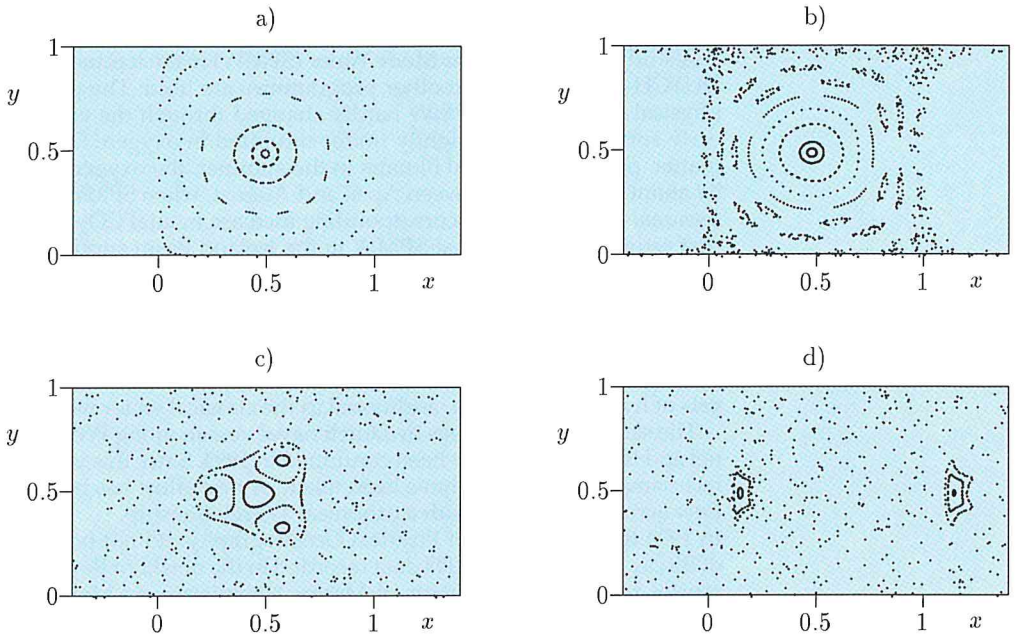
Studies have been performed on the (non)linear dynamics of ocean circulation and tides. Several aspects of the large-scale ocean circulation have been addressed. In an analytical study of the barotropic vorticity equation, governing the wind-driven circulation, an 'almost free' inertial circulation has been obtained that obeys the principal integral constraints of this kind of motion and that seems to approach a linear relationship of the absolute vorticity and the stream function. This study is performed on a beta-plane whose the foundations have been addressed. It is found that the interpretation of the east-west symmetry of the beta-plane, which is connected with the westward drift of eddies, is not well understood. This has inspired a new approach to the description of space-time for oceanic systems. With this approach the motion of solitary masses has been studied, which turns out to move along cycloid-like curves on the globe. Another line of attack has



Internal waves in an enclosed basin are customarily interpreted in terms of seiching modes of that basin, in analogy to the standing surface-wave modes. This interpretation is fuelled by the existence of simple, modal-type solutions in case the basin is of rectangular cross-section. It is observed, however, that in general such modes do not exist. Rather, results of an inviscid, analytical model indicate that internal wave characteristics focus onto a particular limiting attractor, whose specific shape is a fractal function of the period of the internal wave. In this figure the streamline pattern of a standing internal wave is displayed in a parabolic channel filled with a continuously stratified fluid. The location of the attractor is visible as the two connected, rectangular-shaped boxes that form the attractor of propagating, internal waves. It suggests that internal wave energy is selectively deposited near the location of this attractor.

been chosen in a study of the thermohaline circulation on the f-plane, where a simple, nonlinear model that couples the lowest moments of the momentum, salt and temperature fields has been formulated. For a certain parameter range increase of the equator-pole temperature contrast leads from multiple steady states via a period-doubling bifurcation sequence to a chaotic end state.

In the study of tidal phenomena the following approaches have been taken. The strong (lateral) exchange of water (and its properties) in shallow tidal estuaries has been attributed to chaotic advection by the combination of tidal and residual currents. Numerical and analytical studies of mixing caused by chaotic advection have quantified this, using classical and newly developed theories of dynamical systems. Tides near strongly sloping topography such as the shelf edge generate internal tides when the water is stratified. When these waves are steep, they disintegrate into solitary waves. A model has been developed that addresses the effects of the Coriolis force on the generation of these internal tides and solitary waves. In general the earth's rotation impedes the disintegration of the internal tide. When the internal waves are not steep they tend to get focused due to the peculiar nature of internal wave propagation and get attracted to a limiting trajectory which is well-defined for the particular frequency of the wave.



In shallow tidal areas, such as the Wadden Sea, the non-linear interaction of the tidal currents and irregular bottom topography generates (residual) currents, which are often organized in eddy-like structures. It appears that Lagrangean advection in a flow, which is the sum of the tidal flow and the eddy flow, is chaotic. The parameters which tune the chaos are the ratio of the tidal excursion and the eddy diameter and the ratio of the tidal velocity and the eddy velocity. This figure is a stroboscopic (with tidal frequency) plot of particles in a tidally perturbed eddy flow. For small eddy velocities (a) the particles remain on the eddy streamlines, but raising the eddy velocity (b) the outer streamlines break up and mixing occurs in a stochastic 'sea' around unmixed 'islands'. Raising the eddy velocity further (c) the islands shrink until there is a transition from local to global chaos in (d).

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), *Th. Gerkema* (internal solitary waves), *F.P. Lam* (tide-topography interactions), *G. van der Schrier* (student, thermohaline circulation).

2. WATER CIRCULATION AND HYDROGRAPHY OF THE NORTH ATLANTIC

The analysis of the data obtained during the DUTCH-WARP programme in 1989-1991 has been continued. A study of the hydrographic variability of the deep water in the Iceland Basin has shown lenses of Lower Deep Water (LDW) to enter the Deep Northern Boundary Current (DNBC) in the Iceland Basin by isopycnal advection. Due to diapycnal mixing LDW from these lenses is subsequently entrained into the Iceland Scotland Overflow Water in the bottom layers of the DNBC.

The current variability in the Iceland Basin, as observed by moored current meters, has been analysed by means of principal component analysis. In the central northern Iceland Basin the current variability is mainly due to barotropic eddies, while over the slope of the Hatton Bank and the south Icelandic slope the variations have a mixed barotropic/baroclinic character. The long-term mean currents, as observed with current meters, can be modelled adequately as geostrophic currents relative to the σ_θ=27,725 kg·m^{-3} level over the slopes of the Iceland Basin. In the more level central part of the basin, however, a considerable mean eastward baroclinic current has been observed.

The tracks of the ARGOS surface drifters from the DUTCH WARP programme as well as the drifters deployed in the Iceland Basin in the following Dutch Global Change programme have been analysed. The mean Lagrangean flow is mainly in a north-eastern direction, with a tendency for a cyclonic circulation over the western part of the Iceland Basin. Out of 17 drifters deployed, four reached the Norwegian Sea, either across the Iceland-Faroer Ridge or through the Faroe Bank Channel. A jet-like north-eastward surface flow along the slope of the Hatton Bank was found in the data, in agreement with current meter observations. No exchange of surface water from the Iceland Basin across the Reykjanes Ridge has been observed. The eddy kinetic energy of the surface flow in the deeper parts of the Iceland Basin is an order of magnitude larger than over the shallow Rockall Hatton Plateau.

A study of the Sub-Polar Mode Water (SPMW) in the Iceland Basin has been initiated. Data from DUTCH-WARP and from other programmes are used. The preliminary results indicate that the physical properties of SPMW hardly changed through the years 1987 to 1991. It appears that in early spring, SPMW is slightly under-saturated in oxygen. Due to the mineralization of organic matter, produced by algal blooms in the summer, the oxygen concentration of SPMW decreases by about 9 µmol·kg^{-1} between April and August, when SPMW is isolated from the surface due to seasonal stratification. A corresponding increase in total CO_2 and nutrients has been observed. A first estimate indicates that SPMW in the Iceland Basin supports a seasonal carbon storage of at least 60 gC·m^{-2}.

Cluster Analysis (CA) and Principal Component Analysis (PCA) have been studied as alternatives for the classical water mass analysis. These analysis methods are very well suited for the analysis of multi-variate data sets, with temperature, salinity, nutrients and dissolved oxygen as hydrographic parameters. Both CA and PCA appear to be useful tools for a first exploratory analysis of hydrographic data, additional to the classical water mass analysis.

The series of XBT surveys by Dutch naval vessels along WOCE section AX5 between the Channel and the Caribbean has been continued in 1994. Since this year, additional to the XBT casts, surface samples for salinity have been taken. A first effort has been made to model the geostrophic flow across this section with a canonical T-S relationship.

In 1994 the department of Physical Oceanography did not perform its planned cruise in the Bay of Biscay. However, the CTD data recorded in the northern Bay of Biscay/Celtic Sea during OMEX cruises from the departments of Marine Chemistry and Marine Geology, have been processed. The spatial distributions of sea surface temperature and salinity, observed during three cruises of RV 'Tridens' of the Netherlands Institute for Fishery Investigations (RIVO, IJmuiden) in the Bay of Biscay have been analysed.

Efforts have been made to develop a relational data base management system for the hydrographic and current meter data, available in the department of Physical Oceanography. A work station and SYBASE software have been acquired for this purpose. The department's technicians spent part of their time in support of the hydrographic measurements in Atlantic research programmes by other departments. Support for CTD measurements, in the preparatory phase as well as in the post-processing, is especially needed.

Contributors: *H.M. van Aken* (ocean hydrography), *L. Otto* (ocean hydrography), *C.J. de Boer* (ocean hydrography), *T.J. de Bruin* (remote sensing), *J. de Munck* (ocean hydrography), *S. Ober* (instrumentation and standards), *R.X. de Koster* (data management), *N. Haasbroek* (student, satellite altimetry).

3. PHYSICAL ASPECTS OF MARINE ECOSYSTEMS

The physical and biodynamical behaviour of mud and sand beds in tidal inlets and flats

This project is directed towards the study of the behaviour of fine-grained sediments in tidal areas. Various Dutch institutes are involved in this interdisciplinary project. The participation of NIOZ is in the development and application of numerical models. An existing 300-m grid tidal model of the Ems Dollard appeared to be too coarse to simulate the current field in the Dollard area in sufficient detail. Therefore a model with a 100-m grid in this area was developed. Simulated current patterns with this fine grid model, combined with detailed field data on the bathymetry and composition of the sediments at the tidal flat, were used to determine the most

appropriate site for the location of a permanent measurement platform. From this platform semi-continuous measurements on currents, waves and suspended sediment concentrations will be performed in 1995 and 1996.

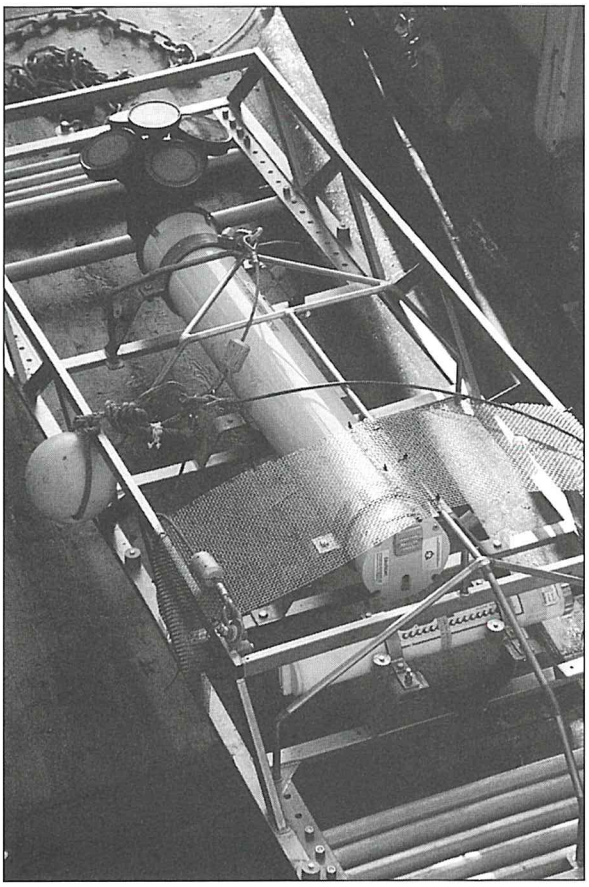
The 300-m grid tidal model was used to study the effect of tidal asymmetries on the large scale net transport of fine-grained sediments. At representative cross-sections along the longitudinal axis of the estuary expressions for the Eulerian and Lagrangean current field were coupled to a very simple model for the behaviour of fine-grained sediments. At most cross-sections this results in a landward directed net transport of sediments which increases in a landward direction. The sensitivity of the net transport to the presence of different harmonic components in the tidal current field as well as to the use of the Eulerian or the Lagrangean current field was examined.

INP-mooring

Within the framework of the Integrated North Sea Project (INP) a multidisciplinary mooring has been deployed between November 1993 and January 1995. The mooring site is located in the seasonally stratified part of the North Sea (Oyster Grounds). The simultaneous recording of physical (oceanographical and meteorological) and biological data will eventually 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 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 apparatus. Self-contained fluorometers, transmissometers, sediment traps and nutrient analysers have been deployed along with current meters, thermistorstrings and acoustic Doppler current profilers. As the data acquisition is still in progress, results are not yet available. Some periods, such as a stormy period during the winter and a prolonged period of good weather during part of the summer, showed unusual responses of parts of the hydrographical/biological system.

Additionally, data will be used in conjunction with those from earlier projects in (approximately) the same part of North Sea for an ongoing study on tides. The focus is on the vertical structure of tidal motions, internal tides, and on tidal harmonics induced by non-linear processes like advection and friction.

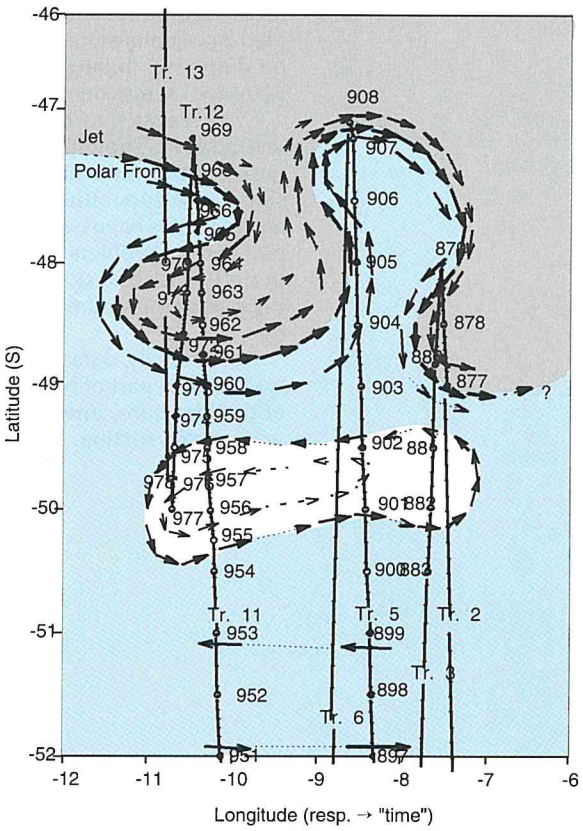


Five beam broadband ADCP (600 kHz) mounted in its mooring frame together with a wave-tide recorder.
Photo: H. van Haren.

JGOFS/Southern Ocean

From a combination of physical and biological data collected during the JGOFS/SO project on board RV 'Polarstern' in austral spring 1992 near the 6° West meridian, a quasi-synoptic reconstruction has been made of the meandering position and flow field of the Polar Front in the Antarctic Circumpolar Current. Strong correlations have been found between definitely localized blooming phytoplankton species and physical features such as spun-off eddies from the Polar Front. Evidence was also found for the presence of the so-called Southern Front, which was recently found in other areas and which is now assumed to be circumpolar.

Modelling runs with the coupled physical-ecological phytoplankton growth model AQUAPHY (C. Lancelot, GMMA, Université Libre Bruxelles) have shown that phytoplankton blooms supposed to occur in the wake of a retreating melting ice-edge, only occur in specific weather conditions. It is possible to derive a length scale equivalent with the 'Sverdrup compensation depth' to predict places where one may expect phytoplankton blooms to occur in the marginal ice-zone.



Quasi-synoptic reconstruction of the flow field near the Polar Front during the JGOFS/Southern Ocean expedition ANT X/6 on board RV 'Polarstern', austral spring 1992. The reconstruction is based upon physical data supplemented with data on species and pigment distributions.

Contributors: *C. Veth* (ocean hydrography and modelling), *J.J.M. van Haren* (ocean hydrography and instrumentation), *H. Ridderinkhof* (numerical modelling), *M.R. Manuels* (oxygen, mooring instrumentation), *J. Thieme* (mooring instrumentation), *S. Ober* (ocean instrumentation), *R.X. de Koster* (data management), *W. Hartog* (student, INP-mooring).

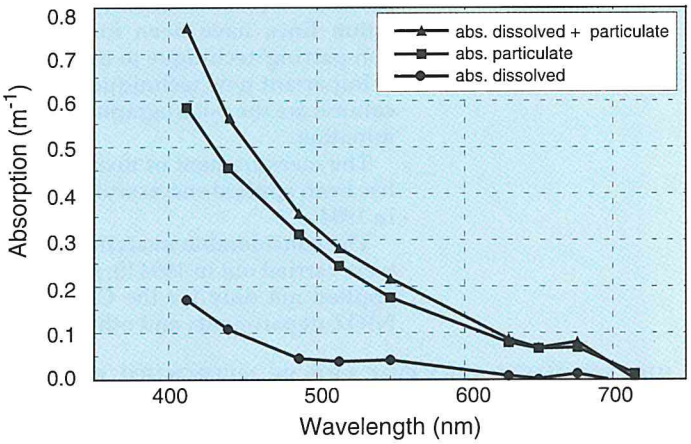
4. APPLICATION OF OPTICS AND REMOTE SENSING

The NIOZ working group on remote sensing (RS) co-ordinates research projects on the application of optics, and space and air-borne data in oceanographic research. Because of the different fields in which RS can be applied the working group has a multidisciplinary character and includes members of the departments of physical oceanography, marine geology and geochemistry, pelagic systems, and applied marine ecology.

Within the OCEAN project, historical North Sea data from the Coastal Zone Colour Scanner (CZCS) were analysed and compared with sea-truth information on chlorophyll *a* distributions obtained from the data base of Rijkswaterstaat. Previously found ocean colour algorithms were applied on the RS data to determine the development of chlorophyll concentrations along the

Dutch coast during the seventies and early eighties. Atmospheric corrections delivered together with the RS data turned out to be unreliable, particularly above case-2 water, and this hindered a positive outcome of the project.

The development of ocean colour algorithms for case-2 water was continued within the BCRS-PMNS project (Particulate Matter North Sea). A cruise dedicated to research on optics was performed in the southern North Sea in July. Several optical parameters were measured together with *in situ* water quality parameters (*e.g.* chlorophyll *a* concentration, suspended matter). Through co-operation with the University of Southampton (UK) a NERC remote sensing aircraft with on board a Compact Airborne Spectrographic Imager (CASI) participated in the campaign. With the data obtained the relationship between the inherent optical properties of attenuation and absorption, and the apparent property of reflectance is currently investigated. The inherent properties are determined solely by the constituents contained in the water column and the reflectance is the optical parameter measured by air-borne and space-borne instruments. Using this approach, algorithms will be developed based on an analytical model.



The absorption of the dissolved and suspended components of water samples from a station near the Frisian Front measured with the newly purchased AC-9. This instrument measures beam attenuation and absorption in nine channels of the visible light spectrum. By measuring before (▲) and after filtration (●) of the water samples the effects of suspended particles can be distinguished from those of dissolved substances. It can be seen that at this particular location most of the absorption is due to suspended particles (■), as opposed to dissolved organic matter.

An SRON grant was obtained to develop techniques to improve the applicability of RS data. Together with the department of Applied Marine Ecology (theme 1, EC-NOWESP project) and in co-operation with Delft Hydraulics existing data sets on suspended matter concentrations in the North Sea were merged. Interpolation of the data was done with a Kriging technique to estimate spatial distributions. This interpolation is hampered, however, by the non-synoptic nature of the data which were measured in a period of several weeks, and by the sampling grids. The objective of this project is to integrate information obtained from NOAA reflectance measurements directly into the interpolation scheme, to obtain the best possible estimate of the spatial distribution of suspended matter in the North Sea.

Within the BCRS project 'Ocean Application of RS images in physical oceanographic investigations', data of infrared and visible light satellite images were applied in conjunction with XBT and CTD measurements, and with data obtained from ARGOS drifters to examine the hydrography of the Iceland Basin (northern Atlantic) during the spring of 1991 and the summers of 1990, 1992 and 1993. Special attention was paid to the location of fronts and eddies and their interaction with the bottom topography. A method was developed to objectively detect oceanic fronts from RS images by applying digital edge-enhancement operators. Further investigations concerned the relationship between meso-scale features below the thermocline and the sea surface temperature. Surface current velocities were successfully computed, using a maximum cross-correlation method, from a number of sequential satellite images in which eddies could be tracked down. A remarkable observation was the presence of patches of colder surface water above various banks in the area, indicative of the presence of Taylor columns over these banks.

Contributors: *J.C. de Munck* (satellite topography), *L. Otto* (ocean hydrography), *T.F. de Bruin* (remote sensing), *S.J. Shimwell* (optics), *M.R. Wernand* (optics and remote sensing), *D. Eisma* (sedimentology), *W. van Raaphorst* (chemistry), *C.J.M. Philippart* (ecology), *J.J.M. de Jong* (data processing), *H.G. Fransz* (plankton biology).

DEPARTMENT OF CHEMICAL OCEANOGRAPHY

The Department continued to work in the following main themes of research:
—1. Biogeochemistry of carbon, nitrogen, phosphorus and sulphur in marine sediments.
—2. Carbon and trace metals in the oceanic water column.
—3. Fate and effects of organic microcontaminants.

The fieldwork of the Netherlands Indian Ocean Programme (NIOP) was finished in 1993; analyses in the laboratory are still going on in some projects.

The EC-funded projects in the Gulf of Lions, the Adriatic Sea, and the Lena Estuary and Laptev Sea came to an end, and results have been published or will be so in the near future. The EC-funded OMEX programme will continue in the coming years.

Within theme 2, the co-operation with AWI Bremerhaven will be continued and co-operative cruises in the Southern Ocean with RV 'Polarstern' have been planned for 1995 and onwards.

Analyses of $^{13}C/^{12}C$ and $^{15}N/^{14}N$ ratios on the Stable Isotope Mass Spectrometer (SIMS) are possible now for sediment samples, for enriched algal cultures, and for seawater. New preparation lines have been installed. A highlight was the successful implementation of the 'ion-pairing' technique to measure denitrification rates in marine sediments.

Important new techniques to measure low-level metal concentrations in the oceanic water column are the polarographic cathodic stripping voltametry and the chemoluminiscence determination.

The measurement of toxicological effects on organisms by determination of DNA integrity has been applied successfully; also the quantitative determination of PAH's was implemented in 1994.

The considerable analytical capacity of the department for nutrient determinations (24 000 were carried out in 1994 !!), for C/N analyses and SIMS application, and for metal analyses was applied not only for the Chemical Oceanography Department, but also for nearly all other NIOZ departments and other institutes (RUG, NIOO, CARMABI, VU, Univ. of Bieleveld.)

1. BIOGEOCHEMISTRY OF CARBON, NITROGEN, PHOSPHORUS AND SULPHUR IN SEDIMENTS

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.

While in recent years fieldwork in this project was mainly associated with the INP-BELS cruises, in 1994 field work was carried out in the context of VvA theme 4. Three cruises were conducted in respectively February, May, and August. Visited stations were in contrasting areas: German Bight, Skagerrak, Frisian Front, Broad Fourteens.

The exchange rates of oxygen, ammonia, nitrate, urea, phosphate, dissolved silicate, sulphate and CO_2 were determined from shipboard incubations of sediment and overlying water.

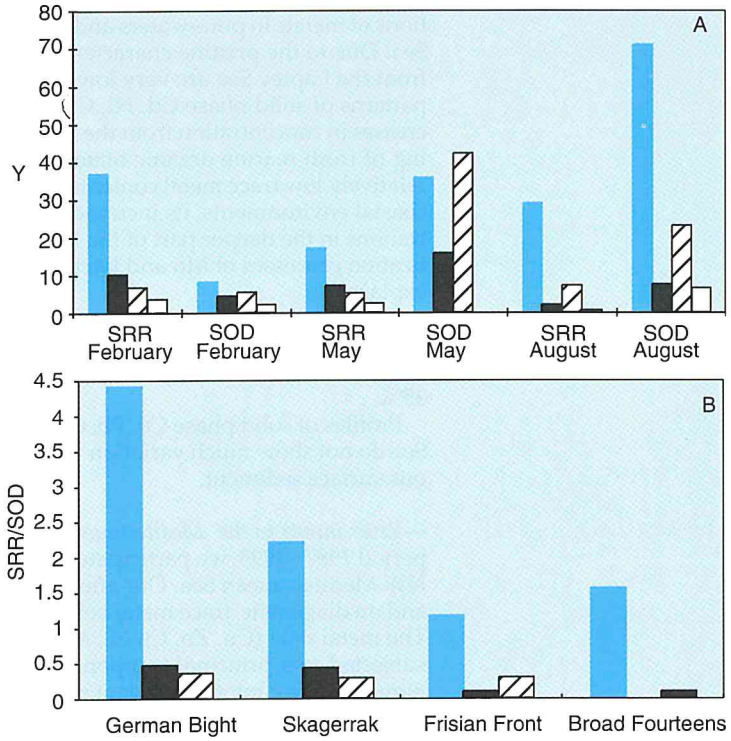
Of the same constituents and also of Mn^{2+} and Fe^{2+}, pore-water profiles were determined to be able to compare measured (sediment-incubations) with calculated (pore-water profiles) fluxes. Comparison of fluxes of the different redox-components and modelling of the pore-water profiles will allow us to determine organic carbon mineralization by oxic, sub-oxic and anoxic diagenetic processes.

Emphasis was put on the modelling of the early diagenesis of nutrients (together with P. Ruardij). Theoretical considerations concerning the vertical distribution in the sediment of reactive organic matter were applied to improve current models of nitrification, denitrification, and silica diagenesis. The results demonstrate that in the North Sea sediments, the vertical decline in the availability of degradable organic matter controls the apparent denitrification rate constant, implying that overall denitrification is not only dependent on ambient nitrate concentrations in the pore water, but also on the presence of organic electron donors.

Because the mineralogy and crystallinity of Fe oxides strongly influence their phosphate sorption characteristics and their susceptibility to reduction, knowledge of the character of these Fe phases is essential for a correct understanding of their role in the phosphorus cycle. Using a combination of differential XRD measurements (S. J. van der Gaast) and extraction procedures, poorly crystalline ferrihydrate and akageneite were identified. These Fe oxides were shown to play a dominant role in the binding of phosphorus in these sediments, acting both as a temporary and permanent sink for phosphorus.

Experimental work was carried out on methods for estimation of denitrification rates in the sediment . We re-visited the Oyster Ground mooring station with the primary aim to compare the acetylene block and the isotope pairing assay for measurement of denitrification activity. In the

former method acetylene is added to sediment cores by which the transition of N_2O to N_2 is blocked and the denitrification rate can be estimated from N_2O accumulation. The disadvantage of this method is that acetylene also blocks the oxidation of ammonia to nitrate (nitrification) and thus in the estimated denitrification rate the contribution of nitrate originating from nitrification (coupled nitrification-denitrification) is ignored. In the ion-pairing technique $^{15}NO_3^-$ is added to the overlying water of a core which then diffuses downward through the oxic part of the sediment column to the oxic-anoxic interface in the pore water. Because in the meantime $^{14}NO_3^-$ is produced from ammonia by nitrification in the denitrification zone, $^{15}NO_3^-$ pairs with $^{14}NO_3^-$ at the anoxic-oxic interface which results in the formation of the isotopes $^{14}N^{14}N$, $^{14}N^{15}N$, and $^{15}N^{15}N$. By this, coupled nitrification-denitrification can be determined simultaneously in one single sediment core.



Sulphate reduction rates were determined by addition of $^{35}SO_4^{2-}$ to overlying water of incubated cores.
A: the sulphate reduction rates (SRR) and the sediment oxygen demand (SOD) are given for the four stations during the three cruises, while in Fig. B the ratios of SRR over SOD are given. It is striking that in February SRR is up to 4.5 times higher than SOD, while in May and August SRR is at the expected ratio of < 0.5. In the solid phase of the sediment analyses of Mn- and Fe-oxides, and of org.C and -N were carried out.

Preliminary results indicate that coupled denitrification-nitrification rates measured by the acetylene block technique are a factor of 5 to 12 lower than rates obtained with the isotope pairing assay. It could be calculated that the nitrate turnover time in these particular North Sea sediments ranges between 15 and 25 minutes. Due to inhibition of nitrification by acetylene, the nitrate pool in the sediment would be exhausted within this period. It was concluded that the rate of coupled nitrification-denitrification is significantly underestimated when the acetylene block technique is used.

Sample treatment and isotope analysis were performed on mass spectrometers at the National Environmental Research Centre, Silkeborg, Denmark (in collaboration with S. Rysgaard) as well as on the instrument in our department. Computation of isotope ratios revealed excellent agreement between both apparatuses.

Experiments were carried out to quantify the adsorption properties of sediments and suspended matter from the Oyster Grounds for ammonium. Basic question behind these experiments is whether sorptive binding and release of ammonium affect sediment-water exchange rates, for instance during resuspension events. Results demonstrate that the adsorption isotherms are non-linear with strong affinities of the sorbing particulates at low dissolved ammonium concentrations. Also, an important hysteresis effect was shown, indicating that not all of the ammonium bound by the sediment due to adsorption can easily be desorbed.

Experiments were performed to assess the role of benthic diatoms on the sediment-water exchange of silicic acid in shallow coastal environments. The experiment was initiated by observations made during the 'Oceanology' course that coastal sediments can act as a net sink for silicic acid during early spring. Whole core incubations, silicic acid pore water profiles, vertical distribution of photosynthetic pigments and of oxygen indicate that the uptake of silicic acid by benthic diatoms is responsible for this observation. At early spring water temperatures (~5°C), approximately 70% of the benthic diatom's demand for silicic acid is contributed by the overlying water.

Consequently, the sediment acts as a sink for silicic acid from the overlying water. During summer (25°C), however, the release of silicic acid from sedimentary particulate reactive silica is sufficient to satisfy the need of benthic diatoms for silicic acid. Considering these fluxes, it can be anticipated that shallow coastal sediments gradually change from a sink in spring to a source in late summer. Therefore, benthic silicic acid fluxes in coastal environments are not merely controlled by temperature and the nature of the reactive particulate silica, but by the activity of benthic diatoms as well. Since silicic acid is assumed to govern the phytoplankton composition and succession in coastal waters, benthic diatoms may play a crucial role in controlling coastal trophodynamics.

Early diagenetic processes at European shelves and slopes

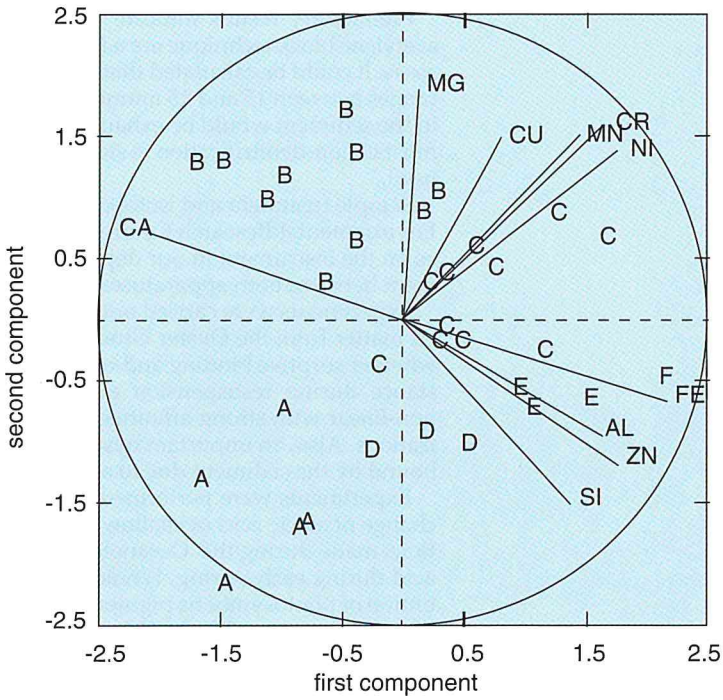
Within this subproject we participate(d) in a number of EC-funded projects:
—*Scientific Programme on Arctic and Siberian Aquatorium (SPASIBA).* We concentrated on distributions of metals in pore-waters and in sediments in the estuary of the Lena river and nearby Laptev Sea. Due to the pristine character of this coastal system trace-metal concentrations in sediments from the Laptev Sea are very low and resemble natural background concentrations. Distribution patterns of solid phase Cd, Ni, Cu, Pb and Zn in sediments from the Laptev Sea show small increases in concentration from the Lena Delta seawards. This increase can be explained by the mixing of fresh marine organic material higher in trace-metal content with fluviatile material with relatively low trace metal contents. Although, the Cd concentration is very low compared to other coastal environments, its increase is more pronounced than that of the other metals. Mn concentrations in the deeper part of the Laptev Sea are higher than those near the river mouth. Remobilization processes of Mn and lateral transport of Mn-enriched particles from the coastal zone can explain this.

Sediments in the Laptev Sea are of the siliceous type with low $CaCO_3$ concentrations (~1%).

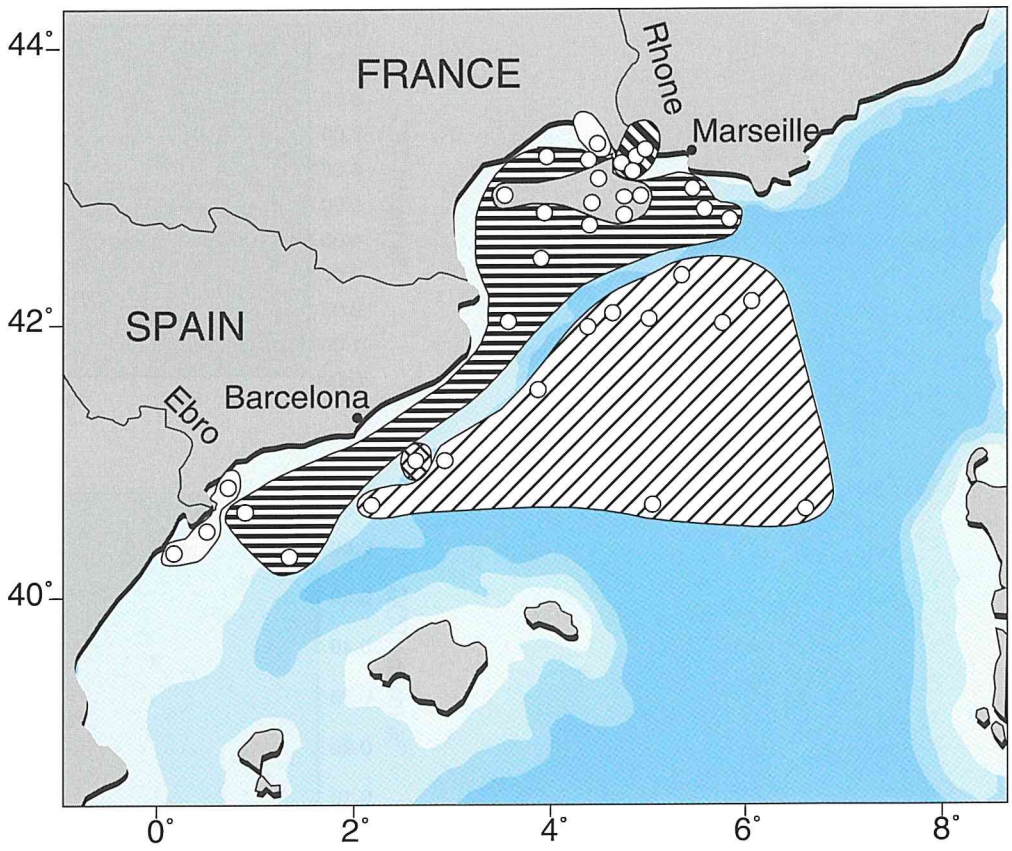
From the sediment C/N ratios it can be derived that about 60 % of the organic carbon in sediments near the river mouth is terrestrial. In the more marine part this content decreases to about 35%.

Profiles of solid phase Cu, Pb, Cd, Ni, Zn and the major elements in sediments from the Laptev Sea do not show much variation with depth and are indicative of a rather well-mixed homogeneous surface sediment.

—*River inputs to the Mediterranean Sea (EROS-2000).* Within this large EC-funded project in the period 1987 - 1993, we participated in four cruises in the research area in the Gulf of Lions and the NW Mediterranean Sea. Our efforts concentrated on mineralization and burial of organic carbon and on diagenetic trace metal behaviour. All analyses have been finished and the data published. The metal data (Cu, Zn, Cr, Ni, Mn, Fe, Al, Si, Ca, and Mg) in the upper 2 cm of sediment were subjected to a principal component analysis in co-operation with J. van der Meer. By this technique, a strong intercomponent relationship between Fe, Al, Zn, and Si on the one hand and between Ni, Mn, and Cr on the other could be identified. Six different geographical regions were discriminated. The final EROS-2000 symposium was held from 18 to 22 October.



Principal component analysis.



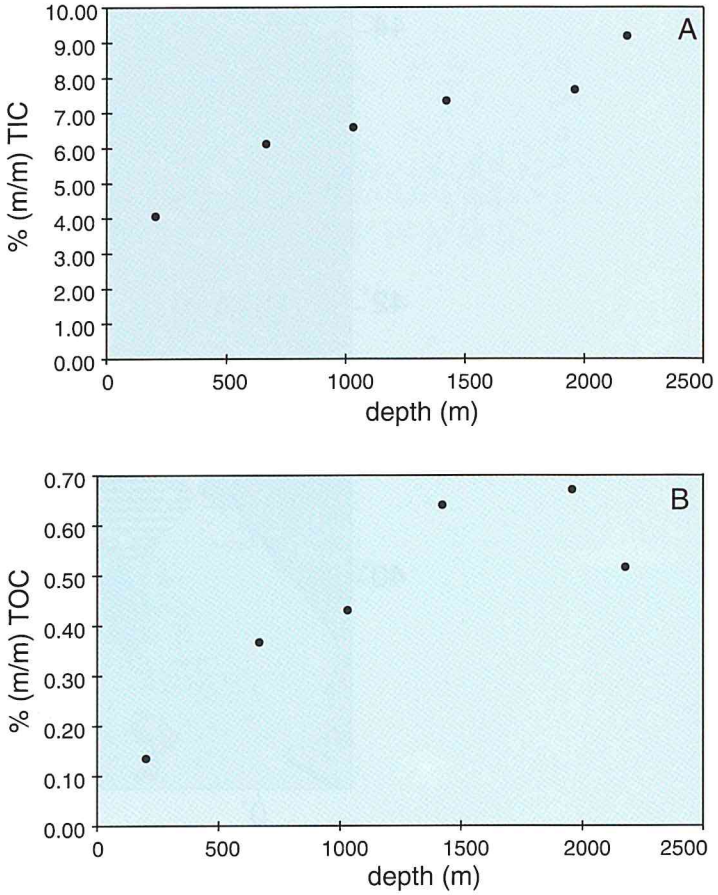
The N.W. Mediterranean Sea divided into six 'sub-areas', based on cluster analysis of the elemental concentrations in the upper 2 cm of the sediment.

—Adriatic Sea. Within this project (1991-1994), funded by EC-STEP, research is carried out in the northern Adriatic and Po delta. It is a co-operative effort of the NIOZ Departments of Chemical Oceanography and Benthic Systems and the Italian CNR (Consiglio delle Ricerche Nazionale) Institute in Bologna. The project finished in March '94. A major NIOZ task in this project was the in situ measurement of oxygen pore-water profiles with the lander TROL and in situ measurement of Sediment Oxygen Demand (SOD) and nutrient fluxes with the lander BOLAS. Both landers gave good results. The final report to the EC-DG XII was approved.

—Ocean Margin Exchange (OMEX).Within this 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, Institut für Meeresforschung Kiel, IFREMER (Brest) and the NIOZ Departments of Chemical Oceanography, Benthic Systems, and Marine Geology.

We participated in the cruise with RV 'Charles Darwin' from Barry to Barry (UK) from 17 May to 13 June. The principal aim of the study was to quantify fluxes of particles, including organic carbon, across the continental slope. In order to identify erosion and sedimentation sites, eleven stations, ranging from 270 to 4475 m water depth, were sampled along two parallel transects perpendicular to the slope. *In situ* measurements of pore-water oxygen concentration by use of the free-falling vehicle TROL, shipboard pore water analysis of oxidants (O_2, NO_3^-, NO_2^-, SO_4^{3-}) and mineralization products (NH_4^+, Fe^{2+}, Mn^{2+}) and experimental fluxes were used to assess carbon mineralization rates. At first glance, carbon mineralization decreases with increasing water depths as deduced from increasing maximum oxygen penetration depths (6 mm at 270 m-80 mm at 4475 m). Pore-water profiles are currently analysed by using one-dimensional diffusion-reaction models. These results will be compared with those obtained during the October 1993 cruise with RV 'Pelagia' in the same area.

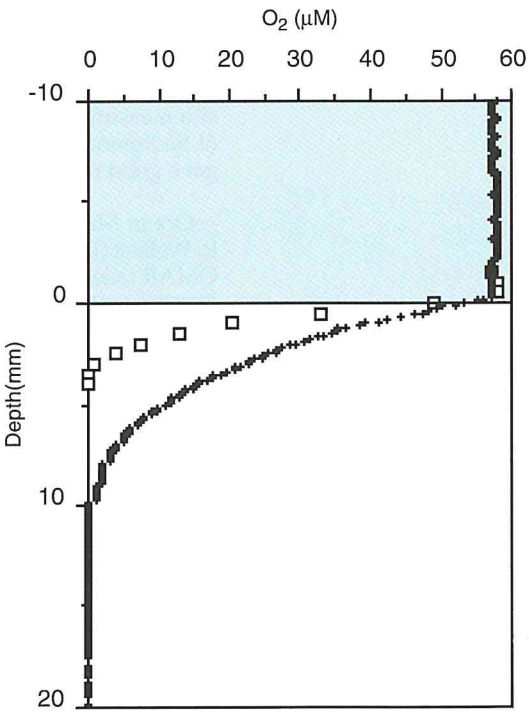
From the two cruises made so far a picture starts to emerge which indicates that indeed accumulation of carbonate and org. C towards the deep stations occurs, that reactivity of this material decreases with depth, and that seasonal differences in reactivity are small or absent.



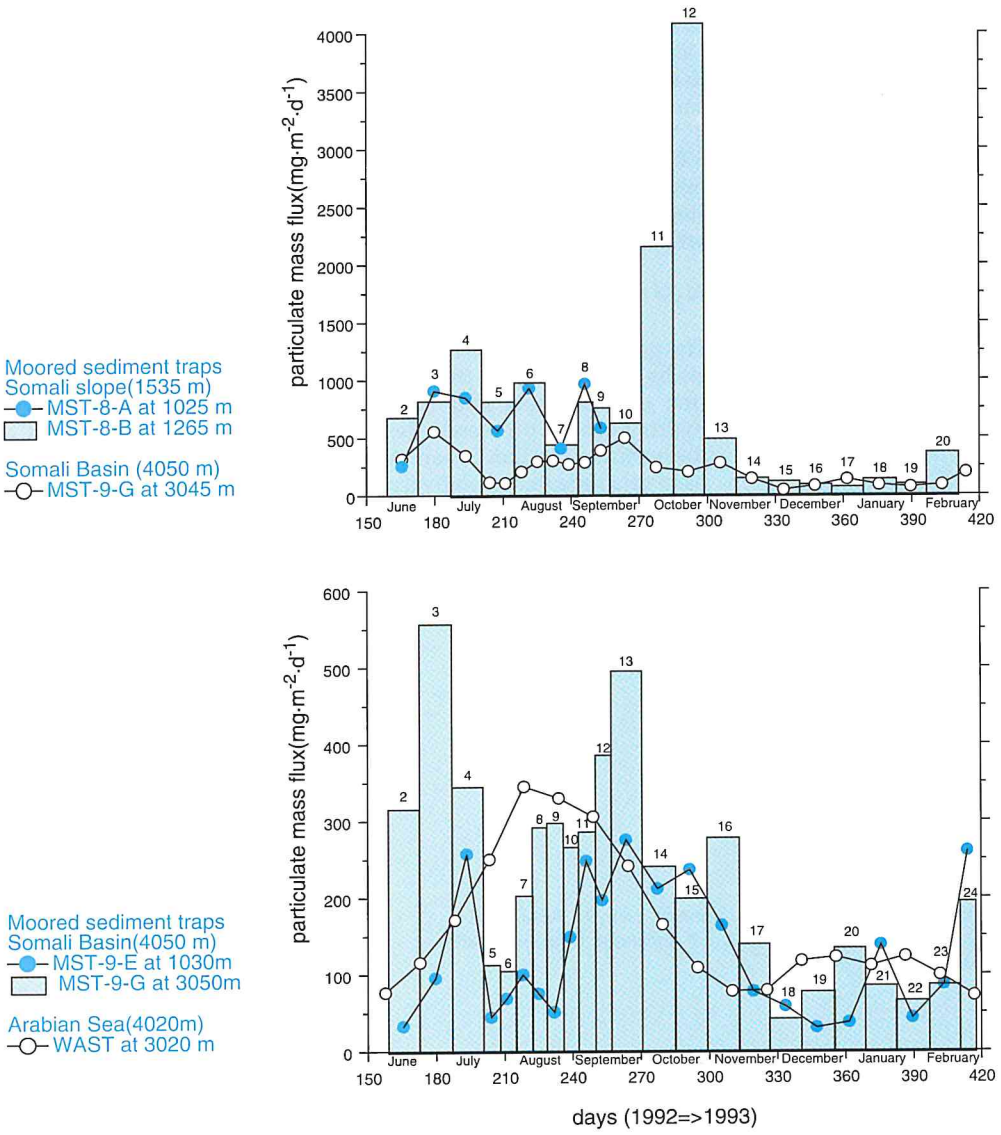
A. Sediment inorganic carbon in top 2 mm;
B. Sediment organic carbon in top 2 mm.

Export production, decomposition, and burial of organic and inorganic matter in ocean sediments

Within this project we now concentrate on the Indian Ocean (NIOP programme). In 1994 pore-water and solid phase analyses of metals (Mn, Fe, Cu, Zn, Ni, Pb, Cd, Cr) were completed. Using these with the shipboard pore- water analyses of electron acceptors for org. C oxidation (O_2, NO_3^-, Mn^{2+},Fe^{2+}) we are able to estimate the organic carbon oxidation rates. Results indicate that these rates are low especially when considering the high deposition rates of org. C. A comparison of the *in situ* pore-water profiles of oxygen made with the Temperature, Resistivity, Oxygen Lander (TROL) and the same profiles made in cores on-deck shows that the effects of pressure and temperature changes in the cores during the upcast create artefacts in the oxygen profiles. Another interesting feature of the pore-water profiles is that, because of the low oxygen concentration in surface sediments and bottom water, the sediments in the Somali and Yemen/Oman upwelling areas are 'leaking' Mn^{2+} and Fe^{2+} to the overlying water.



A comparison of oxygen pore-water profiles, measured *in situ* (+) and measured on deck (□). On deck profiles clearly show a reduced penetration depth for oxygen and a steeper concentration gradient across the sediment-water interface.

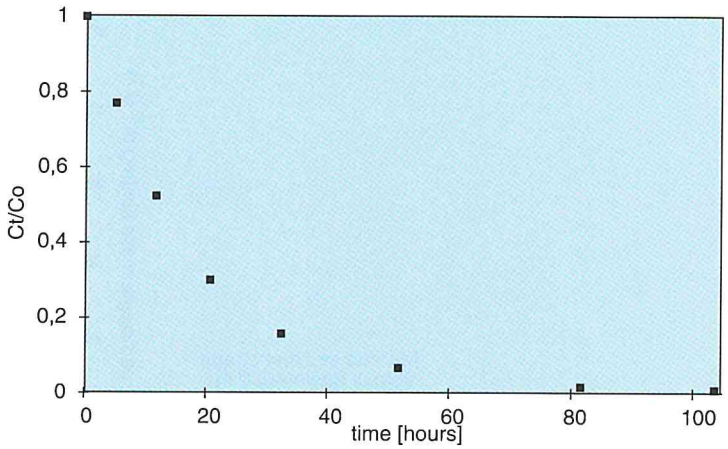


Settling particulate matter intercepted by six automated sediment traps in two arrays was analysed for the magnitude and spatio-temporal change in mass fluxes in the monsoonal upwelling system off NE Somalia, as part of the NIOP-JGOFS effort in the NW Indian Ocean. Results show a strongly dominating SW monsoon period (June-October), at a time when surface productivity is high (~3gC·m^{-2}·d^{-1}) in response to coastal upwelling, gyral offshore transport of coastally upwelled water and enhanced deep vertical mixing. Mass fluxes are almost 3 times higher in the traps moored within the upwelling zone on the Somali slope site (1500 m bottom depth), than in those moored in the deep Somali Basin (4100 m bottom depth) which intermittently received high fluxes when gyral jets of upwelled water passed over this site. On an annual basis the estimated total mass flux to the deep Somali Basin (1 km above bottom) is about 80 g·m^{-2}·a^{-1}, similar to the highest annual values reported earlier from the open Arabian Sea, with organic carbon in the order of 3.6 to 4.8 g·m^{-2}·a^{-1}. Massive particulate fluxes of over 4.1 g·m^{-2}·d^{-1} intercepted 268 m above the bottom on the Somali slope during the better part of October are probably due to submarine across-slope transport given their 70% carbonate content consisting mostly of silt-sized detritus. Yet, they also carry the highest organic carbon fluxes measured (0.1 g·m^{-2}·d^{-1}), with both carbon species and nitrogen bearing a marine stable isotope signature. During the NW monsoon (November-January) mass fluxes are uniformly low (0.1g·m^{-2}·d^{-1}) at all sites and depths, after upwelling and strong circulation have ceased. Generally, mass fluxes are dominated by carbonate rather than opaline silica, and carbonate-carbon rather than organic carbon which is surprising considering the highly productive regime during the SW monsoon. Further research involving various disciplines is being carried out in collaboration with others both at NIOZ and at several other national institutions (CMA, ITZ, LPP, NNM) and abroad (GIUB, LGM, VUB).

Additional isotope studies were carried out on the $\partial^{13}C$ of the ΣCO_2 from several depth profiles, as well as on the $\partial^{18}O$ of the H_2O from numerous surface water samples taken in the NW Indian Ocean during the NIOP, to trace seasonal changes in isotope signature, particularly with respect to equilibrium calcification. As a result, the $\partial^{18}OH_2O$ shows little seasonal change, except in the southern Red Sea due to the change in direction of surface water flow, yet the calculated $\partial^{18}OCaCO_3$ carbonate will change markedly because of the large temperature differences (up to 6°C) in the upwelling affected zones. Analytical problems inherent to our preparation line caused frequent fliers in the $\partial^{13}C\Sigma CO_2$ which we are presently trying to solve by adding a CO_2 stripping step; this problem had also been noticed (but not solved) at other institutes using the same preparation line.

Water-atmosphere fluxes of N_2O and CH_4

The general aim of this NOP study is to contribute to the improvement of current trace gas budgets by (1) quantifying the N_2O and CH_4 exchange between the atmosphere and contrasting marine environments and (2) relating the gas exchange to the underlying biochemical and hydrographical processes. Research was focused on the Dutch Coastal zone, the North Sea and the northwest Indian Ocean. All field work has been completed. The data set now available allows us to conclude that a relatively large proportion of the global marine N_2O and CH_4 concentrations may originate from coastal areas and upwelling regions.



Potential CH_4 oxidation rates, Scheldt, Lillo, 12 April 1994 (100 ml incubations, T=9.5°C, in triplicate poisoning with time).

In the spring of 1994, field work was concentrated on the Schelde river/estuary (in co-operation with J. Middelburg, NIOO/CEMO, Yerseke). This work supported the hypothesis that high CH_4 concentrations along the Dutch coast originate from riverine input. It was found that CH_4 loss by methanotrophic oxidation can be of the same order of magnitude as emission to the atmosphere.

Contributors: *W. Helder* (carbon mineralization, element cycling), *W. van Raaphorst* (nutrient cycling, porewater modelling), *G.J.A. Brummer* (sediment traps), *H.G. Epping* (carbon mineralization, porewater frofile modelling), *L. Lohse (nitrogen cycling)*, *C.P. Slomp* (phosphorus cycling), *H.P.J. de Wilde* (nitrous oxide and methane), *K.M.J. Bakker* (technician, nutrient analysis), *A. van Koutrik* (technician, nutrient analysis), *J.L. van Ooijen* (technician, nutrient analysis), *H.T. Kloosterhuis* (technician, carbon and nitrogen analysis, SIMS), *H. Malschaert* (general research assistant for BEON projects), *E.M. van Weerlee* (technician, nutrient analysis), *R.F. Nolting* (metal analysis).

2. CARBON AND TRACE METALS IN THE OCEANIC WATER COLUMN

Trace metals in the oceans

—*Distributions of metals in the Southern Ocean.* J. de Jong completed analyses of dissolved trace metals in the upper water column of a Southern Ocean transect at 6 °W extending from 48° to 60°S. B. Löscher completed analyses of deep water distributions of dissolved trace metals at the same transect. The findings for dissolved iron in the surface waters were accepted for publication in Nature. Particulate samples collected on filters in 1992 are awaiting analyses. Meanwhile preparations were being made for the next Antarctic expedition aboard RV 'Polarstern' in March-May 1995. Firstly, R. Nolting has received training in the laboratory of Dr. C.S. Van den Berg (University of Liverpool) in Cathodic Stripping Voltammetry techniques for investigation of the organic complexation of iron and other trace metals in seawater, deemed of great significance for their up-

take by planktonic organisms. In collaboration with trainee M. Swagerman these methods were further developed and exercised in the home laboratory, overcoming serious contamination and various other problems. Secondly, J. de Jong, with trainee S. van Wieren, has set up and further refined a chemoluminescence technique for the shipboard analysis of total dissolved iron in the subnanomolar range. While the technique is promising in principle, much time was invested in overcoming baseline instabilities and reducing the overall blanco to below the required subnanomolar level.

—*The role of iron and other trace elements in oceanic ecosystems.* Experiments were performed culturing Antarctic algae under iron limitation at different light intensities. A higher iron demand was recorded for algae grown under low light. Under the latter conditions clear differences in pigment composition resulted in an altered absorption spectrum. In addition, decreased activity of the electron transport system was recorded. Consequently light affinity decreased and the light level of photo inhibition was lowered. Growth rates studied by means of DNA staining are still to be analysed.

During 1994, other trace metals than iron were also taken into consideration. Apart from the effects of iron on nitrogen metabolism, the effects of zinc and cobalt on carbon metabolism in marine phytoplankton were investigated. Nitrate reductase measurements and the effects of ultra low concentrations of iron on the activity of this enzyme system were further elaborated. In co-operation with the carbon dioxide research group a start was made with a study of the effect of zinc and cobalt on carbon metabolism in marine phytoplankton. In this research, a dual approach was chosen. On the one hand, measurements of carbon dioxide in the head space in culture vessels with different zinc and cobalt concentrations were made. On the other hand, an assay for the measurement of carbonic anhydrase activity was developed. The latter activities were done in co-operation with Dr. U. Riebesell, AWI, Bremerhaven.

The historical development of the concept of nutrient limitation of plankton was studied with special emphasis on the role of iron.

Finally, extensive preparations for 1995 field work were done. In total nine people from the carbon dioxide and the trace metal group will take part in the ANT XII/4 cruise with RV 'Polarstern' (March- May 1995, Bellinghausen Sea).

—*Biogeochemistry of Phaeocystis colonies.* In April this project, partially funded by the European Union, was started in collaboration with Dr. C. Lancelot (Université Libre Brussels) and Dr. U. Riebesell (AWI, Bremerhaven). Briefly, for the NIOZ contribution we are testing the hypothesis that the expected higher pH and O_2 concentration within the colony due to photosynthesis are leading to precipitation of ferromanganese oxyhydroxides within the colony, thus affecting the geochemical cycling of these metals. H. Ploug of the Max Planck Institute (Bremen) was invited to participate using micro-electrode techniques for measuring microgradients of pH and O2 across the colonies. Time series sampling in the Marsdiep was done from March to August in order to capture the wax and wane of the spring Phaeocystis bloom. Despite considerable efforts to separate the various particulate and dissolved fractions by physico-chemical techniques and using Al as a tracer for terrigeneous components, it has proved difficult to distinguish in the field the Fe/Mn signal from Phaeocystis colonies from the very strong geochemical background of suspended mineral particles. The hypothesized elevated pH and O_2 within the colonies were observed most convincingly by H. Ploug, noting also a very dynamic response to light. These observations confirm the favourable conditions for precipitation of oxides and also allow the calculation of rates of transport of solutes into the colonies. The seasonal variations of dissolved Fe and Mn in the Marsdiep tidal channel appeared to be consistent with the wax and wane of Phaeocystis blooms, but the effect of diagenetic input of dissolved Fe and Mn from suboxic and anoxic coastal sediments cannot be underestimated. For this reason V. Schoumann, E. Epping and R. Nolting did an additional pilot experiment in the Mok Baai as to assess diagenetic fluxes. All findings were presented and discussed at an international workshop at 7-9 November at NIOZ. Currently, colonial Phaeocystis is being cultured in mesocosms (in 20 dm3 vessels) at ambient concentrations of iron and manganese but devoid of mineral particles as to ascertain the existence of the hypothesized oxide precipitates within the colonies.

Carbon in the oceans

—*CO_2-exchange between the ocean and the atmosphere in temperate South Atlantic waters.* From 21 May to 15 June underway measurements of the CO_2 system in surface waters were executed during a homebound cruise ANT XI/5 (Capetown to Rotterdam) of RV 'Polarstern'. Results of this and several previous expeditions are currently being worked out by D. Bakker, with assistance from the others in the group, for her Ph.D. thesis.

—*CO_2-system in the Antarctic Ocean.* For this joint research project together with Dr. E. Fahrbach (AWI, Bremerhaven), two research cruises aboard RV 'Polarstern' have taken place. Firstly, A. Majoor and E. Koning took part in expedition ANT XI/4 transecting the Antarctic Convergence and

Divergence systems in the Atlantic sector between ports of call Capetown and Punta Arenas. The second expedition ANT XI/4 brought the same team departing on 30 March from Capetown southwards well into the Antarctic Ocean towards the ice edge, in order to return at Capetown on 19 May. Afterwards all running standard gas mixtures have been calibrated in the home laboratory *versus* NOAA certified CO_2 in air mixtures and final CO_2 values for air and surface waters calculated. The performance and dynamic response of the pCO_2 equilibrator and measurements system was intercalibrated at an international workshop organized by Dr. Dickson and Prof. Keeling at Scripps Institute of Oceanography (SIO), 6 to 10 June. Here our team and instrumentation has proved to function excellently, serving as sources of information on methodology for several other participants, whereas we ourselves learned from advice by pioneer Dr. R. Weiss (SIO). The overall findings of the project will be part of the Ph.D. thesis of A. Majoor focusing on the role of frontal systems in the Antarctic CO_2 budget.

Sunset in Antarctica.
Photo: B. Majoor.

—*Dissolved Organic Matter in seawater.* C. Wiebinga as well as J. van Heemst (Department of Marine Biogeochemistry) participated in cruise ANTARES II aboard RV 'Marion Dufresne' in February-April in the Southern Ocean. C. Wiebinga executed shipboard analyses of Dissolved Organic Carbon (DOC) and observed concentrations as low as 25-40 µM, as expected for such remote oligotrophic ocean but well below several recently published oceanic values, indicating major improvements in reduction of the analytical blanco. While at sea intercalibration samples were also analysed and the values communicated to Dr. Sharp (USA), the co-ordinator of the international DOC calibration exercise between about 70 laboratories.

Contributors: *H.J.W. de Baar* (chemistry), *J.T.M. de Jong* (metals), *B.M. Löscher* (metals), *R.F. Nolting* (metals), *H.J.M. Swagerman* (metals), *K.R. Timmermans* (metals/plankton), *M.A. van Leeuwe* (metals/plankton), *A.A.J. Majoor* (CO_2 system), *M.J.W. Veldhuis* (phytoplankton), *G.W. Kraay* (phytoplankton), *V. Schoumann* (metals/plankton), *D.C.E. Bakker* (CO_2 system), *E. Koning* (CO_2 system), *E. de Jong* (CO_2 system), *C.J. Wiebinga* (DOC), *J. Hegeman* (DOC).

3. FATE AND EFFECTS OF ORGANIC MICROCONTAMINANTS

Identification and quantification of organic microcontaminants and their fate in the marine environment

Samples of benthic invertebrates collected during two surveys along transects into the Indian Ocean, perpendicular to the Kenyan coast have been processed and analysed for PCBs and pesticides. Surveys were made in the framework of the study of the coastal ecosystems of Kenya (Project A of the Netherlands Indian Ocean Programme 1990/1995), in order to distinguish the pathways of contaminants in the coastal zone and along the continental slope into the deep sea. Processing of the samples was partly done on board RV 'Tyro'. Preliminary results indicate very low levels of certain selected PCB congeners (*e.g.* CBs -28, -52, -101, -118, -153, -138, -180) and pesticides, such as γ-HCH, Dieldrin, Endrin and members of the DDT-family.

Biological markers of environmental contamination

In ecotoxicology, the use of toxicological effects for the assessment of environmental health has been emphasized. Biological markers have received considerable attention among environmental toxicologists as tools for detecting exposure to and effects of environmental contamination. Research on biomarkers is most relevant since it includes the determination of the physiological status of organisms.

In field studies, DNA damage was measured in the pyloric caeca of female seastars (*Asterias rubens)* and in the liver tissue of female dab (*Limanda limanda*). Samples were collected at locations in different areas along transects radiating into the North Sea, representing areas impacted by contaminants to various degrees.

Strand-breaks in DNA were measured by an alkaline unwinding assay, a technique based on the time-dependent partial alkaline unwinding of DNA followed by the determination of the [double:total] DNA ratio (*F*-value, expressing the percentage double-strandedness).

Areas where seastars and dab showed different DNA integrity could be described. In seastars, the highest integrity (0.75<F<0.85) was found in offshore reference sites. The average percentage double-stranded DNA in seastars from most sampling locations varied between 55 and 75%. The lowest DNA integrity (0.35 <F< 0.55) was found in specimens from sampling locations near the Rhine delta, along the Dutch coast and two offshore areas expected to be uncontaminated. In general, dab showed a little higher integrity, with over 90% double-stranded DNA in pristine areas and an average *F*-value in most sampling stations varying from 0.75 to 0.85.

DNA integrity (strand-breaks) in seastar and dab reflects the physiological status of the individual organism and may be indicative of ambient impairment, but is not necessarily related to anthropogenic or xenobiotic substances.

Heavy metals in the marine environment

The marine environment, including the oceans, shelf seas and estuaries, fulfils a major role in the physical, (geo)chemical and biological processes on a global scale. The state of contamination has to be assessed and the adverse effects of anthropogenic impact have to be determined in order to understand the processes and underlying mechanisms that cause changes in homeostasis of systems. One procedure to establish the quality of the marine environment is measuring certain physical and chemical parameters in the water and sediment and in the biota.

Marine pollution research and monitoring is a priority in the Kenyan Marine Fisheries Research Institute's programmes, necessary for pollution management and decision making. Pollution studies mainly focus on the contaminated estuarine area in the vicinity of Mombasa. However, the Tana and Sabaki rivers also discharge into the coastal area, and the water currents in which the monsoons are the driving forces may distribute land-derived substances along the coast in solution, colloidal or particulate forms.

Surface sediments and epi-benthic invertebrates collected in the Kenyan coastal area and on the continental slope towards the deeper parts of the Indian Ocean (Project A of the Netherlands Indian Ocean Programme 1990/1995) have been analysed for heavy metals (Cd, Pb, Cu, Fe, Mn, Zn). Evaluation and interpretation of the analytical data justify a number of preliminary conclusions. The concentrations of Cd (µg/g Dry Weight) in bulk surface sediment increase from 0.04 - 0.12 µg/g DW at near-coastal stations (±20 m depth) to 0.18 - 0.28 µg/g DW at deep-sea stations (±2000 m depth). These gradients (in the same concentration ranges) were found both during the southeast and northeast monsoon periods. For the other elements except Pb, concentration gradients in the opposite direction are more evident. The concentration of Cd in organisms is significantly above baseline levels, varying from 1.0 to 31.1 µg/g DW in various species, whereas Pb shows very low concentrations in all species investigated, varying from 0.2 to 2.2 µg/g DW. The concentrations of both Cu and Zn are at about baseline levels or a little elevated, depending on species.

Analyses of heavy metals were carried out on samples from the intertidal zone of Pattani Bay, Thailand. The concentrations of copper, zinc, cadmium and lead were measured in surface sediment and organisms representing different trophic levels of a short food-chain (polychaete worms, fish and birds). The results indicate metal-species dependent transfer and biomagnification through different trophic levels, and interspecific differences in uptake and distribution of metals in waders. Data indicate that uptake of a specific metal species does not depend directly on metal levels in the surface sediment. Both metal-species dependent regulation and bioaccumulation were observed.

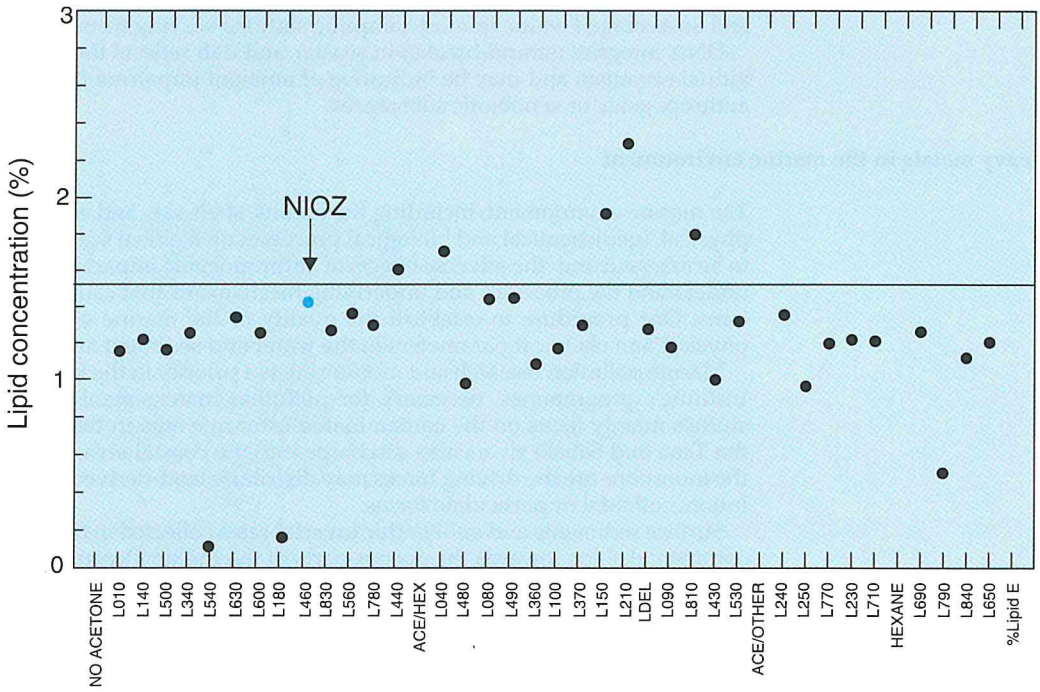
Analytical organic chemistry

The quantitative analysis of PAHs was successfully implemented. After a last validation of the entire procedure, including evaluation of the extraction method and of the calculation methods used by Fisons Opus-quan software, the analysis of environmental samples will start in 1995.

A comparative study was made for the extraction of aliphatic esters in sediments. No significant differences were observed between cold-blend methods with acetone-hexane and with dichloromethane-methanol on the one hand and the traditional soxhlet extraction on the other . From this study as well as from studies made previously for other sample matrices it appears that cold-blend methods with mixed polar/non-polar solvents are as efficient as soxhlet extraction, but that the extraction time is significantly shorter and the solvent demand lower. A second study has been started to develop a uniform method for biota as well as for sediments. This method is based on the principles of the Bligh and Dyer extraction, and allows for rapid and automated operation. The use of non-chlorinated solvents for this method will be investigated.

All important analytical procedures were converted to Standard Operating Procedures (SOPs). The final step in the Quality Assurance (QA), Quality Control (QC) procedures, *viz.* writing a Quality manual, has not yet been undertaken.

The laboratory participated in four intercalibration exercises organised by QUASIMEME:
—Chlorobiphenyls and chlorinated pesticides in organic solvents, sediment and fish oil.
—Chlorobiphenyls and chlorinated pesticides in organic solvents, sediment and cod liver tissue.
—PAHs in pure organic solvents.
—Lipids in marine organisms.
Only the results of the lipid determination are available at present and show that good results have been obtained for the classical Bligh and Dyer method as well as for the standard procedure used in this lab.



Results of the QUASIMEME intercomparison exercise for the determination of lipids in marine organisms. Horizontal axis: lab code. Vertical axis: lipid concentration as determined by the standard methods used by the participating laboratories. The solid line represents the mean value of the total lipid determination according to the Bligh and Dyer method.

Exchange of organic contaminants between sediment and water

Literature values of organic carbon normalized sediment water partition coefficients vary by about one order of magnitude. Although part of this variation is caused by differences in organic matter composition, a significant part may be caused by the divergent experimental procedures, such as phase separation and the determination of concentration levels in the various phases. Therefore, the laboratory has participated in an intercomparison exercise for the determination of sediment-water partition coefficients of chlorinated benzenes, together with four other Dutch laboratories. In one series of experiments the participating laboratories use the same experimental procedure, in a second series the in-house method is used. Evaluation of the results will enable us to validate the various methods that are applied.

Contributors: *J.M. Everaarts* (biological markers, organic microcontanimants, heavy metals), *K. Booij* (analytical organic chemistry, sediment-water exchange), *C.V. Fischer* (organic microcontaminants), *M.Th.J. Hillebrand* (analytical organic chemistry), *J. Nieuwenhuize* (CEMO-NIOO: heavy metals), *E. van Weerlee* (analytical organic chemistry).

The research programme of the Department of Marine Geology and Geochemistry consists of two main subjects: 1. palaeoceanography, and 2. sedimentation and sediment transport processes.

Palaeoceanography is a science which investigates oceanographic processes, their causal relations, and their changes in the course of time, with the use of past oceans. The information is stored in the seafloor sediments in the form of resistant physical, chemical and biological signals. For this reason, palaeoceanography does not confine itself to a study of the sediments and their components. It needs also to focus on the present ocean in order to unravel the way in which the ocean produces the resistant signals, and how these signals change 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. In regions where this is the case, they allow us to correlate precisely the continental with the oceanic climatic changes, which provides a tool to study their causal relations.

Research on sediments and sediment transport processes gives insight into the conditions (physical, chemical and biological) under which recent as well as older sediments are formed. As the sediment in suspension is fine-grained and cohesive, flocculation of (most of) the suspended material is an important process besides deposition, consolidation and resuspension. Deposition (accumulation) rates make it possible to estimate sediment fluxes to the bottom as well as fluxes of elements and compounds associated with the particulate matter. This includes fluxes during previous periods from which sediment is recovered in the bottom samples (box-cores, piston-cores). The composition of sands and clays gives indications of the provenance of the sediment and possible transport paths.

In the North Sea area, including river mouths and estuaries, flocculation was studied in relation to water masses, tidal variations and seasonal differences in composition and concentration of the organic matter. Deposition rates and mixing were estimated with radioisotopes (mainly ^{210}Pb). On a smaller scale sediment fluxes and accumulation of bottom sediments were studied in the Adriatic Sea and in Lake Erhai, a rift lake in China. In this lake, the processes of sediment accumulation as well as the techniques of studying them are very similar to those in a coastal area. On the Northwest European shelf and the adjacent slope (the area covered by the OMEX programme), sedimentary processes were studied in co-operation with the NIOZ Departments of Marine Chemistry and Benthic Systems. Mud volcanoes, which occur on the seafloor in several areas, were studied in the Black Sea. A study of sediment deposition in East Indonesian basins grades into palaeoceanography. The deposition is strongly related to the tectonics of the basin: seismic profiling is an important tool in determining the deeper structure and sedimentary history.

An extensive project in the southeastern Atlantic Ocean focuses on the late Quaternary palaeoceanography in relation with the palaeoclimate of equatorial Africa. The objective of a second project is the monsoonal system of the NW Indian Ocean. The Indonesian basins are the theme of a third palaeoceanographic study. The study of the geochemical cycles of silicium and aluminium is a project which is directed to the actual behaviour of biogenic silica in the water column and its very early diagenetic fate in the surface sediment.

1. PALAEOCEANOGRAPHY

Palaeoceanography of the Angola Basin and the terrestrial climate

—*Planktic foraminifera and surface circulation.* Core T89-32 on the continental slope (15°S, 3300 m water depth) is situated at the actual Angola Benguela front, which separates the coastal branch of the Benguela Current from the Angola Current, the coastal part of the South Equatorial Counter Current (SECC). The contents of this core show that the front has shifted several times in a N-S direction. At present, the front lies rather far south, but it has been much more north several times during the last 200 000 years. Comparison with other cores taken between 5 and 20°S reveals that the front has moved between *ca.* 8 and 15 to 20°S. The movements of the front are not synchronous with the known glacial-interglacial climatic variations; it was far south during the last glacial phase of the cold stage 6, 150 000 to 140 000 years ago, and has been far south during the last 20000 years which include the last glacial. The CLIMAP reconstruction of the South Atlantic during the last glacial maximum 18 000 years BP describes an intensification of the SE boundary current system which brought cold Benguela Current water to the equator. Our work demonstrates that, on the contrary, the Angola Benguela Front was located far south 18 000 years ago, and that Benguela Current water has never reached 6.5°S during the late Quaternary.

The shallow position of core T89-40 (3073 m) on the Walvis Ridge allows us to study the regional oceanography influenced by the Benguela Oceanic Current. The apparently odd concurrence of the subtropical *Globorotalia menardii* and the cool, strongly eutrophic left-coiled *N. pachyderma* is

one of the most striking features in core T89-40 at the Walvis Ridge. In the Annual Report of 1992 this was explained by high interglacial productivity.

New insights into the physical oceanography of the South Atlantic reveal the transport of the Agulhas eddies across the Walvis Ridge. The creation of Agulhas eddies is largely related to the undulating shape of the Subtropical Confluence (STC) and may include filaments of subpolar water. On their way across the Atlantic the eddies pass the southern part of the Benguela system and may entrain filaments of upwelling waters from the near-coastal area.

The warm, eutrophic species *G. menardii* is not related to the oligotrophic Agulhas eddies and is therefore indicative of the local ecology. The presence of *G. menardii* points to interglacial conditions. The left-coiled *N. pachyderma* reflects cool and highly productive waters and can be considered an expatriate supplied by the Agulhas eddies since its habitat is restricted to the upwelling areas of the Benguela system and to subpolar waters south of the STC. During glacial periods a reduction of the formation of Agulhas eddies due to a northward shift of the STC and altered upwelling conditions in the southern Benguela system due to a sea level drop may have contributed to the absence of left-coiled *N. pachyderma*.

Prior to isotopic stage 11 (423 ky BP) the presence of *G. menardii* and its concurrence with left-coiled *N. pachyderma* is limited due to cooling and a strong northward shift of the STC. This shift must have been sufficient to reduce or eliminate the undulating character of the front and, subsequently, the formation of Agulhas eddies.

Therefore the presence of left-coiled *N. pachyderma* is related to a southern position of the STC which has an undulating character. Because of this character eddies may develop.

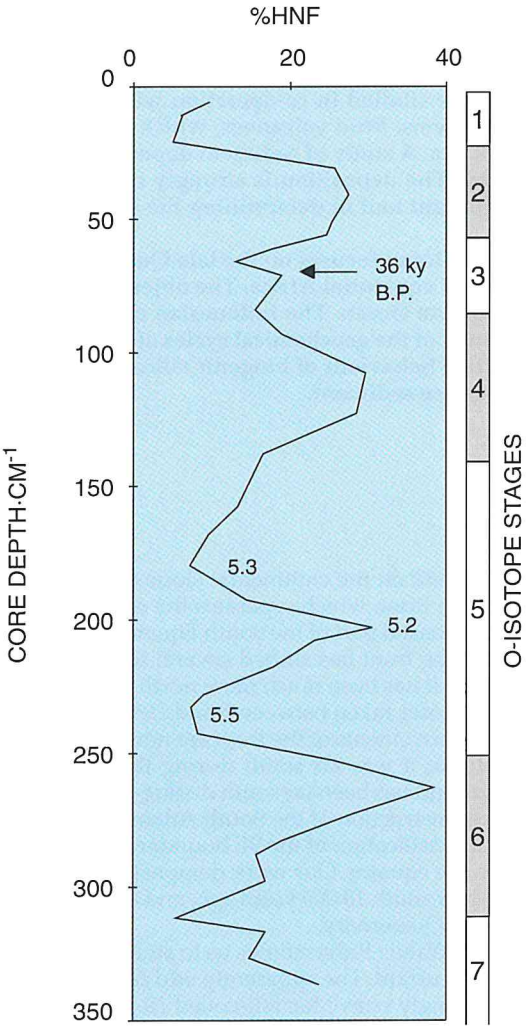
—*Fluctuation patterns of benthic foraminifera as a reaction on surface water productivity.* A morphotype analysis of deep-sea benthic foraminifera from a piston core (T89-40) from the southern Angola Basin (Walvis Ridge, 21°36.3' S / 6°46.6' E; 3073 m water depth) revealed three major groups of benthic foraminifera species. These 'morpho-groups' appear to be trophic groups, since the habitat preferences and feeding habits are closely related to the morphology of the test.

1. 'Opportunistic group'. The opportunistic group consists of species which are highly adapted to environments with strong short-term (seasonal) changes in vertical nutrient fluxes. A high motility enables these species to optimize their food acquisition by dwelling on both the surface and the subsurface of the sediment.

The species with statistically significant abundance (≥5% in at least one subsample) in this group are: *Cibicidoides kullenbergi, Hoeglundina elegans, Oridorsalis umbonatus, Osangularia culter, Pyrgo murrhina, Quinqueloculina seminula*-group, ?*Melonis pompilioides*, ?*M. zaandami*.

2. Low Nutrient Flux (LNF)-feeders. The species of this group are mainly independent of vertical nutrient fluxes. They feed on the suspended matter in near-bottom water by dwelling on elevated parts of the sediment surface. The species ≥5% in this group are: *Cibicidoides wuellerstorfi*, ?*Gyroidina orbicularis*.

3. High Nutrient Flux (HNF)-feeders. Significant fluctuations in the abundance of these species are related to the different climatic periods in the late Quaternary). Being specialized deep dwellers, these species require high inputs of organic material. Only in times of high vertical nutrient fluxes will a sufficient amount of organic matter be buried in deep-sea sediments (>2000 m water depth), to serve as a food source for foraminifera with an endobenthic lifestyle. The species ≥5% in this group are: *Globobulimina subglobosa, Pullenia bulloides, Sphaeroidina bulloides, Uvigerina auberiana, U. hollicki*.



The benthic foraminiferal fauna at site T89-40, dominated by species with opportunistic feeding habits, points to a benthic environment characterized by low vertical fluxes of organic matter and seasonal changes. Nutrient input via lateral transport is indicated by relatively high abundances of specialized suspension feeders. Enhanced percentages of infaunal species indicate higher vertical nutrient fluxes and thus increased primary production during late Quaternary glacial periods in the southern Angola Basin.

Numbers from 1 to 7 indicate positions of oxygen-isotope stages in the core. Number 5.2 points to estimated position of oxygen-isotope substage 5.2, stippled areas indicate cold climatic periods, arrow shows position of ^{14}C dating (36 ky BP). Vertical axis gives core depth in cm.

—*Continental diatoms in deep-sea sediments as a signal for climatic development in equatorial Africa.* The taxonomy of continental freshwater diatoms in the marine sediments is unexpectedly complicated. Marine and continental species are often very much alike, which was unknown because 'diatomists' never study both marine and continental diatoms at species level. Moreover, in the marine environment the continental ones are less well preserved than in lake sediments. The identification at species level is the main job of the project.

The continental diatoms indicate increased river transport in stages 5.4, 5.3, 4, and during 27 to 24.4 ky BP, and arid features around 28.2, 11.4 and 10.5 ky BP. The latter two correspond with the Older and the Younger Dryas, cold climatic events in the northern hemisphere. They fit in closely with marine features recorded in the same cores, the time difference being 100 to 200 years. This corroborates that the Younger Dryas was an ice-cap feature passed on by the atmosphere, and not related to a slow-down of the oceanic conveyor belt. This subproject started in January 1993. It is financed by the NOP 1 programme under project number NOP 206, and carried out in co-operation with the Laboratoire d'Hydrologie et de Géochimie Isotopique, Université Paris-Sud, Orsay, France.

—*Origin and distribution of minerals and biogenic opal in recent sediments of the Angola Basin and the influence of gibbsite on the preservation of opal.* Relative amounts of clay minerals, as well as minerals and concentrations of biogenic opal, were determined for surface sediments of the Angola Basin (SE Atlantic Ocean) with the use of X-ray powder diffraction (XRD). The aim was to define their origin as well as the distribution processes in order to develop a tool for the study of time-series in deep-sea cores. We corrected the mineral amounts for mass accumulation rate, an inevitable step for the study of mineral associations, and measured the crystallinity. With these data, distribution maps were created for the surface sediments in the Angola Basin. Based on these maps, different sediment sources can be distinguished: the Zaire (Congo) River and, possibly, the Kunene River, and the Namibian desert and Kalahari savannah in southern Africa. The latter minerals are thought to be supplied by the SE trade winds. A downcore study of core T89-32, situated at the Angola Benguela (AB) front (see also the paragraph on planktic foraminifera above) shows variations of the mineral associations which reflect the intensity of the SE trades. This signal seems to be closely related to the shifts of the AB front mentioned above.

The project is supported by Drs R. Schneider and G. Wefer from the Department of Geosciences, Bremen University, who provided us with the necessary $\delta^{18}O$ data of the studied cores.

Tracing monsoonal upwelling in the Somali Basin (Indian Ocean)

Piston cores collected during 1992/1993 were opened and described and a few cores were selected for further studies. Recent sedimentation rates and organic carbon contents in surface sediments were measured in box-cores of the Yemen and Oman transects.

The data obtained with the bottom benthic boundary lander (BOBO) show that current velocities near station MST 8 at 1500 m depth are only rarely high enough to prevent sediment settling. Currents directed to the north appear to be related to lower bottom water temperatures. A start to relate biogenic silica to varying monsoonal conditions has been made by measuring a limited number of surface samples for their biogenic silica content, using different methods of chemical pre-treatment.

Because of EC obligations, only little attention was given to the NIOP programme during 1994.

—*Marine diatoms.* Part-time work was carried out on diatoms from top sediments of box-cores from the Indian Ocean Expedition. The results show that diatoms can be used for further downcore investigations, because a distinct upwelling assemblage occurs in the upwelling regions *versus* a warm, tropical oceanic assemblage with high diversities offshore in oceanic deposits. A start has been made with diatom investigations of sediment-trap material collected off Somalia.

Palaeoceanography of the Indonesian waters

Diatom oozes (maximum 6 cm) are found in glacial deposits of some deep-sea cores from the Indonesian Archipelago. They contain a mono-specific assemblage of the giant diatom *Ethmodiscus rex* which can reach a diameter of 2 mm. Because *E. rex* is presently known as an oligothrophic tropical oceanic species, its glacial ooze deposits are at least peculiar. We investigated the non-*E. rex* diatom composition in and between the oozes in order to unravel the environmental circumstances under which they were deposited.

The oozes seem to occur just prior to the Last Glacial Maximum, in the ice-growing phase and just prior to the highest Diatom Accumulation Rate (DAR) peak. 'Glacial' sediments have higher diversities and —though variable— in general a better preservation of the non-*E. rex* diatom assemblages than the 'non-glacial' floras. In the oozes preservation is even better than between the oozes. Concentration of *E. rex* by selective dissolution (one of the hypotheses) can thus be excluded. The unexpected simultaneous occurrence of lower salinity species and the *E. rex* oozes/peaks suggests stratified water masses with different diatom populations living at different depths (*E.*

rex is positively buoyant and can live beneath the euphotic zone). From the negative relation of upwelling species and *E. rex* it can be concluded that the oozes are not associated with upwelling (another hypothesis).

What has not been reported before is that the oozes are graded. This points to gentle deposition from suspension on a seafloor with very little turbulence. The presence of pyrite in the oozes is a result of reducing conditions following oxidation of the abundant organic matter. Common faecal pellets also indicate increased organic carbon levels. The absence of littoral benthic diatoms and low quartz contents show that long lateral distance transport of the easily kept in suspension *E. rex* soup is not the case. It is at most only transported to the deepest part of the basins. The cyclic nature of the *E. rex* oozes suggests very subtle environmental oscillations during the last glacial in the Banda Sea.

Co-operation was started with Prof. B. Stabell (Dept. of Geology, Univ. of Oslo, Norway). The plan is to collect all available data so far of *E. rex* oozes and to organize a workshop on the problem at the next Diatom Symposium.

SEM micrograph. *Ethmodiscus rex* fragment from a diatom ooze of glacial Banda Sea sediment. µ-marker represents 100 µm. Photo: J. v. Iperen.

Sedimentation and suspended matter transport in the Faeroe-Shetland Channel

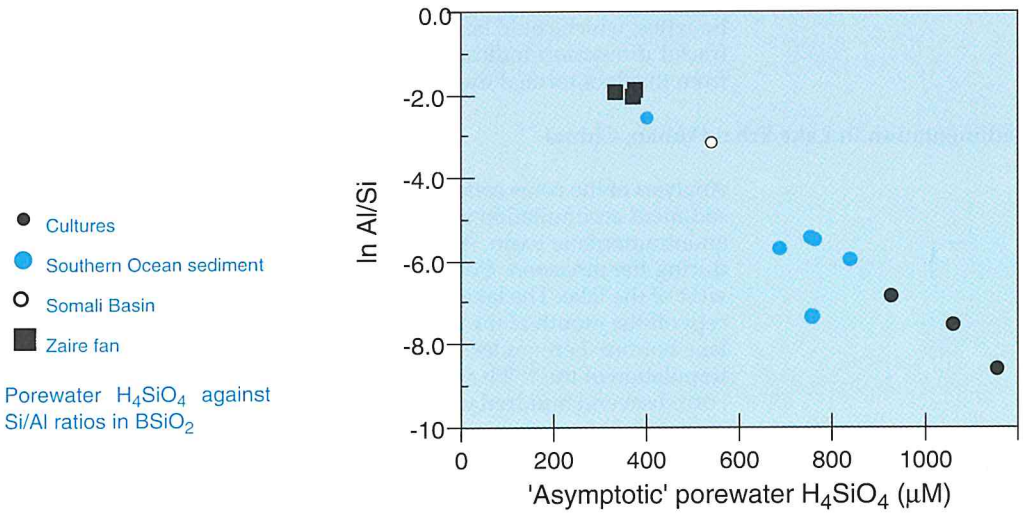
Studies in the Faeroe Shetland Channel and the continental margin east of the Faeroe Islands (within the EC-supported ENAM programme) relate the development of the Norwegian Sea Deep Water in the Norwegian Sea to the effects of overflow of the NSDW into the North Atlantic Ocean and include the determination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

By means of oxygen isotope stratigraphy of high resolution piston-cores taken at contourite deposits formed by NSDW, and further supported by micropalaeontological studies, ^{14}C AMS dating and the presence of the ash layers I and II, the variations of NSDW intensity over the last 80 ky were established. The results indicate that during the Last Glacial Maximum (LGM) the Norwegian Sea was free of ice and had an open circulation. From isotope stage 5A-3 on there was intermittent stagnation and open circulation.

The seismic profiles of the eastern continental margin off the Faeroe Islands perpendicular to the bathymetry show that the contourite development induced by the NSDW started during the Middle Miocene, and that subsequently a drift deposit gradually evolved, characterized by relatively high rates of deposition. At the lower margin of the continental slope extensive slumping has occurred, possibly induced by deglaciation of the Faeroe Island area.

Early diagenesis and palaeo-signals of biogenic silica ($BSiO_2$) in sediments

The work on the content of aluminium in $BSiO_2$ as a controlling factor in the preservation of $BSiO_2$ in sediments was extended to samples from the Somali Basin and the southern Indian Ocean, collected during the Netherlands Indian Ocean Programme and the Antares Expedition, respectively. The latter samples showed the world's highest interstitial silicic acid concentrations, measured so far at low temperatures (843 µM) and also the lowest average Al/Si ratios (0.0027 ± 0.001) measured so far in $BSiO_2$ in sediments. The Somali Basin results are intermediate between the Southern Ocean and the Zaire fan. Surprisingly, all $BSiO_2$ from the Somali Basin samples contained a few per cent of Ca.



Ph.D. research was started on the use of $BSiO_2$ as a tracer of present and palaeo-signals of upwelling in the NW Indian Ocean. Optimum conditions for determination of $BSiO_2$ in sediments with hot alkaline leaching were investigated for different kinds of deep-sea sediments by T. Happee (contract Antarctic project Si/Al cycles in the Southern Ocean). Sodium carbonate (0.5 M) and sodium hydroxide (0.1 and 1 M) were applied at 85°C to sediments from the Southern Ocean, the Somali Basin and the Zaire Fan. Results were checked with microscopic observations and with differential XRD. It is no surprise that no complete separation between $BSiO_2$ (diatoms, radiolarians, sponge spicules) on the one hand and clay minerals on the other is possible, but the ranking in solubility and in leaching results was the same for the southern Ocean, the Somali Basin and the Zaire fan. Clay minerals partly dissolve in 1 N NaOH, and 0.5 N Na carbonate does not dissolve all $BSiO_2$. The optimum method depends on the region; for the NW Indian Ocean 0.1 N NaOH seems the optimum.

Contributors: *J.H.F. Jansen* (palaeoceanography), *L. Ben Khelifa* (continental diatoms), *A.J. van Bennekom* (silica cycle), *S.J. van der Gaast* (XRD), *H. Gipp* (benthic foraminifera), *E. Ufkes* (planktic foraminifera), *E. Okkels* (chemistry), *A.J. Vaars* (XRF corescanner).

2. SEDIMENTATION AND SEDIMENT TRANSPORT PROCESSES

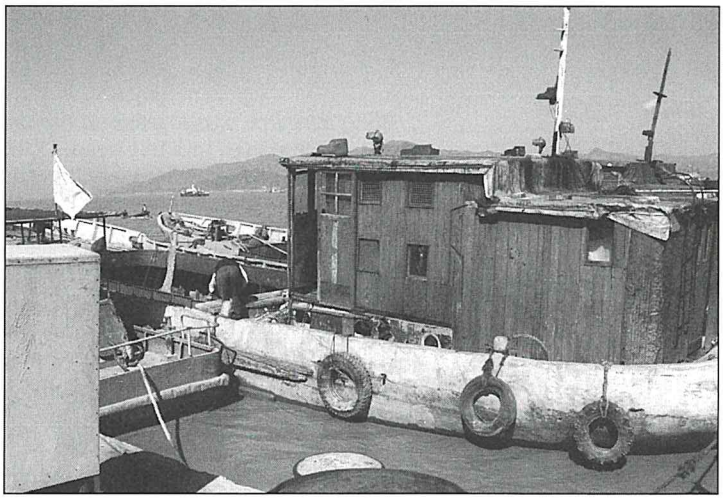
Flocculation

Flocculation and *in situ* floc size distributions have been studied in the North Sea, in the Irish Sea as part of NOWESP programme and in the estuaries of the Elbe, Schelde and Gironde as part of the MATURE programme. In the Irish Sea no results could be obtained because of camera failure. In the North Sea the sampling programme started in 1992 was completed so that all seasons have now been covered. Preliminary results show a strong influence of the primary production on floc size, but stringers such as described by Riebesell in the German Bight were hardly found. Probably they are only formed when a period of quiet weather coincides with a period of plankton bloom, *i.e.* when turbulent shear is low and much organic matter is present. No plankton bloom was observed during the sampling periods, which was also indicated by the relatively low content of lipids, proteins and chitin. The differences in floc size found are probably mostly related to differences in turbulent shear. More in detail this was also shown by the floc size distributions collected along transects off the Dutch coast (collected as part of the PEGASUS Project). Floc size along these transects is much less variable than floc size in the estuaries studied (Elbe, Ems, Schel-

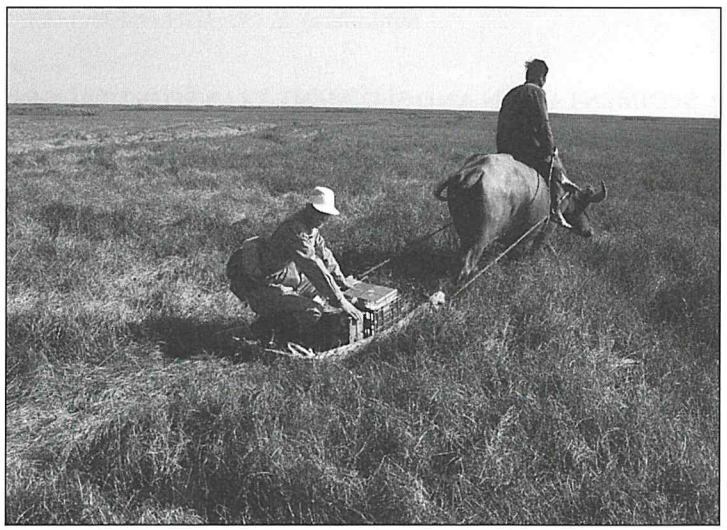
de, Rhine) and indicates a steady equilibrium state between flocculation and floc break-up. During the MATURE programme floc size in the Elbe estuary varied considerably over the tidal cycle —which had been observed before— but also showed a trend towards becoming finer in a seaward direction, *i.e.* in the direction of lower suspended matter concentrations. In the Schelde estuary a similar trend was found, but more detail will be visible when all the measurements have been worked out. Measurement in the Gironde were, unfortunately, limited to the short periods with low suspended matter concentrations, the upper limit of the *in situ* suspension camera being about 300 $mg \cdot dm^{-3}$. Information on the internal structure of the flocs was obtained by considering their fractal dimension. Theoretically and in laboratory experiments the fractal dimension of flocs that were formed under conditions of turbulent shear is systematically lower than for flocs formed during settling. It could be shown that this is also true for natural floc silhouettes, as produced by the *in situ* camera. For this it was necessary to measure the maximum length of floc silhouettes, which could be achieved by adapting the image analysis programme. This difference in fractal dimension indicates that flocs formed under turbulent shear have a structure different from the flocs formed during settling (but not necessarily more or less porosity).

Sedimentation in Lake Erhai (Yunan, China)

Analysis of the cores collected in 1993 in Lake Erhai, a rift lake in southwest China, indicated that sediment accumulation rates are very low, in the order of 0.05 - 0.5 $cm \cdot y^{-1}$. This is surprising for an intramontane basin. A fine lamination (1 mm thickness) can be related to seasonal deposition during the monsoon. Coarse sediment hardly reaches the lake and is deposited on the plateaus west of the lake. The lake floor consists almost entirely of fine mud with some mollusc shells, except off the mouth of the river. There is a marked change in deposition at 40 cm below the present lake bottom: here under the muds a sandy deposit is found with ripples and scour features. Extrapolation of the ^{210}Pb accumulation rates shows that this change in sedimentation probably occurred several hundred years ago and is likely to be linked to an increase in agriculture and water management.



In November 1994 water samples were collected with this 'research vessel' on the Jiao Jiang river for determination of sedimentation rate and organic content. Photo: J. Kalf.



In November 1994 core samples were collected on tidal flats near Chongming Island (Chang Jiang river mouth) for determination of sedimentation rate and organic content. Photo: J. Kalf.

The ^{210}Pb and ^{210}Po system in the North Sea

Dissolved and particulate samples for ^{210}Pb and ^{210}Po measurements were taken in the North Sea in August. Samples taken during the winter and autumn of 1992 and those of the spring and summer of 1993 are currently being measured for their ^{210}Pb contents. Summer ^{210}Po values in 1993 range from 0.4 mBq·kg^{-1} south of Dogger Bank to 2.4 mBq·kg^{-1} in bottom waters on the west slope of the Norwegian trench. The 1993 summer season pattern of ^{210}Po distribution is similar to the 1993 spring distribution.

The contribution of dissolved and particulate ^{210}Po changes with the seasons. While in summer most ^{210}Po is in the dissolved phase, the particulate contribution increases during autumn and winter. In spring most ^{210}Po is from the particulate phase.

The supply of ^{210}Po in the North Sea water is almost entirely by *in situ* decay of ^{210}Pb. The main source of ^{210}Pb in the North Sea is deposition from the atmosphere, with a mean influx of 150 mBq·m^{-2}·d^{-1}. Although the influx of ^{210}Pb is not constant over the year, the production of ^{210}Po is averaged in time.

The flux of atmospheric ^{210}Pb is sampled every week. Collection of rainwater started on Texel in 1988 and in Groningen in 1987. A study of regional variations in the atmospheric influx of ^{210}Pb (if any) requires additional measurements in *e.g.* Scotland and Norway.

Sedimentation and sediment mixing in the Adriatic Sea

In co-operation with Dr. M. Frignani of CNR, Bologna, sediment cores are being analysed. The process of redistribution of isotopes and fine-grained particles in the top layer of sediments in the Adriatic Sea is studied with ^{210}Pb and ^{137}Cs measurements. At three stations in the northwest Adriatic 110 cm gravity cores were collected in February 1994. The silty clay cores show accumulation rates from 5 mm·y^{-1} near the Po delta to 2 mm·y^{-1} near Ancona. Surface mixed layers are 5-7 cm thick. ^{137}Cs profiles show downcore diffusion of Cs as the penetration depth of ^{137}Cs ranges from 32 to 65 cm. Results will be compared with detailed faunal descriptions from the same sites.

Sediment and organic carbon accumulation in the North Sea

During two cruises box- and piston-cores were sampled with the NIOZ research vessel 'Pelagia' in the framework of the VvA-4 project (Global Change Project) in co-operation with the NIOZ Departments of Chemical Oceanography and Benthic Systems. The box-core samples are used to determine recent sedimentation rates, using the ^{210}Pb method. Of these box-core samples, downcore organic carbon concentration measurements were carried out as well. These data are combined with data from the literature to calculate the Recent dry bulk sediment and organic carbon accumulation rates in the North Sea. These calculations have so far been carried out for the Skagerrak and Norwegian Channel. The calculations show that 87.2x10^6 tons of dry weight of sediment are deposited in this area every year. The organic carbon concentration in the cores is on average 1%, resulting in an annual organic carbon accumulation of 0.87x10^6 tons. These results confirm that the Skagerrak/Norwegian Channel area is the most important sink for sediments and organic carbon in the North Sea, and that only a small fraction of the organic matter produced in the water column is finally buried in the sediments.

Piston-cores are being analysed for changes in carbonate, POC, and PON contents and changes in δ^{13}C over longer periods of time (thousands of years).

Sedimentary development of the eastern Sunda forearc basin

The Ph.D. study of W. van der Werff concerning the development of the eastern Sunda forearc basins is nearly finished. The seismostratigraphy of the Lombok and Savu basins has been established and indicate the presence of a Miocene proto-volcanic arc north of the island of Sumba.

The present tectonic activity of the Lombok basin area is governed by late Pliocene collision of the accretionary prism with oceanic plateaus. This resulted in the uplift of the forearc. The present stratigraphy suggests that Sumba has a northerly origin.

Black Sea mud volcanoes and gas seeps

Mud volcano samples obtained during the Training Through Research (TTR) cruise 1993 were analysed for their age and content of mud breccia. It is evident that the mud volcanoes are formed by intermittent outflow of gas-saturated muds from a source 4 to 6 km below the surface. A preliminary analysis of gas of one of the mud volcanoes showed that it had a biogenic isotopic composition with traces of higher alkanes of thermogenic origin. The gas consists of over 90% methane. Mud breccias show two distinct source beds.

Recent sediments and sedimentation in the OMEX area

Within the framework of the EC-supported OMEX project, the Department of Marine Geology is the project co-ordinator of the OMEX Benthic Processes Subproject. During 1994 a cruise was carried out to the Goban Spur in collaboration with the Departments of Chemical Oceanography and Benthic Systems, using the RV 'Charles Darwin'.

During the cruise acoustical profiles were obtained along two transects, showing that the lower continental slope and upper rise of the Porcupine Bight and Pendragon escarpment are characterized by strong hyperbolic reflections along the upper slope and northern part of the transects. Incisions by canyons are frequent and reflectors are discontinuous, which means that sedimentation here is irregular and most probably followed by intermittent erosion and non-deposition.

The southern profile shows that sediment draping and uninterrupted sedimentation occurs between 2500 and 1500 m. Locally we found indications of sediment waves, which may be induced by slope-parallel currents.

Measurements by the BOBO lander in the vicinity of station OMEX II show that near-bed current velocities of up to 15 $cm \cdot sec^{-1}$ do occur and that near-bed currents have a strong tidal component.

Along the two transects covered during the 1994 campaign, surface nepheloid and bottom nepheloid layers of variable intensity were present at all stations. However, no intermediate nepheloid layer was measured. The bottom nepheloid layer is increasingly thick down the slope with a decreasing intensity, suggesting gradual settling of particles along the transect.

^{210}Pb and micropalaeontological studies of the box-cores 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 7 ky, 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.

Contributors: *D. Eisma* (suspended matter, sediments), *J.P. Beks* (isotopes), *S. Chen* (suspended matter, flocculation), *S.J. van der Gaast* (clay minerals), *H. de Haas* (sediments, organic matter), *H. de Stigter* (foraminifera), *Tj.C.E. van Weering* (sediments, sediment transport), *W. van der Werff* (sediments, seismics), *E. Okkels, W. Boer, R. Gieles-Witte, J. Kalf, A.J. Vaars.*

DEPARTMENT OF MARINE BIOGEOCHEMISTRY

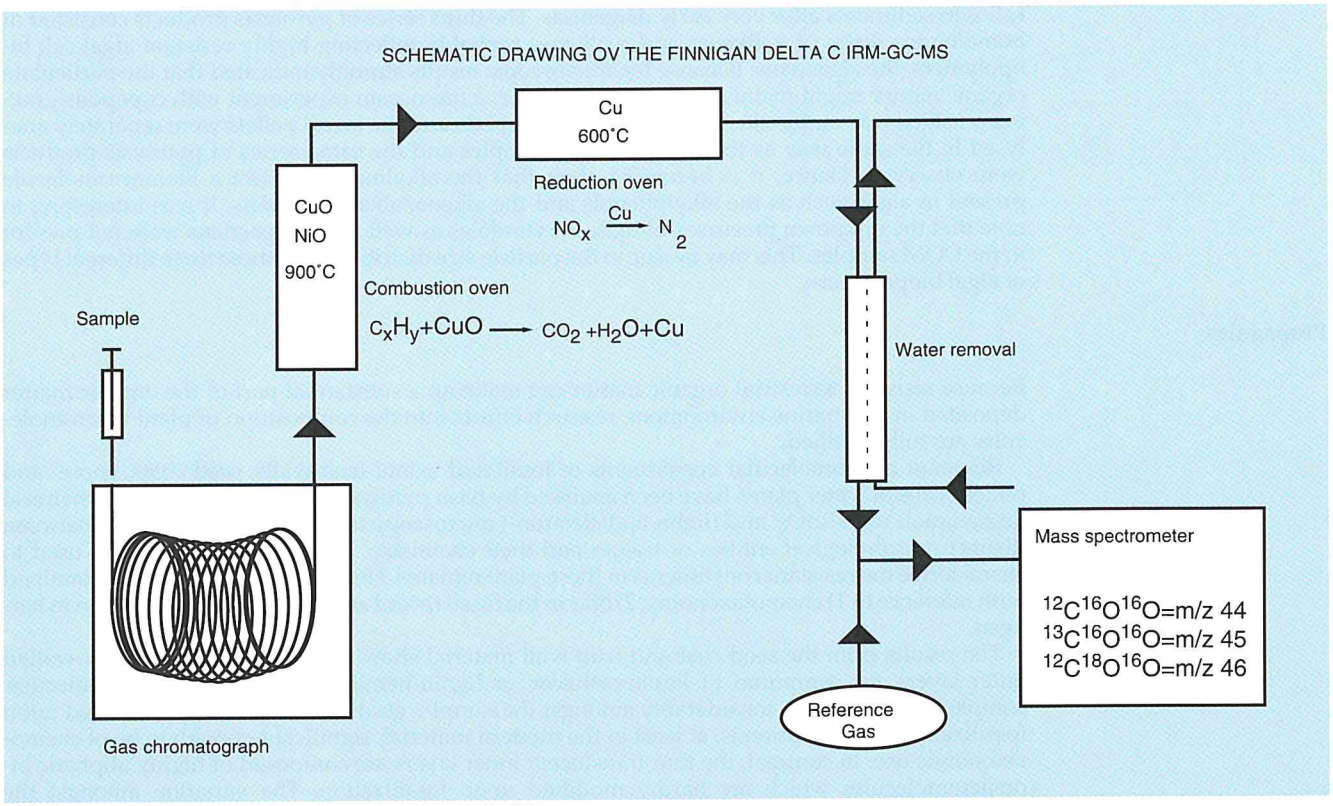
At the end of the second year after implementation of the new Department of Marine Biogeochemistry it can be stated that the Department established itself within the NIOZ and has fully been integrated scientifically and otherwise. The members of the Department are well-embedded in the NIOZ organization and many social contacts have been made.

As indicated in the research plan 1993-1998, the major research topics of the Department, shortly referred to as Resistant Biomacromolecules and Palaeo-environmental Indicators, have been elaborated extensively to improve our knowledge of palaeo-environments and periodical changes thereof, of short- and long-term cycling of organic carbon and of geological events. A gradual shift in the research efforts was initiated so that a further integration with scientific goals of other Departments is warranted. In this respect the intensifying of studies related to the origin, transformation and fate of organic matter in the water column and surface sediments is noted as well as the intensified search for specific low- and high-molecular-weight lipids in macro- and microalgae and picoplankton.

The quality and diversity of data were improved due to three independent developments. Thanks to major financial support from Shell Nederland isotope-ratio-monitoring GC/MS (irm-GC/MS) instrumentation was installed in our laboratory during early summer and has operated smoothly ever since. This instrumentation allows the determination of compound-specific stable carbon isotope data which complement molecular structure data so that improved palaeo-environmental reconstructions can be made.

A new algorithm has been developed to optimize the resolution of GC/MS data significantly. It is expected that after implementation of the appropriate software identifications and particularly quantifications based on GC/MS data can be performed more accurately and reliably.

Unambiguous identifications and quantifications of newly recognized organic compounds in organisms and sediments were performed with the help of synthesized standards. This synthetic support has become available after some adaptations of our laboratory facilities and through the help of trainees.



1. RESISTANT BIOMACROMOLECULES

The search for resistant biomacromolecules in DOM, POM, organisms and sediments was continued this year to further improve our understanding of biogeochemical cycles and to molecularly characterize the bulk of sedimentary organic carbon, *i.e.* kerogen.

Dissolved and particulate organic matter (DOM and POM)

Based on the abundant presence of polyphenols in DOM samples of large depths in the Pacific at Aloha Station off Hawaii as recognized last year, a search for the origin of these obviously resistant DOM constituents was undertaken. To that end cultured algae (the brown macroalgae *Nereocystis luetkeana, Fucus gardneri, Costaria costata, Sargassum muticum,* the green macroalga *Ulva fenestrata,* the red macroalga *Opuntiella californica* and the flagellate *Rhodomonas* sp.) were analysed by Curie-point pyrolysis-gas chromatography-mass spectroscopy (Py-GC-MS) before and after removal of soluble compounds. The same distribution pattern of pyrolysis compounds related to the unknown polyphenolic macromolecules as encountered in the pyrolysates of the DOM samples were encountered in relatively high abundances in all algae studied. Since brown algae are known to contain so-called phlorotannins of a polyphenol nature, these results indicate that the origin of the polyphenols in DOM might be related to the presence of phlorotannin-like structures in other algae. It should be emphasized that until now it was believed that only brown algae biosynthesize these polyphenolic macromolecules.

A series of DOM samples were obtained from the Antarctic part of the Indian Ocean during the French ANTARES-2 programme in February and March to extend our investigations on the molecular composition of DOM and to further test the above-mentioned hypothesis. Water samples of different depths and locations were concentrated onboard by a newly purchased tangential-flow ultrafiltration instrument using 500D filters for the first time. Presently these samples are being analysed.

The composition of particulate organic matter present in a series of sediment traps from the Mediterranean was studied by flash pyrolysis and (electron)microscopic methods. The pyrolysis results showed that selective preservation of organic matter occurs with depth; proteins and storage polysaccharides rapidly disappear and more resistant constituents become dominant. Three types of pyrolysis compounds reflecting three different resistant biomacromolecules were observed. The phenols mentioned above are also present abundantly in the deeper POM pointing to the presence of polyphenols similar to those encountered in the DOM samples. A series of alkylindoles, definitely not originating from aminoacid moieties in proteins, might reflect stabile N-containing biomacromolecules of as yet unknown origin. This source may actually determine C/N ratios in sediments after very early diagenesis. The third series of pyrolysis products consisted of homologous series of *n*-alkenes and *n*-alkanes probably reflecting highly resistant algal cell biopolymers, the algaenans. Because the microscopic results strongly indicated that the particulate organic matter might mainly originate from algae, a mesocosm experiment with copepods grazing on algae was undertaken. The algae, the copepods and the faecal pellets were separately analysed in the same way as the sediment trap samples and the same series of pyrolysis products were observed. Hence, it is becoming clear that the alkylindoles reflect a biomacromolecule present in algae such as the alkylphenols and the alkene/alkane doublets. It was interesting to note that the unknown precursor of these alkylindoles as well as the algaenans were not present in the DOM samples. This may be due to the particle size distribution of these three different types of algal biopolymers.

Propagules

Because resistant terrestrial organic matter can make up a substantial part of the organic matter deposited in the marine environment, research efforts into the composition of plant macromolecules are fully justified.

Resistant macromolecular constituents of fossil and extant fruit walls, seed coats, spore- and pollen walls of water plants have been analysed by flash pyrolysis, solid state ^{13}C NMR, chemical degradation with RuO_4, and (light- and electron-) microscopy to elucidate relationships between distinct morphological entities or tissues and their chemistry. The results were initially used to characterize the resistant constituents in these plant remains. Hereafter, these data were examined with reference to 1) chemotaxonomy, 2) bias in the fossil record and 3) possible contribution to kerogen.

The results from the seed coat and fruit wall material show that, in general, the thick-walled outer layers are composed of lignin-cellulose or lignin-hemicellulose. These macromolecular complexes, which vary considerably amongst the samples studied, are drastically changed upon fossilization. The variation is, at least in the modern material, significant enough to be of chemotaxonomic use. In contrast, the thin translucent inner layers are composed of highly aliphatic biomacromolecules which are hardly modified upon fossilization. The variation amongst the samples studied is large enough to be of chemotaxonomic significance at least at the level of family. Analyses of several water lily propagule walls have revealed that the presence of a tannin-polysaccharide complex rather than a lignin-(hemi)cellulose complex in seed coat or fruit wall material may be the explanation for the absence of these seeds or fruits in the fossil record. Results from fossil spore- and pollen wall material show that sporopollenin, the resistant constituent in most pollen and spores, consists of monomeric units composed of an aromatic and aliphatic part. All types of macromolecules recognized are likely contributors to kerogen upon diagenesis.

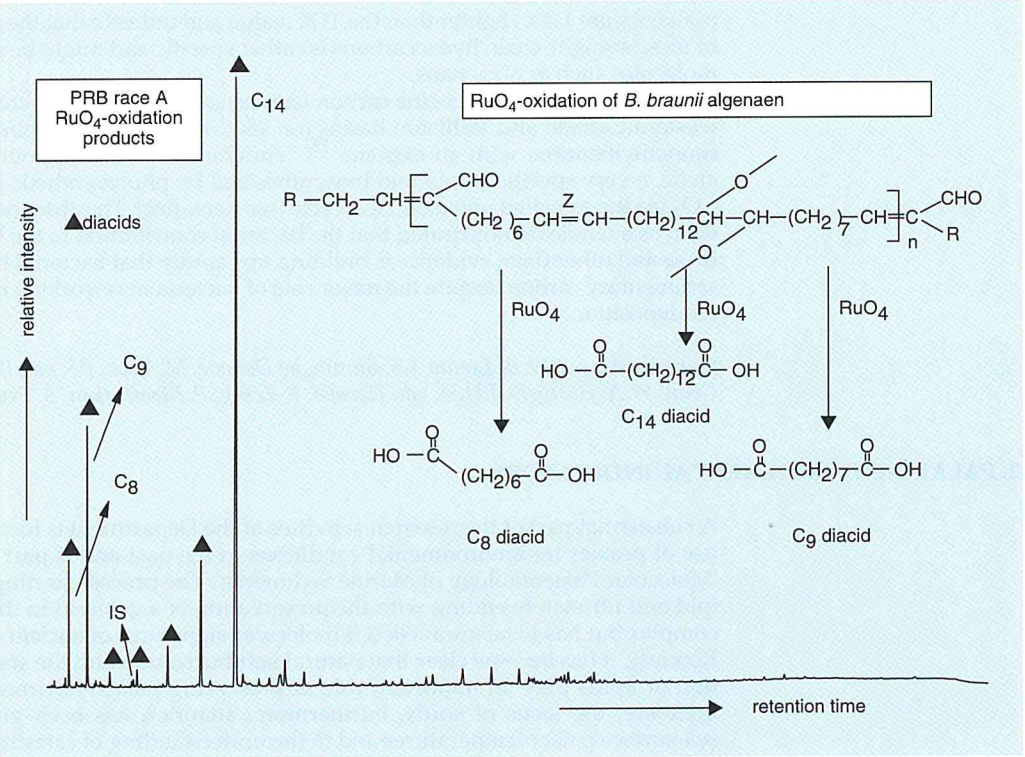
Chitin

The preservation potential of chitin, one of the most abundant biochemicals on Earth, is a matter of debate. To determine the relative survival of this biomacromolecule over other organic constituents during the very early stages of diagenesis in the water column and surface sediments the shrimp *Crangon crangon* was decayed under oxic and anoxic conditions for 8 weeks. Solid state ^{13}C NMR and Curie point-gas chromatography-mass spectrometry demonstrated that slightly transformed chitin represents the major component of the remaining biomass after 8 weeks. This selective preservation confirms that the resistance of chitin to decay may be a major factor in accounting for the extensive fossil record of arthropods lacking a biomineralized skeleton. It also suggests that chitin represents an important sink of organic matter in recent marine sediments.

Algaenans and cutans

Algaenans are highly aliphatic resistant biopolymers which occur in cell walls of several freshwater green microalgae. Lacustrine kerogens are in many cases predominantly composed of these aliphatic biopolymers through selective preservation pathways. Although much circumstantial evidence exists that marine microalgae also contain algaenans this has never been proved. Therefore we have started to analyse cultures of several strains of marine green microalgae in order to determine free lipid compositions and to monitor the potential presence of their macromolecular lipids, *i.e.* algaenans. The macromolecules are isolated after several extractions, saponification and acid hydrolysis and their structural elucidations are undertaken with CuPy-GC-MS, microscopy and chemical degradation with RuO_4. The first results indicate that algaenans indeed occur in several of these algae.

To investigate the macromolecular structures of biopolymers and kerogens a chemical degradation method, RuO_4-oxidation, was developed. Oxidation of biopolymers isolated from the freshwater algae *Botryococcus braunii*, *Tetraedron minimum* and *Pediastrum* sp. and from the leaves of *Agave americana* yielded specific oxidation products. These products revealed that the biopolymers are built from specific monomeric units cross linked via ether bonds at specific sites. These monomeric units are usually also found as free lipids in the algae. The data allow the recognition of these specific highly resistant biopolymers in sedimentary organic matter.



RuO_4-oxidation products of algenaen isolated from *Botryococcus braunii* race A

Kerogens

The term 'kerogen' is defined as the sedimentary organic matter insoluble in organic solvents and is of a macromolecular nature. It is by far the most abundant fraction of organic matter in the subsurface and therefore the most important carbon sink. Kerogen is also considered to be the major precursor of oil and gas. The combined study of (i) the kerogen chemical structure, (ii) its origins and (iii) its diagenetic transformations, is therefore crucial to understand short- and long-term carbon cycles both qualitatively and quantitatively and to understand the origin of oil and gas. Our investigations focus on these three aspects.

Kerogens from the immature evaporites of a Messian Basin (Vena del Gesso, Italy) were investigated. Nine subsamples from one of the organic-matter-rich marl beds corresponding to a short depositional sequence were soxhlet extracted and treated with HCl/HF to isolate the kerogens. Quantitative Curie point-pyrolysis-gas chromatography-mass spectrometry (CuPy-GC-MS) was used to analyse these kerogens. It became clear that two of the nine samples produced high amounts of series of *n*-alkanes, *n*-alk-1-enes, alkylated benzenes and alkylated thiophenes upon pyrolysis. The pyrolysates of these two samples, unlike those of the other seven, also displayed the abundant presence of long-chain alkyl thiophenes and thiolanes (C_{13} and C_{14}) as well as C_{12} and C_{13} 1,3-alkadienes. Based on these and previous results, it was proposed that these two kerogens were largely composed of preserved biomacromolecules present in certain algal cell walls and/or consisted of sulphurized macrolipids of these algae. The latter possibility was supported by re-analysis of these kerogens after desulphurization. Based on stable carbon isotope and molecular data from parallel studies performed with these sediment samples (see hereafter) it is thought that mono-unsaturated C_{30}-1,15-diols and -15-keto-1-ols, omnipresent in Recent sediments and recently encountered in a microalga, represent the building blocks of these macromolecules.

A complementary approach to trace the origin and formation of marine kerogens is based on stable carbon isotope chemistry using irm-GC/MS instrumentation to determine compound-specific carbon isotope signatures. Such an approach will reveal the sources and palaeo-environmental niches of the organic matter making up the kerogen because the impact of diagenetic transformations of organic matter on isotope compositions is considered to be small. Our studies concentrate on the compound-specific carbon isotope analysis of so-called off-line pyrolysates of kerogens from Miocene Monterey samples. Because these analyses require a good separation of chromatographic peaks the off-line pyrolysate is fractionated by column chromatography. Up till now the aliphatic hydrocarbons, which make up a substantial part of the pyrolysates, have been measured. The results show that the $\delta^{13}C$ values of the n-alkanes are 3-4 0‰ and those of the n-alkenes are 1-4‰ lighter than the TOC value and indicate that the macromolecular precursor(s) of these straight-chain hydrocarbons is rather specific and might be related to aliphatic biomacromolecules such as algaenans.

Another compound-specific carbon isotope study of off-line pyrolysates of kerogens from the western Canada and Williston basins (*ca.* 460 My) revealed the abundant presence of 1,2,3,4-tetramethylbenzene with an extreme ^{13}C enrichment. This compound originates from isorenieratene, a very specific carotenoid biosynthesized by photosynthetic green sulphur bacteria fixing CO_2 via the so-called reversed TCA cycle (see hereafter). The absence of ^{13}C enrichment of the kerogen as a whole demonstrated that the bacterial contribution to the kerogen was minor. Based on these and other data, evidence is building up rapidly that bacterial biomass hardly contributes to sedimentary carbon despite the major role of bacteria in reworking organic matter during and after deposition.

Contributors: *J.W. de Leeuw, J.S. Sinninghe Damsté, M. Baas, P.F. van Bergen, M. Dekker, N. Frewin, F. Gelin, W.A. Hartgers, J.D.H. van Heemst, F. Kenig, P. Moerkerken, S. Peulvé, W.G. Pool, S. Schouten.*

2. PALAEO-ENVIRONMENTAL INDICATORS

A substantial part of the research activities 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 palaeo-environmental information and are, therefore, the focus of study. Furthermore, attention has been given to the determination of sea-surface palaeotemperatures and to the understanding of catastrophic events in the geological past.

Natural sulphurization

In order to study the incorporation of sulphur into organic matter during early diagenesis, laboratory experiments to simulate natural (hydro-)sulphurization have been performed. In these experiments model compounds (alkenes, dienes, ketones, *etc.*) are made to react with hydrogen polysulphide ions in a two-phase system (aqueous/ethyl acetate), mediated by a phase transfer agent at 50°C. These experiments provide further information for the interpretation of sulphur-containing biomarkers in sediments. If tetradec-1-ene is used as a substrate with tetrabutylammonium bromide as phase transfer agent, 15% thiols and >65% polysulphides are formed. Other model compounds tested were an isoprenoid chroman (no sulphurized products formed), linoleic acid methyl ester (cyclic mono-, di- and trisulphides, mainly cyclic disulphides) and retinal (many different products, mainly with intramolecular sulphur bonds). Further experiments in progress are the sulphurization of long-chain ketones (isolated from the coccolithophorid alga *Emiliania huxleyi*) and mixtures of compounds in order to simulate the formation of polymeric structures ('artificial kerogen'). Substitution of the phase transfer reagent with sediment of lake Vechten yielded surprising results: tetradec-1-ene was transformed into *ca.* 85% monosulphides, *ca.* 15% polysulphides (di-, tri-) and <1% thiols. This indicates that sediments can act as naturally occurring phase transfer reagents. The activity of marine sediments is presently tested in these reactions.

To determine the effect of natural sulphurization on the stable carbon isotopic composition of sedimentary lipids, dec-1-ene was subjected to hydrosulphurization under phase-transfer conditions at room temperature. Compound specific isotope analysis revealed that 1-decene becomes enriched in ^{13}C with increasing yields of sulphurization whilst the sulphur compounds formed are initially depleted in ^{13}C compared to the starting substrate. The average carbon isotopic fractionation effect of the reaction on the two carbon atoms involved is *ca.* -20‰. Sedimentary sulphur compounds, however, do not show this fractionation effect indicating that either a different sulphurization reaction with different isotope effects has occurred or, more likely, that functionalized lipids have been completely sulphurized.

Diagenetic and catagenetic pathways

—*Diaryl isoprenoids.* Isorenieratene is a diaromatic carotenoid that is produced by photosynthetic green sulphur bacteria (Chlorobiaceae). These photoautotrophic organisms are strictly anaerobic, and their presence therefore points to anoxic water conditions that reach into the photic zone. Isorenieratene has a very specific carbon skeleton and an anomalously high ^{13}C content which finds its origin in the reverse tricarboxylic acid cycle by which carbon fixation occurs in Chlorobiaceae. Thus, isorenieratene makes up an excellent palaeo-environmental indicator for photic zone anoxia.

Diagenetic products of isorenieratene were identified in 15 samples from different geographic locations covering Phanerozoic time. These compounds were formed from isorenieratene through (partial) hydrogenation, sulphur incorporation, cyclization and aromatization, molecular mechanics calculations and by compound-specific isotope analyses that revealed the relatively high ^{13}C contents of these diagenetic products of isorenieratene. A triaromatic component formed by cyclization and aromatization of isorenieratene has been isolated by HPLC and characterized by ^{1}H and ^{13}C NMR. Since all of these compounds are diagenetically related to isorenieratene, they can all be regarded as indicators of photic zone anoxia in the palaeo-environment.

The presence of diagenetic products of isorenieratene in organic-matter-rich sediments throughout the Phanerozoic suggests that anoxygenic photosynthesis was a more common process during deposition of petroleum source rocks than previously recognized.

—*Hopanoids.* A myriad of hopanoids occur in sediments. These components are thought to be derived mainly from bacteriohopanepolyol derivatives but the pathways of their formation are only poorly understood. To gain insight into these processes, both low-molecular-weight and sequestered C_{30+} hopanoids were quantified in twelve core samples from the Cretaceous Jurf ed Darawish Oil Shale (Jordan) and for a number of compound classes ^{13}C contents of individual components have been determined. The results demonstrate that in these sediments sulphurization of bacteriohopanepolyols is the controlling diagenetic pathway. Isomerization from 17β,21β(H) to 17α,21β(H) epimers occurs over a very narrow depth span (*ca.* 30 m). The isotopic data show that the formation of fossil homohopanoids is a complex process and does not start with a single bacteriohopanetetrol derivative from one type of organism but that instead multiple bacteriohopanetetrol derivatives produced by various sources have to be invoked.

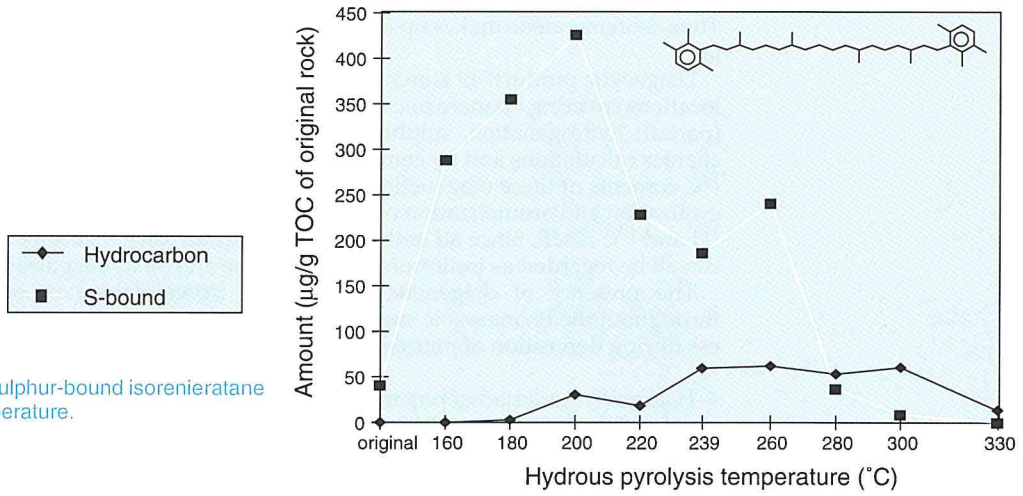
Two novel series of benzothiophene hopanoids have been identified in marl stones and carbonates of the Hauptdolomit Formation, bituminous laminites of the Calcaires en Plaquettes Formation and bituminous marls of the Ghareb Formation. These compounds are probably formed by early diagenetic sulphur incorporation into the side chains of hopanoid precursors, followed by cyclization and aromatization of the side chains. Structural elucidation of several novel sulphide hopanoids is in progress.

—C_{25} *HBI's.* Recent Black Sea sediments show a large decrease in the upper few centimetres of diatom-sourced C_{25} HBI (Highly Branched Isoprenoid) alkene concentrations. This decrease cannot entirely be accounted for by biodegradation, since other more easily biodegradable compounds do not show this sharp drop in concentration. In order to test the hypothesis that HBI alkenes rapidly become intramolecularly and intermolecularly sulphur-bound, three subsurface samples were quantitatively analysed for their HBI content. It was found that sulphur incorporation leading to sulphur-bound C_{25} HBI's in asphaltenes and smaller molecularly sized fractions, is insufficient to account for the decrease in free C_{25} HBI's. Pyrolysates of the kerogens do contain isoprenoid components, but these may originate from multiple sources. Therefore, the concentration profile of HBI alkenes in Black Sea sediments remains enigmatic.

—*Thermal stability of organic sulphur compounds and sulphur-containing geomacromolecules in the geosphere.* Organic sulphur compounds (OSC) are omnipresent in immature sedimentary rocks and crude oils, albeit with different distribution patterns. Therefore, it was proposed that OSC could be used as molecular indicators for biological and physical properties of the depositional environment. This has been successfully demonstrated in the case of immature sediments. However, it is presently unclear to what level of thermal maturity OSC can still be used for palaeo-environmental reconstruction.

Therefore, an immature sulphur-rich sediment sample from the Messinian Gessoso-Solfifera Formation in the Vena del Gesso Basin (Italy) was artificially matured at different conditions (160°C-330°C; 72h) by means of hydrous pyrolysis. Analysis of the produced maturation series indicates that relatively mild maturation conditions already have a large impact on the abundance and distribution of OSC in this sediment. Sulphur-containing geomacromolecules break down into smaller molecules, probably due to cleavage of weak (poly)sulphide bridges. Low molecular weight OSC that have been used as biomarkers are still present at relatively high levels of thermal maturity (330°C). Moreover, the position of the sulphur-containing functional group in these OSC has not changed, and therefore these OSC still display information on their precursors and thus on the palaeo-environment.

A second maturation series (200°C-365°C; 72h) that had been previously prepared from an immature sulphur-rich high-TOC sedimentary sample from the upper Cretaceous Ghareb Formation (Jordan) is presently under investigation. The preliminary results seem to fit well with those obtained from the Vena del Gesso Basin. Recently, a third maturation series was produced from the immature Mahogany Shale in the Green River Formation (USA). This series will enable us to compare our results of samples from marine settings (Gessoso-Solfifera and Ghareb Formations) with lacustrine settings (Green River Formation).

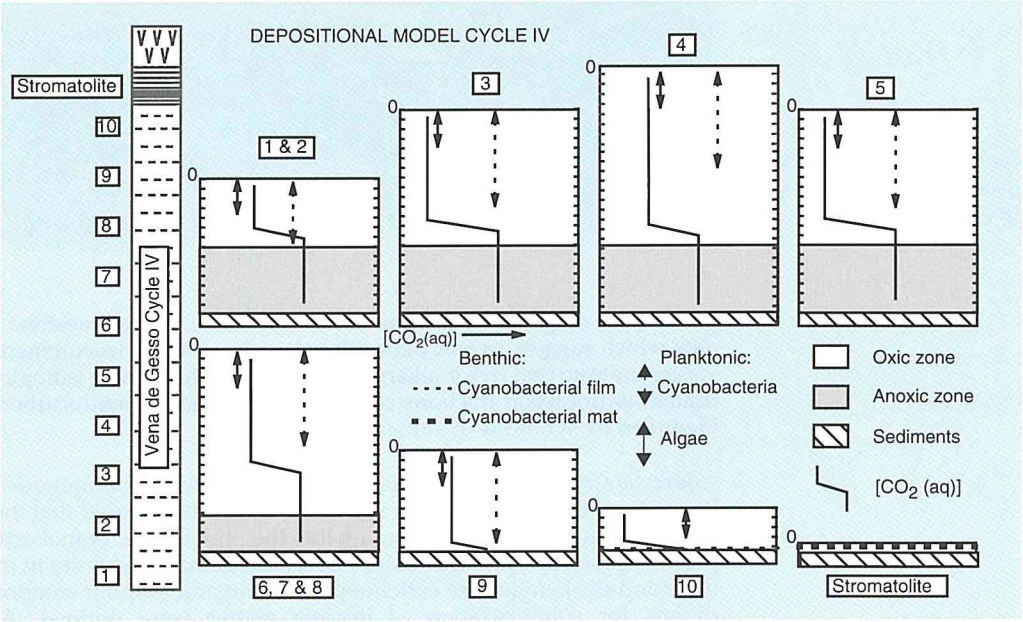


Generation profiles of free and sulphur-bound isorenieratane as a function of maturation temperature.

Palaeo-environmental reconstruction

—*Miocene Gessoso Solfifera Formation.* As a continuation of our project on the palaeo-environmental reconstruction of the Gessoso Solfifera Formation, Messinian, Italy, the stable carbon isotopic compositions of free hydrocarbons and of hydrocarbons released by desulphurization of polar fractions were measured in a sequence of ten samples collected from a marl bed in one of the evaporitic cycles of this formation. Relationships between these carbon skeletons, precursor biolipids, and the organisms producing them could then be examined. Values of δ for individual compounds were plotted *vs.* depth in the marl bed and the profiles were interpreted in terms of variations in source organisms, ^{13}C content of the carbon source, and environmentally induced

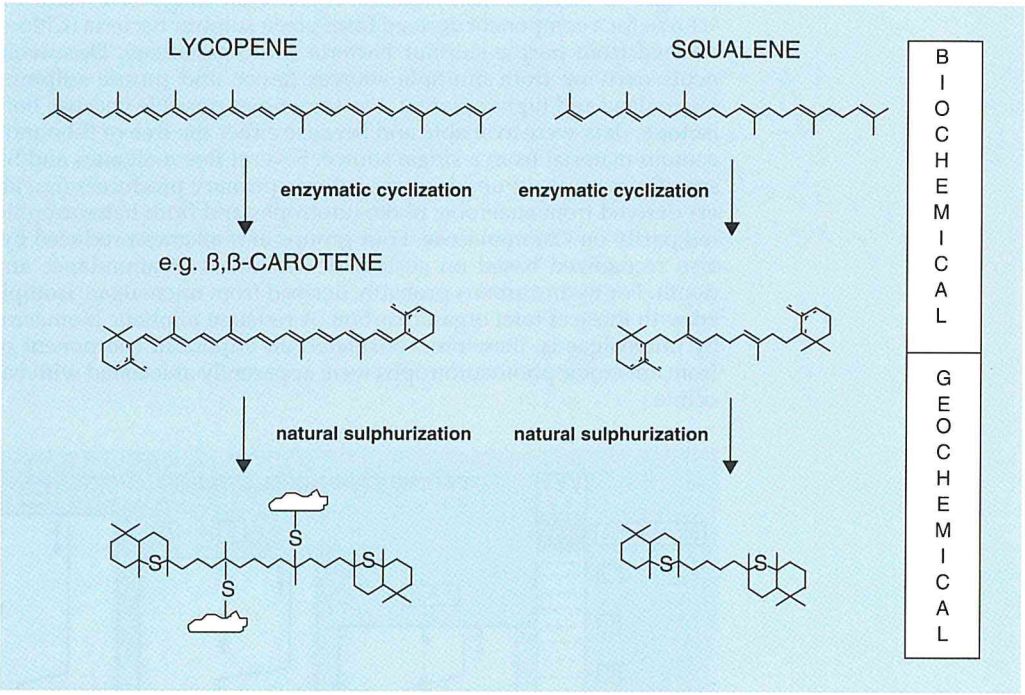
changes in isotopic fractionation. The overall range of δ values measured was -24.7‰, from -11.6‰ for a component derived from green sulphur bacteria (Chlorobiaceae) to -36.3‰ for a lipid derived from purple sulphur bacteria (Chromatiaceae). Deconvolution of mixtures of components deriving from multiple sources (green and purple sulphur bacteria, coccolithophorids, microalgae and higher plants) was sometimes possible because both quantitative molecular and isotopic data were available and because either the free or S-bound pool sometimes appeared to contain material from a single source. Several free *n*-alkanes and S-bound lipids appeared to be specific products of upper-water-column primary producers (*i.e.*, algae and cyanobacteria). Others derived from anaerobic photoautotrophs and from heterotrophic protozoa, which apparently fed partly on Chlorobiaceae. Four groups of *n*-alkanes produced by algae or cyanobacteria were also recognized based on systematic variations of abundance and isotopic composition with depth. For hydrocarbons probably derived from microalgae, isotopic variations are well correlated with those of total organic carbon. A resistant aliphatic biomacromolecule probably produced by microalgae is, therefore, considered an important component of the kerogen. Contributions from anaerobic photoautotrophs were apparently associated with variations in depth of the chemocline.



Proposed depositional model for the marl layer of Cycle IV of the Messinian Gessoso Solfifera Formation (northern Apennines, Italy). This model has been developed on the basis of concentration and ^{13}C content profiles of sulphur-bound molecular fossils.

—*Miocene Monterey Formation (USA).* As a continuation of the project on the molecular biogeochemistry of the Monterey sediments at Shell Beach, several fractions containing organic sulphur compounds were examined in more detail. Two new sedimentary compounds, not yet reported in the literature, were discovered. The first concerned a novel sterane, 27-nor-24-methylcholestane, which was identified by synthesis of an authentic standard. Based on its isotopic composition and the occurrence of its precursor molecule in the biosphere it is suggested to be derived from either diatoms or dinoflagellates. The second novel compound is a sulphur compound which possesses a unique bicyclic triterpenoid carbon skeleton. This carbon skeleton was identified by desulphurization of the sulphur compound and synthesis of an authentic standard. Its structure suggests that it is derived from squalene *via* an as yet unknown biochemical pathway. It is presently unknown which organism biosynthesizes this compound and for which biological purpose.

—*Jurassic Kimmeridge Clay Formation (UK).* Biomarker distributions in three lithologically different samples of the Kimmeridge Clay Formation with large differences in their TOC contents (23-40%) are almost similar. This suggests that the palaeo-environment is relatively stable through time and that the differences in TOC content are not related to differences in production and/or preservation of organic matter but instead are due to dilution by inorganic material. This is consistent with the presence of a large array of diagenetic products of isorenieratene in all three samples, indicating photic zone anoxia and thus optimal conditions for the preservation of organic matter. The



Proposed biochemical and geochemical reactions with lycopene and squalene.

presence of diagenetic products of isorenieratene in the limestone is at variance with literature data which suggest an oxic depositional environment. Measurements of compound specific $\delta^{13}C$ values indicate that free *n*-alkanes derive from at least three isotopically distinct sources. The saturated hydrocarbon fractions contain novel branched hydrocarbons which are presently being identified by synthesis of authentic standards.

—*Jurassic Calcaires en Plaquettes Formation (France).* A bituminous laminite of the Calcaires en Plaquettes Formation has been studied in detail. It appeared that the sediment received little terrestrial input, anoxia was extending into the photic zone, cyanobacteria were the most important primary producers and that there was a normal marine salinity in the photic zone. Both the sediment and the kerogen are extremely rich in organic sulphur compounds indicating that the conditions for sulphurization of organic matter were optimal. A novel series of alkylated bithiophenes were identified in the kerogen pyrolysate.

—*Organic-rich sediments from the Alpine orogen.* A biogeochemical study of three organic-rich shales and marls has been undertaken in order to better understand the depositional palaeo-environment and the processes leading to the accumulation of organic matter. The samples studied are ancient marine sediments of different ages and geological settings taken from different locations within the Alpine orogen.

The organic-rich marls intercalated within the Hauptdolomite formation (Triassic, Bavaria/Germany) were deposited in shallow restricted lagoons on a carbonate platform. The high abundance of hopanes in the lipid fraction reveals that cyanobacteria were important primary producers. Highly anoxic conditions and the low availability of iron led to a substantial incorporation of sulphur into organic matter. For example, C_{35} hopanoids are selectively preserved as sulphur-containing moieties.

The organic-rich marls of the Allgäu formation were deposited in a restricted marginal basin of the Tethys ocean. The lipids are dominated by steroids and methyl-steroids identifying algae and more specifically dinoflagellates as major primary producers. Aromatic subfractions contain substantial amounts of polyaromatic carotenoids derived from green sulphur bacteria indicating the existence of anoxia within the photic zone. An isotopic study of individual compounds by irm-GC-MS has shown three distinct groups of isotope data representing compounds derived from photoautotrophic primary producers in the upper water column, green sulphur bacteria living deeper in the basin at the chemocline, and heterotrophic organisms.

The Menilite formation (Oligocene, southeast Poland) was deposited in a flysch basin during the active overthrust phase of the Alpine fold belt. In the northern part of the Polish Carpathians these sediments are frequently associated with diatomaceous shales and diatomites. The lipids are rich in free and sulphur-bound highly branched isoprenoids which will allow a detailed study on the preservation and diagenesis of these markers for diatoms. In sections where black shales

are associated with turbidites organic matter and lipid compositions are highly variable. Also in this presumably very deep basin, isorenieratane has been identified indicating that anoxia existed in the photic zone at least temporarily. Future work aims at the biogeochemistry of samples of different sedimentological settings and maturity.

Biogeochemistry of the Cretaceous/Tertiary boundary

Samples from three K/T boundary sites, El Kef (Tunisia), Stevns Klint (Denmark) and Geulhem (The Netherlands) have been investigated biogeochemically in order to understand the causes and effects of the K/T boundary crisis by reconstructing environmental change before, at, and after the K/T biotic crisis.

The Geulhem samples contain highly functionalized organic compounds which demonstrate the extreme immaturity and preservation of the Geulhem K/T boundary sediments. The organic compounds suggest various sources of the organic matter, both allochthonous and autochthonous. A dominant $C_{40:2}$ ethyl ketone is thought to derive from a specific, highly abundant non-coccolithophorid Prymnesiophyte alga. Fatty acids, along with their randomly oxidized hydroxy and keto fatty acid counterparts are probably indicative of bacterially transformed biochemicals of terrestrial origin transported into the depositional environment. ω-hydroxy and keto- fatty acids with specific distribution patterns may be derived from the same alga producing the ethyl ketone due to biochemical relationships between these compounds. Nanoplankton, palynological and molecular data were found to be highly complementary. Isolated organic matter from Geulhem, containing abundant dinoflagellate cysts and bryophyte spores, was investigated by Curie-point pyrolysis-gas chromatography and Curie-point pyrolysis-gas chromatography-mass spectrometry in order to explain unusual distribution patterns and highly functionalized components found in the free lipids from this site.

The El Kef study provides the longest section of K/T boundary sediments studied to date by organic biogeochemical methods. A higher signal of terrestrial matter at the K/T boundary, along with palaeontological results, suggests that at this time the sea level was lower than before or after the crisis event. This section reveals that the environment returned to one similar to the pre-crisis environment in a very short period of time after the K/T event.

Contributors: *J.S. Sinninghe Damsté, J.W. de Leeuw, S. Schouten, M. Baas, W.I.C. Rijpstra, M. Dekker, K. Ficken, I.M. Höld, J. Jellema, H. van Kaam-Peters, M. Kok, M.P. Koopmans, J. Köster, R. van Malderen, W.G. Pool, H.J. Bosch, J. Thio.*

DEPARTMENT OF PELAGIC SYSTEMS

The Department of Pelagic Systems investigates the role of plankton in marine cycles. This contributes to a description of planktonic food web structure and an estimate of the biomass, consumption and production of dominant functional groups and species in relation to their physical and chemical environment. Characteristic hydrodynamic and climatological phenomena influencing plankton production are studied in various regions. In the temperate zone effects of nutrient enrichment by river discharge and tidal mixing are studied, as well as the effects of vertical stratification, upwelling and frontal systems. Special attention is given to physical/chemical conditions and trophic interactions that induce algal blooms, *e.g.* in the calciferous algal species *Emiliania huxleyi*. In tropical seas the focus is on upwelling and wind-induced mixing. In polar seas the effects of the extreme seasonal variation and ice-edge blooms are of interest. Properties of phyto- and zooplankton key species are studied in the laboratory to understand their functioning in nutrient uptake kinetics, growth and reproduction, size-dependent prey selection and energy-balance at 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. Adaptation of life cycles to diurnal and seasonal variation in environmental conditions receives attention to find out what role it plays in the response of plankton systems and carbon fluxes to climatic change. The extensive research at sea is only possible in co-ordination with other NIOZ departments and national and international working groups. The present work contributes to JGOFS, GLOBEC, EHUX, GEM, INP and the ESF projects EPOS and SEAS. Two North Sea cruises were financed by GOA.

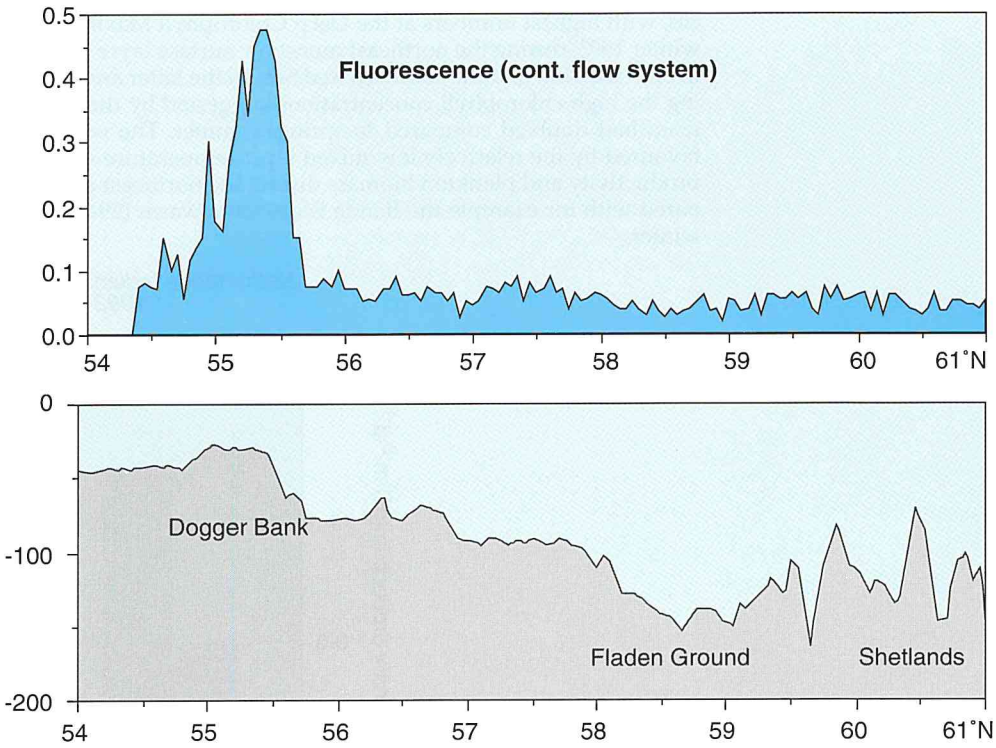
1. PELAGIC SYSTEMS IN THE TEMPERATE ZONE

In July 1993 an extensive study was made of a large bloom of the coccolithophorid *Emiliania huxleyi* situated halfway between Shetland and Norway at the northern edge of the North Sea. Data on the hydrography, primary production, inorganic carbon system and sedimentation of particulate organic carbon (POC) and calcite-C were analysed. The coccolithophorid bloom appeared to be confined to North Sea waters, while the initial populations may have originated in coastal waters. Bloom development had entered the decaying phase, judged by the relatively low number of living cells (maximally 1200 cells·cm^{-3}), the high number of loose coccoliths (up to 350,000 coccoliths·cm^{-3}), and by the fact that sedimentation of calcite-C exceeded production. The dominating algal species was *Synechococcus* sp. (>50,000 cells cm^{-3}). In the photic zone calcite appeared to be dissolved at a rate of up to 25% of the calcite standing stock per day. In the bloom the mean fluxes of calcite-C and POC at 50 m water depth amounted to 152 mg C·m^{-2}·d^{-1} and 177 mg C·m^{-2}·d^{-1}, respectively. Faecal pellets and other aggregates were stuffed with coccoliths. These particles were the major vehicles for the downward transport of POC and calcite-C. Outside the bloom the amount of faecal matter sedimenting was insignificant. It is hypothesized that faecal pellets outside the bloom were mostly so lightweight that they did not sink very far before degradation, whereas the pellets produced in the *E. huxleyi* bloom in general sank rapidly due to their heavy load of calcite. This implies that recycling of materials in the mixed layer of this bloom is relatively low due to the strong downward flux.

Data from this cruise and mesocosm studies were used for a numerical model to predict production and export of calcite-C and the perturbation of the carbonate system in an *E. huxleyi* bloom. The model shows that a total of 3.76 g calcite-C·m^{-2} is exported from the mixed layer and that within two weeks after culmination pCO_2 levels drop below the levels present in the initial stages of the bloom, because of the facilitated transport of POC by heavy faecal matter out of the mixed layer.

A 400-mile transect of 50 sampling stations between the Dogger Bank and the Shetland Islands is the research area of the Stratified North Sea Project since the first cruise in winter 1991. The transect was visited from 25 March to 12 April with RV 'Pelagia' and from 28 June to 15 July with RV 'Zirfea' of RWS, both times in the framework of INP and financed by GOA. Participants are basically the mesocosm group. The aim of the cruises was to study the structure and functioning of the natural plankton system under different conditions of light input and nutrient content as the 'field-counterpart' of the mesocosm project in the laboratory.

During the spring cruise the deeper part of the transect was still in winter condition with nutrient concentrations at high levels from surface to bottom, only sporadic traces of temperature stratification, low light limited production of small algae, little grazing by microzooplankton and no copepod egg production. An exception was the water within the 30-m depth line over Dogger Bank, where phytoplankton was blooming heavily as a result of 'bottom-stratification' or because deep mixing of algae, which limits their light uptake elsewhere, was absent .



Phytoplankton spring bloom starting on top of the Dogger Bank in April 1994.

In the area south of the Dogger Bank, the spring bloom was already declining because of nutrient depletion, whereas mass-sedimentation led to the initial formation of the deep chlorophyll maximum. A heavy storm did not immediately stir up the sinking plankton; its first effect was replacement of the clear and oligotrophic surface layer by nutrient-rich water from neighbouring areas to the west. The impact of this storm event was not followed any further.

During late summer, nutrient depletion characterized the transect, with a picophytoplankton-microzooplankton maintenance system in the euphotic zone and a heavily producing deep chlorophyll layer at the thermocline. North of the Fladen Grounds, nutrient levels gradually increased due to upward mixing at the ocean front and circulation to the south of the Shetlands. The planktonic system changed into a pico- and nanophytoplankton-microzooplankton-mesozooplankton food chain, with copepods showing high egg production. Promising results were obtained on the role of water-column bacteria as competitors of algae for nutrients in the oligotrophic summer situation.

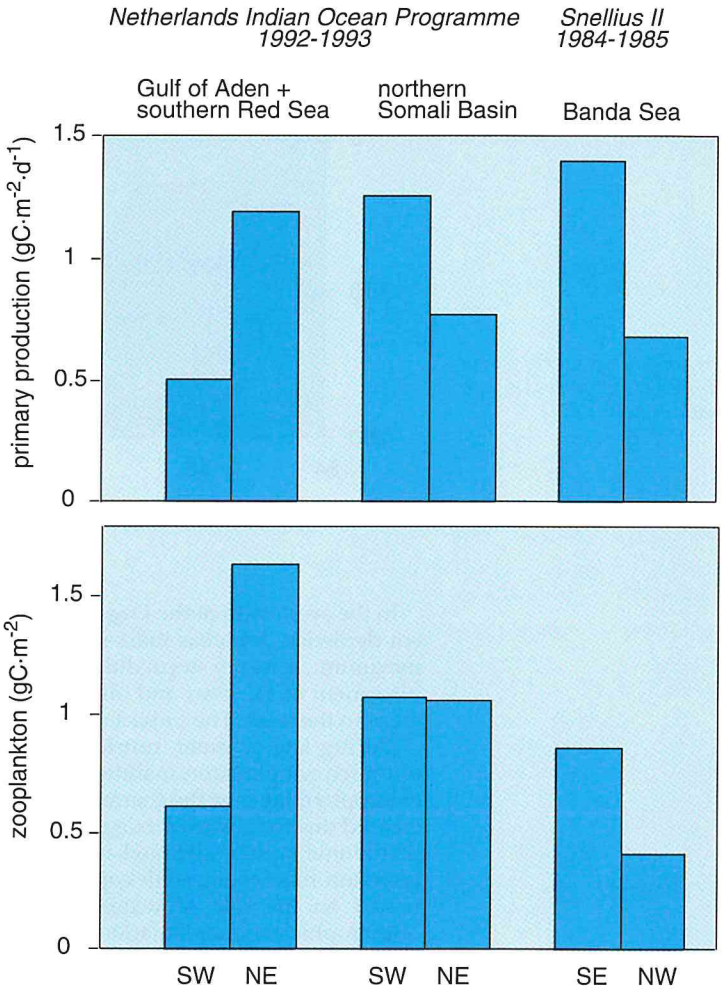
Contributors: *B.R. Kuipers* (microzooplankton), *R. Riegman* (phytoplankton ecophysiology), *M.J.W. Veldhuis* (phytoplankton), *P. van der Wal* (phytoplankton), *J.D.L. van Bleijswijk* (phytoplankton), *E.T. Buitenhuis* (carbon fluxes), *R. Kempers* (phytoplankton), *G.W. Kraay* (phytoplankton), *S.R. Gonzalez* (zooplankton/sedimentation), *A. Noordeloos* (phytoplankton ecophysiology), *G. van Noort* (microbiology), *H.J. Witte* (microzooplankton).

2. PELAGIC SYSTEMS IN TROPICAL WATERS

In January/February a phytoplankton field programme was executed during transit of the navy vessel 'Hr. Ms. Pelikaan' from Las Palmas to Curaçao, in co-operation with RUG and RIVM to study the influence of UV-B on phytoplankton growth and distribution. Samples taken from the surface layer showed a dominance of small species, *Synechococcus* and pico-Eukaryotes. During the cruise, 4 different communities were encountered according to cell distribution and HPLC characteristics. These observations fit well with provinces recognized in the past from chlorophyll distributions by the Coastal Zone Color Scanner. Preliminary tests to examine the collected cells for potential damage by UV-B were not very successful.

The JGOFS project 'Monsoons and Pelagic Systems' of the Netherlands Indian Ocean Programme 1992-1993 (NIOP) has revealed varying seasonal patterns in primary production in different areas. In spring/summer 1992, during the onset and maximum of the southwest monsoon,

the Red Sea and Gulf of Aden were generally oligotrophic. Picoplankton comprised *Prochlorococcus*, with highest numbers at the Deep Chlorophyll Maximum, and two strains *Synechococcus*. In winter 1993, during the northeast monsoon, surface layer waters were far from nutrient-depleted in both the Gulf and the southern Red Sea. In the latter area, diatom blooms occurred, corroborating the high chlorophyll concentrations suggested by the CZCS archive. Mesozooplankton biomass had doubled compared to spring/summer. The wind-induced entrainment of nutrients, favoured by the relatively low mixed layer temperature in winter (25-26°C), might explain why productivity and plankton biomass during the northeast monsoon were high in these areas compared with for example the Banda Sea, with a warm (29-30°C), oligotrophic upper layer during winter.



Primary production and zooplankton biomass (320 µm net; 0-300 m) during the summer of 1992 (SW monsoon) and the winter of 1993 (NE monsoon) in the northwestern Indian Ocean, compared with the seasonal pattern in the Banda Sea (SE-NW monsoon). Note the high zooplankton biomass in the Somali Current during the NE monsoon, earlier observed during the IIOE 1959-1965 and INDEX 1979, and now referred to as the 'Arabian Sea Paradox'.

The summer situation in the Somali Current corresponded largely with earlier studies in the area. Main upwelling occurred between 7° and 11°N, with primary production ranging between 0.8 in freshly upwelled water and 3.0 $gC \cdot m^{-2} \cdot d^{-1}$ in diatom blooms in gyres north of Ras Hafun. By the strong wind and Somali Current, the enrichment was diluted over a vast area, into the Great Whirl and along Socotra into the Arabian Sea. In these regions down stream of the upwelling, mixed layer depths of 150-200 m largely surpassed the photic zone, so phytoplankton productivity and stock remained far below potential, and nutrients were not depleted. Recent modelling of the Somali Current system by J. McCreary (Dania, Florida) revealed virtually the same picture.

In contrast, primary productivity during the winter 1993 leg in the Somali Current was much higher than previously measured in the NE monsoon during the International Indian Ocean Expedition (IIOE 1959-1965) and the Indian Ocean Experiment (INDEX 1979). Winter cooling, like in the Gulf of Aden and Red Sea, gave relatively high upper layer nutrient concentrations during periods of strong wind, resulting in primary production ranging from 0.5 to 1.0 $gC \cdot m^{-2} \cdot d^{-1}$, half of which was new production. Though picoplankton predominated like in oligotrophic situations, a Deep Chlorophyll Maximum was largely absent. Most of the production was consumed by heterotrophic flagellates of size <10 µm. However, total zooplankton biomass in the epipelagic zone too was surprisingly large during winter 1993. The absence of a drop in zooplankton stock from the summer upwelling season to the more oligotrophic winter season had been observed earlier dur-

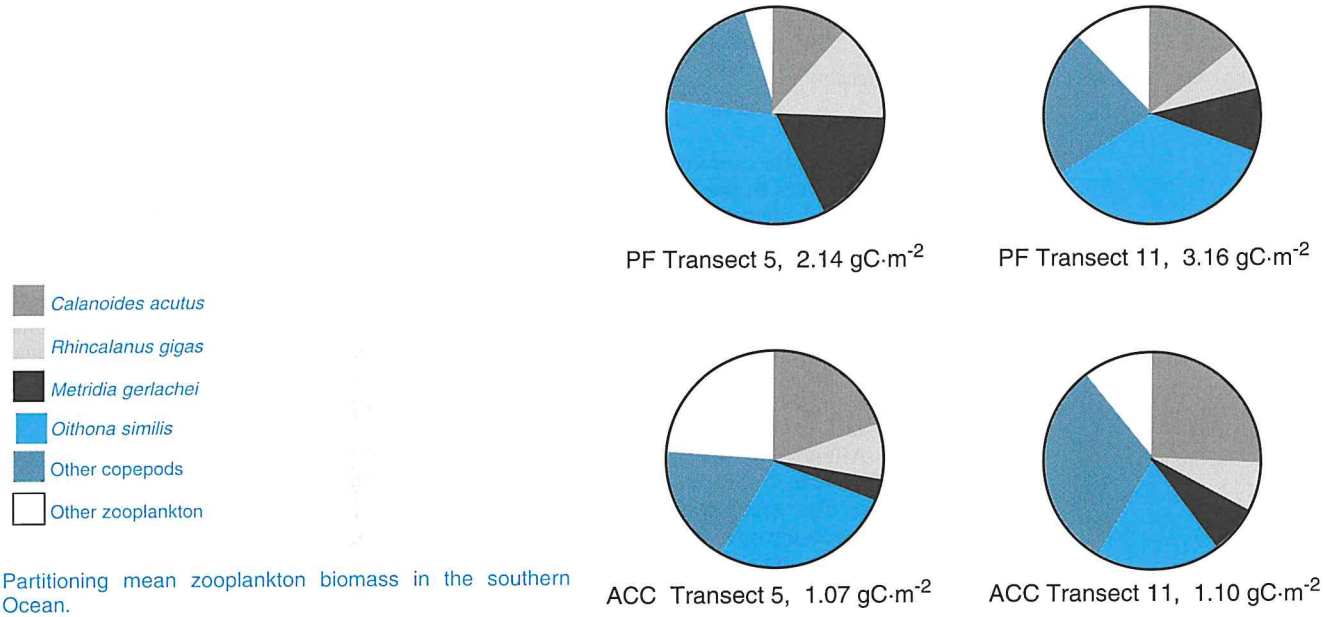
ing IIOE and INDEX. Even if winter cooling effects occur more regularly than recognized in the past, it remains puzzling why there is no decrease in zooplankton biomass with increasing length of the food chain from the 'diatom season' to the 'picoplankton season'. It is proposed to call this phenomenon, in analogy of the Antarctic Paradox (high nutrients - low chlorophyll), the 'Arabian Sea Paradox' (low chlorophyll - high zooplankton). Detailed analysis of the zooplankton samples is now carried out in co-operation with the Institute of Biology of the Southern Seas (Sevastopol, Ukraine) to specify the shifts in zooplankton groups and species between the monsoons.

Contributors: *M.A. Baars* (zooplankton, ecosystem dynamics), *M.J.W. Veldhuis* (phytoplankton), *J.D.L. van Bleijswijk* (phytoplankton), *E.T. Buitenhuis* (carbon fluxes), *G.W. Kraay* (phytoplankton), *S.S. Oosterhuis* (zooplankton), *J.IJ. Witte* (micronekton).

3. PELAGIC SYSTEMS IN POLAR SEAS

Zooplankton distribution, production and life cycles were studied from data of the projects JGOFS Southern Ocean 1992 and the Study of the European Arctic Shelf (SEAS) 1991. In addition a compilation of all available data was prepared about the seasonal distribution of the cyclopoid copepod *Oithona similis* to estimate its production in the Southern Ocean. With Dr. F. Carlotti of CNRS population models of the Antarctic copepod species were constructed on the base of a literature study of their ecophysiological characteristics. The aim is to study seasonal development and production as a function of temperature and food relationships of growth, respiration and ingestion, and to construct a zooplankton submodel for Antarctic ecosystem models.

The latitudinal and vertical distribution of abundance, biomass and population structure were studied in two transects at the 6°W meridian between the Weddell Gyre and the Polar Front Zone (PFZ) in October and November 1992. For this purpose carbon weight-length relationships were estimated for the dominant copepod species *Calanoides acutus*, *Rhincalanus gigas*, *Metridia gerlachei* and *Oithona similis* from carbon measurements of selected length classes. Total biomass as measured by weighing filters of two size fractions and as calculated from specific abundance and length estimations both averaged about 3 g C·m^{-2} in the PFZ (somewhat lower in October than in November) and 1 g C·m^{-2} in the Antarctic Circumpolar Current (ACC). Calanoid copepods dominated biomass in both water masses as a group, whereas the cyclopoid copepod *Oithona similis* had the highest numerical abundance and also the highest biomass of all species Daily egg production of *Calanoides acutus* was highest in the PFZ. Sampling with 64 µm nets in addition to 200 µm nets added 25% to the estimates of total biomass, but as much as 49% to the biomass of *Oithona similis*, since instars of this species younger than C5 were rarely caught in the coarser net. The latitudinal and vertical distribution and the population structure of the stock-forming copepod species conformed to common patterns and life cycle theories. It may be concluded that the PFZ is an exceptionally productive area for Antarctic zooplankton. The role of cyclopoid copepods in Antarctic food webs and carbon fluxes has escaped the attention, because the organisms pass through the meshes of commonly used nets. But according to their diet and abundance they are important

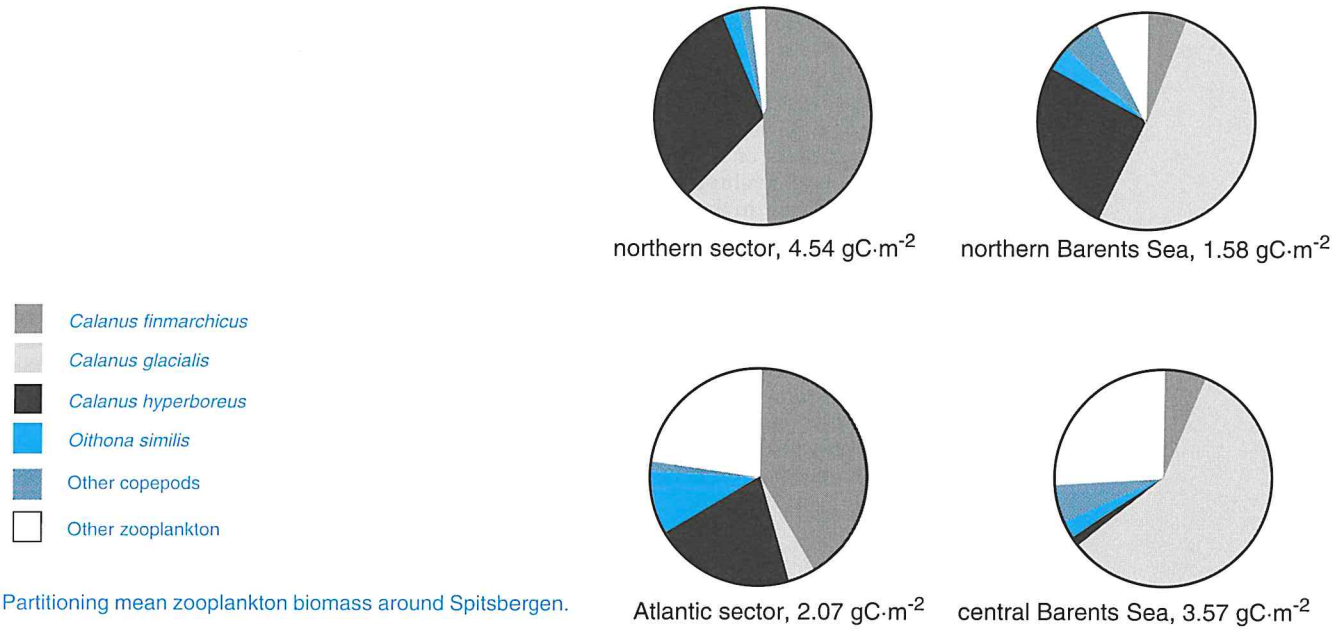


Partitioning mean zooplankton biomass in the southern Ocean.

grazers of the small algae and heterotrophic microorganisms dominating the Antarctic pelagic system. In the ACC, ciliates dominated the microzooplankton biomass with highest values at 40 m depth ranging from 15 to more than 50 µg C· dm^{-3}.

Seasonal variation in abundance and biomass of different instars of *Oithona similis* was studied for stations in the Weddell Sea and the Antarctic Circumpolar Current south of 60°S sampled in some years between 1986 and 1993. Egg production was more spread over the seasons than in most calanoid copepod species and the mean stage was more constant, indicating a mixing of age classes and overlap of generations. Juvenile stages increased in abundance between October and January, but the main development of copepodids was between January and May. A minimum estimate of daily growth rate of 1.5% body weight corresponds with a development from first naupliar stage to the fifth copepodite stage between 1 November and 30 May and leads to an annual P/B ratio of 3.3. The mean population biomass in the southern waters was 150 $mgC \cdot m^{-2}$ in the epipelagic zone, and the minimum estimate of annual production 0.5 $gC \cdot m^{-2}$. Because the contribution of the species to zooplankton biomass is probably higher in the Southern Ocean than elsewhere and the annual P/B is generally much higher than in the larger calanoid species, the production of *Oithona similis* may well be the highest of all zooplankton species in the Antarctic region.

The study of the structure of zooplankton populations on the European Arctic shelf (SEAS 1991) in co-operation with Dr. H.J. Hirche of AWI indicated that in July-August the metazoan plankton biomass was evenly spread around Spitsbergen in the order of 1-8 g C per m^2. About 70% was consistently in the upper 50 m. Copepods dominated in biomass (from 80% in the southern stations to 98% in the north. While biomass was mainly in organisms between 1 and 10 mm length



Partitioning mean zooplankton biomass around Spitsbergen.

(copepodids of the larger calanoid species *Calanus finmarchicus, C. glacialis and C. hyperboreus*), numerical dominance was in the 0.1-0.5 mm class (smaller developmental stages, mainly of the cyclopoid copepod *Oithona similis*). *Calanus finmarchicus* was dominant in the Atlantic sector, decreasing in egg and juvenile stage numbers towards the north. *Calanus glacialis* took its place on the east side of Spitsbergen, where its eggs and juvenile stages were found in high numbers in the ice edge zone and open waters of the Barents Sea. *Calanus hyperboreus* co-occurred with *C. finmarchicus,* but with highest densities at the northern stations. In the ice-covered waters north of Spitsbergen the large calanoid species did not reproduce. Reproducing *Pseudocalanus elongatus* was most abundant at the southernmost Barents Sea and Atlantic stations. The abundant *Oithona similis* showed extremely high egg/female ratios at the southern stations of the Barents Sea, but it was also abundant and producing eggs and nauplii in the northern sector, even under the ice.

Presumably Atlantic species such as *Calanus finmarchicus* drift with the West-Spitsbergen current towards the north, but reduce in number and egg production by decreasing food conditions and temperature. The Arctic species such as *C. glacialis* may be transported towards the south in the East-Spitsbergen current. Ice edge blooms and primary production in open water may enhance its egg production and population development. Transport backwards to the north seems necessary for persistence of such populations. This transport may be induced by vertical migration towards deeper layers of the older stages at the end of the summer, as deeper currents generally move northwards. It is preliminarily estimated that during July-August in the Barents Sea

on average 450 mg $C \cdot m^{-2} \cdot d^{-1}$ of algae are ingested by herbivorous zooplankton, while 180 mg $C \cdot m^{-2} \cdot d^{-1}$ are egested. The excrements are the main carbon input to the sediment, which leaves room for only a poor bottom fauna.

Contributors: *H.G. Fransz* (zooplankton, modelling), *B.R. Kuipers* (microzooplankton), *S.R. Gonzalez* (zooplankton).

4. PELAGIC SYSTEMS IN THE LABORATORY

After more than a year of test runs with natural plankton, two-year experiments with artificial communities of monocultured species were started in November 1993.

The aim of the project is to test the hypothesis on steady-state structure and functioning of a planktonic food web as function of boundary conditions. According to the experimental design the systems (4) were filled with filtered oligotrophic ocean water enriched with N (>50 µM) and kept at 15°C and non-limiting light input, so that phosphorus controls the growth rates of the 12 species of the algal size spectrum. Four microzooplankton species, one rotifer and one copepod species completes the mesocosm food web.

The development towards the model-predicted equilibrium (optimalization of energy fixation rate) was followed by detailed weekly measurements of nutrients (dissolved and particulate), densities of all species, and oxygen balance. In May 1994 this first oligotrophic step was concluded by two measuring weeks concentrated on the quantification of all state variables and fluxes. The four experimental communities all showed the predicted biomass dominance of microzooplankton exerting a heavy grazing control on a mixture of only the smallest phytoplankton. Oscillations and unexpected peaks illustrated the dynamic character of such an equilibrium. The next step, *viz.* a repetition of the experiments at higher P-levels, started at the end of 1994.

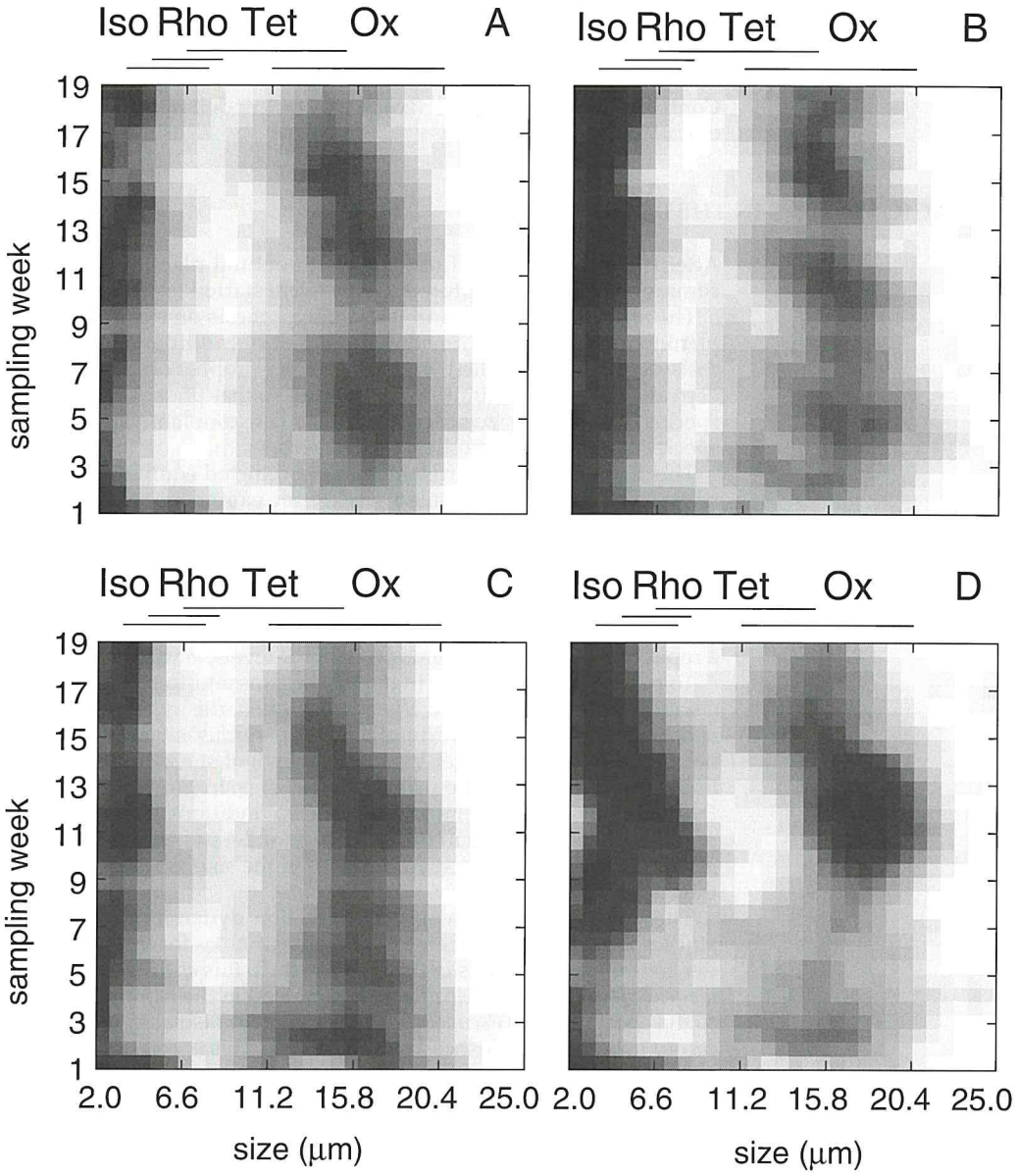
To use microzooplankton in the mesocosms and to study their grazing behaviour, the scuticociliates *Ancistrumina* sp. and *Uronema marinum*, the hypotrich ciliates *Diophrys* sp. and *Euplotes cf. mutabilis*, the heterotrophic dinoflagellate *Oxyrrhis marina* and the rotifer *Brachionus plicatilis* have been monocultured. Larger volumes (5 dm^3) of stock cultures of these five species were used to build up food webs in the pelagic mesocosms. In growth experiments, the (semi-benthic) ciliate *Euplotes* grew just as well under turbulent conditions as in stagnant water. Growth was best supported by food particles in the size range of 2-4 µm. Size-selective grazing experiments with *Euplotes* and *Diophrys* using food particles in the size range of 1-8 µm will have been performed by the end of 1994.

The experimental research on population dynamics and bio-energetics of mesozooplankton studies the significance of environmental variables for the ecophysiology of marine copepods under controlled conditions in the laboratory. To this end stock cultures of the pelagic species *Temora longicornis* and *Acartia clausi* were maintained in the laboratory for many generations. In addition to the above species *Pseudocalanus elongatus* was isolated from the field and cultured in the laboratory to be used in mesocosm experiments. This species carries its eggs in egg-sacs, which probably have a better chance to survive in the mesocosm. Unfortunately the adult animals did not survive long in the mesocosm; nor did they produce offspring. It seemed that they were killed mechanically by the circulation device. Probably stress due to turbulence or directly due to the light evokes escape responses towards the light (phototaxis), which concentrates them in the danger zone of the cleaning scoop.

The possibilities to use an Image Analysis System for semi-automatic quantification of autotrophic and heterotrophic microorganisms were further studied. Preparation of samples is a major cue for successful counting and sizing of microscopic cells. Experiments were performed to find the best preservative. Lugol's solution appeared to preserve delicate algae and heterotrophic flagellates better than glutar-aldehyde, both with regard to cell numbers and cell shape. Since glutar-aldehyde fixation permits epi-fluorescence microscopy and pigment detection, utilization of the true-colour capacity of the system will require time-consuming measurements to correct for species-specific loss and shrinkage of cells due to the preservation method.

A start was made to study the role of food quality on the growth of copepods. As a pilot study, an N-limited continuous culture of *Rhodomonas* was grown at different dilution rates. The aim is to produce algae with different C/N-ratios and to determine the consequences for copepod productivity.

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



Particle spectra (Elzone) followed over 5 months in oligotrophic mesocosms show relatively stable food structure and similarity between the four separate systems. Size of dominating species (*Isochrysis, Rhodomonas, Tetraselmis* and *Oxyrrhis*) is indicated above the figures, shading refers to density on a relative log-scale.

DEPARTMENT OF BENTHIC SYSTEMS

The seabed forms one of the largest coherent ecosystems on earth. However, by geographical, hydrographical and evolutionary circumstances it shows a wide variety of benthic communities. Often these communities harbour an astonishing biodiversity, whereas numerous complex biological and chemical processes underlie the maintenance and functioning of the living components of the community. Benthic boundary processes also play an important role in the cycles of elements and as such are vital in our understanding of global change.

Technological and logistic barriers have retarded access to the vast plains of the deep sea, the continental slopes, polar regions and remote coastal areas. Many of them have still hardly been subjected to consistent scientific exploration. But also close by, in apparently well-studied areas such as the North Sea, numerous aspects of the fine structure and organization of bottom systems have long remained insufficiently known. From an autecological point of view, the great majority of the benthic invertebrates are poorly studied. Functional and evolutionary ecology in terms of genetic variation and fitness of marine benthic species and populations is still virtually a blank space.

The current research projects of Benthic Systems are grouped into two major themes.

1. Structure and dynamics of benthic ecosystems:
Deals with the composition and structural properties of selected benthic communities in terms of biodiversity, size spectra, numerical density and biomass. Attention is paid to the forcing factors, including the effects of natural and man-induced perturbations. Comparative studies in areas that offer a wide range of extremes (*e.g.* high *versus* low altitude, neritic-oceanic, shallow-deep, soft-hard bottom, oligotrophic-eutrophic) will further our understanding of the structure of the ecosystem, its maintenance/resilience capacities and long-term alterations.
2. Supply, quality and utilization of organic matter in benthic communities:
Attention is mainly focused on the origin, supply, quality and utilization of organic matter in benthic ecosystems. Studied are pelagic-benthic coupling, metabolic activity of major groups of organisms and decomposition/mineralization. This includes benthic boundary interactions and processes in shelf sea and deep sea, metabolic activity and growth of single species, community metabolism, partitioning of food over major groups of organisms and mineralization.

Studies range from particle interception in the water column to sedimentation and burial; from single species activity to community metabolism and from shallow areas to the deep-sea environment.

From the wealth of possible research options the following three target areas have been selected:
- the benthic system of the North Sea
- transition areas between coastal shelf sea areas and the deep sea
- coral reef environments

Attempts have been made to further improve benthic observation and measuring methods and techniques, particularly with respect to the assessment of the quality of available food particles for benthic organisms. Moreover, a design for a second generation of an Autonomous Lander for Biological Experimentation ALBEX was prepared and discussed.

1. STRUCTURE AND DYNAMICS OF BENTHIC ECOSYSTEMS

BIOMON (BIOMONitoring North Sea)

In 1994 the analysis was completed of the third survey in succession of the macrobenthic fauna in the Dutch Sector of the North Sea, commissioned by the National Institute for Coastal and Marine Management of Rijkswaterstaat. On the basis of the data from the three surveys, supplemented with earlier data (*e.g.* ICES North Sea Benthos Survey in 1986), a report was made on the year-to-year variation in species densities and in principal attributes of the macrofaunal community at individual stations as well as in subregions of the North Sea.

The analysis showed no significant variations in species densities in subregions and very few significant trends. Though species densities varied more at the individual stations (and even more so when earlier data were added), we did not find concomitant decreases in species that are sensitive to physical disturbance (bivalves, tubicolous polychaetes).

Significant variations and trends in community structure (*e.g.* biomass, diversity) in subregions were sparse. Noteworthy is the absence of trends in total biomass in any of the subregions because biomass increases are usually linked to organic enrichment. At a number of individual stations

we found concurring trends (increase or decrease) in major community attributes such as diversity, density, and biomass. Local causes must be invoked to explain these community changes since there were no consistent changes over subregions.

As a time span of three years is too short for detecting long-term trends in species or biomass such as for instance induced by eutrophication, the monitoring programme is being continued. A fifth survey was carried out in May 1994.

MILZON (MILieuZONering/environmental zonation)

During the period 1988-1993, the spatial distribution of macrozoobenthos in the Dutch Sector of the North Sea was studied in the framework of the MILZON-BENTHOS project, commissioned by the North Sea Directorate of Rijkswaterstaat.

Boxcore samples taken at more than 500 stations were analysed with regard to macro- and meiobenthos and sediment parameters (grain size, chlorophyll). The results from separate cruises have been published in official, but non-refereed reports. The overall results will be summarized in an atlas describing the distribution of 75 important macrobenthic species and of the principal macrobenthic communities and their attributes (biomass, diversity). In order to present as complete an overview as possible of the gradients in benthic infauna in Dutch waters, the MILZON dataset will be supplemented with earlier data from 250 locations on the Dogger Bank, the Delta estuaries and the Dutch Wadden Sea.

Long-term trends in *Arctica islandica* (Bivalvia)

The long-term growth variations in *Arctica islandica* from the Fladen Ground (northern North Sea) have been estimated by dendrochronological methods. Samples were collected in 1983 and 1991. Chronologies obtained from both samples show very similar patterns and a detailed study of the long-term variations in growth tentatively indicates that the growth rate is related to the inflow of Atlantic water into the northern North Sea. Hypotheses have been formulated to explain the existence of a few *Arctica* banks in the Fladen Ground, where the species is otherwise rare.

In addition to the earlier pilot study the effects of bottom fisheries on *Arctica* have been investigated in a larger area. The long-term trend in scar frequencies in additional samples from the southeastern North Sea confirms the earlier findings. They all show an increased occurrence of scars towards recent times. A comparison with shell collections from unfished areas from the Canadian east coast confirms the view that the increase of scars is caused by bottom fisheries.

Dynamics and diversity of coral reefs

The common denominator is processes which determine composition and diversity in reef communities. Ongoing research is on short- and long-term dynamics, including the role of intra-specific variation in modular/clonal organisms.

A new angle is investigations into the role of microbial processes in reef dynamics, presently focused on microbial variables in the water column in relation with coral reef eutrophication and the linkage to reef benthos. First results along the reefs of Curaçao show limited spatial variability in bacterial production and abundance except close to the harbour. Exchange between ocean and coastal waters is significant. Monthly variations in bacterial production over the reef may be related to either upwelling events or the passage of Orinoco waters, and coincides with slight drops in temperature along the coast.

The role of nanoflagellates in the water column as bacterivores is studied in grazing experiments. Very low densities of flagellates close to the reef bottom may be indicative of the filtration effects of the reef organisms. These studies will be expanded to pristine and polluted reefs.

Microbial biomass and the filter-feeding bivalves, oysters and mussels

A common human activity in estuaries all over the world is harvesting and cultivation of bivalves. The effect of oysters and mussels on the microbial content of the water was studied in Gazi Bay, Kenya, and in the Dutch Wadden Sea, respectively. The bacterial and seston concentrations of the water flowing through the beds was estimated over several tidal periods. Mussels and oysters remove a part of the suspended particles and use them as food; another part is discharged as faeces and pseudo-faeces. In mussel cultures these products tend to accumulate in the beds, while in the oyster beds they are carried away with the water current. A large variability in bacterial and seston was observed due to the continuously changing circumstances during the tide; in general resuspension overruled the effect of the bivalves.

Temperature effect on bacterial growth in Wadden Sea

During the season at high water slack and at low water slack, the bacterial numbers and their specific growth rate was estimated in the Marsdiep tidal inlet. The growth rates follow the tempera-

ture curve indicating that temperature regulates the growth rate and not the energy or nutrient concentration. This contrasts with observations in the North Sea in summer.

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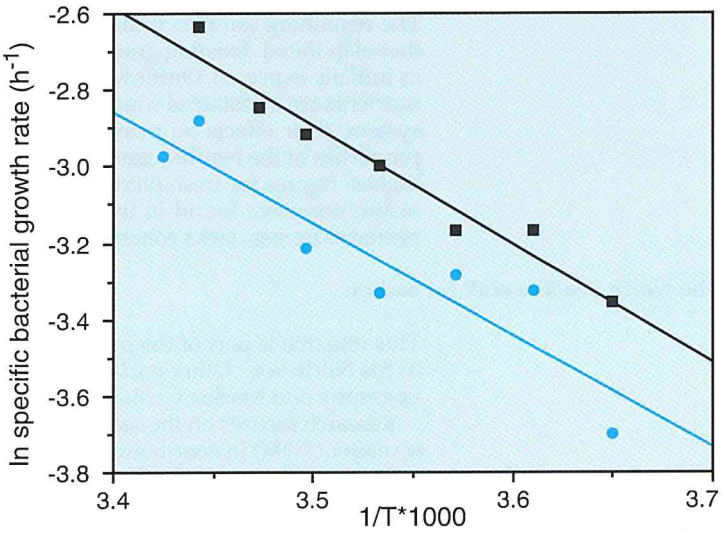


Arrhenius plot of specific growth rate of bacteria in the Dutch Wadden Sea at high water (■) and low water (●) slack during the seasons at various temperatues. The lower abscissa is the reciprocal of the absolute temperature times 1000. Activation energies are 6000 and 6200 cal per Mol. Calculated Q10=1.5 for 0°-10°C.

2. BENTHIC BOUNDARY PROCESSES AT CONTINENTAL SHELVES AND DEEP-SEA SLOPES

OMEX (Ocean Margin Exchange)

In the framework of the OMEX project, in May 1994 a second cruise was executed with the RV 'Charles Darwin' (NERC) to the transect running across the Goban Spur. Eight stations were visited where sediment oxygen demand (SOD) was measured in shipboard incubated cores, usually in combination with *in situ* (BOLAS lander) methods. Besides the activities at the international OMEX stations, supplementary measurements were conducted at four stations located along a southern parallel transect on the Goban Spur. Because of the facilities available on the RV 'Charles Darwin', the deepest stations (3600-4400 m) were also fully covered this time.

The results from the two cruises indicate that, apart from local scatter, there is no consistent deviation from a downslope decrease in SOD. Although this pattern in SOD can be explained by the vertical temperature gradient, benthic food resources seem to decrease downslope as well. Evidence for this comes from the distribution of nucleic acids, meiofauna densities and phytodetritus measured in November 1993. We found no distinct seasonal difference in SOD at the stations that were sampled during both the spring and autumn cruises. The analyses of the sediment samples taken in 1994 may yield more insight into the seasonal variation in the input of fresh organic material to the OMEX transect.

A comparison between the SOD estimates from *in situ* and shipboard measurements shows that the shipboard methods using decompressed cores from depths below 1500 m give rise to serious overestimates of SOD. *In situ* methods are therefore imperative for the assessment of the role of the deep sea sediments in the mineralization of organic carbon.

NIOP (Netherlands Indian Ocean Programme)

The ongoing analysis of sediment samples collected during the NIOP cruise to the Kenyan continental shelf and slope supports the earlier conclusions based on measurements of Sediment Oxygen Demand (SOD) that there is an increase in the benthic food supply from the southern to the northern transect. This trend is reflected by the benthic biomass (macro-and meiobenthos, total DNA), as well as the phytodetritus content of the sediment. There is no clear evidence for accumulation of phytodetritus in the depth zone of the oxygen minimum layer along the Kenyan continental slope. This contrasts with sediments in the oxygen minimum zone along the continental slope of the Arabian Peninsula (Yemen, Oman) where relatively high amounts of phytopigments

were found. The major fraction was formed by accessory pigments derived from cyanobacteria. Chlorophyll *a* and phaeopigments were either absent or very low in concentration in sediments from the oxygen minimum zone, possibly indicating deposition of highly reworked material. The SOD measurements that were carried out during the two monsoon periods off the Arabian Peninsula clearly demonstrate the negative effect of oxygen-poor upwelled water on SOD of shallow sediments. The SOD of deeper sediments did not show great differences in the two monsoon periods.

STEP-Adria

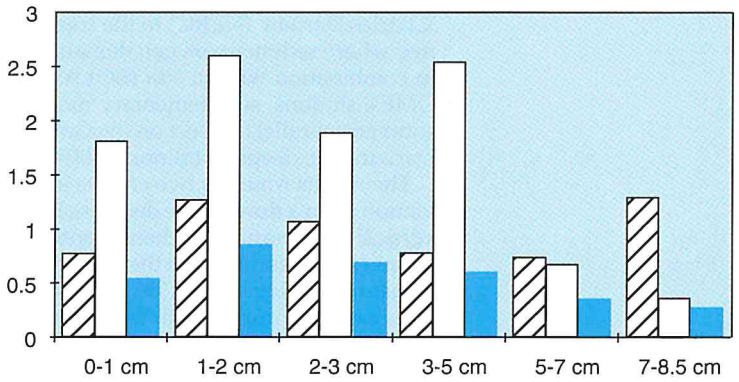
The remaining samples from the March 1992 and August 1993 EC STEP Adria cruises were further elaborated. Existing gradients in the northwestern part of the Adriatic Sea were not as simple as initially expected. Outflow of the Po river was considered to be a point source for nutrients. As nutrients are transferred southward along the Italian coast by the prevailing anticlockwise current system, their effects on primary productivity, organic matter deposition and consequently the properties of the benthic communities, were expected to gradually diminish. Though some of the highest figures for fresh phytopigments, macrofauna density and biomass, and aerobic sediment respiration were found in the northernmost stations, the overall picture, with numerous unexpected extremes, lacks coherency and is difficult to explain.

The North Sea as a sink for carbon

This research is part of the project 'Disturbance of Earth Systems - theme 4: Benthic carbon sinks in the North Sea'. Other parts of the project are conducted at the Departments of Chemical Oceanography and Marine Geology of NIOZ, and at NIOO-CEMO, Yerseke.

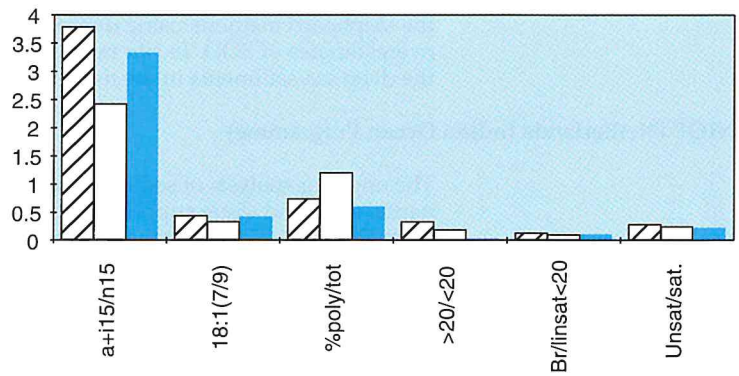
Research focuses on the seasonal variations in the quality and quantity of the particulate organic matter (POM) in near-bottom seston, sediment and macrobenthos (field samples), as well as the influence of macrobenthos on the quality of this material (experiments).

In 1994, cruises were made in February, May and August to the stations Broad Fourteen, Frisian Front, German Bight and Skagerrak. At each station, samples were taken of near-bottom seston, sediment and macrobenthos. On board measurements were performed: biochemical oxygen demand on seston, and sediment community oxygen consumption. The samples are currently being analysed on phytopigments, RNA/DNA (only sediment) at the Department of Marine Biogeochemistry. These parameters give insight into the (bacterial, algal or animal) nature of the POM, the quality of POM as food for benthic organisms, and the feeding ecology of these animals.



Phytopigment ratios in German Bight sediments, February 1994. Ca=chlorophyll *a*; Pht=Phaeophytine *a*; Phb=Phaeophorbide a; Phtot=sum both phaeopigments.

0-1 cm 1-2 cm 2-5 cm



Fatty acid methyl ester ratios in German Bight sediments, February 1994. a+i1 15/n15=anteiso+iso c15: 0/nc15:0; 18:1(7/9)=c18:1(n-7)/c18:1(n-9); %poly/tot=%poly-unsaturated fatty acids (only c20:5); >c20/<c20=total fatty acids >20 c-atoms/total fatty acids ≤20 c-atoms; Br/insat<20=total bronched fatty acids ≤20 c-atoms/total linear saturated fatty acid ≤20 c-atoms; unsat/sat=total unsaturated fatty acids/total saturated fatty acids.

Ca/Phb Ca/Pht Ca/phtot

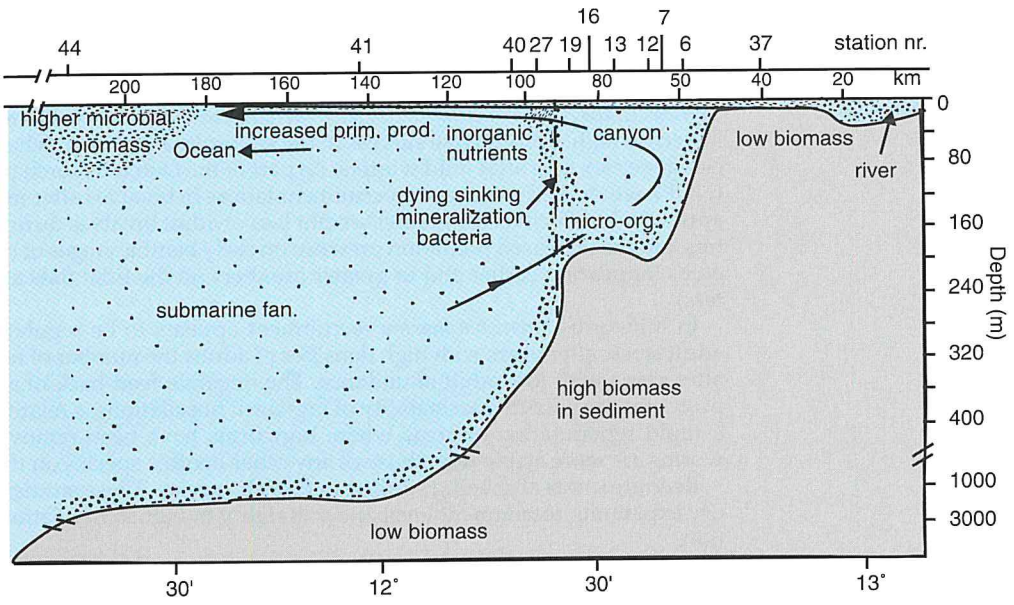
Small food web studies (protozoans)

Protozoan trophic interactions in marine sediments were studied through variation of nanoflagellate densities, community feeding activity and grazing rates on bacteria.

Trophic relations between heterotrophic nanoflagellates and bacteria were demonstrated using monodispersed fluorescently labelled bacteria (FLB). However, low grazing rates in field experiments are interpreted as possible discrimination by flagellates against FLB. To test if this is caused by preference of benthic nanoflagellates for attached, surface-associated bacteria over suspended cells, a method to stain sediment-attached bacteria was adapted so that they could be used as experimental food particles. Growth and grazing experiments during exponential and stationary growth were continued. There is consistent evidence that gross growth efficiency (= yield) must be higher during exponential growth for some flagellate species.

Bacterial growth in an estuary

Microbial biomass and bacteria in the Zaire estuary:
Measurements of the microbial biomass in water and sediment collected in the Zaire estuary have been worked out. The Zaire river with its canyon and submarine fan is the world's second largest river in terms of water discharge. From earlier studies it is known where the suspended load of the river is deposited and where increased primary production occurs in the plume. Microbial observations fit well into these patterns. In the surface water there is first a small decrease in microbial biomass from the river towards the ocean, probably because riverine freshwater microorganisms die; then at the ocean stations there is an increase of microorganisms. The bacterial biomass is highest at the end of the canyon, where most of the suspended load carried seawards by the river is deposited. After that there is a dip, while at the stations with the increased microbial biomass the bacterial biomass increases, probably stimulated by the excreted organic material of the blooming phytoplankton. In the bottom water the microbial biomass is low at the end of the canyon and in the fan, but higher in the centre of the canyon. The sediment at the very end of the canyon is rich in microbial biomass. Perhaps the inward directed bottom current resuspends some of this biomass which may cause an increase of microbial biomass in the bottom water of the central part of the canyon.



Cross section of the Zaire estuary.

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DEPARTMENT OF COASTAL SYSTEMS

The Department of Coastal Systems studies ecosystems and their biotic components in coastal marine areas, primarily in the Dutch Wadden Sea.

The project 'Autecological studies of key species' clusters studies on individual species of great importance to the functioning of the Wadden Sea ecosystem and similar systems in other coastal areas. Interrelationships between key species are also being studied. Species included are: the alga *Phaeocystis pouchetii*, several species of macrozoobenthos (*e.g. Cerastoderma edule, Mytilus edulis, Macoma balthica, Arenicola marina, Corophium volutator*), some flatfish species (*e.g.* plaice, flounder and dab) and wader birds (particularly the knot *Calidris canutus*).

The project 'Integrated studies of the functioning of Wadden ecosystems' quantifies food chains and production processes in the western part of the Wadden Sea by integrating studies on individual species.

In several groups of species quantitative sampling started long ago and has continued in a uniform way for decades. Such studies are clustered in the project 'Long-term studies on dynamics of populations'. Such groups include: phytoplankton in Marsdiep (densities, chlorophyll concentrations, primary production), macrozoobenthos (>30 species) on Balgzand (and in some other Wadden Sea areas), fishes in Marsdiep, eider ducks on Vlieland, wader birds around Griend. These data series are not only valuable as a documentation of long-term changes in the western part of the Wadden Sea (caused by eutrophication, fishery and possibly climate change), but also contribute to our knowledge on the biology of key species and on the year-to-year variability of the functioning of the ecosystem.

Finally, physiological studies (project 'Physiology') contribute to an insight into the functioning of key species and unravel physiological mechanisms.

1. AUTECOLOGICAL STUDIES OF KEY SPECIES

Nutrient concentrations and light conditions are the main factors governing intensity and duration of the annual bloom period of *Phaeocystis*. The increase in the duration of these blooms, which started in the late 1970s, is due to eutrophication of the Dutch coastal waters. Though nutrient concentrations have been declining in recent years, so far no clear signs of a decline of the annual *Phaeocystis* blooms are apparent. In 1994, the bloom started unusually late, *viz.* in early July, two months later than normal. This delay may be related to the abnormal (dark and cloudy) weather conditions in spring.

Weather conditions also affect several species of benthic animals. In such important bivalves as *Mytilus edulis, Cerastoderma edule, Mya arenaria,* and *Macoma balthica* cold winters are usually followed by high reproductive success in the subsequent summer, whereas recruitment in these species generally fails after mild winters. As part of the Dutch research programme on climate change (NOP), we study the causes of recruitment failure in bivalves after mild winters. Two mechanisms appear to be effective: the greater weight loss of adult bivalves during mild than during cold winters and the increased predation pressure on early benthic stages of bivalves by shrimps and shore crabs (appearing earlier and in greater numbers on the tidal flats after mild than after cold winters).

In lugworms *Arenicola marina* recruitment appears to be regulated mainly by the size of the adult stock: after years with high densities of adults the number of recruits is generally lower than after years with low adult abundance. The negative feed-back of adults on numbers of recruits promotes the year-to-year stability of lugworm populations, a relatively uniform distribution and a rapid repopulation of areas where lugworms have been removed. Indeed, numbers of lugworms are more stable than those of any other benthic species on the tidal flats.

Recruitment is also being studied in flatfish species. These studies are guided by a general theory explaining recruitment level and variability in flatfish in relation to their latitudinal distribution.

As part of an overview of all existing information and knowledge on recruitment in flatfish, a detailed analysis has been made of the impact that juvenile growth has on recruitment. The results of this review support the general view that year-class strength in flatfish is mainly determined during the larval stage. Subsequent processes operating in the demersal phase only appear to dampen the interannual variability in recruitment.

The mean recruitment level in North Atlantic flatfish species appears to be related to the size of the nursery area for the 0-group. These relationships have been found both within and between species. This finding has resulted in a 'nursery size' hypothesis. As extensive research in the nursery areas never suggested the presence of density-dependent growth or mortality processes, the key factor underlying the above relationship between level of recruitment and nursery size is thought to be the larval supply. Water exchange and hence larval supply will be directly related to the size of a nursery area. However, it is expected that this relationship varies with latitude. Since temperatures increase with decreasing latitude, the metabolic costs will increase and the

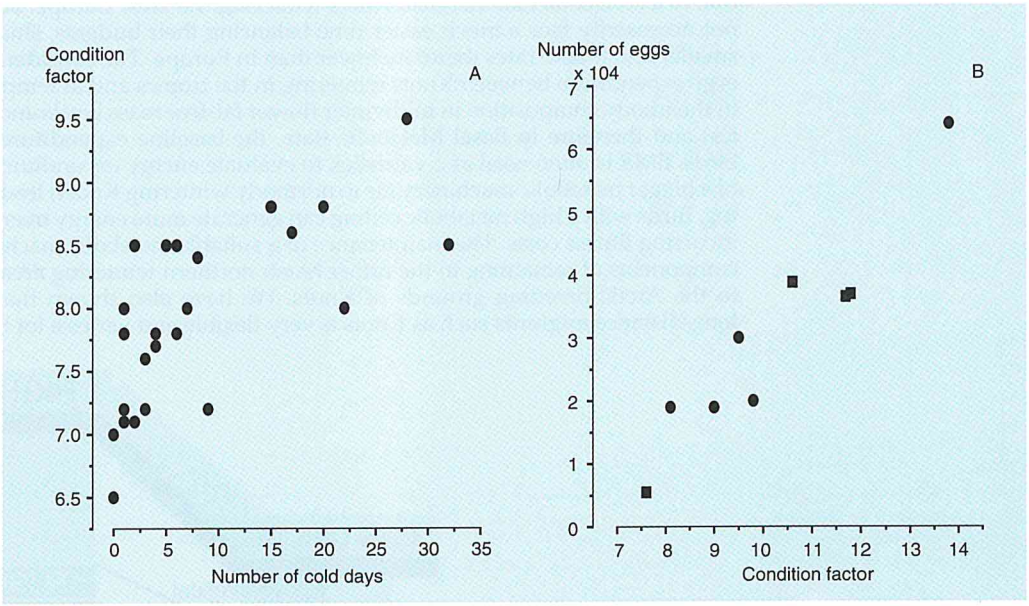
scope for reproduction decrease. Thus, two relationships are expected to determine the ultimate level of recruitment. To test the general value of the hypothesis, these relationships will be tested in other species, especially in (sub)tropical waters.

Since there is every indication that year-class strength is generated in the larval stage, larval transport is also thought to be a key factor in determining the ultimate level of between-year variability in recruitment. Beverton's 'concentration' hypothesis states that the level of variability in recruitment appears to be inversely related to the degree of concentration of juveniles in nursery areas. So far no clear mechanism has been suggested which might explain such a relationship. Based on the assumption that especially the larval phase is the critical period in the early life history of flatfish, an inverse relationship is expected between duration of the larval stage and ultimate variability in recruitment. A long larval stage might result in a greater dispersion of pelagic larvae than in the case of a shorter larval period. If true, it means that over the range of distribution of a species, the variability in recruitment will increase with increasing latitude. Water temperature decreases with increasing latitude and hence larval development will be longer and potential dispersion greater. Recently published information on long rough dab in the North Atlantic supports this view.

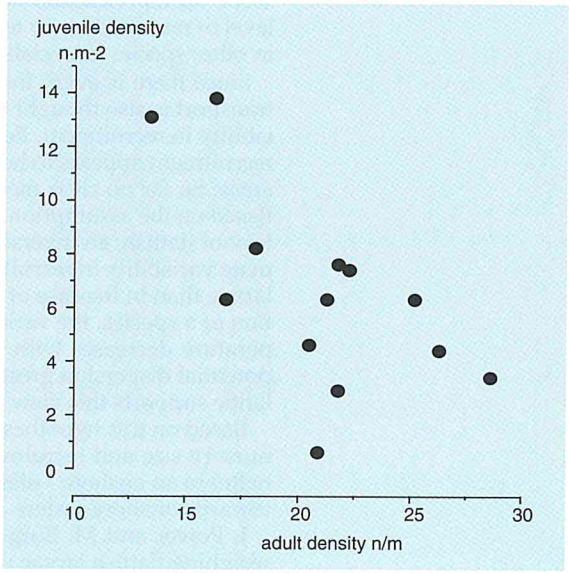
Based on this hypothesis, field investigations are carried out to study the relationship between nursery size and recruitment in a number of North Sea flatfish species (dab, scaldfish and solenette) in an onshore - offshore gradient. Preliminary results suggest that mortality rate decreases towards offshore waters.

J. Power and M. Burger from the Louisiana State University (USA) tested the possibility of weighing flatfish larvae under water. Tests were carried out with larvae of plaice and sole in different stages of development. Sole larvae were reared from fertilized eggs supplied by the MAFF - Fisheries Laboratory in Conwy (Wales). Fertilized eggs and larvae of flounder were obtained from fish kept in our laboratory.

The abundance of rays has seriously declined in the North Sea. These fishes are characterized by a low fecundity and their populations are therefore prone to negative effects of fishery and pollution. To study their biology in more detail, several thousands of rays were tagged in the eastern North Sea as part of a co-operative tagging programme with the Dutch institute for Fishery Research RIVO-DLO.

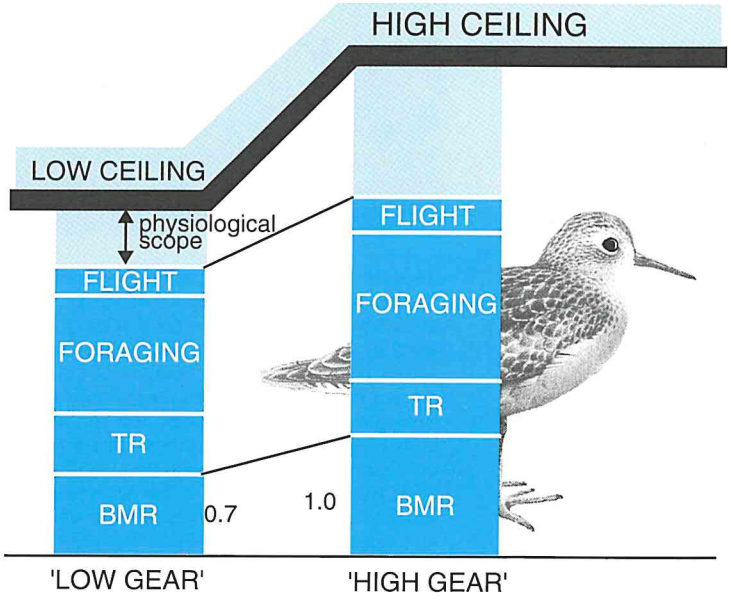


Bivalves living in the Wadden Sea usually produce a larger number of offspring in a summer following a cold than in a summer following a mild winter. One of the factors contributing to this difference in reproductive success is that adult bivalves lose less weight during cold than during mild winters, resulting in relatively high body weights after cold winters. Heavy adults produce more (and in some species bigger) eggs than light ones. **A** shows field data on body weights of the bivalve *Macoma balthica* at the end of 24 winters (1970-1994), arranged from mild to cold by the number of cold days (*i.e.* maximum air temperature < 0˚C). Body weights are expressed as condition factor: the ash-free dry weight in mg of an animal with a shell length of 10 mm. High body weights were indeed observed particularly after cold winters. **B** shows results of experiments with groups of *Macoma* which were subjected to different temperatures and food supplies during winter to obtain different body weights at the start of the spawning season in spring. Condition factors were high after simulated cold winters or high food supplies and low after simulated mild winters or low food supplies. The higher the condition factor at the end of winter, the higher was the mean number of eggs produced per spawning female. By this mechanism, higher numbers of eggs are spawned by *Macoma* stocks after cold than after mild winters.



In the lugworm *Arenicola marina*, new generations of juveniles are significantly larger after years with a small adult stock than after years with large numbers of adults. This inverse relationship between parent stock size and progeny abundance is thought to be caused by the intensive reworking of the sediment by adults, leaving very little undistubed space for juveniles in years with a dense adult population. Juveniles thrive only in the 'empty' space where adults are few or absent.

A key component in the ecology of every species is its energy budget. Studies of one of the main mollusc-eating shorebirds in the Wadden Sea, the Knot *Calidris canutus*, have come some way in quantifying the two components of an energy budget. Energy expenditure is predicted on the basis of activity budgets and climatic conditions. Energy intake is a function of the abundance of the harvestable fraction of benthic prey and feeding time. Our work has indicated that Knots wintering in coastal intertidal areas in West Africa incur much lower costs of living (energy expenditure), due to a congenial climate, than Knots wintering the West Europe. Still, Knots in West Africa do not necessarily face a much easier time balancing their budgets, since prey animals are usually smaller and intake rates therefore lower than in Europe. The considerable differences in daily energy expenditure between Knots wintering in the tropics and at temperate latitudes are reflected in their body composition in midwinter (lower fat-free mass levels and smaller organs in the tropics) and therefore in Basal Metabolic Rate, the baseline expenditure of non-digesting sleeping birds. BMR is often used as a yardstick to evaluate energy expenditure. A higher BMR as a result of a bigger metabolic machinery (as in northerly wintering Knots) leads to a higher metabolic ceiling. Birds with a high metabolic ceiling can generate more energy over a longer time span without incurring fitness costs. The maintenance of a suitable metabolic machinery is thus one of the cost components of remaining in the rather harsh northern wintering areas which are relatively close to the Arctic breeding grounds of Knots. We have also shown that the body composition of long-distance migrants such as Knots is very flexible and varies a lot in the course of their annual



An increase in the Basal Metabolic Rate (BMR) of a shorebird with a factor 1.4 from left to right (*i.e.* the difference between Knots wintering in tropical Africa and Knots wintering in the Wadden Sea) results in a much higher maximum sustained working level (or 'metabolic ceiling'). This allows a greater energy expenditure (*i.e.* colder climatic conditions and/or longer working hours). It would also lead to a greater physiological scope to carry out various activities, if climatic conditions (expressed by TR, see below) remained similar in the two conditions (as in this example). Note that the actual expenditure is indicated in this example with the filled parts of the stacked bars, with 'FLIGHT' indicating the daily cost of flying, 'FORAGING' indicating the daily cost of foraging, 'TR' indicating the cost of thermoregulation and 'BMR' indicating the contribution of basal metabolic rate.

cycle, probably to accommodate the various cost levels incurred in the different climate zones visited in the course of the year. In June-August 1994 we worked in the high Arctic of Siberia, at Sterlegova on Taymir Peninsula, to study the energetics of reproduction in Knots. The preliminary results of experiments with double-labelled water carried out to estimate daily energy expenditure confirm that Arctic breeding is an energetically costly strategy. During incubation Knots were expending more than 4 Watt, *i.e.* more than 4 times BMR. This is close to the energy expenditure of Knots in the Wadden Sea in midwinter, and also close to the suggested metabolic ceiling.

Contributors: *J.J. Beukema* (zoobenthos), *G.C. Cadée* (algae), *H.W. van der Veer* (flatfish), *P.J.C. Honkoop* (bivalves), *M. Fonds* (flatfish), *T. Piersma* (birds), *L. Bolle* (flatfish: dab), *P.A. Walker* (rays); *P. Duiven* (birds), *W. de Bruin* (benthos), *J. Hegeman* (algae), *D. Kwast* (bivalves), *P. van der Puyl* (fish), *J.IJ. Witte* (fish), *J. Zuidewind* (benthos).

2. LONG-TERM STUDIES ON DYNAMICS OF POPULATIONS

The long-term studies of phytoplankton, zoobenthos, flatfish and birds were continued.

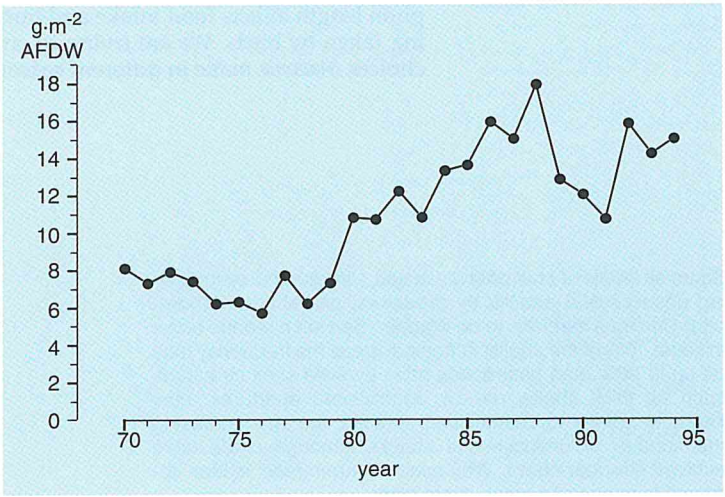
The long series of Marsdiep data on phytoplankton (numbers per cm^3 in several tens of species, concentrations of chlorophyll, rates of primary production), which started in the early 1970s, were converted to a computer-stored data base to ensure conservation and easier handling.

The long-term series of zoobenthos data collected twice-annually at 15 stations on Balgzand reached the 25-year landmark. So far, there are no clear indications that the high level of zoobenthos biomass of the last 15 years (a doubling of the level observed during the 1970s) has started to decline. Such a decline might be expected as a response to a possible reduction of the eutrophication in the western part of the Wadden Sea. So far, reduction has been substantial only in phosphate concentrations, but this reduction did not clearly affect primary production or chlorophyll concentrations. Perhaps the recently increased transparency of the water that has been observed in some parts of the western Wadden Sea (though not in Marsdiep) is counteracting the effects of reduced nutrient concentrations.

At the request of Rijkswaterstaat (RIKZ), a zoobenthos sampling programme is carried out in subtidal parts of the western Wadden Sea and in intertidal areas in the eastern part of the Dutch Wadden Sea. RIKZ also contributes to the Balgzand programme. Dynamics of benthos observed in subtidal areas mostly parallel those in the nearby intertidal. For the first time since 1987, a highly successful spatfall of mussels occurred all over the Wadden Sea in 1994, both subtidally and intertidally. By the continued absence of a substantial recruitment, mussels have been relatively scarce ever since 1990, when the natural mussel beds were removed by the fishery for seed mussels to stock commercial plots. Recovery of natural mussel beds has been a slow process. It proceeded most rapidly on Balgzand, an area recently closed to mussel and cockle fishery.

Long-term changes in abundance of epibenthos and fish species have been studied by means of fyke-net catches since the 1960s. The emphasis is now on an analysis of the sampling strategy to evaluate the fyke catches as indicators of the variability in abundance of the populations. It is expected that the results will allow a distinction to be made between natural variability and anthropogenic influences.

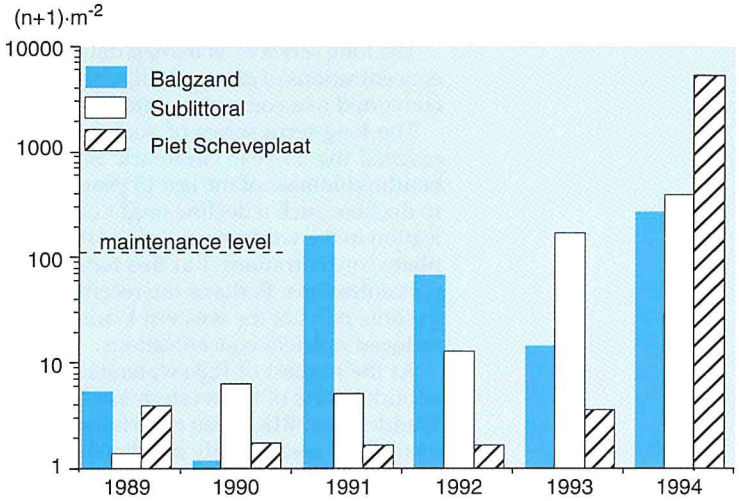
The long-term studies on the population dynamics of Eiders, *Somateria mollissima*, on Vlieland were continued. From high-tide counts of males and females of different age classes in the first week of May, a total number of 2430 breeding females was calculated, of which 639 nests were



A 25-year record of the total biomass of the group of deposit-feeding benthic animals on Balgzand (g ash-free dry weight per m^2, means of 15 stations, late-winter values). This group responded more clearly than other groups (filter feeders, predators) to the eutrophication of the western Wadden Sea. Eutrophication included threefold increases of nutrient (P and N) concentrations during the 1970s, doubling of chlorophyll concentrations in the 1980s as compared to the 1970s, and a significant increase in zoobenthic biomass over the same period. Though the increasing trend of biomass seemed to reverse around 1990, values observed in the last few years are again at the high level of the late 1980s (*i.e.* twice the level of the 1970s). Thus, like in Marsdiep phytoplankton, no clear signs have been found that the Balgzand ecosystem is already responding to the recent substantial decline in phosphate concentrations in the western Wadden Sea.

found in a restricted survey. A total of 467 females were captured on the nest, 281 (60%) of which had already been ringed in the years before. By keeping a large part of the resident female Eider population ringed we keep a good handle on their fate. In case of calamities to the population, this will immediately show up in the recovery rate. A survey to determine the reproductive success of the Eider ducks on Vlieland was carried out in the first week of July. We found a total of 138 ducklings (0.056 ducklings/breeding female). Jointly with RIKZ (Middelburg), a midwinter count of the Wadden Sea population of Eiders was carried out from the air in the first week of February. In the Wadden Sea proper 85000 birds were counted, whereas another 29300 birds were seen in the adjacent coastal zone of the North Sea. In the rest of The Netherlands (Delta area) only 4500 Eiders were seen.

Contributors: *J.J. Beukema* (zoobenthos), *G.C. Cadée* (algae), *R. Dekker* (zoobenthos), *H.W. van der Veer* (flatfish), *T. Piersma* (birds); *P. Duiven* (birds), *W. de Bruin* (benthos), *J. Hegeman* (algae), *J.IJ. Witte* (fish), *J. Zuidewind* (benthos).

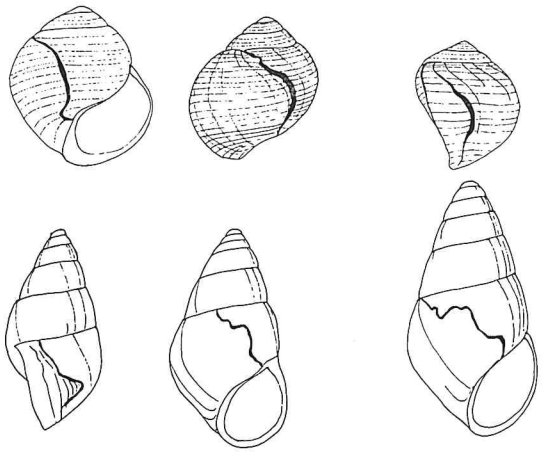


Densities of spat of mussels *Mytilus edulis* at several sites in the Wadden Sea as observed in the late summer of the years 1989 to 1994 inclusive. After three successive years (1988, 1989, and 1990) of recruitment failure in most of the Wadden Sea, mussel populations became extremely small by early 1991. Recovery of the mussel populations proceeded slowly. The mean annual number of recruits necessary for the maintenance of adult population size would amount to slightly more than 100 per m^2. This level was reached on the westernmost tidal flats (Balgzand) in 1991, in the sublittoral of the western half of the Wadden Sea in 1993 and in the eastern half of the Dutch Wadden Sea (represented by the sampling area Piet Scheve Plaat) only in 1994.

3. INTEGRATED STUDIES OF THE FUNCTIONING OF THE WADDEN ECOSYSTEMS

The studies of predator-prey relationships focus on consumption of benthic prey by wader birds and flatfish.

The small bivalve *Macoma balthica* is an important prey for many waders, such as oystercatchers *Haematopus ostralegus* and knots *Calidris canutus*. Prey buried deeper than 3 cm are beyond the reach of knots, those deeper than 8 cm are unavailable to oystercatchers. The depth of *Macoma* in European estuaries varies between about 10 cm in winter and about 2.5 cm in the main reproductive and growing season in spring. Strategies of this species to reach maximum growth and reproduction under the constraints of the risks of lethal predation and loss of replaceable parts are studied. Waders take whole animals, epibenthic predators (flatfish, shrimps) nibble siphons. Siphon length affects food intake and burying depth. Burying depth strongly affects the risk of being taken by birds. We are trying to entangle this network and to determine what governs the choices *Macoma* make in different seasons.



Scars on shells of *Hydrobia ulvae* and *Littorina littorea* indicating unsuccessful attacks by predators, probably the shore-crab *Carcinus maenas*. In de Wadden Sea such repairs occur in some 10% of the shells; in tropical areas the frequency may be up to 90%, and gastropods have evolved shell structures such as thick shells, narrow denticulated apertures, ribs, knobs or spines to counter crab attacks, thereby increasing the number of unsuccessful attacks although crabs have evolved stronger claws. Why such an 'arms race' is less apparent in temperate areas is not clear.

The Wadden Sea offers ideal opportunities to study the fate of shells during the first steps in the fossilization process. Particularly fragmentation and transport are being studied. The role of shell-consuming birds in producing shell fragments has been quantified. A start has been made with the study of shell fracturing by the shore crab *Carcinus maenas* in aquaria.

Contributors: *J.J. Beukema* (zoobenthos), *G.C. Cadée* (palaeobiology), *T. Piersma* (wader birds); *P.J. de Goeij* (*Macoma*); *J. Zuidewind* (benthos).

Mass mortality of cockles on a tidal flat near Texel due to low oxygen content, July 1994.
Photo: G.C. Cadée.

4. ENVIRONMENTAL PHYSIOLOGY

Environmental physiology aims to study the functional relations in the interactions between organisms and their environment and attempts to explain the mechanisms of the interactions in physical, chemical or mathematical terms. In the past year, four different problems were tackled which has led to the results shortly indicated below:

Metabolic rate and body size: a new view on the 'surface law' for basic metabolic rate

In larger animals a considerable part of the total body mass (*e.g.* body water, dissolved substances, mineral and organic deposits) does not consume significant amounts of oxygen. These materials can be considered to form a metabolically inert infrastructure mainly serving three functions: (1) structural support (2) storage of building material and energy and (3) transport and distribution of these materials. Considering the transport and support function of the metabolically inert infrastructures it is likely that it will basically show a tree-like, branching building plan. The weight of the metabolically inert infrastructure of an organism can be expressed by a simple formula. With increasing size its weight increases disproportionally. Experimental data concerning basic metabolic rate in relation to body weight better fit a new equation, based upon the above considerations, than they fit the conventional power law.

The problem of measuring the heat production of small aquatic animals

This work considers the construction of a very sensitive and rapidly responding flow-through microcalorimeter to be used for studying the effects of environmental circumstances (various kinds of stress) on the metabolic rate of small aquatic organisms. The new measurement principle, which in a unique manner allows random fluctuations of the inflow and outflow temperature, is based on the repetitive determination of the temperature differences between inflow and outflow of a small measuring vessel. Temperature differences between inflow and outflow are recorded at a high rate of several measurements per second. In the design of the calorimeter special attention is paid to the temperature homogenization in the measuring vessel. The temperature data are then used to calculate (the extremely low) heat dissipation according to an algorithm as derived theoretically. The performance of the design was tested in a numerical model in order to derive optimal parameter settings for measuring frequency in relation to measuring accuracy.

A functional model for describing the responses to salinity stress in aquatic animals

A functional mathematical model was derived which perfectly describes osmotic and ionic concentrations in the body fluids of aquatic species in response to environmental conditions. Any

regulation curve can now directly be described by four parameters, *viz.* (1) the regulation strength, (2) the tolerance range, (3) the centre or set-point for regulation and (4) the level of internal concentration at the set-point (all values expressed in the same units as those used for expressing internal and external concentrations). Fitting regulation curves in the proposed model greatly facilitates accurate inter- and intraspecific comparison of different species and judgement of their physiological evolutionary position.

The effect of salinity stress on a particular species was studied by C.G.N. de Vooys. It could be demonstrated that in the mussel *Mytilus galloprovincialis*, the betaine-glycine concentration in the adductor muscle is related to the external salinity: low in diluted seawater, high in normal seawater salinities. Biosynthesis of betaine-glycine could be traced with ^{14}C-choline. This work was carried out at the Laboratoire ARAGO in Banyuls sur Mer, France, with a grant of the Royal Academy of Arts and Sciences.

Ovarian development during the reproductive cycle of *Crangon crangon* (L.)

The reproductive cycle in shrimps strongly depends on external circumstances. In aqua culture systems it is often very difficult to find the right conditions. Changes in weight and volume of the ovary of shrimps during ovarian development were subjected to mathematical treatment to estimate duration of developmental stages, to assess ovarian stage from relative weight of the ovary, and to predict the number of ova in ovaries at different developmental stages and body weights. Ovarian development is preceded by a swelling of the hepatopancreas representing food storage for vitellogenesis. In the pollution literature this is erroneously ascribed to the effect of heavy metals. Future studies may reveal how the reproductive cycle is connected to external conditions.

Contributor: *D.H. Spaargaren* (physiology).

Young scientists working so hard that they forgot the tide.
Photo: Pieter Honkoop.

DEPARTMENT OF APPLIED MARINE ECOLOGY (BEWON)

BEWON executes research to improve the scientific basis for the management of marine ecosystems. Special attention is given to the politically sensitive issues: eutrophication, micropollutants, fisheries and general habitat disturbance. The research, carried out by the 16-member permanent staff and several temporary co-workers, is partly financed by various Dutch ministries through the BEON (Policy related Ecological Research in the North Sea) programme. Additional funding is received from the EC, GOA, NOP and industry. Most programmes are carried out by a multidisciplinary team in close co-operation with other Dutch and foreign institutes.

The awareness that different anthropogenic disturbances may have similar effects on the complex marine ecosystem, and that it may be impossible to determine actual cause-effect relationships in the field has led to a new thematic subdivision within BEWON.

Theme 1 focuses on the small food web with the emphasis on the effects of nutrient concentrations and recycling. Theme 2 focuses on the higher trophic levels, defined as macro-invertebrates and higher, and emphasizes the effects of microcontaminants, offshore mining and fisheries. Theme 3 focuses on the long-term, natural and man-induced, variability of the entire marine ecosystem.

1. EFFECTS OF NUTRIENT CONCENTRATIONS AND RECYCLING ON THE STRUCTURE AND PRODUCTIVITY OF THE MARINE ECOSYSTEM

Basic questions underlying this project were related to the effects of decreasing nutrient loads on the structure and productivity of the North Sea food webs, with emphasis on the blooming of nuisance-causing algae such as *Phaeocystis*. The reduction of total nutrient availability was considered, and attention was given to the shifts in the N:P ratios due to the stronger reduction of P than of N. Another major research question was: How important is natural (short-term) variability for the productivity of the (benthic) food web?

Nutrients and the pelagic food web

The concept of size-differential control of phytoplankton and its impact on the structure of plankton communities was studied during two cruises (April and July) from the Oyster Grounds to the Shetland Islands (in co-operation with the Department of Pelagic Systems, theme 1). Size selective grazing was determined according to the Landry & Hasset dilution method in combination with flowcytometry. In addition, size-differential ^{14}C fixation rates and ^{14}N uptake (regenerative *versus* new production) were measured. The acquired data are still in the process of evaluation. A theoretical model on size-related phytoplankton competition for nutrients was developed. The major conclusion is that in severely nutrient-limited systems competition does not discriminate on size related uptake and growth. These properties are more distinct at higher growth rates, indicating that competition leads to size-related exclusion of species in meso- and eutrophic environments.

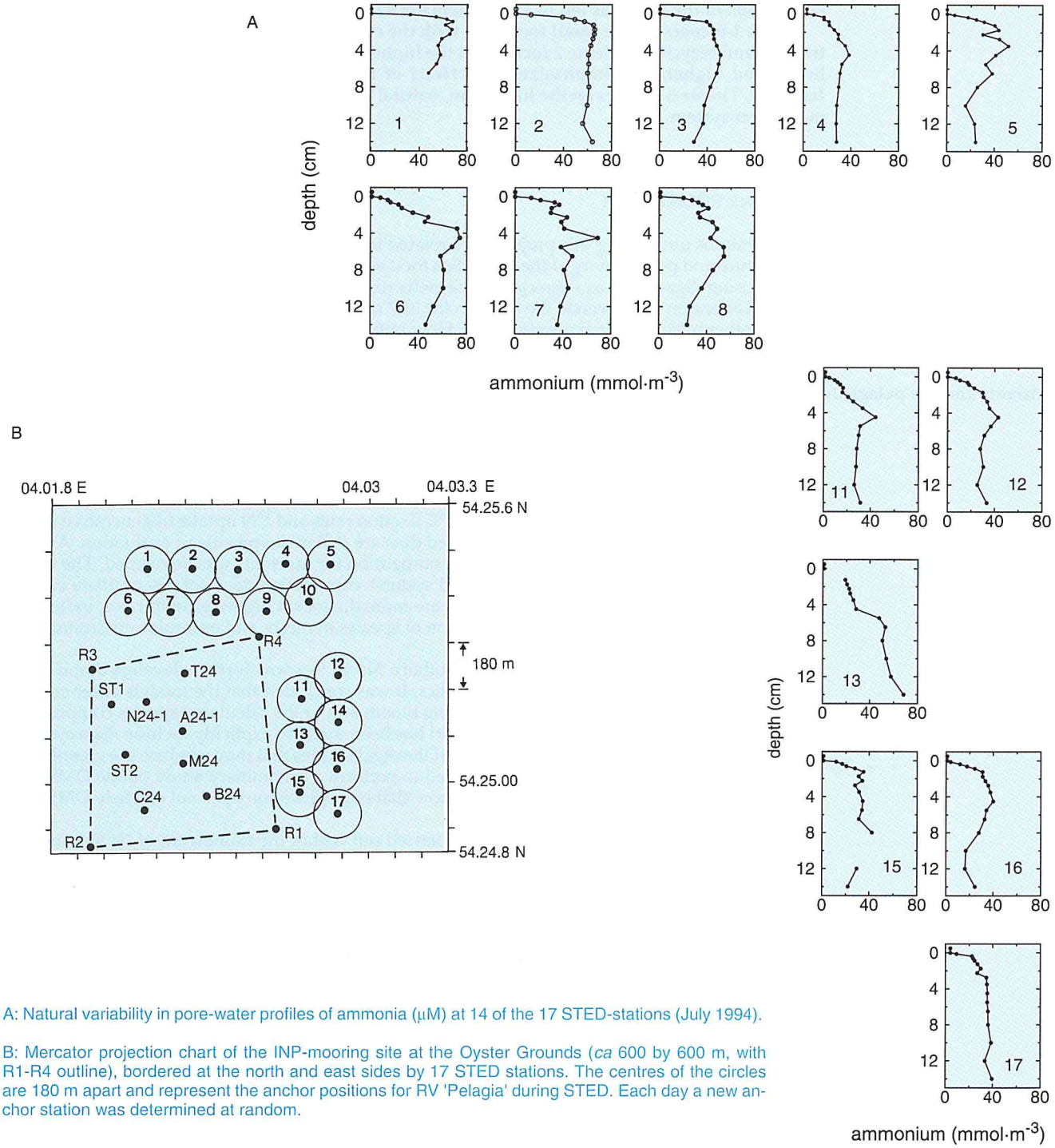
The algal succession model FYFY for the southern North Sea was further developed and compared with the MANS-NZB of Delft Hydraulics. It was concluded that the models differ considerably in the onset of the phytoplankton spring bloom and in the calculated species composition of the phytoplankton community. A first effort has been made to explicitly include *Phaeocystis* as one of the species in FYFY. *Phaeocystis* is one of the algal species that may produce the greenhouse gas DMS (di-methyl sulphide). FYFY was used to perform a preliminary study on the DMS production in the southern North Sea. Results show that eutrophication does not enhance DMS production in the North Sea.

Further research on DMS production was carried out within the framework of NOP-I and the EC project 'Role and significance of biological processes in DMS release from ocean to atmosphere, a close examination of the black box'. Experiments were carried out with intact sediment cores supplied with different amounts of DMS-containing algae and in pelagic mesocosms (together with TNO-Den Helder), to study the DMS production during the *Phaeocystis* bloom. Increased DMS concentrations were measured at the end of the exponential growth phase before the decline of the bloom, but not during the decline.

Phosphorus speciation in the water column of the Marsdiep was measured from October 1993 to May 1994, thus including the winter period dominated by inorganic processes and the phytoplankton spring bloom of *Phaeocystis* (in co-operation with G.C. Cadée, J. Hegeman and H.J.W. de Baar). Results indicate the transition from dissolved inorganic P (DIP) to organic P (DOP) during the phytoplankton bloom and also the occurrence of easily hydrolysable DIP inside the algal cells. Hydrolysing processes (autolysis, grazing) by which DIP or DOP are released can thus play an important role in the nutrient turn-over during the plankton bloom. These results were confirmed

by similar data obtained from pelagic mesocosms (co-operation with the Department of Pelagic Systems).

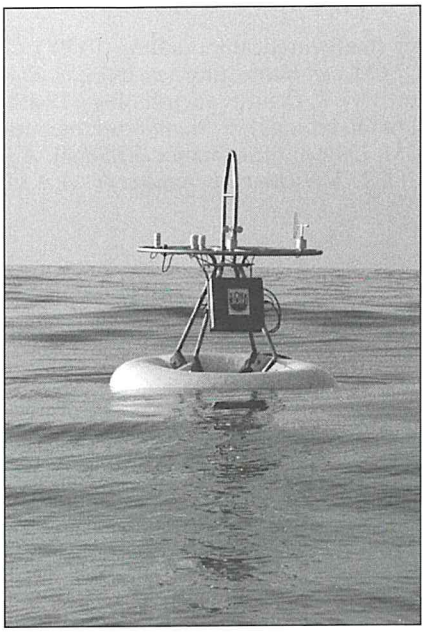
Data collected in 1993 on loss factors of algal blooms were further elaborated. It was concluded that at least 70% of the 1993 *Phaeocystis* bloom in the Mardiep area disappeared due to autolysis induced by nutrient depletion. The remaining 30% was lost through herbivore grazing. The impact of fluctuating nitrogen supply on the autolysis rates of the diatom *Ditylum brightwellii* was studied in laboratory cultures. First results show the so-called phenomenon of substrate accelerated death. So far, this was only known to occur with some heterotrophic bacteria after a pulse of organic substrate. Another loss factor is mortality due to viral infection. Two different viruses were discovered in natural populations of the coccolithophore *Emiliania huxleyi* blooming near the Shetland Islands. One of these virus-like particles has not been described before.



A: Natural variability in pore-water profiles of ammonia (μM) at 14 of the 17 STED-stations (July 1994).

B: Mercator projection chart of the INP-mooring site at the Oyster Grounds (*ca* 600 by 600 m, with R1-R4 outline), bordered at the north and east sides by 17 STED stations. The centres of the circles are 180 m apart and represent the anchor positions for RV 'Pelagia' during STED. Each day a new anchor station was determined at random.

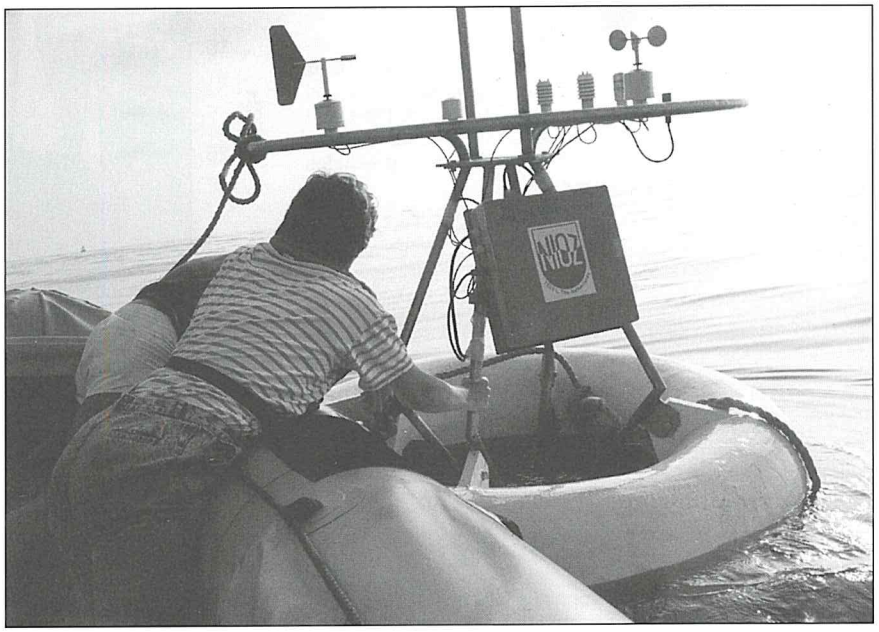
Nutrients and the benthic food web



Top: Buoy for meteorological data acquisition, deployed in the North Sea.
Photo: A. van Koutrik.

Right: Check-up of meteo buoy.
Photo: A. van Koutrik.

The availability of nutrients and organic carbon to the benthic food web is controlled by the benthic-pelagic coupling, *i.e.* the deposition of organic matter carrying particles on the sea floor. Short-term variations (hours, days) in benthic-pelagic coupling with respect to benthic microbial variables and the early diagenesis of nitrogen were addressed during the three-week STED (Short-TErm Dynamics) cruise to the Oyster Grounds in July 1994. STED was integrated with the INP-MOORING programme at the Oyster Grounds (Department of Physical Oceanography). The Oyster Grounds were temperature stratified during the STED cruise with bottom waters rich in nutrients. Water column mixing events and tidal movements resulted in variations in sedimentation and resuspension (indicated by sediment trap data and suspended matter concentrations). The stimulating effect of resuspension on sediment-water fluxes of nutrients was demonstrated. Special attention was paid to spatial heterogeneity of benthic variables within a scale of a few 100 m. Most samples of the cruise still await analysis.



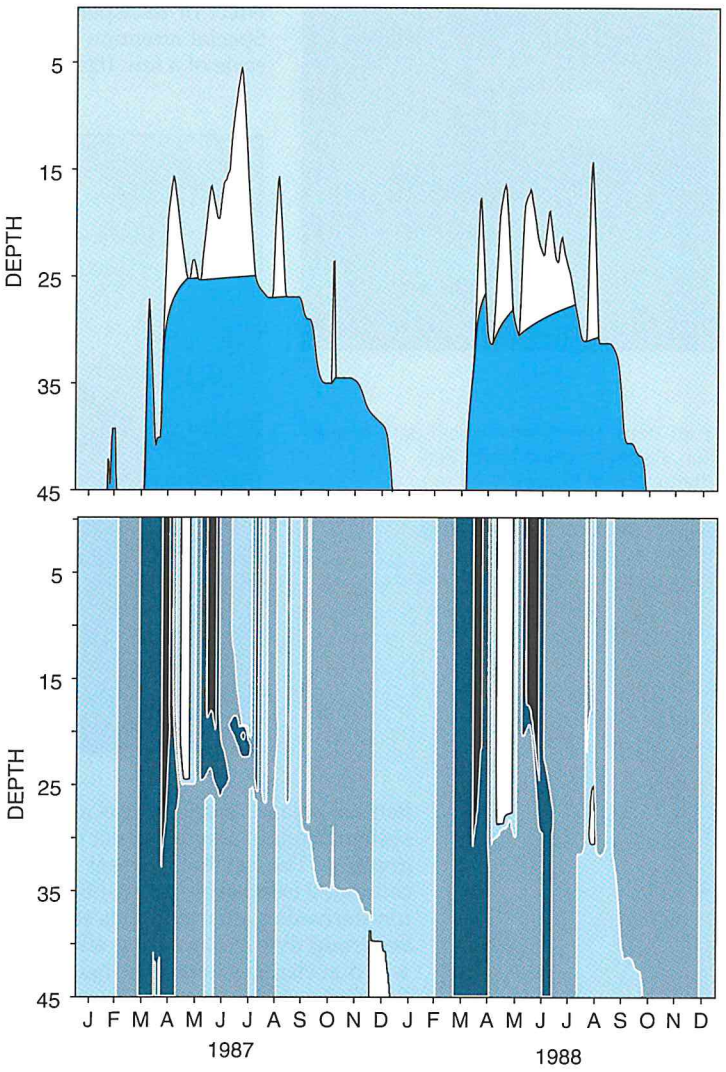
Benthic-pelagic coupling was also studied with the ERSEM model (European Regional Sea Ecosystem Model), a joint project of 7 European institutes and subsidized by the EC MAST II programme. The benthic nutrient model of ERSEM, which was developed at NIOZ and has been calibrated extensively against field data, was used to examine how the deposition of phytoplankton-derived organic materials affects the benthic nutrient dynamics in different areas of the North Sea (roughly corresponding with the ICES boxes). A major conclusion of the model calculations was that changes in organic matter deposition directly affect benthic nitrification and denitrification through changes in the oxygen availability to the nitrifiers and, due to this, the supply of nitrate to the denitrifiers. Refinement of the description of slow processes and decomposition of organic matter in the sediment is needed to allow long-term (decades) calculations with ERSEM. As part of this, we evaluated the statistical aspects of the estimation of organic matter decomposition kinetics from laboratory experiments in combination with models published in the literature.

The full ERSEM model was integrated with a physical model calculating the vertical stratification of the North Sea water column under different meteorological conditions. The objective of this integrated model is to analyse benthic-pelagic coupling in an area such as the Oyster Grounds for which many data become available from the INP-Mooring programme and STED. First results point to the importance of short-term variations in the depth of the thermocline for the exchange of nutrients from the bottom water towards the productive upper layer of the water column.

Transport and deposition of suspended matter (SPM) and particulate organic carbon (POC) play a dominant role in the supply of nutrients and organic matter to the benthic community. Within the EC MAST II NOWESP project (NOrth West European Shelf Programme) existing data sets on SPM and POC in the NW-European shelf were merged in a single data base and evaluated. Aim of the project is to assess fluxes and budgets (including sources and sinks) in the NOWESP area.

First results point to the need for sophisticated interpolation schemes to analyse available pseudo-synoptic data sets.

Contributors: *W. van Raaphorst* (chemistry), *A.J. van de Berg* (mathematical modelling, FYFY), *C. Brussaard* (plankton biology), *F.C. van Duyl* (microbiology), *J.J.M. van Haren* (physics, INP), *H. Ridderinkhof* (physics), *H.J. Lindeboom* (ecologist), *L. Lohse* (chemistry), *R. Osinga* (microbiology, DMS), *C.J.M. Philippart* (data analysis, NOWESP), *R. Riegman* (plankton biology), *P. Ruardij* (mathematical modelling, ERSEM), *W. Stolte* (plankton biology), *E.G.M. Embsen* (informatics, ERSEM), *A.J. Kop* (microbiology), *W.E. Lewis* (microbiology, DMS), *J.F.P. Malschaert* (chemistry), *A.A.M. Noordeloos* (plankton biology).



Vertical structure of the water column at the Oyster Grounds as simulated by the combined stratification-ERSEM model for the years 1987 and 1988. Shaded areas indicate the well-mixed lower layer of the water column during the stratification period, hatched areas the occurrence of a 'diffusion-resistance-zone' near the thermocline that precludes vertical transport of dissolved substances.

Calculated distribution of chlorophyll *a* for the years 1987 and 1988. Note that increased concentrations of chlorophyll *a* develop directly after the breakdown of the diffusion-resistance zone.

2. ANTHROPOGENIC INFLUENCES ON HIGHER TROPHIC LEVELS

This theme focuses on different aspects of human impact on the benthic fauna of the North Sea and lung-breathing predators. Three main items are investigated, *viz.* the impact of microcontaminants, drilling-fluids used in the offshore mining industry, and the impact of fisheries.

Environmental chemistry and toxic effects of microcontaminants

Practical work on the *in vitro* biotransformation of the pesticide mixture toxaphene was started in co-operation with the Institute of Fisheries Research (RIVO-DLO) at IJmuiden. Research of that institute has indicated unexpectedly high concentrations in biota from the northern North Sea despite the fact that toxaphene has never been allowed for use in Western Europe. Preliminary results indicate changes in this mixture due to enzymatic metabolism.

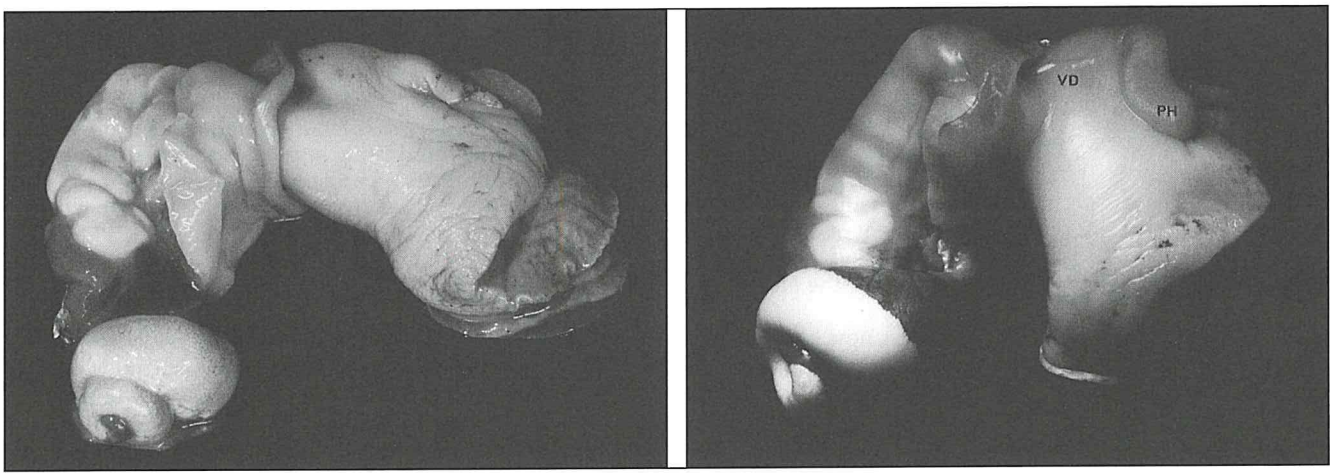
The toxic effects of halogenated aromatic hydrocarbons such as polychlorinated biphenyls (PCBs), dibenzo-*p*-dioxins (PCDDs) and dibenzofurans (PCDFs) are mediated through a common mode of action, resulting in the induction of the hepatic isoenzyme cytochrome P450 1A (CYP1A). The applicability of measurement of this enzyme system in dab (*Limanda limanda*) from the North Sea as an indicator of exposure to these classes of compounds was further investigated.

The hypothesis was tested that the optimal sampling period for application of these biomarkers is in the autumn. In spring and summer, differences in seawater temperature in the North Sea were shown to have a strong effect on CYP1A expression. A strong migratory activity in winter related to spawning makes this period less suitable for measurements on CYP1A for monitoring purposes. Four locations in the North Sea with varying levels of contamination were sampled in the autumn of 1993. Induction of the enzyme system was measured by both biochemical and immunochemical methods. Persistent CB congeners in dab muscle tissue were used as markers for exposure to chlorinated polyaromatic compounds in general. The results indicate that the CYP1A response in dab was stronger at increased exposure in the more polluted coastal area than in three areas farther offshore. In these more pristine offshore areas PCB levels and CYP1A expression were similar.

To investigate which PCB congeners were responsible for the induction, laboratory studies with non- and mono-*ortho* Cl substituted congeners were conducted. CYP1A could be induced by the planar non-*ortho* 3,3',4,4'-tetrachlorobiphenyl (CB77), but not with the mono-*ortho* Cl substituted 2,3,3',4,4'-pentachlorobiphenyl (CB105), 2,3',4,4',5-pentachlorobiphenyl (CB118) and 2,3,3',4,4',5-hexachlorobiphenyl (CB156). This indicates that only the most planar PCB congeners are likely to influence the CYP1A levels.

The whelk (*Buccinum undatum* L.), a marine neogastropod snail, is also a major research topic. Research is carried out in co-operation with the Institute for Coastal and Estuarine Management of Rijkswaterstaat (RIKZ-RWS).

The whelk population has declined over the last two to three decades especially in the Dutch and western German Wadden Sea, and coastal areas of the Netherlands and East Anglia. Whelks are still present further offshore, but imposex was again found in areas with dense shipping traffic. Imposex is the development of male sexual characteristics in female animals. The cause of imposex in other gastropod species is exposure to tributyltin (TBT), the active agent in antifouling paints still allowed for use on ships larger than 25 m.



A normal female whelk (left) and a female whelk suffering from an advanced stage of imposex (right). The shell has been removed. The female with imposex shows a complete vas deferens (VD) and a penis homologue (PH), two typically male sexual characteristics. Photos: Hans Kralt.

In 1992, 1993 and 1994, imposex incidences of >90% were found in the Eastern Scheldt. In contrast to the situation in the North Sea, animals with a penis homologue as well as a vas deferens were found here. This represents a more advanced stage of imposex.

The sex ratio of the whelks collected in 1993 and 1994 of 3:1 in favour of males differed considerably from the 1:1 ratio that is found in the open North Sea. This might be due to premature death of females with advanced stages of imposex.

For whelks, sensory perception of chemical stimuli is the most important guidance in functional behaviour. Their chemoreception acuity for recognition of mussel odour after exposure to sediments mixed with contaminated harbour dredge spoil, in comparison to clean sediments, was tested in Y-maze experiments. Exposure to contaminated sediments resulted in some delay in orientation response. The difference in positive choice ratio between exposed and non-exposed whelks was not significant, although non-exposed whelks appeared to perform slightly better.

Earlier chemoreception experiments with synchronous exposure indicated a stronger effect on chemoreception acuity. The results indicate that adverse effects on chemoreception responses may be (partly) restored when the animals are transferred to a clean environment. Y-maze choice experiments with synchronous exposure could generate more adequate data, but at present such experiments have to be postponed due to a lack of funding.

Environmental effects of offshore mining activities

Studies on the environmental impact of offshore drilling activities concentrated on the long-term effects of discharges of oil-based mud (OBM) cuttings on the benthic system and the short-term effects of discharges of cuttings contaminated with a newly developed drilling mud based on esters (EBM) instead of oil.

The results are now available of a field survey carried out in the southern erosion area of the North Sea in 1993, around a production platform where the last OBM drilling took place in 1987. This study was performed in co-operation with IMW-TNO. Environmental effects appeared to be still detectable 6 years after the discharges. Residuals of the discharged material (Barium or oil) could still be detected up to 250 m from the platform. Substantially elevated oil concentrations were found only at distances ≤ 100 m. The oil was found to a depth of at least 20 cm in the sediment, indicating that the discharged material is stored in the deeper sediment layers. In the benthic fauna composition an accumulation of effects was established up to 250 m from the platform (residual current direction). At these stations the fauna was substantially impoverished. At 500 m only the absence of adult *Echinocardium cordatum* indicated a long-term effect of the former discharges.

The EBM study concentrated on a location 50 miles west of Texel, where during August-September 1993 an exploration well was drilled with ester-based drilling muds. After a baseline survey in July 1993 just before drilling, field surveys around the location were carried out 3 times, *viz.* 1 month, 4 months and 1 year after discharges of EBM-contaminated drill cuttings had been terminated. Sediment samples were collected at increasing distances from the location to assess the spatial extent of sediment contamination by esters and to investigate degradation rates of esters and possible effects of the discharges on the macrobenthos. Analysis of the samples is still in progress, but some preliminary results are available. Substantially elevated concentrations of esters were found up to 200 m from the well site during both the first and second post-drilling surveys. Smaller elevations were established up to 1000 m away during the first survey. Replicate samples collected at a location 125 m from the drilling site showed a very patchy distribution of the concentration levels. The sediment appeared to be anaerobic, indicating that degradation of the esters was in progress. The macrofauna analyses of the samples from the second post-drilling survey revealed a number of clear gradients in abundance patterns of individual species. Several species which were frequently found in the samples before drilling started (and which in former studies had shown to be sensitive to OBM cutting discharges) appeared to be absent or to occur in reduced densities in the vicinity of the EBM location. Also at the community level an evident impoverishment of the macrofauna could be observed in the vicinity of the location.

Effects of trawl fisheries on the ecosystem of the North Sea

The results are now available of the field studies carried out in 1992-1993 in co-operation with the North Sea Directorate of Rijkwaterstaat (DNZ-RWS) and the Netherlands Institute for Fishery Investigations (RIVO-DLO). After trawling of an area twice with commercial 4- and 12-m beam trawls for sole fishing, the direct mortality was estimated for a number of species. For different fish species, mortality varied from 2% of the numbers initially present (small under-sized fish) to 75% (larger fish). Mortality was 100% for dab. This species showed rapid immigration into the trawled area, already during the trawling. Mortality of invertebrates was variable and species dependent, and estimated at 0-85% of the initial numbers for different species of molluscs, 4-80% for crustaceans, 0-60% for annelid species, and 0-45% for echinoderm species. Discard composition varied, depending on the type of beam trawl and the fishing ground. The amount of discard was estimated as approximately 8-10 kg dead fish and 4-6 kg invertebrates per kg marketable sole. This sets the total yearly amount of discard produced by sole fishery in the southern North Sea at about 260.000 tonnes of dead fish and 120.000 tonnes of dead invertebrates. Dab was a predominant species in the discard, but also appeared to be an important scavenger on damaged or exposed fauna on a recently trawled seabed.

In 1994 new field programmes were started within the EC project IMPACT-II: a comparative study of the direct effects of 4-m beam trawls, 12-m beam trawls, 4-m beam trawls with chain mats and otter trawls, and a study to identify species scavenging on dead fish and benthos. The studies were carried out at several sites in the Belgian, German and Dutch sectors of the North Sea. Preliminary results have shown that the most important scavenging species on damaged bottom fauna are dab (*Limanda limanda*), dragnet (*Callionymus lyra*), gadoid fish (*Gadus morhua, Merlangius maligns, Trisopterus luscus*), starfish (*Asterias rubens*), swimming crab (*Liocarcinus holsatus*), hermit

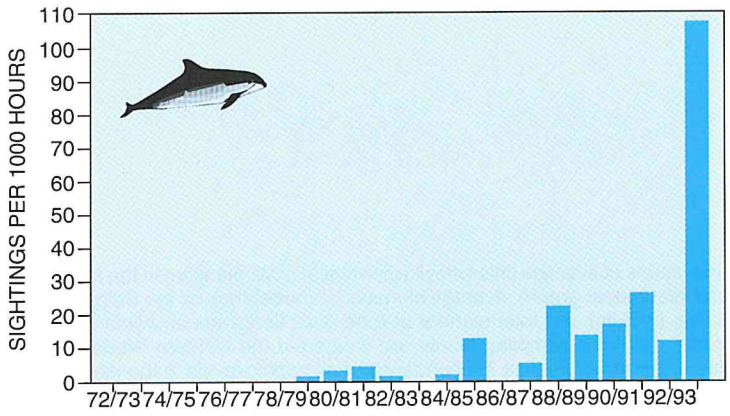
crab (*Eupagurus bernhardus*) and edible crab (*Cancer pagurus*). Dead crustaceans were particularly consumed by two species of scavenging amphipods (*Scopelocheirus* spec, *Orchomenella* spec.). Scavenging fish mainly fed on damaged molluscs and *Echinocardium cordatum*.

In co-operation with Glasgow University, Norsk Institut for Naturforskning (Trondheim), Ornis Consult (Copenhagen), Joint Nature Conservation Committee (JNCC, Aberdeen) and Inselstation 'Vogelwarte Helgoland' (Helgoland), an EC-funded project was launched, aiming at an assessment of distribution, numbers, behaviour, and feeding efficiency of scavenging seabirds in 6 subregions in the North Sea. The fieldwork for this project was carried out in April-June, August-September and October-November and comprised an intercalibration cruise onboard RV 'Pelagia' and actual field studies during the International Bottom Trawl Survey (IBTS) onboard the fisheries research vessels 'Tridens', 'Dana', 'Scotia', 'Cirolana', 'Thalassa', 'M. Sars' and 'Walter Herwig'. Spectacular fluctuations in numbers of seabirds in the different regions were found, as well as fluctuations in the relative importance of discards for these birds. In some regions, over 50% of all seabirds observed were associated with commercial trawlers, in other areas or seasons, the majority of all seabirds were feeding 'naturally'. Overall consumption rates for discards and offal were calculated, indicating that between 90 and 100% of all offal (intestines of gutted fish) were consumed by seabirds, 70-85% of all roundfish, 5-20% of all flatfish.

More detailed studies onboard commercial beam trawlers as part of a BEON contract were finished. The following conclusions were drawn: Some 28 species of seabirds occurred as scavengers associated with commercial trawlers in the southern North Sea. The most important consumers of discards and offal in the southern North Sea are Fulmar *Fulmarus glacialis*, Gannet *Sula bassana*, Black-headed Gull *Larus ridibundus*, Common Gull *Larus canus*, Herring Gull *Larus argentatus*, Lesser Black-backed Gull *Larus fuscus*, Great Black-backed Gull *Larus marinus* and Kittiwake *Rissa tridactyla*. In the breeding season, considerable numbers of Herring Gulls (2.8% of the NE Atlantic population) and Lesser Black-backed Gulls (12.9%) were found in the Dutch sector of the North Sea. Of these, 23.9% and 41.9%, respectively, were found within the sector qualifying for protection that borders the Wadden Sea islands. In Dutch beam-trawl fisheries, the most important fishery in the area, large amounts of benthic invertebrates and offal are discarded. An estimated 5-10 kg of flatfish (variable 45-50%), roundfish (1-5%) and benthic invertebrates (45-50%) were discarded per kg landed, marketable fish. All the offal and virtually all fish were suitable for consumption by seabirds. The proportion (%) of discards, offal and benthic invertebrates consumed by seabirds amounted to 87% in roundfish, 82% in offal, 28% in flatfish and less than 1% in benthic invertebrates. Of seabirds breeding in the Netherlands, only Herring Gull and Lesser Black-backed Gull profited significantly from discards and offal. The establishment of 'protected areas', closed to fisheries, will probably only negatively affect the foraging possibilities of Lesser Black-backed Gulls, particularly the breeding population on Texel, Vlieland and Terschelling (*ca.* 50% of the Dutch population).

Sightings of marine mammals

Populations of marine mammals may be affected by toxic microcontaminants as well as drowning in fishing gear. Sightings of cetaceans in the North Sea were collected during surveys for seabirds and marine mammals at sea and during sea watching from coastal sites in and around the North Sea (NIOZ, IBN-DLO, NZG, RIVO and other sources) from 1972 to 1994. The data from the various sources have been stored in one database. For most of the data observer effort is known and relative abundance can be worked out. From this database, a description has been made of the status of harbour porpoises *Phocoena phocoena* in Dutch waters. Sightings in the coastal zone have increased slightly since 1986. An interesting finding in 1994 was the sudden rise in numbers of harbour porpoises in Dutch coastal waters, which indicate that a come-back is now seriously under way.



Numbers of harbour porpoises *Phocoena phocoena* in the Netherlands per 1000 hours of observation, December-April 1972/73-1993/94.

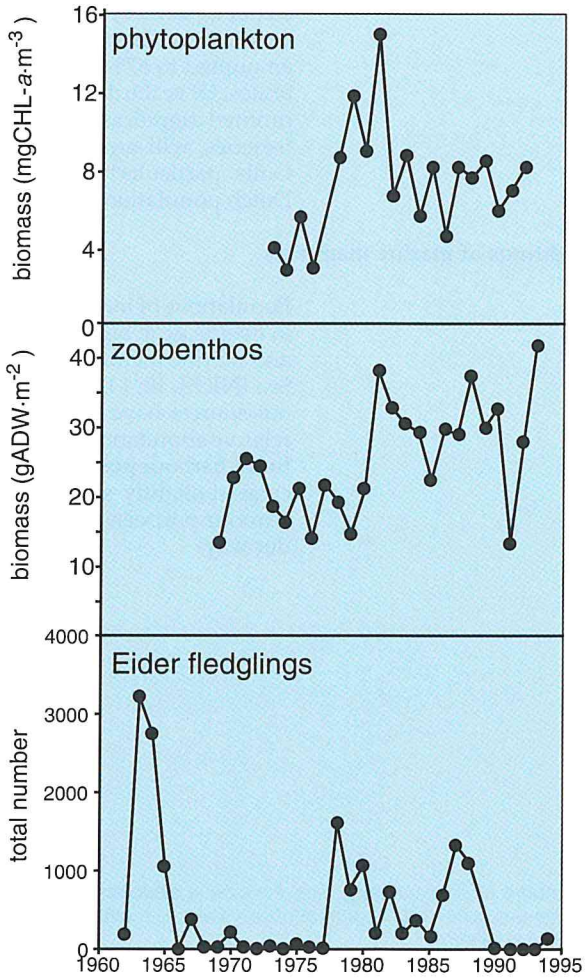
Contributors: *J.P. Boon* (micropollutants), *M.J.N. Bergman* (zoobenthos, fisheries), *K. Booij* (chemist, drilling muds), *R. Daan* (zoobenthos, drilling muds), *M. Fonds* (fish), *S. Groenewold* (fish), *C.C. ten Hallers-Tjabbes* (TBT, whelks), *M.F. Leopold* (birds), *H.J. Lindeboom* (ecologist), *J. van der Meer* (biomathematician), *B.P. Mensink* (TBT, whelks), *H.M. Sleiderink* (micropollutants, CYP1A expression), *C.J. Camphuysen* (birds), *C.V. Fischer* (micropollutants), *J. van der Hoek* (zoobenthos, drilling muds), *H. Kralt* (micropollutants), *M. Mulder* (zoobenthos, drilling muds), *P. van der Puyl* (fish), *J.W. van Santbrink* (zoobenthos, fisheries), *E.M. van Weerlee* (chemist, drilling muds), *C.J.N. Winter* (birds), *E. Roex* (micropollutants).

3. LONG-TERM OBSERVATIONS AND PROTECTED AREAS

NIOZ has a solid tradition concerning long-term time series of the North Sea and 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, breeding success of Eiderducks on Vlieland since 1962, distribution of seabirds since 1979 and landings of rare marine vertebrates and invertebrates since 1930.

A first analysis of the time series on phytoplankton abundance, zoobenthos biomass and breeding success of Eiderducks showed that all these variables significantly increased between the mid and late 1970s. These shifts in the Wadden Sea ecosystem coincided with changes in other marine ecosystems, such as an increase of the abundance of herring and the breeding success of kittiwakes in the North Sea, an increase of phytoplankton and zooplankton in the Atlantic Ocean and a major shift in the ecosystem of the Pacific Ocean.

It is hypothesized that the observed changes in marine ecosystems are mediated by climatic variations. In the North Sea, the anti-clockwise residual current is thought to be reinforced by westerly winds. In addition, weather conditions can affect the amount and composition of the influx from the Atlantic Ocean. An increase of nutrient-rich Atlantic water may subsequently result in a change from a pelagic to a more benthic structure of the marine food web.

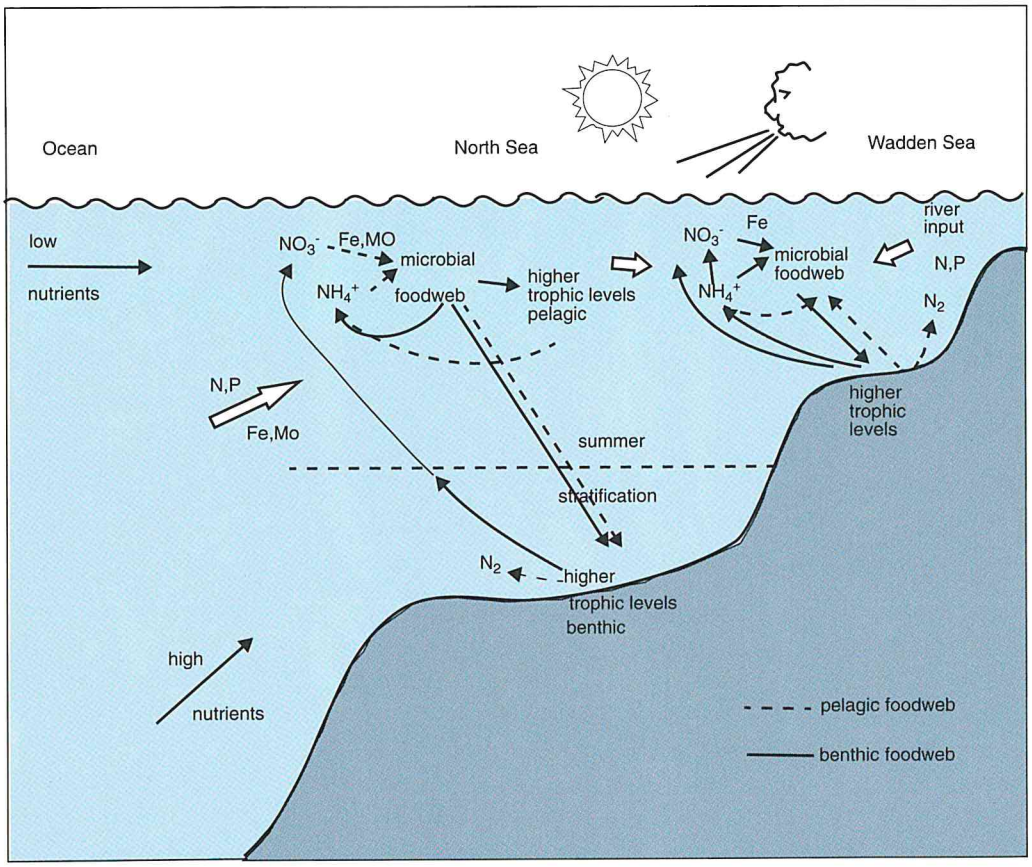


Time series of average chlorophyll *a* content of phytoplankton in the Marsdiep tidal inlet (upper graph), average biomass of zoobenthos on the Balgzand tidal flats (middle) and total number of Eiderduck fledglings on Vlieland (lower graph). All three sampling points are located in the western Wadden Sea. Note the sudden change in abundance of all trophic levels in the late 1970s.

Analysis of the available time series on climate (*e.g.* temperature, wind, sea surface pressure) and environmental variables (*e.g.* nutrients, phytoplankton, zooplankton, zoobenthos, fish) will be used to test hypotheses. New mathematical techniques for analysis of non-equidistant, non-linear and non-stationary time series are under development.

In close co-operation with institutes in the UK, Germany, Canada and the USA, a joint research project on long-term changes has been set up.

The final report of the ICES working group contained an extensive chapter on the need for and possible implementation of areas closed to fishing. The necessity of such areas for scientific research was underlined. A proposal for the establishment of protected areas in the North Sea is presently being considered by the EC.



Nitrogen pathways in the marine environment. The influx of nitrogen (N) into the North Sea ecosystem is realized by means of input of ocean, atmosphere and river water. Organic nitrogen is mineralized by bacteria to ammonia (NH_4^+). Ammonia can be used for building cell material or as energy source for autotrophic bacteria which convert it into nitrate (NO_3^-). Nitrate can be transferred into cell material by algae and bacteria, which use enzymes containing iron (Fe) and molybdenum (Mo). Nitrate can also be used in the denitrification process by anaerobic bacteria and mainly converted into gaseous nitrogen (N_2). The structure of the food web is considered to be 'pelagic' if the primary production is mainly consumed in the water phase, and 'benthic' if a considerable part of the primary produced material settles on the sediment.

Contributors: *H.J. Lindeboom* (ecologist), *C.J.M. Philippart* (ecologist), *A. Zuur* (mathematician), *J. van der Meer* (biomathematician).

SHELLS OF *ENSIS DIRECTUS* ON THE BEACHES OF TEXEL.

Ensis directus (Conrad, 1843) is an immigrant to the North Sea, which arrived from the North American east coast around 1980. Seven other species of the Cultellidae are known from the Netherlands, but *E. directus* is the only species that lives in the Wadden Sea. However, it is also common in the coastal water of the North Sea. As in other species of bivalves, there are large differences in year class strength; 1991 had by far the largest settlement (up to 100 000 post-larvae·m^{-2}), resulting in mean population densities of 1 adult·m^{-2}, and maximum densities of 4-10 adults·m^{-2}, in 1993.

In the winter of 1993-94 a mass mortality occurred, followed by stranding of huge numbers of shells in winter and spring 1994. Similar strandings were observed on Terschelling and Schiermonnikoog.

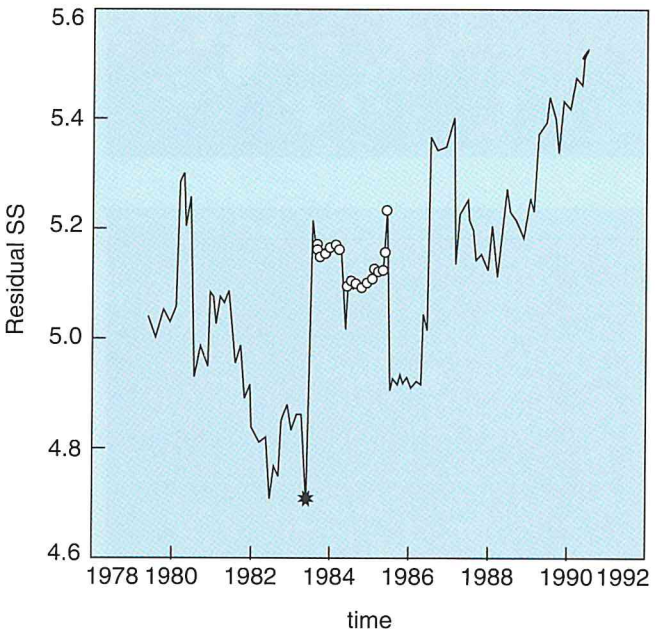
Observations on the east coast of Texel showed that the empty shells were arranged at right angles to the coast line on the sandy beach, in a belt between mid-tide level and just below low-tide. In places with low densities on an otherwise empty beach the *Ensis* shells were more or less randomly distributed. On a beach with low densities and a limited number of other shells (*e.g. Cerastoderma edule* and *Mytilus edulis*) *Ensis* shells tended to orientate with the slope of the beach (photo top). In areas with high densities of *Ensis* shells (up to 800 shells·m^{-2}; length of shells 10-16 cm) the beach was completely covered, over areas of hundreds of metres' length, and up to 10 m wide. The orientation at right angles was maintained, and followed small local changes in the contours of the coast. The shells orientate relative to each other (photo bottom). At very high densities the shells form 'nests', one folded into the other, of up to 6 - 7 shells (photo left).

The pattern is thought to evolve through sorting by onshore-offshore currents produced by small waves, until a situation of minimal energy for the shells exists; apparently shell nests form the most stable position. It is remarkable that they do not orientate uniformly with either the anterior or the posterior end up on the beach, although the anterior half of the shell is significantly heavier than the posterior end.

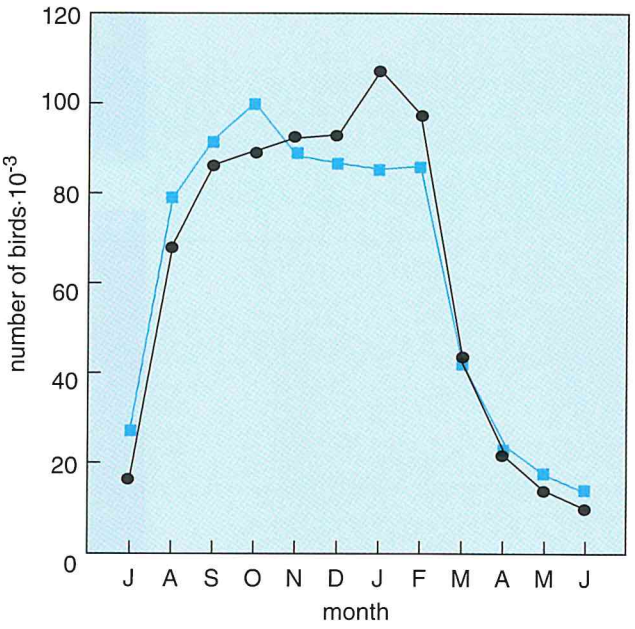
P. de Wolf & G.C. Cadée

BIOMETRICS AND STATISTICS

Standard statistical methods are not well suited for the analysis of biological time-series. Data are not independent, usually contain many zero values, have a skew distribution, are often not measured at equidistant time intervals, and do not have constant mean, but show non-linear time trends. A further characteristic is that knowledge on the exact relationship between the many species and the many environmental variables measured is sparse. Finally, the data contain large sampling noise and other measurement errors. A programme was started that aims to settle at least some of these problems. A model that contains a sudden change in the mean was fitted for thirteen years of monthly shore-bird counts. The problems of dependence, and non-constant mean were addressed. In co-operation with Alain Zuur (BEWON) other techniques and data sets were also explored. As usual, in-house advice has been offered to other researchers on for instance the statistical design of experiments and sampling surveys, and on the statistical analysis of the data obtained.



Residual sum of squares, which indicates the goodness of fit of models that assume a single sudden change in Oystercatcher abundance in the Oosterschelde and Westerschelde *versus* the time of the sudden change. The best fit is indicated by a star. It suggests that the change occurred in June 1983. This is three years before the final partial closure of the Oosterschelde. Those months for which missing counts were imputed are indicated by a circle.



The seasonal pattern before (●) and after (■) the sudden change. Mid-winter numbers decreased considerably. Summer and autumn values increased.

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

LOICZ is one of six Core Projects which comprise the 'International Geosphere-Biosphere Programme: A study of Global Change'. The overall aim of the IGBP is 'to describe and understand the interactive physical, chemical and biological processes that regulate the total Earth system, the unique environment that it provides for life, the changes that are occurring in the system and the manner in which they are influenced by human activities'.

The overall goal of LOICZ is to determine at regional and global scales: the nature of that dynamic interaction; how changes in various compartments of the Earth system are affecting coastal zones 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 spatial and temporal heterogeneity of the world's coastal zones is considerable, and as a consequence considerable methodological problems are associated with developing global perspectives of the role of this compartment in the functioning of the total Earth system. Identifying and quantifying this role and developing scenarios of change in the coastal compartment of the Earth system under anthropogenic and geocentric driving forces of change will require considerable research. This research must be undertaken in a co-ordinated manner, and the results will require considerable integration if the global objectives of the project are to be met. Providing this co-ordination and integration is the primary purpose of the Core Project Office.

Staffing of the Office at NIOZ

The project commenced in 1993 with the publication by IGBP of the LOICZ Science Plan and establishment of the Core Project Office at the Netherlands Institute for Sea Research. The Office is financially supported by the Netherlands Government and like all IGBP projects, LOICZ is scheduled to run for 10 years. The LOICZ Office was officially opened in December 1993, and thus 1994 was the first full year of operation. The staff consists of Dr John Pernetta (Project Manager), Ms. Sheila May Lunter (secretary), and Mr Paul Boudreau (Project Scientist coastal databases and modelling management).

Development of the Implementation Plan

The Core Project Manager and Scientific Steering Committee have developed an Implementation Plan. This lays out objectives and charts a course towards their achievement based on the co-ordination of nationally funded research. This co-ordination will require the continued leadership of the International Scientific Steering Committee and strong management on a day-to-day basis through the Core Project Office. Over 400 scientists were involved in developing the Science Plan published in 1993 and this network has already been extended to about 1 000 scientists in 124 countries who have provided inputs to the development of the Implementation Plan.

The Office organized a series of meetings and workshops to support the development of the Implementation Plan, including a small workshop at the Vrije Universiteit in Amsterdam, concerned with developing the socio-economic research tasks and activities. Two workshops on biogeomorphology were organized, one at the Australian Institute of Marine Science focused on accreting shorelines with emphasis on mangrove-dominated systems, and one at the Bermuda Biological Station for Research on carbonate shorelines and coral reefs. A small workshop on riverine inputs to coastal seas was held in Strasbourg and a preliminary draft of a Global Land Ocean River Inputs database has been prepared. A workshop in Sapporo, Japan, reviewed the modelling of carbon in the coastal oceans which will be applied in LOICZ research. In addition the Office organized the third Scientific Steering Committee Meeting in June and a smaller drafting committee meeting in September which finalized sections of the Implementation Plan and drafted two proposals for large-scale Integrative Research Projects which have been submitted to UNEP for inclusion in UNEP's Work Programme for funding under the Global Environment Facility.

The Activities and Tasks described in each chapter of the Implementation Plan, provide a blueprint for the design of individual and national research, contributing to the overall goals of the LOICZ Project. To achieve the overall goals and objectives a truly global network of coastal scientists must be developed and the active participation of scientists from developing countries is vital to the ultimate success of this project. Financial and other support must therefore be provided through the Core Project.

Other Activities

The Core Project Manager, Chairman and members of the SSC have participated in a number of workshops and symposia at which they have publicized the development of the LOICZ Project and solicited wide participation in project activities. These included: the EU workshop to develop

the ELOISE Science Plan; the IUCN General Assembly; various meetings of ad hoc panels concerned with the development of the coastal components of the Global Ocean Observing System of the Intergovernmental Oceanographic Commission (IOC); other meetings of the IOC; meetings of ECOPS; UNEP/UNDP data meeting; WOTRO meetings concerned with research in Southeast Asia; and of course various IGBP meetings and meetings of other Core Projects. As a result of these activities, various collaborative arrangements have been developed including the signing of a formal memorandum of understanding concerning joint activities between LOICZ and the IOC; the involvement of a number of large-scale regional projects in LOICZ research; collaboration between LOICZ and WOTRO in the development of large-scale regionally co-ordinated research programmes; and financial support to LOICZ organized activities.

The LOICZ Research agenda

In the context of global change impacts in the coastal zone, sea level rise has received considerable attention from the international community and public media. Eustatic sea level rise is, however, relatively small, and of more immediate concern is the subsidence and recession of certain coastlines through natural or anthropogenically caused processes. Many highly productive and densely populated low-lying lands are currently threatened by such changes. Undisturbed coastlines counteract such recession by building beaches, sand spurs or coral platforms and filling lagoons with mangroves, peat or marsh. These interactions are the subject of biogeomorphological research which forms the topic of LOICZ Focus 2.

Annually roughly 0.4 gigatons of organic carbon (dissolved and particulate) reach the ocean via river discharge and may be partly or totally respired, thus forming a potential natural source of CO_2 for the atmosphere. How much is actually respired is unknown, since apparently much of the riverine carbon (specifically the dissolved organic carbon) is highly inert and is mixed into ocean water conservatively. Furthermore, the anthropogenic input of nutrients (nitrate and phosphate) to the coastal sea via rivers and through direct waste discharge can now produce more biomass and may therefore constitute a new, additional sink for atmospheric carbon of the order of 0.07-0.12 Gt C a^{-1}. Many of the uncertainties in global carbon flow models may represent unquantified processes occurring in the coastal zone and cycling of carbon and nutrients, and the global significance of the coastal seas for the carbon cycle are therefore the primary research targets of LOICZ Foci 1 and 3.

Much of the land-derived carbon, nutrients, freshwater and sediments enter the coastal zone at point inputs, the river mouths. Changes in these inputs have major consequences not only for the mixing zone between fresh and seawater, the estuary in the wider sense, but also for the entire sediment, carbon and nutrient balance of the coastal sea, down current of the river mouths. Understanding the mechanisms which mobilize these materials in the catchment basin is a natural task of LOICZ and in Focus 1, one of the aims will be to build a model linking the continental water discharge with material transport. This will be based on a similarity analysis of river discharge behaviour, seasonally and inter-annually and will involve assembling a large data base of GIS-based river networks, long-term discharge curves, and material transport.

Because of the central importance of the coastal zone for humanity and the ICSU policy of fostering co-operation between natural and social scientists, LOICZ Focus 4 has been designed as a forum for collaboration between IGBP and HDP (Human Dimension of Global Change Programme). The experience of the first three foci will be used to develop scenarios of coastal zone development under changing climate, changing river inputs and changing biogeochemical and biogeomorphological forcing functions. This information will be used to investigate possible feedback on coastal populations and environment. Finally, LOICZ will assess the extent to which scientific understanding of coastal zone changes could contribute to the formulation of integrated management strategies for sustainable use of coastal environments and resources.

Contributors: *J.C. Pernetta* (project manager), *S.M. Lunter* (secretary)

The Netherlands Marine Research Facilities (NIOZ-F) became a responsibility of the Institute on 1 January 1994, as a result of the integration of the operational part of the former SOZ into NIOZ. Accordingly, the programme-co-ordinator transferred his office to Texel.

NIOZ-F gives advice to GOA on the technical and financial aspects of the execution of the National Programme of sea research. It provides suitable ship capacity and sea-going equipment and takes care of maintenance of the equipment. When sea-going projects are approved NIOZ-F takes care of the planning, preparation and execution of the research cruises.

NIOZ-F gives advice on long-term investments. The advice is prepared by the programme co-ordinator in consultation with the financial and technical divisions of NIOZ, the chief-scientists of the projects, and the users advisory committees (on CTD systems, Autoanalyser systems, and Moored systems).

The National Programme in 1994 consisted of the following projects:

1. Training Through Research: a co-operative Russian/Dutch cruise in the western Mediterranean and Black Sea; project manager Dr. J.M. Woodside (VU). The cruise was executed by RV 'Gelendzhik' with scientists and students from Chile, Ireland, Italy, the Netherlands, Russia, Spain, and the UK. This project was funded by the participating countries, ESF and UNESCO.
2. Relations between short-term changes in the physical structure of a stratified water column, and phytoplankton biomass, activity and sedimentation; project manager C. Veth (NIOZ). Twelve five-day cruises were made with RV 'Pelagia' to service moored equipment, and to sample for calibration.
3. Changing plankton community structure along a North Sea transect: development and test of a biological model; project manager B. Kuipers (NIOZ). Two three-week cruises were carried out; one in April with RV 'Pelagia', one in summer with RV 'Zirfaea' (owned by the North Sea Directorate of Rijkswaterstaat).
4. The partial pressure of CO_2 in the South Atlantic Ocean; project manager H.W. de Baar (NIOZ). The cruise was executed with the German RV 'Polarstern', as part of the Dutch-German Antarctic co-operation.
5. Ocean Margin Exchange (OMEX), Benthic processes; project manager Tj.C.E. van Weering. For this project a suitable ship had to be found; RV 'Charles Darwin' (UK) was hired, adapted, and loaded in England. In May a successful four-week cruise was carried out.
6. Palaeofluxes 3. Project manager G. de Lange (UU). For the recovery and deployment of moored sediment traps the Italian RV 'Urania' was hired for a two-week cruise in the Mediterranean.

—*Planning.* Advice to GOA for 1995: For the ANAXIPROBE cruise 1995 (project manager Dr. J.M. Woodside) NIOZ-F recommended hiring two ships: the Russian RV 'Gelendzhik' (for the deep-towed side-scan sonar and coring), and the French RV 'l'Atalante' (for the swath bathymetry system). For the OMEX 1995 cruise (project-manager Tj.C.E. van Weering) and the Triple-B cruise (project-manager H.M. van Aken) NIOZ-F advised the use of RV 'Pelagia'.

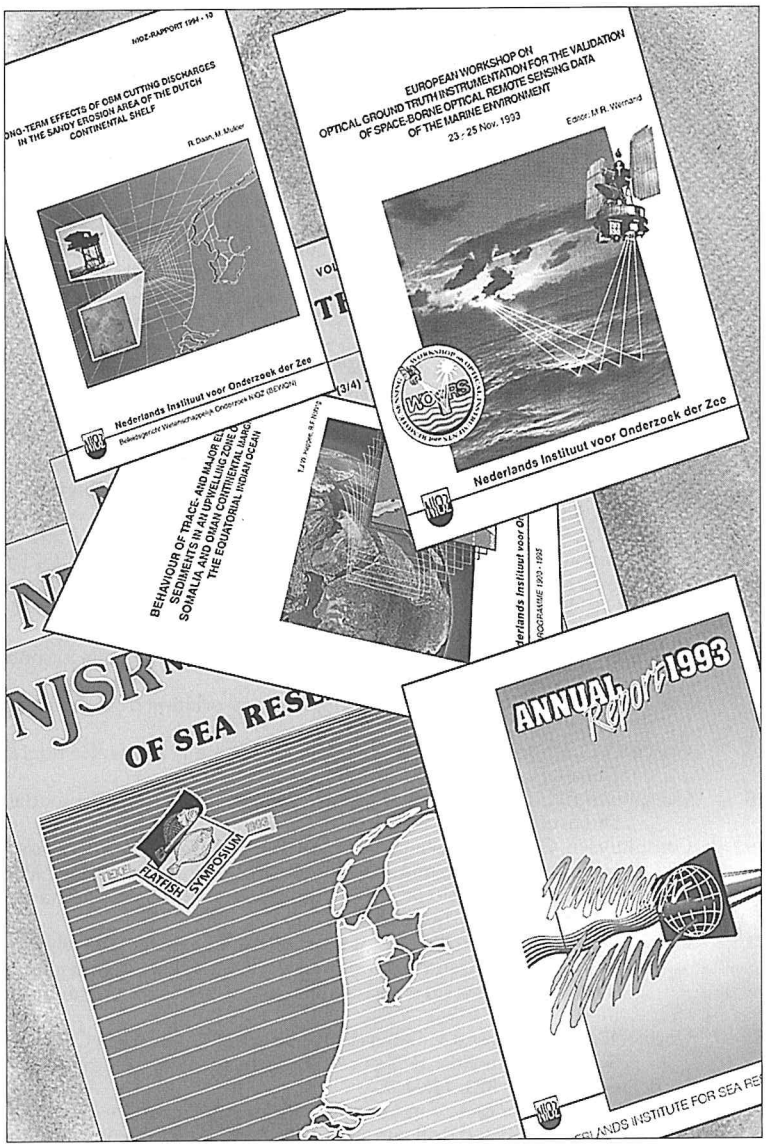
Mrs. M.J. Rietveld and C.N. van Bergen Henegouw (executive secretary) took part in the 8th Meeting of the International Ship Operators (chairman Dr. S. McPhee), at the Bedford Institute of Oceanography, Halifax, Canada; subjects discussed were: insurance, staff-exchange, reports on lost equipment, research fleet changes and containerization.

The total effort of NIOZ-F in terms of cruise, shipdays and personnel involved is given in the Table.

Contributor: *C.N. van Bergen Henegouw* (co-ordinator)

project		shipdays	scientists	students	F support	others
1	leg 1	1	2	3	0	1
	leg 2	1	1	5	0	0
	leg 3	1	2	4	0	0
2		60	3	0	1	3
3	a	19	8	1	2	4
	b	18	7		2	2
4		-	2	0	0	0
5		26	8	0	4	3
6		-	4	0	2	3

2. Publications and presentations



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PUBLICATIONS

NETHERLANDS JOURNAL OF SEA RESEARCH AND OTHER SERIES ISSUED

In 1994, vol. 32 and the first issue of vol. 33 of the Netherlands Journal of Sea Research appeared. Only one issue was published of the NIOZ Publication Series (no. 22: the Annual Report 1993). It was edited by G.C. Cadée, P. De Wolf, H.A. Van Aken and B. Bak.

The Proceedings of the Second International Symposium on Flatfish Ecology (held on Texel in October 1993) started with vol. 32 (2), dedicated to Raymond J.H. Beverton. It contains the key-note addresses and the evaluation of the Symposium by the rapporteurs. The 11 papers deal with flatfish recruitment and most of them are reviews. The double issue vol. 32 (3-4) contains 21 other papers contributed to this Symposium. A final special issue with papers on flatfish ecology will appear in 1995. All of these special issues with Proceedings of this Symposium are edited by R. Berghahn, A.D. Rijnsdorp and H.W. Van der Veer with the assistance of J.G. Baretta-Bekker.
In 1994, two regular issues (edited by the permanent editors) appeared, *viz.* vol. 32 (1) and vol. 33 (1). They contain 9 and 12 papers, respectively. Of these 21 papers in regular issues, 15 are on marine biology, 3 on marine gelogy, and 3 on marine chemistry.

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3 Baker, A.J., T. Piersma & L. Rosenmeier. Unraveling the intraspecific phylogeography of Knots *Calidris canutus*: a progress report on the search for genetic markers.—J. Ornithol. **135:** 599-608.

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5 Beerens, S.P., H. Ridderinkhof & J.T.F. Zimmerman. An analytical study of chaotic mixing in tidal areas. —Chaos, Solitons & Fractals **4:** 1011-1029.

6 Bergman, M.J.N. & J.W. Van Santbrink. A new benthos dredge (Triple-D) for quantitative sampling of infauna species of low abundance.—Neth. J. Sea Res. **33:** 129-133.

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9 Booij, K., B. Sundby & W. Helder. Measuring the flux of oxygen to a muddy sediment with a cylindrical microcosm.—Neth. J. Sea Res. **32:** 1-11.

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14 Cadée, G.C. Eider, shelduck, and other predators, the main producers of shell fragments in the Wadden Sea: paleoecological implications.—Palaeontology **37:** 181-202.

15 Cadée, G.C. *Mya* shell manipulating by turnstones (Aves) results in concave-up position and left/right sorting.—Palaios **9:** 307-309.

16 Cadée, G.C. & F. McKinney. A coral-bryozoan association from the Neogene of northwestern Europe. —Lethaia **27:** 59-66.

17 Cadée, G.C., Ma Hong Guang & Wang Bao Can. Animal traces on a tidal flat in Hangzhou Bay, China.—Neth. J. Sea Res. **32:** 73-80.

18 Camphuysen, C.J. The Harbour Porpoise *Phocoena phocoena* in the southern North Sea, II: a come-back in Dutch coastal waters?—Lutra **37**: 54-61.

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Beks, J.P. Influence of seasonal forced scavenging on the ^{210}Po distribution in the North Sea. 2e Nederlands Aardwetenschappelijk Congres, Veldhoven, 21-22 April.

Booij, K. Abnormal biota/sediment concentration ratios for PCBs. Symposium on chemistry and fate of PCBs, PAHs and dioxins, Lancaster, 5-6 January.

Booij, K. Can aqueous ternary mixtures solve our extractions problems? QUASIMEME Lipids Workshop, Dublin, 13-16 October.

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Brummer, G.J.A., A.J. Van Bennekom & Tj.C.E. Van Weering. Monsoonal sedimentation and hydrography in the NW Somali Basin (NIOP- JGOFS,1992-1993 C-Project). 2e Nederlands Aardwetenschappelijk Congres, Veldhoven, 21-22 April.

Brussaard, C., A. Noordeloos & R. Riegman. Phytoplankton loss factors. NATO-ASI meeting on molecular ecology of aquatic microbes, Lucca, Italy, 28 August-9 September.

Buitenhuis, E.T. Trend of inorganic and organic carbon in a bloom of *Emiliania huxleyi* in the North Sea. Fifth International GEM workshop, Chateau de Blagnac, Cabara, France, 3-7 September.

Cadée, G.C. Shell repair in gastropods of the Wadden Sea. 64 Jahrestagung Paläont. Gesellschaft, Budapest, 26-30 September.

Cadée, G.C. Fragmentation of shells by birds in the Dutch Wadden Sea. 64 Jahrestagung Paläont. Gesellschaft, Budapest, 26-30 September; and Opening Research School of Sedimentary Geology, Free University Amsterdam, 17 November.

Cadée, G.C. Long-distance seed dispersal, examples from the Dutch coast. 6th Intern. Workshop on Plant Taphonomy, Bonn, 12 November.

Daan, R., H. Van het Groenewoud, M. Mulder, J. Asjes & W. Zevenboom. Short- and long-term impact of a discharge of oil contaminated drill cuttings on the Dutch Continental Shelf. Scientific Symposium on the 1993 North Sea Quality Report, Ebeltoft, Denmark, 18-21 April.

De Bruin, T.F., L. Otto, S. Ober, R.X. De Koster & H.M. Van Aken. Repeated XBT sections in the framework of WOCE. International Conference on Climate Change Research, Maastricht, the Netherlands, 6-9 December.

De Haas, H. & Tj.C.E. Van Weering. Sedimentation and accumulation rates in the North Sea. 2e Nederlands Aardwetenschappelijk Congres, Veldhoven, The Netherlands, 21-22 April.

De Wilde, H.P.J. & W. Helder. Nitrous oxide and methane in the Indian Ocean. Studiedag van het IGBP, KNAW; JGOFS, Nederlandse bijdragen 1989-2001, Amsterdam, 17 June.

Ficken, K.J., H.J. Bosch & J.W. De Leeuw, Molecular palaeontology of the K/T boundary. Earth, Energy and Environment: Challenges for Advanced Training and Research, Amsterdam, 17 November.

Fransz, H.G. & S.R. Gonzalez. The production of *Oithona similis* (Copepoda, cyclopoida) in the Southern Ocean. Plymouth, UK, 15-19 August.

Ganssen, G., S. Troelstra & Tj.C.E. Van Weering. Younger Dryas style event and the possible correlation with Heinrich events in deep sea cores offshore Somalia (Indian Ocean). KNAW, Younger Dryas Workshop, Amsterdam, 10-13 April.

Gipp, H.J.W. & J.H.F. Jansen. Late Quaternary variations in deep-water oceanography in relation to surface productivity; examination of the benthic foraminiferal record in a deep-sea core from the Angola Basin. 2e Nederlands Aardwetenschappelijk Congres, Veldhoven, 21-22 April; Symposium The South Atlantic: Present and past circulation, Bremen University, 15-19 August.

Gonzalez, S.R. The role of macrozooplankton and microheterotrophic grazers in the Antarctic Circumpolar Current. AGU/ASLO Ocean Sciences, San Diego, 25 February.

Hansen, F.C. & J. Passarge. Size selective-grazing by the heterotrophic dinoflagellate *Oxyrrhis marina*. ICES Symposium on Zooplankton Production, Plymouth, UK, 15-19 August.

Heesen, H.J.L. & P.A. Walker. Distribution and biology of four ray species in the North Sea. ICES Annual General Meeting, Newfoundland, Canada, 22-27 September.

Hoefs, M.L.J., J.S. Sinninghe Damsté & J.W. De Leeuw. Preliminary Organic geochemical results from some Arabian Sea sediment samples. Earth, Energy and Environment: Challenges for Advanced Training and Research, Amsterdam, 17 November.

Hondeveld, B.J.M. Influence of flagellate growth phase on bacterivory. Verwey-dagen, NIOZ, Texel, 31 January - 2 March.

Honkoop, P.J.C., J.J. Beukema & D. Kwast. Winter temperature and reproductive success in shell-fish in the Dutch Wadden Sea. International Conference on Climate Change Research, Evaluation and policy implications, Maastricht, The Netherlands, 6-9 December.

Jansen, J.H.F. The Younger Dryas in the SE Atlantic and equatorial Africa: a marine record off the Congo (Zaire) River mouth. Younger Dryas Workshop, ARA Royal Netherlands Academy of Arts and Sciences and Netherlands Research School of Sedimentary Geology (NSG), Amsterdam, 10-13 April.

Jansen, J.H.F. & L. Ben Khelifa. Continental diatoms in sediments of the Angola Basin (SE Atlantic): a study of climatic change in equatorial Africa. International Conference on Climate Change, Maastricht, The Netherlands, 6-9 December.

Klein, R. The potential use of scars on the shell of *Artica islandica*. Scientific symposium on the 1993 North Sea Quality Status Report, Ebletoft, Denmark, 18-21 April.

Koopmans, M.P., J. Köster, F. Kenig, H.M.E. Van Kaam-Peters, W.A. Hartgers, S. Schouten, J.W. De Leeuw & J.S. Sinninghe Damsté. Diagenetic products of isorenieratene: Indicators for photic zone anoxia. Gordon Research Conference 1994, Plymouth NH, USA.

Koopmans, M.P., J. Köster, F. Kenig, H.M.E. Van Kaam-Peters, W.A. Hartgers, S. Schouten, J.W. De Leeuw & J.S. Sinninghe Damsté. Diagenetic products of isorenieratene: Indicators for photic zone anoxia. Earth, Energy and Environment: Challenges for Advanced Training and Research, Amsterdam, 17 November.

Kuipers, B.R., S.R. Gonzalez, C. Dubischar, C. Klaas & S. Reimeyer. The role of macrozooplankton and microheterotrophs in the Antarctic Circumpolar Current. ASLO Ocean Sciences Meeting, San Diego, USA, 24 February.

Löscher, B.M. The deep water distribution of Fe, Cd, Cu, Zn and Ni between the Polar Frontal Zone and the Weddell Sea Gyre. AGU/ASLO Ocean Sciences, San Diego, 25 February.

Nolting, R.F. Sampling and analytical methods for trace metals in seawater and their interaction with phytoplankton. AGU/ASLO Ocean Sciences, San Diego, 25 February.

Nolting, R.F., J.T.M De Jong., B.M. Löscher & H.J.W. De Baar. Sampling and analytical methods for trace metals in seawater and their interaction with phytoplankton. AGU spring meeting, San Diego, California, USA. 21-25 February, and IGBP/JGOFS Studiedag, KNAW, Amsterdam, 17 June.

Nolting, R.F., R.J. Van Hoogstraten, J. Den Das, W. Helder & J. Van der Meer. The distribution of trace- and major elements in sediments of the N.W. Mediterranean Sea. EROS 2000 Symposium, Palma de Mal-

lorca, Spain, 18-22 October.
Otto, L., H.M. Van Aken & R.X. De Koster. Determination of the NE Atlantic current field with ARGOS drifters. International Conference on Climate Change Research, Maastricht, The Netherlands, 6-9 December.
Pool, W.G., J.W. De Leeuw & B. Van de Graaf. Backfolding applied to differential gas chromatographic mass spectrometry. 13th International Mass Spectrometry Conference, Budapest, Hungary.
Rasmussen, T.L. & Tj.C.E. Van Weering. Norwegian Sea Deep Water variability over the last 80 KA. ENAM Workshop, Lisbon,10-12 March, and 2e Nederlands Aardwetenschappelijk Congres, Veldhoven, 21-22 April.
Rasmussen, T.L., Tj.C.E. Van Weering & L. Labeyrie. The Younger Dryas event in piston cores from the Faeroer Shetland Channel area. KNAW, Younger Dryas Workshop, Amsterdam, 10-13 April.
Rommets, J.W. The CO_2 system within the overall database of RV 'Polarstern' 1992 JGOFS Spring in the Ice Programme. AGU/ASLO Ocean Sciences, San Diego, 25 February.
Schouten, S., J.S. Sinninghe Damsté, M.E.L. Kohnen & J.W. De Leeuw. The effect of hydrosulphurization on the stable carbon isotopic composition of free and sulphurized lipids. Gordon Research Conference 1994, Plymouth NH, USA.
Schouten, S., J.S. Sinninghe Damsté, M.E.L. Kohnen & J.W. De Leeuw. The effect of hydrosulphurization on the stable carbon isotopic composition of free and sulphurized lipids. Earth, Energy and Environment: Challenges for Advanced Training and Research, Amsterdam, 17 November.
Stolte, W. & R. Riegman. The effect of phytoplankton cell size on nutrient uptake kinetics. NATO-ASI meeting on molecular ecology of aquatic microbes, Lucca, Italy, 28 August-9 September.
Thomsen, L., Tj.C.E. Van Weering & M.M. Rutgers van der Loeff. Lander Deep Sea Technology. ECOPS Meeting, Bremen, 12-16 September.
Timmermans, K.R. Effects of low iron concentrations on marine phytoplankton physiology. NATO-ASI, Lucca, Italy, 1 September.
Ufkes, E., J.H.F. Jansen & R. Schneider. Late Quaternary changes at the Angola-Benguela Front as reflected by planktonic foraminifera. Symposium The South Atlantic: Present and past circulation, Bremen University, 15-19 August.
Van Bergen, P.F. The preservation, diagenesis and evolution of resistant biomolecules in plants. Gordon Research Conference 1994, Plymouth NH, USA.
Van der Gaast, S.J. & J.H.F. Jansen. Origin and distribution of clay minerals and biogenic opal in recent sediments of the Angola Basin and the influence of gibbsite on the preservation of opal. Symposium The South Atlantic: Present and past circulation, Bremen University, 15-19 August.
Van der Wal, P. Perturbation of the carbonate system by *Emiliania huxleyi* blooms: A model study. Fifth International GEM workshop, Chateau de Blagnac, Cabara, France, 3-7 September.
Van Iperen, J. & S. Troelstra. *Ethmodiscus rex* oozes in deep-sea cores from the Indonesian Archipelago. 13th Internat. Diatom Symposium, Aquafredda di Maratea, Italy, 1-7 September.
Van Kaam-Peters, H., J.S. Sinninghe Damsté & J.W. De Leeuw. Sulphur-bound biomarkers in sediments of Kimmeridgian palaeolagoon. Earth, Energy and Environment: Challenges for Advanced Training and Research, Amsterdam, 17 November.
Veth, C. & C. Lancelot. The Control of Phytoplankton Bloom Development at the Receding Ice Edge of the Southern Ocean: Observational Evidence and Mathematical Modelling. AGU-ASLO 1994 Ocean Sciences Meeting, San Diego, USA, 21-25 February.
Veth, C. & C. Lancelot. The control of phytoplankton bloom development at the receding ice edge of the Southern Ocean: observational evidence and mathematical modelling. Studiedag van het IGBP: Joint Global Ocean Flux Study. Amsterdam, 17 June.

ORAL PRESENTATIONS

Baars, M.A. An overview of the biological oceanography of the NW Indian Ocean. Meeting US JGOFS Arabian Sea Process Study, Atlanta, 26 April.
Baars, M.A., P.H. Schalk & M.J.W. Veldhuis. Seasonal fluctuations in plankton biomass and productivity in the ecosystems of the Somali Current, Gulf of Aden and southern Red Sea. JGOFS Seminar, Royal Netherlands Academy of Art and Sciences, Amsterdam, 17 June.
Bak, R.P.M. (Tropical Marine Biology) Lecture series, University of Amsterdam, February.
Bak, R.P.M. Dynamics of coral reef communities. Invited plenary speaker. Annual meeting, German Association for Tropical Ecology. University of Bremen, 19 February.
Bak, R.P.M. (Marine Biology) Lecture series, University of Groningen, June.
Bak, R.P.M. Impact of organic sedimentation and the presence of macrofauna on benthic marine nanoflagellate communities. Second Int. Symp. Free Living Heterotrophic Flagellates, St. Petersburg, 16 August.
Bak, R.P.M. Changes in reef benthos related to water column eutrophication? Annual Meeting Int. Soc. Reef Studies, Luxembourg, 9 September.
Bakker, D.C.E. Surface water CO_2 changes in a Southern ocean spring. AGU/ASLO Ocean Sciences, San Diego, 23 February.
Bakker, D.C.E. CO_2 uitwisseling tussen lucht en zee: speelt de koude filmlaag een rol? IGBP/JGOFS Studiedag, KNAW, Amsterdam, 17 June.
Beerens, S.P. Chaotic mixing in tidal residual eddies. ICPF'94, Noordwijkerhout, 4-7 July.
Ben Khelifa, L. & J.H.F. Jansen. Allochthonous diatoms as a tool for climate reconstruction: continental diatoms in sediments of the Angola Basin (SE Atlantic). 2e Nederlands Aardwetenschappelijk Congres, Veldhoven, 21 April.
Bergman, M.J.N. Direct effects of beam trawl fishery on bottomfauna in the southern North Sea. Scientific Symposium on the 1993 North Sea Quality Report, Ebeltoft, Denmark, 20 April.

Bergman, M.J.N. Effects of beam trawl fisheries on bottom fauna. Lecture for students course Oceanography, NIOZ, 17 March.

Beukema, J.J. Consequences of the sudden removal of nearly all mussels and cockles from the western part of the Wadden Sea. EMBS, Vienna, 29 August-2 September.

Boon, J.P. (The use of fish as an indicator organism for marine pollution. Possibilities and reflections.) Caput college ecotoxicologie, Van Hall Instituut Groningen, 24 March.

Boon, J.P. (Bioaccumulation of PCBs and related compounds.) Caput College Milieuchemie, Rijksuniversiteit Groningen, 29 September.

Boon, J.P. (Environmental fate and toxic effects of halocenated polyarometic compounds in the marine environment.) Cursus Marien Milieu, Rijksuniversiteit Groningen, 17 May.

Boon, J.P. The statistical analysis of PCB patterns in relation to biotransformation in marine mammals and fish-eating birds. Annual Meeting of the ICES Marine Chemistry Working Group, Brest, 6-11 February.

Boon, J.P. Invited Lecture: The influence of biotransformation on the bioaccumulation and toxicity of polychlorobiphenyl congeners (PCBs) in marine mammals and birds. Annual Symposium of the Society of Environmental Toxicology and Chemistry (SETAC), Denver, Colorado, USA, 30 October-4 November.

Brummer, G.J.A. Monsoonal biogeochemistry of the NW Indian Ocean. Laboratoire de Géologie et Océanographie, Université de Bordeaux I, 6 May.

Brummer, G.J.A. Monsoonal sedimentation and hydrography in the NW Somali Basin (NIOP-JGOFS, 1992-1993, C-project). 2e Nederlands Aardwetenschappelijk Congres, Veldhoven, 22 April.

Brummer, G.J.A. Sedimentation in the Arabian Sea. IGBP/JGOFS studiedag, KNAW, Amsterdam, 17 June.

Brummer, G.J.A. (The dynamics of particulate fluxes between ocean surface and bottom). NIOZ course in oceanography, Texel, 21- 25 November.

Buitenhuis, E.T. Trend of inorganic and organic carbon in a bloom of *Emiliania huxleyi* in the North Sea. Fifth International Phycological Congress, Quindao, China 28 June-2 July, and Fifth International GEM workshop, Chateau de Blagnac, Cabara, France, 3-7 September.

Cadée, G.C. Are *Phaeocystis* blooms related to eutrophication? Workshop Eutrophication and eutrophication phenomena, Wilhelmshaven, 3 May.

Cadée, G.C. Eutrophication. Workshop Global change & the marine environment: extent, significance & policy implications, Rhode Island, 15 May.

Cadée, G.C. Eutrophication of the Wadden Sea: a continuing story? Ned. Vlaamse Kring Diatomisten, Wageningen, 8 December.

Camphuysen, C.J. (The importance of fisheries to sea-birds). SOVON Landelijke dag, Nijmegen, 10 December.

Camphuysen, C.J. Kittiwakes, *Rissa tridactyla*, in the North Sea: pelagic ecology, fisheries relationships and feeding strategies. NOU ESAS2 symposium Seabirds at Sea in the North Sea, NIOZ, Texel, 8 October.

Camphuysen, C.J., K. Ensor, R.W. Furness, S. Garthe, O. Hüppop, G. Leaeper, H. Offringa & M.L. Tasker. Seabirds and commercial fisheries in the North Sea. Scientific Symposium on the 1993 North Sea Quality Report, North Sea Task Force, Ebeltoft, Denmark, 18-21 April and NOU ESAS2 symposium Seabirds at sea in the North Sea, NIOZ, Texel, 8 October.

Camphuysen, C.J. & C.J.N. Winter. Seabird distribution in the North Sea. NOU ESAS2 symposium Seabirds at sea in the North Sea, NIOZ, Texel, 8 October.

Daan, R., M. Mulder & K. Booij. Field research on the effects of EBM-contaminated drill cutting discharges and preliminary results. Meeting NAM-SHELL, The Hague, 3 May.

De Baar, H.J.W. Iron and plankton in the Antarctic Circumpolar Current. NSF workshop on iron speciation and availability to phytoplankton, Bermuda, 2 May.

De Baar, H.J.W. Air sea gas exchange of CO_2 and the skin temperature effect. NOP Workshop, De Bilt, 20 May.

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

De Baar, H.J.W. The Law of the Minimum and Plankton Ecology of the Sea: Karl Brandt (1899) - John Martin (1992). Invited opening lecture special symposium on the Scientific Quests of John Martin. AGU/ASLO Ocean Sciences, San Diego, 23 February.

De Baar, H.J.W. Iron availability may affect the nitrate/phosphate ratio (A.C. Redfield) in the Antarctic Polar Front. AGU/ASLO Ocean Sciences, San Diego, 23 February.

De Baar, H.J.W. The Law of the Minimum and Plankton Ecology of the Sea: Karl Brandt (1899) - John Martin (1992). NSF workshop on iron speciation and availability to phytoplankton, Bermuda, 4 May.

De Baar, H.J.W. Physical forcing, plankton dynamics and CO_2 budget of the Southern Ocean. Colloquium, Royal Netherlands Meteorological institute (KNMI), De Bilt, 17 May.

De Baar, H.J.W. Pollutant metals; greenhouse gases. Lecture series in course Marine Environment, University of Groningen, 18 May.

De Baar, H.J.W. (The fate of fossil fuel carbondioxide: land, ocean or atmosphere?) Invited lecture, summer conference KNCV, Delft, 1 September, and National Public Science Day, NIOZ, 9 October.

De Baar, H.J.W. The oxidation and reduction chemistry of iron and manganese. *Phaeocystis* workshop, NIOZ, Texel, 7 November.

De Baar, H.J.W. The distributions of Fe, Mn and Al in the Marsdiep in Spring of 1994. *Phaeocystis* workshop, NIOZ, Texel, 7 November.

De Baar, H.J.W. Contributions of the Netherlands to the proposed JGOFS Irminger Sea process study. Royal Society, London, 14 December.

De Baar, H.J.W. (Contributions of Netherlands JGOFS towards balancing the carbondioxide budget: 1989-2001.) IGBP/JGOFS Studiedag, KNAW, Amsterdam, 17 June.

De Bruin, T.F. (The application of Remote Sensing during NIOP.) Najaarsvergadering Nederlandse Oceanografen Club, Amsterdam, 11 November.

De Goeij, P., T. Piersma & N. Davidson. Conservation implications of peak energy demand in the annual cycle of a long-distance migrant, the Knot. Symposium on Shorebirds as a model for global conservation, 21st International Ornithological Congress, Vienna, Austria, 23 August.

De Haas, H. & Tj.C.E. Van Weering. Recent sedimentation and sediment accumulation rates in the northern

North Sea and Norwegian Channel. ENAM Workshop, Lisbon,10-12 March.
De Jong, J.T.M., B.M. Löscher & H.J.W. De Baar. Iron in surface waters and sea-ice in the Antarctic Circumpolar Current. AGU spring meeting, San Diego, California, USA, 21-25 February.
De Leeuw, J.W., S. Schouten, P. Moerkerken, F. Gelin, P.F. Van Bergen, W. Hartgers & J.S. Sinninghe Damsté. Analytical pyrolysis and chemolysis as complementary tools to characterize resistant aliphatic and aromatic biomacromolecules in organisms and sedimentary organic matter. Pyrolysis '94, Nagoya, Japan.
De Stigter, H. & Tj.C.E. Van Weering. Holocene sediments and Recent Sedimentation Rates in the Goban Spur OMEX Area. OMEX Benthic Processes Workshop, Bordeaux, 4-6 April.
De Wilde, H.P.J. Marine N_2O emissions. Meeting Integrated N_2O Grassland project group, Wageningen, 18 May.
De Wilde, H.P.J. Water/atmosphere exchange of N_2O and CH_4 in marine systems. NRP1 workshop, theme 'water'. Bilthoven, 19 May.
De Wilde, H.P.J. (Laughing gas and methane in the Arabian Sea.) Meeting Geochemical Society (KNCV/KNGMG). Utrecht, 2 June.
De Wilde, H.P.J. & W. Helder. Nitrous oxide and methane in the Indian Ocean. IGBP/JGOFS Studiedag, KNAW, Amsterdam, 17 June.
De Wilde, H.P.J. N_2O emissions in relationship to N_cycling and upwelling in the Somali Basin. Scientific Meeting NIOP Project B1, Texel, 2 November.
De Wilde, P.A.W.J. Benthic observations along OMEX transects in the Celtic Sea. Bordeaux, 5-7 April.
De Wilde, P.A.W.J. Series of 16 lectures on marine ecosystems. University of Groningen, 6-9 June.
De Wilde, P.A.W.J. (Spatial and temporal variability). Presentation School of Functional Ecology, University of Groningen, 10 June.
De Wilde, P.A.W.J. Distribution of phytopigments. DNA and sediment oxygen demand across the continental slope. Brussels, 30 June-1 July.
Dekker, R. The identity of the nudibranch mollusc *Corambe batava* Kerbert. Dutch Malacological Society meeting, Amsterdam, 16 april.
Eisma, D. Intercalibration of *in situ* size measurements in the Elbe estuary, June 1993. Symposium Particulate matter in estuaries, Hamburg/Reinbek, 22 March.
Eisma, D. Climate change; impact on coastal habitation. Workshop on coastal zone research in SE Asia, Jakarta, 9 May.
Eisma, D., K.R. Dyer & W. Van Leussen. The *in situ* determination of the settling velocities of suspended fine-grained sediment - a review. INTERCOM Meeting, Wallingford, 11 July.
Epping, H.G. Light enhanced respiration in microbial mats: two distinct community responses. Department of Microbiology, University Groningen, 10 March.
Epping, H.G. Quantitative aspects of diffusion. Ph.D. course Microbial Ecology, NIOO, Centre for Limnology, Nieuwersluis, 20 April.
Epping, H.G. The effect of benthic diatoms on the sediment-water exchange of silicic acid. Max Planck Institute for Marine Microbiology, Bremen, 7 September.
Epping, H.G. On the role of benthic primary production on sediment-water exchange of dissolved manganese in coastal environments. NIOZ, Texel, 7 November.
Epping, H.G. Benthic diatoms control the sediment-water exchange of silicic acid. Department of Microbiology, University of Groningen, 28 November, and Department of Microbiology, University of Amsterdam, 1 December.
Everaarts, J.M. Biological markers of environmental health. National Institute of Oceanography, Chemical Oceanography Division, Pesticide Research Group, CEC-NIO-NIOZ-Joint Research Project, Goa, India, 26 April-5 May.
Everaarts, J.M. (Toxicology of North Sea organisms). College Cursus Marien Milieu, Rijks Universiteit Groningen, 18 May.
Everaarts, J.M. Polycyclic chlorinated hydrocarbons in the tropical marine environment. First research coordination meeting of the IAEA CRP on the distribution, fate and effects of pesticide residues on biota in tropical marine environment; use of radiotracers, International Atomic Energy Agency-marine environment laboratory, Monaco, 20-24 June.
Flach, E.C. The influence of the cockle, *Cerastoderma edule*, on the macrozoobenthic community of the tidal flats in the Wadden Sea. 29th EMBS, Vienna, 29 August-2 September.
Fransz, H.G. Zooplankton, stock and activity around Svalbard. Final workshop of the Study of the European Arctic Shelf (SEAS), Bremerhaven, Germany, 15 March.
Fransz, H.G. Introduction to zooplankton ecology. NIOZ Ph. D. course Introduction to Marine Science, Texel, 24 November.
Gerkema, T. (The generation of (nonlinear) internal tides and solitary waves). IMAU, Utrecht University, 20 January.
Gerkema, T. The generation of (nonlinear) internal tides and solitary waves near the continental shelf. EGS XIX General Assembly Grenoble, 25-29 April.
Gerkema, T. Nonlinear internal tides and solitary waves. ICPF'94, Noordwijkerhout, 4-7 July.
Gonzalez, S.R. Mesozooplankton abundance, composition and copepod egg production from the polar front to the ice edge during spring in the Southern Ocean. ASLO Ocean Sciences Meeting, San Diego, USA, 24 February.
Helder, W. Application of biogeochemical sensors in oceanography. State of the art and needed improvements. European Research Conference: The deep sea floor as a changing environment, San Feliu de Guixols, Spain, 8 February.
Helder, W. Early diagenesis and carbon mineralization in sediments of the Yemen/Oman upwelling region. 2e Nederlands Aardwetenschappelijk Congres, Veldhoven, 22 April.
Helder, W. Early diagenesis and sediment-water exchanges along the OMEX transect in the Goban Spur area. OMEX Workshop, Brussels, 2 July.
Helder, W. Carbon mineralization and sediment-water exchanges in the northern Adriatic Sea. Workshop of EC-programmes in the Adriatic Sea, Cesenatico, Italy, 4 October.

Helder, W. (Early diagenesis and carbon mineralization in marine sediments.) NIOZ course in oceanography, Texel, 21-25 November.

Helder, W. & T.H. Blackburn. Carbon mineralization and oxygen consumption in sediments of the north-west Mediterranean Sea. EROS-2000 final symposium, Palma de Mallorca, Spain, 19 October.

Hondeveld, B.J.M. The effect of flagellate growth phase on bacterivory. Second international symposium on free-living heterotrophic nanoflagellates, St. Petersburg, Russia, 16 August.

Ivanov, M.K., Tj.C.E. Van Weering, A.F. Limonov, N.H. Kenyon & L.B. Meisner. Mud volcanoes and evidence of shallow gas occurrence in the central part of the Black Sea. 3rd International Meeting Gas in Marine Sediments, NIOZ, Texel, 25-28 September.

Jansen, J.H.F., E. Ufkes, S.J. Van der Gaast & L. Ben Khelifa. Latitudinal shifts of the Angola-Benguela front and climate in southern and central Africa during the last 200 ky. Symposium The South Atlantic: Present and past circulation, Bremen University, 18 August.

Jansen, J.H.F. & W.H. Berger. The glacial ocean. MAST Advanced Course on Paleoceanography, Bremen, 27 September.

Jansen, J.H.F. CORTEX, an XRF-scanner for chemical analyses of sediment cores. DYTEC-GDR (Dynamique de la Terre et Évolution du Climat, Groupement de Recherche) meeting, Paris, 1 April.

Jansen, J.H.F. The Younger Dryas in the SE Atlantic and equatorial Africa: a marine record off the Congo (Zaire) River mouth. Younger Dryas Workshop, ARA Royal Netherlands Academy of Arts and Sciences and Netherlands Research School of Sedimentary Geology (NSG), Amsterdam, 12 April.

Jansen, J.H.F. South Atlantic paleoceanography and African climate. Utrecht University, Biology/Paleobotany Department, 16 November.

Kenig, F., N. Frewin, J.S. Sinninghe Damsté & J.W. De Leeuw. Sulphur-containing molecular fossils as indicators of cyclicity in a Miocene evaporite sequence, northern Italy. 208th ACS meeting, Washington DC, USA, 22 August.

Klein Breteler, W.C.M. Introduction to zooplankton ecophysiology. NIOZ Ph.D. course Introduction to Marine Science. Texel, 24 November.

Koopmans, M.P., M.D. Lewan, J.S. Sinninghe Damsté & J.W. De Leeuw. Artificial diagenesis of organic-sulphur-rich sedimentary rocks: Implications for palaeoenvironmental reconstruction. 2e Nederlands Aardwetenschappelijk Congres, Veldhoven, Netherlands, 22 April.

Koopmans, M.P., M.D. Lewan, J.S. Sinninghe Damsté & J.W. De Leeuw. Thermally induced transformations of organic sulphur compounds and sulphur-rich geomacromolecules as revealed by hydrous pyrolysis. 208th ACS meeting, Washington DC, USA, 23 August.

Koopmans, M.P., J.S. Sinninghe Damsté, M.D. Lewan & J.W. De Leeuw. Distinct precursors for pristane and phytane in the marine environment: Impact on the use and rationale of the Pr/Ph ratio. 208th ACS meeting, Washington DC, USA, 24 August.

Köster, J., J.S. Sinninghe Damsté & J.W. De Leeuw. Distribution of hopanoid biomarkers in sulphur-rich organic matter. 208th ACS meeting, Washington DC, USA, 22 August.

Kühnel, R.A. & S.J. Van der Gaast. Clay minerals of different generations in basaltic rocks. 13th Conference on Clay Mineralogy, Prague, Czech Republic, 29 August to 2 September.

Kuipers, B.R. Introduction to microzooplankton. NIOZ Ph.D. course Introduction to Marine Science,Texel, 24 November.

Lambrechts, D.Y.M. Reef Care's coral research programme for volunteers on Curaçao. Annual Meeting Int. Soc. Reef studies, Luxembourg, 9 September.

Lindeboom, H.J. Effects of fisheries and the need for protected areas. Course environmental law at NIOZ, 25 March and lecture at EcoMare, Texel, 15 December.

Lindeboom, H.J. (Sudden) changes in the ecosystem of the North Sea and the Wadden Sea: Oceanic influences underestimated? Scientific symposium on the 1993 North Sea Quality Status Report, Ebeltoft, Denmark, 18 April.

Lindeboom, H.J. Effects of beam trawling on benthic organisms. ESF Research Conference on Oceanography: Biodiversity and Production in the Ocean. San Feliu de Guixols, Spain, 4 May.

Lindeboom, H.J & L. Dijkhuizen. Air-sea exchange of DMS. Workshop 'water lucht' NOP 1 programma. Bilthoven, The Netherlands, 19 May.

Lindeboom, H.J. Areas closed to fisheries for scientific research. Visit by Ministry of Agriculture, Nature Preservation and Fisheries to NIOZ, 26 May.

Lindeboom, H.J. Effects of beamtrawl fisheries for sole and changes in the North Sea: Oceanic influences underestimated. Symposium Aktuelle Probleme der Meeresumwelt, Hamburg, BRD, 31 May.

Lindeboom, H.J. Together for a sustainable use of the North Sea. Symposium Ecology and Management. The Hague, 28 October.

Lindeboom, H.J. & N. Dankers. Long-term changes in number of organisms: causes micropollution? BEON presentation, The Hague, 21 June.

Lindeboom, H.J., W. Van Raaphorst, J.J. Beukema, G.C. Cadée & C. Swennen. (Sudden) Changes in the biota of the North Sea: Oceanic influences underestimated? ICES scientific symposium and statutory meeting, St John's, Canada, 24 September, and Colloquium at Bedford Institute of Oceanography, Halifax, Canada, 30 September.

Lohse, L. Sediment-water fluxes of inorganic nitrogen compounds along the transport route of organic matter in the North Sea. Verweij dagen, NIOZ, Texel, 31 January-2 February.

Maas, L.R.M. (Focusing of internal waves in a basin with parabolic bottom.) TUE, 12 April and IMAU, RUU, 13 April.

Maas, L.R.M. A simple model for the three-dimensional, thermally and wind-driven ocean circulation. EGS meeting, Grenoble, 26 April, and ICPF '94, Noordwijkerhout, 4 July.

Maas, L.R.M. & K. Zahariev. An exact, stratified model of a meddy. EGS meeting, Grenoble, 26 April, and ICPF '94, Noordwijkerhout, 4 July.

Maas, L.R.M. & K. Zahariev. Evolution of an exact, stratified eddy in a rotating, stratified Boussinesq fluid. 4th ICSF, Grenoble, 29 June.

Meesters, E.H. Regeneration of tissue lesions in corals: A biomonitoring tool? Pacific Congress on Marine Science and Technology, Townsville, Australia, 8-15 July.
Meesters, E.H. (The ecological role of lesions and regeneration in corals: how regeneration affects growth.) Onderzoekschool Biodiversiteit, University of Utrecht, 1 September.
Meesters, E.H. Regeneration of tissue lesions in corals: A biomonitoring tool? Annual Meeting Int. Soc. Reef Studies, Luxembourg, 9 September.
Otto, L. The World Ocean Circulation Experiment and the North Atlantic Circulation. Colloquium KNMI, De Bilt, 22 March.
Philippart, C.J.M. (Tropical marine biology.) Lecture Series, University of Amsterdam, Amsterdam, February.
Philippart, C.J.M., J. Van der Meer & W. Van Raaphorst. Preliminary analysis of concentration and organic carbon content of suspended matter in the North Sea during winter. NOWESP annual meeting, Plymouth, UK, 29 June-1 July.
Piersma, T. Thermostatic cost in the energy budget of arctic breeding shorebirds. Colloquium NIOO-CTE, Heteren, 19 January.
Piersma, T. Bird migration. Lecture Gerrit Rietveld Akademie, Amsterdam, 20 January.
Piersma, T. The economy of bird migration. Seminar Department of Zoology, University of Ghana, Legon Campus, Ghana, 1 February.
Piersma, T. & Y. Verkuil. Are there geographical differences in depth distribution of *Macoma*? Workshop Life-history of *Macoma*, NIOZ, Texel, 15 February.
Piersma, T. Cyclic growth in the adult, fat and protein deposition in migratory birds. Symposium on the energetics of growth: modelling and empirical studies, Zentrum für Interdisciplinaire Forschung der Universität Bielefeld, Germany, 21 February.
Piersma, T. Wintering strategies of a polar traveller: explanations for the winter distribution of Knots. Bird migration in an evolutionary perspective. Presentation of the Dutch Zoology Prize 1994 NDV, KNAW, Amsterdam, 11 March.
Piersma, T. Knots in the Wadden Sea and elsewhere. Lecture course marine environmental biology, Van Hall Institute Groningen, NIOZ, Texel, 11 April.
Piersma, T. Time and energy constraints and shorebird migration systems. Symposium on Physiological constraints during long-distance migration, 21st International Ornithological Congress, Vienna, Austria, 22 August.
Piersma, T. Interactions between birds and their prey. Lecture Summer School Interactions between species, AIO course Functional Ecology, NIOZ, Texel, 30 August.
Piersma, T. Migration and energetics of Knots and related shorebirds. Press presentation of 'Dreams on the Dike', EcoMare, Texel, 20 September.
Piersma, T. Life of Knots. Lecture for Nederlandse Kristallografen Vereniging, NIOZ, Texel, 4 November.
Piersma, T. Migration schedules of Knots and other sandpipers. Key-note address at Workshop on the behavioural ecology of Western Sandpiper migration, Simon Fraser University/Canadian Wildlife Service, Vancouver, Canada, 20 November.
Piersma, T. Intertidal food resources and Knot distribution. Seminar at Canadian Wildlife Service, Delta, British Columbia, Canada, 22 November.
Piersma, T. Body flexibility *versus* energy expediture in Knots. Seminar at Simon Fraser University, Burnaby, Vancouver, Canada, 24 November.
Piersma, T. Seasonal energetics of long-distance migrants. Seminar at Department of Zoology, University of Washington, Seattle, USA, 28 November.
Piersma, T. Time-energy budgets of Knots in an annual cycle perspective. Workshop on Energy budgets in Wadden Sea birds, Vogelwarte Helgoland, Wilhelmshaven, Germany, 12 December.
Rasmussen, T.L. & Tj.C.E. Van Weering. Norwegian Sea Deep Water variability over the last 80 KA. ENAM Workshop, Lisbon, 10-12 March.
Ridderinkhof, H. Hydrodynamical aspects of the transport of cohesive sediments in estuaries. Lecture University of Amsterdam, Amsterdam, 28 April.
Ridderinkhof, H. Lagrangian flows in complex Eulerian tidal current fields. International Conference on Nonlinear Dynamics and Pattern Formation in the Natural Environment, Noordwijkerhout, 5 July.
Ridderinkhof, H. The effect of tidal asymmetries on the net transport of suspended sediments in the Ems Dollard estuary. Conference Physics of Estuaries and Coastal Seas. Woods Hole, USA, 28 November.
Riegman, R. The impact of eutrophication on planktonic foodwebs in marine environments. Department of Microbiology, University of Amsterdam, 25 January.
Riegman, R. Algal dynamics in pelagic, marine environments. National AIO/OIO course microbial ecology, Nieuwersluis, 20 April.
Riegman, R. The impact of eutrophication on algal growth in the North Sea. Symposium Society for General Microbiology and Nederlandse Vereniging voor Microbiologie, Noordwijkerhout, 10 September.
Riegman, R. *Phaeocystis* ecophysiology. Workshop on modelling *Phaeocystis* blooms, Schiermonnikoog, 27 October.
Riegman, R. Ecophysiology of phytoplankton. OIO/AIO course Biology of pelagic systems, NIOZ, Texel, 22 November.
Schouten, S., M. Schoell, J.S. Sinninghe Damsté, R.E. Summons & J.W. De Leeuw. Reconstruction of the depositional palaeoenviroment of the Miocene Monterey Formation by a combined molecular and isotope geochemical study. Het systeem aarde, 2e Nederlands Aardwetenschappelijk Congres, Veldhoven, 21 April.
Schouten, S., J.S. Sinninghe Damsté & J.W. De Leeuw. Identification of novel steroids and triterpenoids in immature sulphur-rich sediments. 208th ACS meeting, Washington DC, USA, 22 August.
Sinninghe Damsté, J.S., W.A. Hartgers, M.P. Koopmans, H. Van Kaam-Peters, F. Kenig, N. Frewin, J. Köster & J.W. De Leeuw. Molecular palaeontological evidence for photic zone anoxia in depositional environments through time. Het systeem aarde, 2e Nederlands Aardwetenschappelijk Congres, Veldhoven, 21 April.
Sinninghe Damsté, J.S., D.J. Hollander & J.W. De Leeuw. Early diagenesis of bacteriohopanepolyol deriva-

tives: Formation of fossil homohopanoids. 208th ACS meeting, Washington DC, USA, 24 August.
Slomp, C.P. Phosphorus cycling in North Sea sediments: the role of sorption processes. Verweydagen, NIOZ, Texel, 31 January-2 February.
Slomp, C.P. Phosphorus cycling in North Sea sediments. Microbial Ecology Course, NIOO-CL, Nieuwersluis, 18-22 April.
Tahey, T. Benthic oxygen respiration, nutrient fluxes and macrofauna in the northern Adriatic Sea. Cesenatico, Italy, 1-4 October.
Timmermans, K.R. Interactions between a phytoplankton bloom and trace metals. AGU/ASLO Ocean Sciences meeting, San Diego, 22 February.
Timmermans, K.R. Iron in the sea in relation to phytoplankton growth and nitrate assimilation. Marine Sciences Department, Univ. of California, Santa Cruz, 5 March.
Ufkes, E. & J.H.F. Jansen. Paleoceanography of the Angola Basin: actual features recognized in Quaternary planktonic foraminifera. 2e Nederlands Aardwetenschappelijk Congres, Veldhoven, 21 April.
Van Aken, H.M. Variability of sea surface temperature and salinity in the Bay of Biscay. ICES Working Group on Oceanic Hydrography, Bergen, Norway, 19 April.
Van Aken, H.M. On the synoptic hydrography of intermediate and deep water masses in the Iceland Basin. Sun Yat-Sen University, Kaoshiung, Republic of China, 1 November.
Van Bennekom, A.J. Silica signals in the South Atlantic. Symposium The South Atlantic: Present and past circulation, Bremen University, 15-19 August.
Van Bergen, P.F., M.E. Collinson & J.W. De Leeuw. Molecular palaeobotany of 'propagules'. 1994 Lyell meeting, Geol. Soc. London, UK.
Van Bergen, P.F., M.E. Collinson & J.W. De Leeuw. Combined chemolytic, spectrometric and pyrolytic analyses of microscopically well-characterized extant and fossil seed coats. Pyrolysis '94, Nagoya, Japan.
Van Bergen, P.F., J.W. De Leeuw, M.E. Collinson & A.C. Scott. Unusual resin chemistry from upper carboniferous pteridosperm resin rodlets. 208th ACS meeting, Washington DC, USA.
Van Bleijswijk, J.D.L. Monitoring *E. huxleyi* cell proliferation in the ocean. Fifth International GEM workshop, Chateau de Blagnac, Cabara, France, 3-7 September.
Van der Gaast, S.J. & J.H.F. Jansen. Origin and distribution of clay minerals, other minerals and opal in recent sediments of the Angola Basin. 2e Nederlands Aardwetenschappelijk Congres, Veldhoven, 21 April.
Van der Gaast, S.J. Mineralogy, and opal from the surface sediments of the Angola Basin. Laboratoire de Sédimentologie et Géochimie Marine, University of Perpignan, France, 30 May.
Van der Meer, J. Multivariate statistical analysis of a four-step interlaboratory study on the measurement of chlorobiphenyl congeners in marine media. ICES Chemistry Working Group, IFREMER, Brest, 8 February.
Van der Meer, J. Long-term trends in the spatial pattern of *Macoma balthica*. Workshop on *Macoma balthica*, NIOZ, Texel, 15 February.
Van der Meer, J. Scaling of migration. Lectures in aquatic ecology, IBN, Texel, 22 February.
Van der Meer, J. Spatial statistics. NOWESP workshop, NIOZ, Texel, 29 March.
Van der Meer, J. Statistical analyis of long-term bird counts. Lectures in aquatic ecology, IBN, Texel, 11 October.
Van der Meer, J. Power and sampling design of long-term macrobenthos studies. RIKZ, The Hague, 29 October.
Van der Meer, J. Results of the ICES/IOC/OSPARCOM interlaboratory study on the determination of chlorobiphenyls in seal, marine sediment and fish. 14th International Symposium on Chlorinated Dioxins, PCB and Related Compounds, Kyoto, Japan, November.
Van der Meer, J. & T. Piersma. On the size dependency of the energy budget. Workshop Reconstructing the energy budget, Wilhelmshaven, Germany, 12-13 December.
Van der Veer, H.W. Impact of size-selective predation in 0-group flatfish on recruitment. 18th Annual Larval Fish Conference, St. Andrews, Canada, 26-28 June.
Van der Veer, H.W. Recruitment in North Atlantic flatfish species. International workshop 'Survival Strategy in Early Life Stages', Yokohama, Japan, 11-14 October.
Van der Veer, H.W. Variability in growth and mortality of juvenile flatfish species in the open North Sea: a test of the 'concentration' hypothesis. International workshop 'Survival strategy in early life stages', Yokohama, Japan, 11-14 October.
Van der Veer, H.W. Towards a recruitment theory for flatfish. Tohoku National Fisheries Research Institute, Shinhama, Japan, 19 October.
Van der Wal, P. Production of particulate organic carbon and calcite in a bloom of the coccolithophore *Emiliania huxleyi*. Ocean Sciences Meeting, San Diego, California, 21-25 February.
Van der Wal, P. Overview of the 1993 NIOZ cruise results. Fifth International GEM workshop, Chateau de Blagnac, Cabara, France, 3-7 September.
Van Kaam-Peters, H.M.E., J.S. Sinninghe Damsté & J.W. De Leeuw. Reconstruction of the depositional environment of a Kimmeridgian lagoonal system (French southern Jura). 2e Nederlands Aardwetenschappelijk Congres, Veldhoven, The Netherlands, 22 April.
Van Kaam-Peters, H.M.E., J.S. Sinninghe Damsté & J.W. De Leeuw. Reconstruction of an Upper Jurassic lagoonal system using free and sulphur-bound biomarkers. 208th ACS meeting, Washington DC, USA, 23 August.
Van Leeuwe, M.A. The effect of iron on algal physiology. AGU/ASLO Ocean Sciences, San Diego, 23 February.
Van Leeuwe, M.A. (The effect of iron on biological production in the Polar Front). IGBP/JGOFS Studiedag, KNAW, Amsterdam, 17 June.
Van Weering, Tj.C.E. Gas. Post cruise meeting Training Through Research cruise 1993, VU Amsterdam, 30 January-4 February.
Van Weering, Tj.C.E. Sedimentation at the Somali Basin Margin. Ned. Oceanografen Club, Amsterdam, 11 November.

Van Weering, Tj.C.E. OMEX Benthic Processes Overview. OMEX Annual Workshop, Brussels, 30 June-2 July.
Van Weering, Tj.C.E., Y. Kok, T. Nielsen & T. Kuijpers. Seismic stratigraphy and current induced sedimentation of the continental margin east of the Faeroer Islands. ENAM Workshop, Lisbon, 10-12 March.
Van Weering, Tj.C.E. & H. De Stigter. Recent Sedimentation and Sediment transport in the OMEX area. OMEX 1st Annual Workshop, Brussels, 30 June-2 July.
Van Weering, Tj.C.E. Norwegian Sea Deep Water Variability over the last 87 KA. IMAU, Utrecht, 8 December.
Veldhuis, M.J.W. Introduction to phytoplankton ecology. NIOZ Ph.D. course Introduction to Marine Science. Texel, 24 November.
Veldhuis, M.J.W. Calcifying phytoplankton, a sink or source of carbon dioxide. Fifth International Phycological Congress, Quindao, China, 28 June-2 July.
Veldhuis, M.J. W. Picophytoplankton in the North Atlantic Ocean. IGBP/JGOFS Studiedag, KNAW, Amsterdam, 17 June.
Veldhuis, M.J. W. Picophytoplankton dynamics in the Indian Ocean. Ned. Oceanografen Club, Amsterdam, 11 November.
Veldhuis, M.J. W. Role of the smallest phytoplankton in the oceanic carbon cycle. North Atlantic Planning Group Meeting Roscoff, France, 21 May-4 June.
Veth, C. Anatomy of the Polar Front and the ACC-Weddell Front near the 6° west meridian during Austral Spring 1992. AGU-ASLO 1994 Ocean Sciences Meeting, San Diego, USA, 21-25 February.
Veth, C. Biophysics and elementary ecology (C, N, P, O, Si and Fe) of the Antarctic Circumpolar Current. Challenger Society Meeting on the results from the Sterna Expedition, Plymouth, 14-15 April.
Veth, C. The water column in the marginal ice-zone. Ned. Oceanografen Club, The Hague, 15 June.
Veth, C. Physical anatomy of the polar front and the deep water. IGBP/JGOFS Studiedag, KNAW, Amsterdam, 17 June.
Veth, C. Sea-ice and the CO_2-problem. Vereniging voor Weer- en Sterrenkunde, KNMI, De Bilt, 1 October.
Vosjan, J.H. Lecture series on Marine Bacteriology. International Postgraduate Training course on Fundamental and Applied Marine Ecology of the Free University Brussels, Belgium, 24-30 October.
Vosjan, J.H. Microbiological studies in Antarctica. Van Hall Instituut, Groningen, 12 April.
Walker, P.A. Tagging experiments on rays in the North Sea and eastern English Channel. Workshop on tagging of sharks and rays, London, 14-15 February.
Witbaard, R. (Long-term growth variations in *Arctica islandica* in the northern North Sea. An indication of food availablity?) NIVAE Themadag, KNAW, Amsterdam, 25 November.
Zimmerman, J.T.F. Mixing processes in tidal areas. Workshop Spectral dynamics of turbulent dispersion, The Hague, 9 March.
Zimmerman, J.T.F. Internal waves, tides and solitons. Alg. Fys. Colloq. TU Eindhoven, 21 March.

EXTERNAL PROFESSIONAL FUNCTIONS

M.A. Baars
- member Indian Ocean Committee (GOA)
- member JGOFS Indian Ocean Planning Group
- member Working group JGOFS Nederland

R.P.M. Bak
- Professor Tropical Marine Biology, University of Amsterdam
- member International Association of Biological Oceanographers, Coral Reef Committee
- board member Working group 'Biologisch Aardwetenschappelijk Onderzoek Tropen'
- Senior Editorial Advisor Marine Ecology Progress Series
- board member 'Natuurwetenschappelijke studiekring voor het Caraïbisch gebied'
- member Neth. SCOR Committee (KNAW)

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

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 Editorial Board of The Science of the Total Environment

G.J.A. Brummer
- member 'SOZ gebruikers-adviesgroep Verankerde Systemen' (GOA)
- reviewer of several research proposals submitted to NERC (UK)

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

C.J. Camphuysen
- board member NOU
- chairman NZG
- editor Sula
- co-ordinator NSO
- secretary BEON working group 'Effecten van visserij op vogels en zeezoogdieren'

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

H.J.W. De Baar
- Professor General Oceanography, Rijksuniversiteit Groningen
- interim-chairman 'Vakgroep mariene biologie, Rijksuniversiteit Groningen'
- chairman Working group Joint Global Ocean Flux Study NWO/SOZ
- member NWO/NOP Programmeringsgroep Thema 1
- member MAB/SCOPE/IGBP Committee (KNAW)
- member JGOFS Southern Ocean Working Group
- associate editor Marine Chemistry
- convenor symposium 'Process Studies during Spring in the Southern Ocean' at Ocean Sciences Conference jointly organized by American Geophysical Union/American Society Limnology & Oceanography, San Diego, February 1994
- member steering commitee Carbon Fluxes and Dynamic Processes in the Southern Ocean, symposium to be held at Brest, August 1995

P. De Goeij
- general secretary International Wader Study Group

J.W. De Leeuw
- lecturer Organic Geochemistry University of Utrecht, fac. Earth Sciences
- board member AWON-NWO
- board member LPP, University of Utrecht, Biology faculty
- board member Inst. für Chem. und Biologie des Meeres, Univ. Oldeburg
- board member EAOG (European Association Org. Geochem.)
- board member working group Mol. Mech. and Anal. Chem. NIOZ-TUD
- Professor Geochemistry, Univ. Barcelona

J.C. De Munck
- member Dutch Alti Meter Team
- member Working group remote sensing

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 'Kontaktgroep ecotoxicologie van de commissie TNO/CNB
- member 'BION werkgemeenschap Biologische Toxicologie'
- 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: Aquatic Toxicology - Metals
- member Editorial Board Ecotoxicology
- member Editorial Board Wallaceana

M. Fonds
- member Mariculture Committee ICES

H.G. Fransz
- member Committee marine biology SOZ
- member 'Stuurgroep JGOFS Nederland'
- member Committee 'Nederlands Arctisch Onderzoeks Programma'
- member 'GLOBEC werkgroep voor numerieke modellering' (NMWG)
- member ASMO-working group for International Model Comparison
- project leader NIOZ contribution BCRS-project Particulate Matter North Sea

W. Helder
- member Dutch SCOR commission
- member Dutch LOICZ commission
- chair ' Gebruikers-Adviesgroep Auto Analysers' (GOA)
- member editorial board Netherlands Journal for Sea Research
- member editorial board Estuaries
- member board 'European Lander Group Symposia'

J.H.F. Jansen
- member GEONETH, Geoscience Network of the Netherlands for International Cooperation
- member 'Nederlandse Ocean Drilling (ODP) Werkgroep'
- member Scientific Program Committee Symposium 'The South Atlantic: Present and past circulation', Bremen University, August 15-19

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

M. Leopold
- board member 'Nederlandse Zeevogelgroep' (working group offshore)

H.J. Lindeboom
- member MER commission on a gaspipe to the northern part of the Netherlands and a gasprocessing unit in Eemshaven
- 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)
- coördinator EG-project IMPACT-II

W.G. Mook
- Professor of Isotope-Fysics, University of Groningen
- Professor Application of Isotopes in Earth Sciences, Free University, Amsterdam
- member 'Koninklijke Nederlandse Academie van Wetenschappen'
- 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'
- chairman 'Curatorium van het Centrum voor Isotopen Geologisch Onderzoek, Vrije Universiteit Amsterdam'
- member PACT-committee Raad van Europa
- member Scientific Steering Committee IGBP core project PAGES
- Associate Editor Radiocarbon

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)

L. Otto
- chairman Neth. WOCE working group
- chairman IOC/WMO Intergovernmental WOCE Panel
- co-ordinator subthema 'Water' NOP
- member Comité scientifique d'Oceanologica Acta

C.J.M. Philippart
- board member Nederlandse Vereniging voor Aquatische Ecologie

T. Piersma
- vice-chairman International Wader Study Group (WSG)
- associate editor of Ardea (journal of NOU)
- member editorial board of Current Ornithology, Plenum Press, New York
- member Grebe Specialist Group of the International Waterfowl and Wetland Research Bureau (IWRB, Slimbridge) and ICBP (Cambridge)
- member Estuaries Unit Consultative Committee, British trust for Ornithology, Thetford, England
- member 'Adviesraad voor het Ringwerk, Nederlandse Ringcentrale, Instituut voor Oecologisch Onderzoek, Heteren'

R. Riegman
- secretary SLW Working group 'Aquatische Oecologie'

M.J. Rietveld
- 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
- member Council of European Working Group on Chemical Evolution, Early Biological Evolution and Exobiology, Strassbourg
- member Groupement pour l'Avancement de la Biochemie Marine, Gif sur Yvette, Frankrijk
- member Society for Experimental Biology, London

C. Swennen
- member Stork specialist Group, ICBP
- member 'jury Heimans & Thysse prijs'
- member Dutch section ICBP

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

H.M. Van Aken
- member Arctic Oceans Sciences Board
- member Working Group on Oceanic Hydrography ICES
- member Hydrography Committee ICES
- member WOCE Hydrographic Programme Planning Committee

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

A.J. Van Bennekom
- deputy member Antarctica-committee SOZ
- editor Circumpolar Journal

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 Third International Symposium on Flatfish Ecology, Texel 1996
- member Organizing Committee 6th International Conference of Coelenterate Biology, Noordwijk, 1993
- member Working Group on Larval Fish Ecology ICES
- adjunct associate-professor Zoology Department, North Carolina State University, Raleigh U.S.A.
- adjunct associate-professor of Marine Science, University of South Carolina, Columbia U.S.A.

F.C. Van Duyl
- board member Treub-Mij

W. Van Raaphorst
- member 'Begeleidingscommissie Vastlegging van fosfaat in sedimenten' (DBW/RIZA, Lelystad)
- member 'Begeleidingscommissie Denitrificatie-onderzoek in de Randmeren' (DBW/RIZA, Lelystad)
- member Steering committee NOWESP (ECMAST II)
- member 'Begeleidingsgroep Eutrofiëring' (BEON)

Tj.C.E. Van Weering
- associate lecturer 'tweede fase onderwijs Mariene Aardwetenschappen,' Free University, Amsterdam
- member Committee Marine Earth Sciences SOZ
- member Steering Group ESF Network on Mediterranean Marine GeoSciences
- member Steering Committee OMEX (MAST II)

M.J.W. Veldhuis
- member 'Werkverband JGOFS-Nederland' (GOA)
- project leader NWO/NOP 'Platform Verstoring van Aardsystemen no. 9 '(NIOZ)
- member JGOFS North Atlantic Planning Group

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

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

MEETINGS, COURSES AND COLLOQUIA HELD AT NIOZ

Meetings, *etc.*

IMPACT. The annual IMPACT meeting was held at NIOZ from 19 to 20 January, co-ordinated by Drs H.J. Lindeboom and S.J. De Groot (RIVO). IMPACT is an EC-AIR project dealing with the effects of fisheries on the benthic ecosystems of the North Sea and Irish Sea. Nineteen scientists participated in the meeting, which resulted in a final report on the IMPACT-I project.

Verwey-dagen. From 31 January to 2 February the sixth annual Verwey Symposium was held at NIOZ. These symposia are part of a Ph.D. programme in marine biology organized by the University of Groningen, NIOZ, the Centre for Estuarine and Coastal Ecology of the Netherlands Institute of Ecology (Yerseke) and the Institute of Taxonomic Zoology of the University of Amsterdam.

Life History Decisions of *Macoma balthica*. This workshop, organized by Petra De Goeij, was held at NIOZ on 14 and 15 February. About 20 scientists of 6 institutes participated in presentations and discussions on how to build a life-history model and particularly the role of predators therein.

The International Course on Environmental Law, organized by Dr. T. IJlstra of the Netherlands Institute for the Law of the Sea (University of Utrecht), visited NIOZ on 25 March to be informed on the ecology and environmental problems of marine ecosystems.

NOWESP workshop: This first workshop of the task groups D and E (suspended matter, phytoplankton) workshop of the NOWESP (EC-MAST II) project, organized by Drs C.J.M. Philippart and W. Van Raaphorst, was held at NIOZ from 28 to 31 March. The 15 participants from Germany, Ireland, the UK, France and the Netherlands discussed the set-up of a joint data base for the northwest European shelf.

LOICZ 3rd Scientific Steering Committee Meeting, was held at NIOZ from 6 to 10 June.

LOICZ SSC the subgroup meeting Development of LOICZ Implementation Plan and Integrative Activities was held at NIOZ from 2 to 4 September.

Third International Conference 'Gas in marine sediments: Geology, chemistry, microbiology'. This conference, held at NIOZ from 25 to 28 September, was organized by Dr. Tj.C.E. Van Weering (NIOZ), Prof. Dr. R. Prins (University of Groningen), Prof. Dr. C. Green (SIPM, the Hague) and Dr. G. Klaver (RGD, Haarlem). The conference was attended by 80 scientists from throughout the world.

NOU ESAS2 symposium 'Seabirds at sea in the North Sea' was held at NIOZ on 8 October with participation by British, Danish, Dutch and German ornithologists.

BEWON NAM MER workshop: A workshop on the environmental impact of NAM exploitation drillings in the Wadden Sea and North Sea was held at NIOZ on 12 and 13 October. Scientists from NIOZ and IBN/DLO discussed possible drilling sites and allocated the sites with the lowest impact risks.

DMS workshop: The annual meeting of the EC Environment DMS project was held at NIOZ from 2 to 4 November. The meeting was attended by 20 scientists from Germany, France, the UK and the Netherlands.

Biogeochemistry of *Phaeocystis* colonies. An international workshop sponsored by the European Union was held at NIOZ from 7 to 9 November with participants from Belgium and Germany, with Dr. C. Lancelot (Université Libre, Brussels) and Prof. Dr. H.J.W. De Baar (NIOZ) serving as

convenors. About 22 scientists took part in presentations and discussions, leading to both an outline of research papers to be prepared as well as a strategy for the project in 1995.

NIOZ Courses

The course **Introduction to Oceanology** was attended by 32 students, mainly from the University of Groningen. This course is part of the second year's Marine Biology curriculum in Groningen, where the theoretical part is given. The practical part was held at NIOZ from 14 to 25 March. About 50 NIOZ staff members contributed to the course. Four days were spent on board RV 'Navicula' and two days on RV 'Pelagia'.

The course **Marine Ecosystems**, which is part of the Marine Biology programme of the University of Groningen, was held from 6 June to 1 July. There were 26 participants: 20 from the University of Groningen and six from other universities.
The course started with introductory lectures by Prof. Dr. P.A.W.J. De Wilde given at the Biological Centre, Haren, from 6 to 10 June. The practical part started at NIOZ on 13 June and comprised three field trips with RV 'Pelagia' (P.A.W.J. De Wilde, P. De Wolf, R. Daan, S. Gonzalez). One was a zooplankton-ctenophore study and two were benthos expeditions to the Frisian Front and the Oyster Grounds. Two estuarine benthos and fish-sampling excursions were held with RV 'Navicula' (W. De Bruin, J.IJ. Witte).

The participants also worked on a two-week ecosystem experiment in the four pelagic mesocosms of the Department of Pelagic Systems (H. Witte, G. Van Noort, B. Kuipers, S. Kip, W. Klein Breteler, N. Schogt). These 850-litre systems contained identical oligotrophic ocean communities of nanophytoplankton, bacteria and microzooplankton. They had been enriched with N two weeks prior to the course and with P one day before. One functioned as a control. Developments were followed by microscopic counting (including bacteria and heterotrophic nanoflagellates), electronic particle counting, an oxygen study, ^{14}C production measurements and protozoan grazing incubations (dilution series) with size fractionated chlorophyll measurements and flow-cytometry. The results were recorded in the usual 'results book' and discussed on 24 June. The participants wrote individual reports, and prepared for the final examination, which 22 out of the 26 passed.

The course **Physical Oceanography** was held at NIOZ from 20 June to 1 July. The course was organized in co-operation with IMAU (University of Utrecht). The aim is to teach students how to carry out physico-oceanographic observations on board RV 'Pelagia' in the North Sea and on board RV 'Navicula' in the Wadden Sea. Attention is also given to the processing of physico-oceanographic data such as the analysis of time series, the study of frequency spectra, and producing temperature and salinity sections by hand and by computer. The participants were mainly from IMAU and the technical universities.

The course **Introduction to Marine Sciences.** The first part of this new course for OIOs (Ph.D. students) was held at NIOZ from 21 to 25 November. Twenty-four OIOs participated in the course, which is a co-operation between NIOZ and the Research Schools. The books used are those of the English Open University. Subjects treated were the physics of ocean circulation, the geology of ocean basins, the chemistry of seawater and the biology of pelagic ecosystems. The second part of the course is to be held in November 1995.

Colloquia

25 February	*J. Pernetta* (LOICZ/NIOZ) LOICZ, a core programme of IGBP
11 March	*J. Everaarts* (NIOZ) (Molecular responses as indicators of contamination: DNA-damage strand-breaks) and enzyme induction in the seastar *Asterias rubens*)
	H. Sleiderink (NIOZ) (Cytochrome P450 1A expression in dab as biological indicator of pollution with chlorinated polyaromatics)
	C. ten Hallers (CATO) Whelks in the North Sea: state, imposex and shipping traffic
18 March	*P. Ruardij* (NIOZ) (Incorporation of benthic nutrient regeneration in the ERSEM-ecosystem model of the North Sea)
25 March	*A. Murk* (LUW) (Biochemical effects as biomarkers of organo-halogen compounds in marine birds and animals)
	J. Boon (NIOZ) (A model of the bioaccumulation of PCBs in marine top predators)
8 April	BELS
	F. van Duyl (NIOZ) (Bacterial production in North Sea sediments)
	B. Hondeveld (NIOZ) (The role of heterotrophic nanoflagellates in North Sea sediments)
15 April	K/T boundary in the Netherlands discovered!

	H. Brinkhuis (RUU): (Introduction)
	T. Roep (VU) (Sedimentology of the K/T boundary at Geulhem)
	H. Brinkhuis (RUU) (Palynology of the K/T boundary at Geulhem)
	J.W. de Leeuw (NIOZ) (Biogeochemistry of the K/T boundary at Geulhem)
22 April	BLOOM93: Phytoplankton research in the northern North Sea
	M. Veldhuis (NIOZ): General introduction
	K. Timmermans (NIOZ) (N and Fe as limiting factors in the growth of phytoplankton)
	P. van der Wal (NIOZ) (Production and transport of particulate organic and inorganic carbon in an *Emiliania huxleyi* bloom)
27 May	*T. de Bruin* (NIOZ) (From Texel to Curaçao: oceanography along a greatcircle)
	C. Veth (NIOZ) (The anatomy of eddies in the Southern Ocean; physical and biological aspects)
3 June	*P. Vellinga* (Instituut voor Milieuvraagstukken) Integrated coastal zone management; a multidisciplinary and sectoral approach (in particular the international cooperation activities)
	H. de Baar (NIOZ) (Elementary ecology of the Southern Ocean: carbon, nitrogen, phosphorus, oxygen, silicon and iron)
9 September	*T. Oatley* (Univ. Cape Town, South Africa) Longer survival rates of African (song-) birds
29 September	*Ph. Battley* (Massey Univ., Palmerston North, NZ) Benthos and birds on a New Zealand mudflat
7 October	*M. Conte* (WHOI, USA) Lipid biomarker studies in coccolithophorid blooms in the North Atlantic
13 October	*K. Hulsman* (Griffith Univ., Brisbane, Australia) Energy flow through an estuarine food web in sub-tropical Australia: the use of stable isotopes
20 October	*J.H.F. Jansen* (NIOZ) Orbital cycles and palaeoceanography of the SE Atlantic Ocean
21 October	*L. Otto* (NIOZ) Farewell lecture: Sea or Ocean?
27 October	*R. Osinga* (NIOZ) The fate of organic matter produced by marine phytoplankton
3 November	*S. Schouten* (NIOZ) Compound-specific isotope analysis: a novel tool for reconstruction of past and present biogeochemical processes
10 November	*H. Sleiderink* (NIOZ) Enzyme induction in fish as indicator of the contamination of the marine environment with chlorinated polyaromatics
17 November	*W. Stolte* (NIOZ) Influence of phytoplankton cell size on competition for nutrients
24 November	*J. van Bleijswijk* (NIOZ) *In situ* gross growth of *Emiliania huxleyi* revealed by diel changes in DNA content
1 December	*B. Bosveld* (RITOX, Univ. Utrecht) Effects of polychlorinated hydrocarbons on fish-eating birds
8 December	*W.G. Mook* (NIOZ/Univ. Groningen) ^{14}C, the future of the past

3. Additional Research

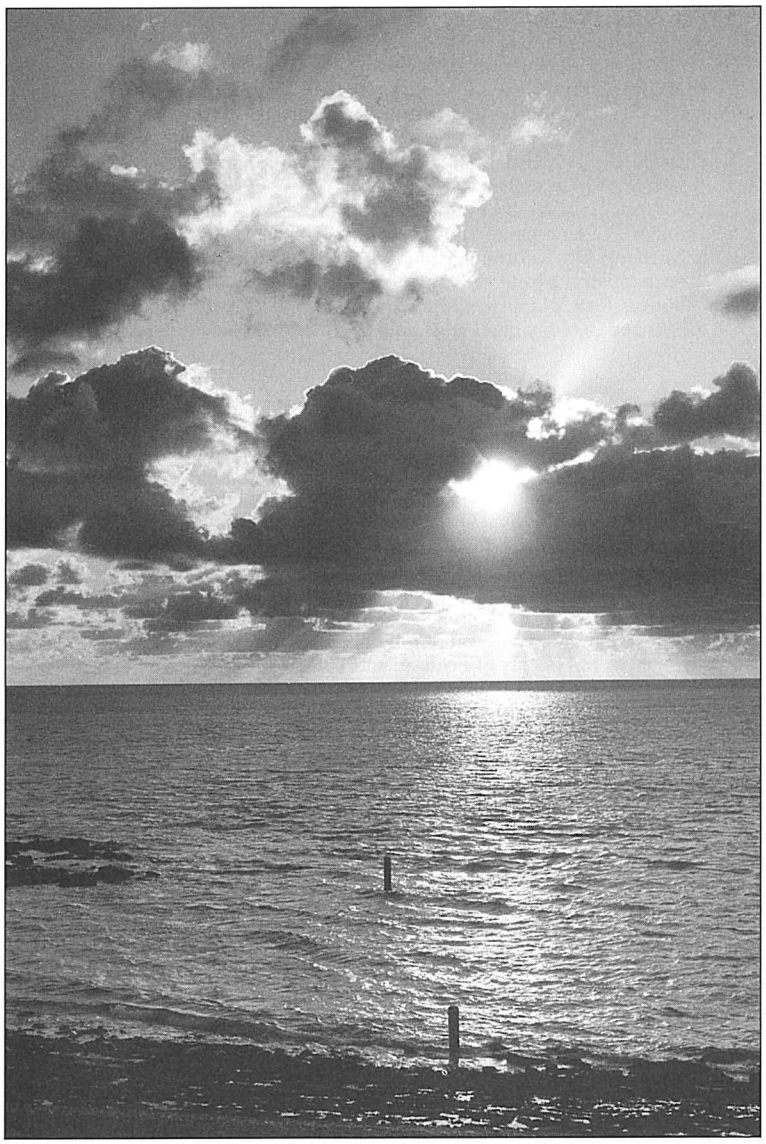


Photo: NIOZ archives.

GUEST SCIENTISTS

- Barranguet, Dr. C., University of Marseille, France: Department of Pelagic Systems, from 1 October to 6 January 1995.
- Battley, Ph., Department of Ecology, Massey University, Palmerston North, New Zealand: Department of Coastal Systems, 27 August - 22 November.
- Bijma, Dr. J., AWI, Bremerhaven: Department of Chemical Oceanography, 1-8 October.
- Billones, R.G., Free University,Brussels,Belgium: Department of Benthic Systems, 23-27 September.
- Blomert, A.-M., Rijkswaterstaat Flevoland, Lelystad: Department of Coastal Systems, October-November.
- Broerse, A.T.C., Centrum voor Mariene Aardwetenschappen, Vrije Universiteit, Amsterdam: Department of Chemical Oceanography, November-December.
- Carlotti, Dr. F., CNRS Station Zoologique, Villefranche-sur-Mer, France: Department of Pelagic Systems, 4-15 July.
- Checa, Dr. A., Dep. Estratigrafia y paleontologia. Univ. Granada, Spain: Department of Coastal Systems, 4-14 September.
- Cheewasedtham, Mrs Wilairat, Prince Songkla University, Pattani, Thailand: Department of Chemical Oceanography, April - May.
- Conan, S.M.H., Centrum voor Mariene Aardwetenschappen, Vrije Universiteit, Amsterdam: Department of Chemical Oceanography, November-December.
- Druzhkov, N.V., Murmansk Marine Biological Institute, Murmansk, Russia: Department of Pelagic Systems, until 21 September.
- Flessa, Prof. dr. K.W., Geol. Dep. University of Arizona, Tucson USA: Department of Coastal Systems, 10-16 July.
- Hua Di, Dr., East China Normal University, Shanghai, China: Department of Marine Geology and Geochemistry, from 24 October.
- Jianjian Lu, Dr., East China Normal University, Shanghai, China: Department of Coastal Systems, Department of Marine Geology and Geochemistry, from 24 October.
- M'harzi, A., Free University Brussels, Belgium: Department of Benthic Systems, March-April.
- Mwangi, S.N., Kenyan Marine FIsheries Research Institute, Mombasa, Kenya: Department of Benthic Systems, until September 1994.
- Ploug H., Max Planck Institute, Bremen: Department of Chemical Oceanography, May.
- Poliquin, M., Dalhousie University, Canada: Department of Chemical Oceanography, December.
- Power, J. H., Coastal Fisheries Institute, Lousisana State University, USA: Department of Coastal Systems, 5 February-21 April.
- Rasmussen, Dr. T.L., University of Aarhus, Denmark: Department of Marine Geology and Geochemistry, 1 January-31 December.
- Riebesell, Dr. U., AWI, Bremerhaven: Department of Chemical Oceanography, 1-8 October.
- Schoumann, V., Université Libre, Bruxelles: Department of Chemical Oceanography, from March.
- Song Xueliang, Dr., Kunming, China Institute of Geological Sciences: Department of Marine Geology and Geochemistry, 1 June - 1 November.
- Sun Shuncai, Prof., Nanjing, China, Academia Sinica, Institute of Geography and Limnology: Department of Marine Geology and Geochemistry, 1 July - 1 November.

VISITORS

- Altenbach, Prof. Dr. A., Museum Basel, Switzerland.
- Åkesson, S., Department of Animal Ecology, Lund University, Sweden.
- Baker, Prof. Dr. A. J., Royal Ontario Museum, University of Toronto, Canada.
- Beijderwellen, W., BBC, UK.
- Bijma, Dr. J., Alfred Wegener Institute, Bremerhaven, Germany.
- Boxal, Dr. S., Univ. of Southampton, UK.
- Chernichko, Dr. Y., Bird Ringing Centre, Melitopol, Ukraine.
- Clayton, Dr. J., U.S. Geological Survey, Federal Center, Denver, USA.
- Daro, Prof.Dr. M.H., Lab. of Ecology and Systematics, Free University, Brussels, Belgium.
- Davidson, Dr. N.C., Joint Nature Conservation Committee, Peterborough, England.
- Dekker, Paul, Environmental Rersource Management, UK.
- Evans, Prof. Dr. P.R., Department of Biological Sciences, University of Durham, England.
- Flynn, Dr. K.J., Algal Research Unit, University of Wales, Swansea, UK.
- Gordeev, Dr. V., P.P. Shirshov Institute of Oceanology, Moscow, Russia.
- Gordon, D. Dr., Bedford Institute for Oceanography, Halifax, Canada.
- Hayes, Prof. Dr. J.M., Biogeochemical Laboratories, Indiana University, Bloomington, USA.
- Hedenström, A., Department of Theoretical Ecology, Lund University, Sweden.
- Ivanov, Dr. M., Faculty of Geology, Moscow State University, Russia.
- Iwasaki, Dr. N., Usa Marine Biological Institute, Kochi University, Usa-cho, Tosa Kochi, Japan.
- Kempe, Prof. Dr. S., TH Darmstadt, Heidelberg, Germany.
- Kuypers, Dr. A., Geological Survey, Copenhagen, Denmark.
- Lancelot, Dr. C., Université Libre, Brussels, Belgium.
- Lebedeva, Dr. E., BirdLife International, Moscow, Russia.
- Lemmens, Dr. S. Division of Fisheries CSIRO, Australia.
- Lindström, Dr. Å., Department of Animal Ecology, Lund University, Sweden.
- Loder, J.W., Bedford Institute of Oceanography, Bedford, Nova Scotia, Canada.

- Meleshko, V.V., Institute of Hydromechanics, Kiev, Ukraine
- Mienert, Dr. J., GEOMAR, Kiel, Germany.
- Milliman, Dr. J., College of William and Mary, Gloucester Point, Virginia, USA
- Ntiamoa-Baidu, Dr. Y., Department of Zoology, University of Ghana, Accra, Ghana.
- Ofori-Frimpong, Y., Department of Game and Wildlife, Accra, Ghana.
- Osore, M., Kenya Marine and Fisheries Research Institute, Mombasa, Kenya.
- Prusowa, I., Institute for the Biology of the Southern Seas, Sebastopol, Ukraine.
- Reckermann, M.U.A., Institute for Baltic Research, Warnemünde,Germany.
- Riebesell, Dr. U., Alfred Wegener Institute, Bremerhaven, Germany.
- Rospondek, M., Institute of Geological Sciences, Department of Mineralogy and Petrography, Jagiellonian University, Krakow, Poland.
- Saliot, Dr. A., Laboratoire de Physique et Chimie Marines, Université Pierre et Marie Curie, Paris, France.
- Sicre, Dr. M.-A., Laboratoire de Physique et Chimie Marines, Université Pierre et Marie Curie, Paris, France.
- Silvert, B. Dr., Bedford Institute for Oceanography, Halifax, Canada.
- Susani, Lucia, Environmental Resource Management, UK.
- Ten Haven, Dr. H.L., TOTAL, Scientific and Technical Center, Saint-Rémy-les-Chevreuse, France.
- Thanh, Prof. Dr. N.D., Vice President National Center for Natural Science and Technology, Hanoi, Vietnam.
- Tilbrook, Dr. K.J., Department Earth Sciences. University Cambridge, UK.
- Tomascik, Dr. Th., Environmental Management Development, Jakarta, Indonesia.
- Tomkovich, Dr. P., Zoological Museum, Moscow University, Russia.
- Troy, Dr. D., Troy Ecological Research Associates, Anchorage, Alaska, USA.
- Ward, Prof. Dr. D.M., Dept. of Microbiology, Montana State University, Bozeman, Montana, USA.
- Zmijewska, Dr. M.I., University of Gdansk, Poland.

UNDERGRADUATE UNIVERSITY STUDENTS

- Basov, E., Moscow State University, Russia.
- Bosch, H.-J., Institute of Earth Sciences, Geochemistry Department, RUU.
- Brookes, R., University of Hertfordshire, Hatfield, England.
- Bruinzeel, L., Animal Ecology, RUG.
- De Koning, H.W., Department of Geology, Institute of Earth Sciences, RUU.
- Dekinga, A., Animal Ecology, RUG.
- Haasbroek, N., Geodesy, Delft Technical University.
- Hartog, W., IMAU, RUU.
- Joenje, M., ISP, UvA.
- Jonkers, P.J., Department of Marine Biology, RUG.
- Kloff, S. Department of Marine Biology, RUG.
- Kok, Y.S., Department of Geophysics, Institute of Earth Sciences, RUU.
- Koolhaas, A., Animal Ecology, RUG.
- Koskela, S.H., University of Oulu, Finland.
- Lambrechts, D.Y.M., ISP, UvA.
- Mars, J.-F. Rijksinstituut Toxicologie, RUU.
- Minnaard, J.J., Natuurbeheer, LUW.
- Roeks, E., Vakgroep Toxicologie, LUW.
- Steinhoff, W., ISP, UvA.
- Thio, J., Institute of Earth Sciences, Geochemistry Department, RUU.
- Thomasse, E., Department of Sedimentology, Institute of Earth Sciences, RUU.
- Van der Schrier, G., IMAU, RUU.
- Van Oyen, B., Institute for Soil Science and Geology, LUW.

4. Support Services

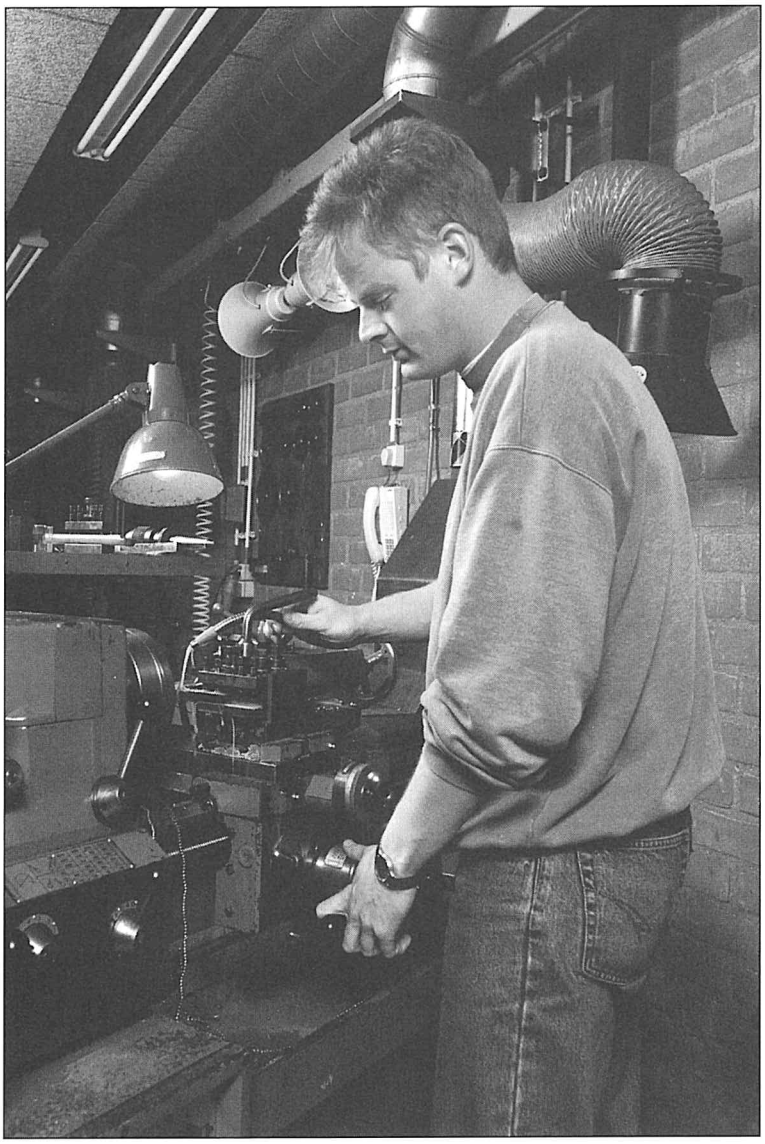


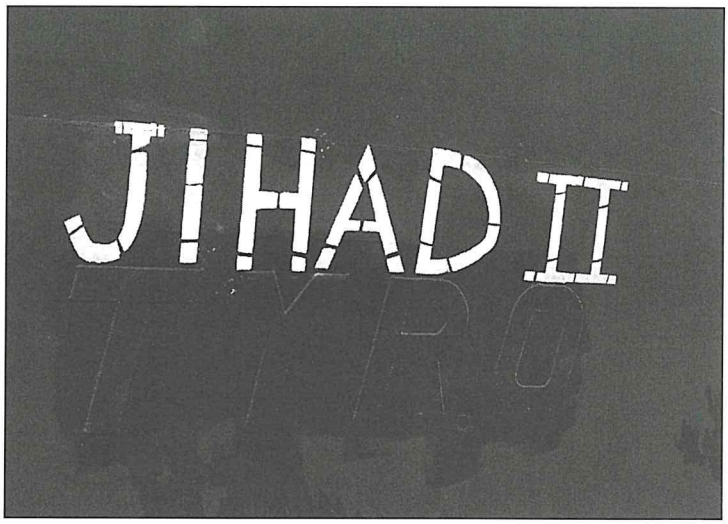
Photo: B. Aggenbach

1994 was characterized by changes such as the sale of RV 'Tyro' by the Netherlands Marine Research Foundation (SOZ). This involved the search for other ships that could be chartered to replace RV 'Tyro'. Possible replacements are RVs 'Jean Charcot', 'Livonia', 'Charles Darwin' and 'Zirfaea'. These ships, however, have less capacity and are not as suitable as was RV 'Tyro' for long multidisciplinary expeditions.

A special (A&O) grant to NIOZ allowed the production of a video information film entitled 'Eén hand voor de wetenschap en één voor jezelf' to ensure safety on board RV 'Pelagia'. The film is shown at the start of each cruise and illustrates all unsafe working situations, the standard security regulations and house rules on board a research vessel.

Preliminary work has been carried out to meet the demands made by environmental legislation. Discussions are being held with the Texel environmental office and RWS (Haarlem) on what needs to be done. NIOZ will have to draw up a set of environmental regulations for its own use to obtain the permit required by law.

NWO has commissioned the construction consultancy Kraan in Rotterdam to draw up a long-term maintenance plan for the buildings, installations and grounds of all its institutes, including NIOZ. The intention is to obtain insight into the expected costs for replacement and maintenance over the next ten years.



RV 'Tyro' renamed.
Photo: B. Aggenbach.

Instruments

A new pivot for the anchoring systems was developed. The bearing part has been provided with ceramic balls. The proto-type was tested for pitting in running seawater at 27 °C for 2 and a half months. The pivot can sustain a pulling force of 4.5 tons.

A sediment trap was furnished with wormwheel drive instead of an inadequate toothed drive-belt. The device has been mounted in a very flat housing underneath the turning disk with the sampling trays, which has greatly simplified the whole construction.

The instrument that was developed last year for *in situ* observation of underwater sediment transport and flocculation in the water column by means of superfast flashlight synchronized with a video camcorder was successfully tested in the Elbe river. After a few adaptations, which allow the instrument to be transported to the bottom while in operation, the construction is considered to be complete.

As agreed during the European Workshop on Optical Instruments and Remote Sensing in November 1993, a start has been made with the development of a 6-channel light meter with a very large dynamic range. The instrument is to be the standard measuring instrument of the European oceanographic community.

The benthic bottom lander has been adapted in various ways, and a new water sampling system has been produced.

Software was written for the EK 500 echo-sounder of RV 'Pelagia' to work out data output for research on internal waves and isotherms.

To facilitate the sorting and conservation of fish on board, a fish distribution system with conveyor belt and rinsing was developed and fitted into an adapted container.

A ten-foot container was adapted for incubations and for storing of all necessary auxiliary instruments.

A 1-m^3 water sampler was constructed to be able to collect and drain large water samples quickly.

The auxiliary frame of the vibrocorer was finished and successfully tested during a cruise with RV 'Pelagia'.

A bottom lander was produced for the acoustic Doppler current profiler.

A complete set of piston-corers with 40 six-metre cores and auxiliary instruments were built.

Onboard support

Technical support was rendered by the Electronics, Instrumentation and Sea Technology Services on board RVs 'Charles Darwin', 'Cirolana', 'Pelagia', 'Urania' and 'Zirfaea' to a total of 112 man-weeks.

Logistic support

All equipment on board RV 'Tyro' was removed and stored in the new shed at the NIOZ harbour. In December the lorry was replaced by a new one, and a second-hand tractor was purchased to facilitate the transport of goods within the NIOZ grounds.

Besides a great deal of road transport within the Netherlands, ship and road transport was arranged to Curaçao, Denmark, Germany, England, France and Italy for land-based research programmes and sea-going programmes with RVs 'Belgica', 'Charles Darwin', 'Holland', 'Isis', 'Marion Dufresne', 'Mitra', 'Navicula', 'Pelagia', H. Neth. M.S. 'Pelikaan', 'Polarstern', 'Urania' and 'Zirfaea'.

Permission was obtained for storage of so-called customs goods in a section of the harbour shed. This requires a shadow administration to be kept at the shipping agents, besides our own administration.

Ship and harbour affairs

RVs 'Pelagia' and 'Navicula' were dry-docked to obtain the prolongation of the required certificates of seaworthiness and for general maintenance.

Because of damage RV 'Pelagia' had two new hydraulic pumps installed in the constant pressure system for the auxiliary cranes. The system was also provided with noise/vibration dampers, which reduced the sound-level on deck from 105 to 70 dBA. The ship cruised for 44 weeks, including 12 weekends, with over 400 scientists participating in the cruises.

Partly because of hire to NAM, RV 'Navicula' had its GPS position-finding system replaced by a DGPS system with video plotter, which allows very accurate navigation. The hydraulic system was fitted with a remote control for the A-frame and the winches. The ship cruised for 2115 hours over 43 weeks.

RV 'Griend' was completely steel-grittted on the outside and again painted in the NIOZ-colours. The ship cruised for 107 days.

As in the past 35 years, fish traps were deployed and the catch identified and measured.

Two heavier bollards were placed on the quay.

RV 'Navicula' on a tidal flat near Vlieland (Scheur-Omdraai). Photo: G. Nieuwland.

Buildings and installations

Besides the general maintenance, a number of projects were carried out or initiated:

A new aviary was constructed for use in the observation of birds, for instance knots, as mentioned at the end of this chapter.

A preliminary plan and budget were made as a basis for an application for financing of a wader bird unit.

The wind generator was fitted with a new gearbox and smaller wings to reduce the slamming-force on the gearwheels.

All the water transport pipes of the central heating system and valves of the boilers in the main buildings were overhauled.

The construction of a formalin laboratory has been started.

FINANCE AND ACCOUNTING SERVICE

The Finance and accounting Service, FED, in its new form, was in its first full year of operation. However, the start was slow, due to personnel constraints.

1994 was the first year NIOZ managed the national sea-going facilities, including the former SOZ facilities and the NIOZ contribution to it, mainly the research vessel 'Pelagia'. All administrative consequences of this task were sorted out.

The generally acknowledged need to take better control of the whole organization, together with the recommendations of the Peer Review in 1993, resulted in an orientation about a new way to finance the departments.

The registration of all financial facts was in order, but the audit and control should be improved. The control function within the organization should be geared towards the requirements of the board and the management. The audit function has its own requirements, but should also fit neatly into the organization.

The bookkeeping department selected new bookkeeping software, which will be put into effect in the middle of 1995.

The project manager supported the scientific departments in their search for and control of externally financed projects. This part of NIOZ's work is gaining a greater importance, especially since the basic financing and the size of the institute are growing further apart. The project management was strengthened with a full time project administrator.

The inventory control and the supply service have been able to meet the day-to-day demands, but still lack time to catch up on incomplete parts of the inventory administration of the past.

SCIENTIFIC SUPPORT SERVICES

Centre for Information Processing and Automation (CIA)

A great deal of work was involved in keeping the NIOZ network running, connecting an increasing number of PCs and Macs to it, installing a growing number of SUN-workstations, and supervising the enormous expansion of available disk space. The problems with the hardware side of the daily and monthly back-up and the stream-lining of the planned procedure took more time than expected.

The ABC data logging system of RV 'Pelagia' again required a great deal of attention. It is difficult for the CIA to assess how frequently it will be used. J. Derksen of the Electronics Service is now responsible for the system.

The CIA is frequently requested to develop new software for a growing and insatiable market. Advice was given on an inventory programme, new software for the Finance and Accounting Service, and a programme for drawing geographic maps.

The CIA assisted in establishing the connection between the computers of NIOZ and the library of the University of Groningen, which is the first step towards the automation of the NIOZ library.

Technical Committee and User Committee

The User Committee deals with questions and problems about hard- and software. The Committee also advises the director on the automation management within the institute. Committee members are: J. van der Meer (chairman until 15 Sept.), K. Booij (Chemical Oceanography; chairman from 15 Sept.), G.M. Manshanden (CIA), L.R.M. Maas (Physical Oceanography), J.H.F. Jansen (Geology), J.J. Beukema (Coastal Systems), H.J. Witte (Pelagic Systems), A. Kok/G. Duin-

eveld (Benthic Systems), H. Malschaert (BEWON), M. Baas (Marine Biogeochemistry), J. Nieuwenhuis (on behalf of the Technical Services) and P. Ruardij (chairman Technical Committee). N. Barten-Krijgsman (Editorial staff), the Reprographic Department, the Financial Department and the Library receive the Committee's papers. C.S. Blaauboer-de Jong is secretary of the Committee. The User Committee met five times in 1994.

The Technical Committee discusses the technical aspects of automation problems and gives advice to the director. Committee members are: P. Ruardij (chairman), R. Dapper, F. Eijgenraam, G.M. Manshanden, E. Embsen, W. Pool, B. Koster, R.X. de Koster, J. van der Meer as chairman of the User Committee (until 15 Sept.), and K. Booij (from 15 Sept.). C.S. Blaauboer-de Jong takes care of the minutes of Committee meetings; in 1994 three meetings were held.

The editorial staff of the periodical 'Octopus' consists of G.M. Manshanden, H. Malschaert and C.S. Blaauboer-de Jong. The periodical gives the users 'hot' information on automation and has been issued twice in 1994.

The library

—*Automation.* In 1994 an agreement 'Overeenkomst van dienstverlening' was concluded between NIOZ and the University Library Groningen (UBG). This means that NIOZ will have access to the facilities of the university library network. The university library is to include the NIOZ collection in its computerized catalogue. NIOZ staff will have on-line access to the university library catalogue and to the catalogues of other PICA-libraries in the Netherlands, as well as to articles contained in about 10 000 scientific journals. The system is now available on one of the PCs in the NIOZ library.

—*Library Committee.* A new library committee was installed. Its members are: J. v.d. Meer (chairman), G.C. Cadée (Department of Coastal Systems), L.R.M. Maas (Department of Physical Oceanography), T. Piersma (Department of Coastal Systems) and J.S. Sinninghe Damsté (Department of Marine Biogeochemistry).

—*Library collection.*
In 1994, 134 books and the following periodicals were added to the library collection:

- Atmosphere-Ocean / Canadian Meteorological and Oceanographic Society. Vol. 31 (1993) -
- BIOS: Scientific Annals of the School of Biology / Aristotle University Thessaloniki Vol. 1 (1993) -
- Deinsea: Jaarbericht van het Natuurmuseum Rotterdam (1994) nr. 1 -
- Arquipelago: Bulletin of the University of the Azores Vol 1 - 6, 8 (1990) -
- Die Vogelwarte: Zeitschrift für Vogelkunde Bd. 37 (1993) 2 -
- Information Alley / Apple Computer, Inc. Support Information Services Vol. 1 (1994) nr. 1 -
- Global Biochemical Cycles / American Geophysical Union Vol. 1 (1987) nr. 1 -
- Marine Ornithology Vol. 21 (1993) 1/2 -
- Anales del Instituto de Investigaciones Marinas de Punta de Betin Vol. 12 (1982) -
- Journal of Shellfish Research Vol. 12 (1994) nr. 2 -

Editorial office

—see 2. *Publications and presentations*

Reprographic Service

The Reprographic Service has again been busy producing drawings by hand, or with the assistance of the drawing computer system, which has been extended with a second drawing computer. The Service assisted in the production of internal and external reports as well as drawing assignments for the Netherlands Journal of Sea Research and other publications. Large quantities of slides were made for workshops and symposia; the production of slides and photographic work is steadily increasing.

The use of the copiers as a medium for the production of internal and external reports is increasing, which necessitates more attention and maintenance.

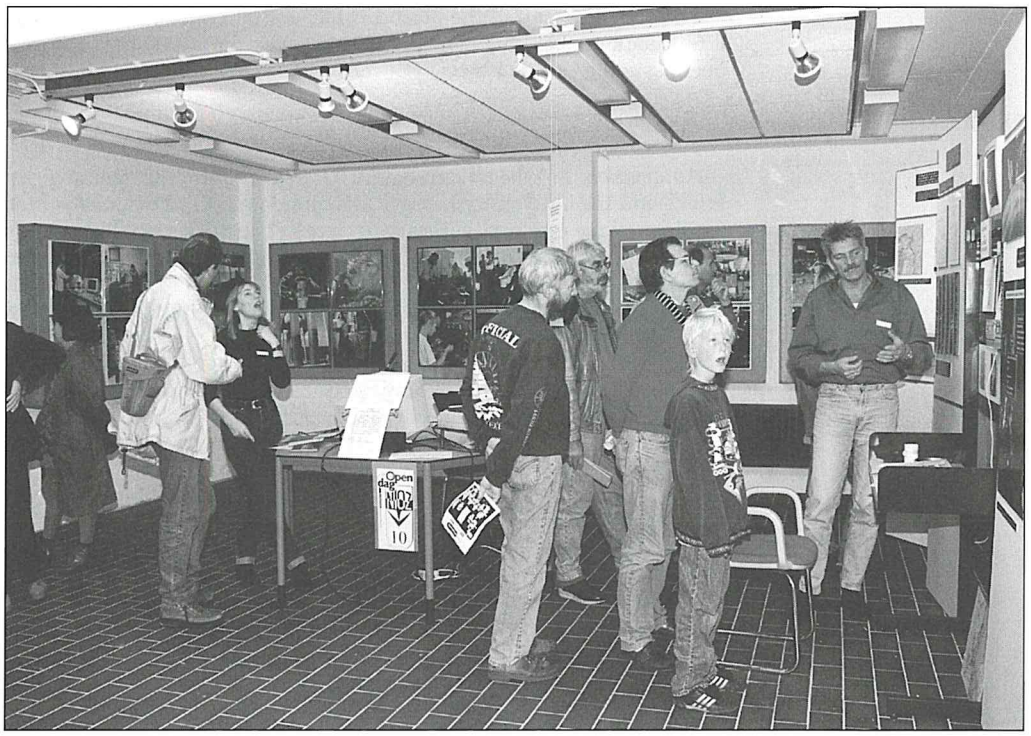
Audio-visual Service

Already in January preparations started for the conference 'Gas in Marine Sediments', which was to be held at NIOZ in September. At the conference itself, assistance was rendered at the poster sessions and video presentations. Six posters were produced for the ASLO congress, which was held in San Diego, USA, in February. Three posters were produced for the congress Zooplankton Production, held in Plymouth, UK, in August. All posters were well received. A total of 37 posters were produced over the year.

In co-operation with Ecomare, Texel, a stand set up at the environmental weekend (4-5 June) to mark the 75th anniversary of the VARA radio programme Vroege Vogels. Because of the good standing of Ecomare, such co-operation is recommended also in the future.

A great deal of video work was carried out for NIOZ scientists and also for the NOS tv programme Het Klokhuis. Copies were produced of the JGOFS 1992 film 'Springtime in Antarctica'. In August slides were made for the Department of Marine Biogeochemistry on behalf of the Reprographic Service.

One of th highlights of the year was the Open Day at NIOZ on 9 October. The Audio-visual Service assisted with posters and in arranging the exhibitions throughout the Institute.



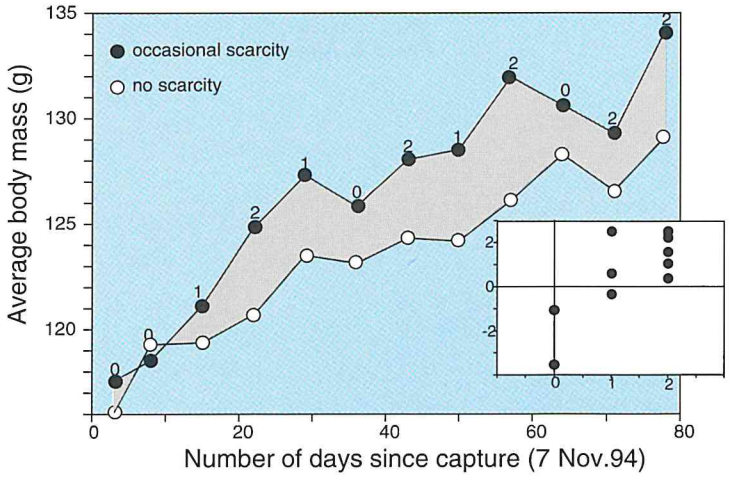
Some of the posters shown at the Open Day. Photo: W. Hart

NEW AVIARIES ENABLE NEW STUDIES: *INSURANCE POLICIES* IN KNOTS

In 1994 a new set of eight aviaries for keeping experimental flocks of shorebirds were built at NIOZ. This construction will be part of an *Experimental Shorebird Facility*, also including the two existing tidal-flat aviaries and the three "tundra cages" (ex-seabird cages), and the climatized mudflat and climate rooms of which the construction will hopefully start in 1995.

The eight experimental aviaries built at NIOZ in 1994. Photo: B. Aggenbach.

Shorebirds wintering in the Wadden Sea live in a very demanding and unpredictable environment. Periods during which the mudflats hardly emerge due to storms from the northwest alternate with periods of southeasterlies, bringing low temperatures and frozen mudflats. Knots and other shorebirds have thus to cope with many days without food but with high energy demands, and one of the means to avoid starvation is to store some bodily nutrients (usually fat) to overcome these periods. Although the storage of fat is important for survival, being fat and heavy also has a cost. Heavier birds spend more energy to carry that mass around, and may have greater difficulty in escaping from predators such as peregrines when they attack flocks. Wintering shorebirds have to balance the cost of being heavy against the risk of starvation.

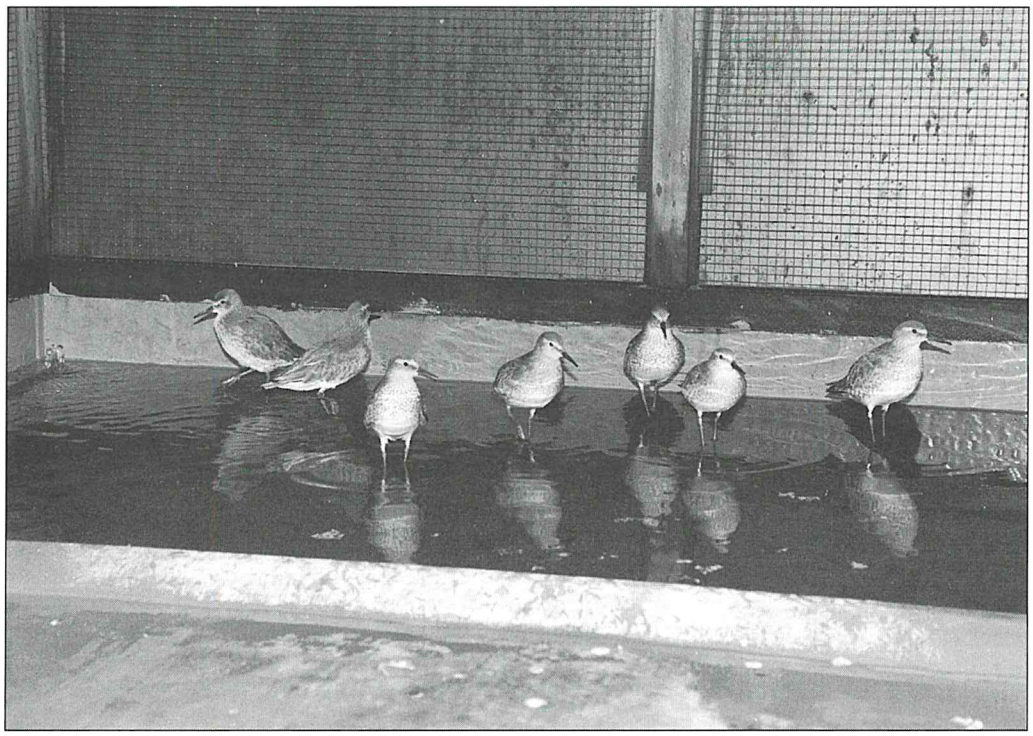


Body mass of knots in the course of the winter 1994-1995 (10 November 1995 to 24 January 1995) in relation to their experience of food scarcity. Four flocks of 7 birds occasionally had no food for 1 or 2 days (the number above the closed dots indicating the number of days without food in the preceding week). Three flocks of 7 birds (open dots) always had food. The inset shows the difference in weekly change in body mass between starved and fed flocks as a function of the number of days without food in the preceding week.

With the completion of the eight experimental aviaries in 1994, we are now in a position to address this problem of insurance policies in shorebirds. By comparing 3 flocks that always had plenty of food with 4 flocks that sometimes faced scarcity (no food on offer for 0, 1 or 2 days in the week between weighings), we should be able to see if birds facing scarcity deposit greater nutrient stores than birds that don't. During the next winter season we also hope to see whether the present experiences influence the nutrient stores put up by knots during the subsequent winter

On 7 November 1994 we captured 160 Knots at Normerven, Wieringen. From this flock we selected 49 (7 x 7) adult birds which had completed primary moult. Birds were assigned to different flocks such as to give each group the same mean body mass and size, and the same variance terms. Since 10 November the birds have been weighed every week.

The data collected in the period up to 24 January 1995 are summarized in the figure. Flocks facing scarcity clearly put on the largest nutrient stores. Indeed, there was an immediate response, with flocks that were without food for 1-2 days, directly gaining more mass than flocks with continuous food. To our surprise there was no obvious difference in the response to 1 or 2 days without food. So, if they experience the need, knots are prepared to pay an extra insurance premium. This behavioural mechanism is probably one of several that allow shorebirds such as knots to survive the winters in the Wadden Sea.



A flock of knots in one of these aviaries, showing the hygienic soft floor that is easy to clean up, and the little piece of mudflat that allows knots to probe, walk on mud, that is: to behave as much as knots behave. Photo: B. Aggenbach.

5. Sociaal jaarverslag

Photo: NIOZ archives.

ALGEMEEN

In het vorige jaarverslag werd reeds aangekondigd dat naar aanleiding van het peer review, waarvan eind december 1993 het rapport aan het gebiedsbestuur BOA werd uitgebracht, de organisatiestructuur van het wetenschappelijk onderzoek en de daarmee samenhangende financieringsstructuur zou worden herzien in 1994.

Medio 1994 besloot het bestuur van de stichting NIOZ aan het adviesbureau Anderson Elffers Felix BV (&AEF) opdracht te verlenen onderzoek te doen naar de topstructuur van het instituut: de directiestructuur, de leiding van de wetenschappelijke afdelingen, de diensten en NIOZ-F en naar de gewenste relaties en structuur van overleg tussen de directie en de hoofden van de diensten en afdelingen.

&AEF heeft begin november advies uitgebracht betreffende de directiestructuur. Het bestuur heeft daarop in principe besloten de aanbevelingen om te komen tot een eenhoofdige directie over te nemen. Zijn voornemen tot reorganisatie heeft het bestuur op 29 november 1994 formeel bekend gemaakt. De Ondernemingsraad NIOZ is om advies gevraagd.

Over de structuur van de wetenschappelijke afdelingen wordt begin 1995 geadviseerd. Het bestuur zal zich bij die advisering laten bijstaan door de Wetenschapcommissie NIOZ. Voorzien wordt dat de reorganisatie en herstructurering van het instituut medio 1995 zijn afgerond.

BESTUUR EN WETENSCHAPCOMMISSIE

Bestuur stichting NIOZ

Per 1 september 1994 is Prof.dr. H.J.Th. Goos teruggetreden als lid van het bestuur. Per 7 oktober 1994 is Prof.dr. R.A. Prins eveneens teruggetreden als lid van het bestuur; hij blijft wel lid van de Wetenschapcommissie. Per 1 september 1994 werd benoemd Prof.dr. K. Verhoeff en per 30 september 1994 Prof.ir. H.P. van Heel.
Per 31 december 1994 was het bestuur als volgt samengesteld:

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

Het bestuur kwam in het verslagjaar 1994 drie maal met de directie in vergadering bijeen; op 10 maart te Amsterdam, 14/15 juni op Texel en 30 september te Amsterdam. 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 organisatie van de topstructuur van het instituut kwam het bestuur in november en december driemaal in besloten zitting bijeen.

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.

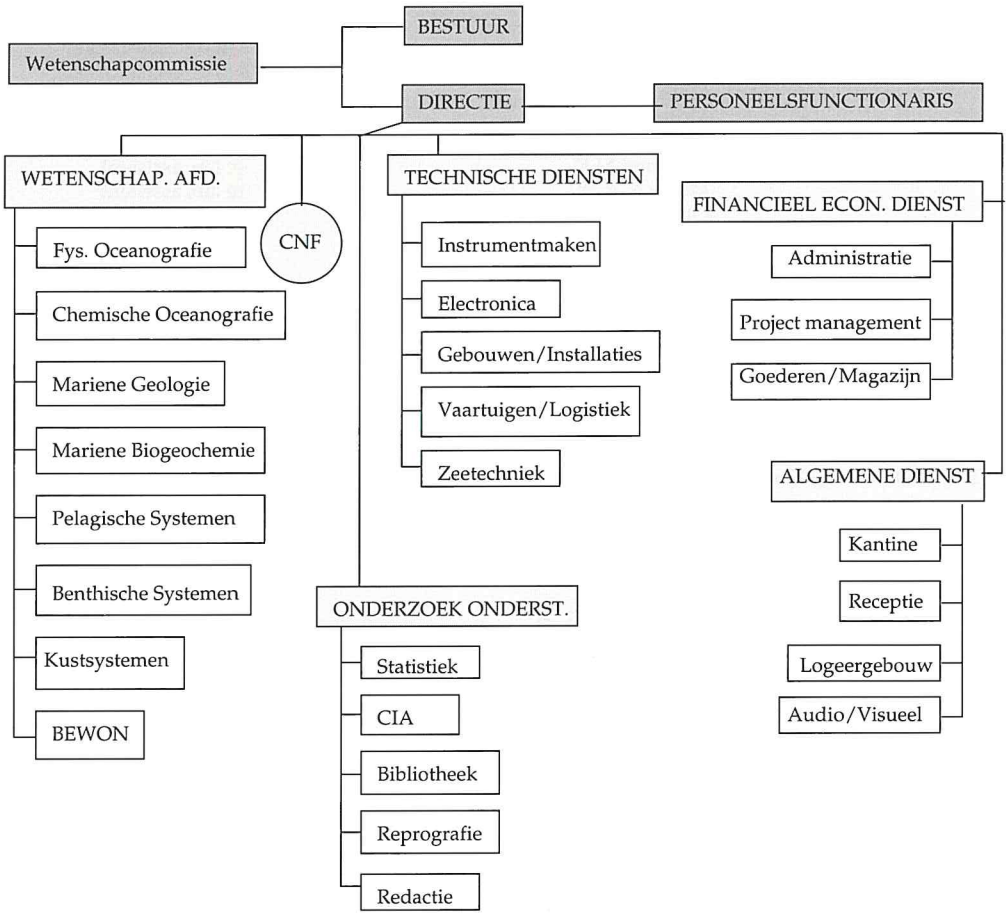
Prof.dr. R.A. Prins heeft om gezondheidsredenen het voorzitterschap overgedragen aan prof.dr. R.H. Drent. Prof.dr. B.L. Bayne is in verband met drukke werkzaamheden teruggetreden als lid. In zijn plaats wordt als lid voorgesteld Prof.dr. R. Warwick. Prof.dr. W.P.M. de Ruyter is volgens rooster afgetreden. Hij is opgevolgd door Prof.dr.ir. G.J.F. van Heijst.
De Wetenschapcommissie was per 31 december 1993 als volgt samengesteld:

Prof.dr. R.H. Drent	voorzitter	Zoölogisch Laboratorium, Universiteit 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, Universiteit Groningen
Prof.dr. V. Smetacek		Alfred-Wegener-Institut für Polar- und Meeresforschung, Bremerhaven, Duitsland
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 20 - 21 april 1994. Aan de vergadering werd deelgenomen door de directeuren Prof.dr. W.G. Mook en mevrouw drs. M.J. Rietveld. De verslaglegging werd verzorgd door J.W. Rommets.

De afdeling Benthische Systemen presenteerde zich aan de Commissie en werd door haar beoordeeld.

ORGANOGRAM NIOZ



PERSONEELSLIJST 31-12-94

DIRECTIE

Mook W.G. *Prof. dr.*	34.6 uur	hoofddirecteur, tevens wetenschappelijk directeur
Rietveld M.J. *Drs.*		directeur planning en beleid
Abs E. van *Ing.*		directeur beheer
Hart-Stam J.M.G.		dir. secretaresse
Blaauboer-de Jong C.S.		dir. secretaresse
Rommets J.W.		wet. dir. ass.
Witte J.IJ.		wet. dir. ass.
Vooys P.C.		stafm. pers. zaken
Heetvelt L.H.M.	7.6 uur	formatiedeskundige
Wolf P. de *Dr.*		*onderzoeker*

CORE PROJECT OFFICE (LOICZ/IGBP)

Pernetta J.C. *Dr.*	projectmanager	
Lunter S.M. *Drs.*	secretaresse	m.i.v. 14-02

NATIONALE ZEEGAANDE FACILITEITEN

Bergen Henegouw C.N. van *Drs. Ing.*		coordinator (detachering NWO)	m.i.v. 15-06

WETENSCHAPPELIJKE AFDELINGEN

AFDELING FYSISCHE OCEANOGRAFIE

Veth C. *Drs.*		afdelingshoofd	
Aken H.M. van *Dr.*		senior onderzoeker	
Otto L. *Dr.*		senior onderzoeker	tot 01-10
Zimmerman J.T.F. *Prof. dr.*	26.6 uur	senior onderzoeker	
Maas L.R.M. *Dr.*		onderzoeker	
Munck de J.C. *Dr.*	30.4 uur	post doc.	tot 15-08
Bruin T.F. de *Drs.*		onderzoeker BCRS	
Wernand M.R.		1e lab. assistent	
Manuels M.W.		1e lab. assistent	
Ober S. *Ing.*		1e lab. assistent	
Koster R.X. de		data-analist	
Hiehle M.A.		fysisch assistent	
Toorn R. v.d. *Ir.*	32.0 uur	OIO NIOZ	
Lam F.P.A. *Drs.*		OIO NIOZ	
Boer C. de *Drs.*		OIO NWO/GOA	tot 01-02
Gerkema Th. *Drs.*		OIO NWO/GOA	tot 01-07
Beerens S.P. *Drs.*		OIO NWO/GOA	
Thieme J. *Ing.*		fysisch assistent (project-)	

AFDELING CHEMISCHE OCEANOGRAFIE & ZEEVERONTREINIGING

Helder W. *Dr.*		afdelingshoofd	
Everaarts J.M. *Dr.*		onderzoeker	
Baar H.J.W. de *Prof. dr. ir.*	30.4 uur	senior onderzoeker	
Booy K. *Dr.*		onderzoeker	
Brummer G.J.A. *Dr.*		post doc. NIOZ	
Timmermans K.R. *Dr.*		post doc. NWO/GOA	
Hillebrand M.T.J.		lab. hoofd assistent	
Nolting R.F.		lab. hoofd assistent	
Ooyen J.C. van		lab. assistent	
Kloosterhuis H.T.		1e lab. assistent	
Bakker K.M.J.		lab. assistent	
Koutrik A. van		analist	
Weerlee E.M. van		analist	m.i.v. 01-02
Sleiderink H.M. *Ir.*		OIO NIOZ (50% BEWON)	
Lohse L. *Drs.*		OIO NIOZ	tot 01-09
Leeuwe M.A. van *Drs.*	34.2 uur	OIO NIOZ	
Epping H.G. *Drs.*		gewetensbezwaarde	tot 01-10
Bakker D.C.E. *Ir.*		OIO NOP	
Wilde H.P.J. de *Ir.*		OIO NOP	
Löscher B.M. *Drs.*		OIO NWO/GOA	
Wiebinga C.J. *Drs.*	30.4 uur	OIO NWO/VVA	
Majoor A.A.J. *Drs.*		OIO NWO/VVA	
Hey H. de *Drs.*	30.4 uur	onderzoeker (project-) NWO/VVA	
Jong J.T.M. de		lab. assistent (project-)	
Fischer C.V. *Drs.*	28.0 uur	analist (project-)	
Jong E. de		analist (project-)	
Koning E. *Ing.*		lab assistent (project-) NWO/VVA	
Das J.H. den		lab. assistent (project-)	m.i.v. 01-01 tot 01-08 m.i.v. 05-09

AFDELING MARIENE GEOLOGIE EN GEOCHEMIE

Eisma D. *Prof. dr.*		afdelingshoofd	
Jansen J.H.F. *Dr.*		senior onderzoeker	
Weering T.C.E. van *Dr.*		senior onderzoeker	
Bennekom A.J. van *Drs.*		onderzoeker	
Gaast S.J. v.d.		wet. assistent	
Kalf J.		lab. assistent	
Iperen J. van	8.0 uur	lab. assistent	

Okkels E.	32.0 uur	analist	
Vaars A.J.		appl. technicus	
Ufkes E. *Drs.*		OIO NIOZ	tot 01-06
Gipp H.J.W. *Drs.*		OIO NIOZ	
Beks J.P. *Drs.*		OIO NIOZ	
Werff W. van der *Drs.*		OIO NIOZ/UvA	tot 15-11
Witte A.	19.0 uur	analist (project-) EU	
Ben Khelifa L.M. *Dr.*		post-doc NWO/VVA	
Vreeze J.F.M de *Ir.*	30.4 uur	OIO NIOZ	m.i.v. 01-09
Haas H. de *Drs.*		OIO NWO/VVA	
Boer W. *Ing.*		lab. assistent	m.i.v. 01-09
Happee T.J.W. *Ing.*		analist (project-)	m.i.v. 01-07 tot 01-10
Borssen J.	11.0 uur	laborante	m.i.v. 15-04 tot 15-07
Stigter H.C. de *Drs.*		gewetensbezwaarde	

AFDELING MARIENE BIOGEOCHEMIE

Leeuw J.W. de *Dr.*		afdelingshoofd	
Sinninghe Damsté J.S. *Dr. ir.*	34.2 uur	senior onderzoeker	
Pool W.G.		wet. assistent	
Rijpstra W.I.C.	19.0 uur	lab. hoofd assistent	
Baas M.		lab. hoofd assistent	
Dekker M.H.A.	36.0 uur	lab. assistent	
Schouten S. *Ir.*		OIO NIOZ	tot 01-11
		onderz. (project-) NWO/pionier	m.i.v. 01-11
Hartgers W.A. *Drs.*		OIO NIOZ	tot 01-02
Koopmans M.P. *Drs.*		OIO NIOZ	
Kaam H. van *Drs.*		OIO/NWO/AWON	
Koster J. *Dr.*		post-doc NWO/pionier	
Kok M.D. *Drs.*		OIO NIOZ/pionier	17-01
Hold I.M. *Drs.*		OIO NWO/pionier	01-02
Heemst J.D.H. van *Ir.*		OIO NWO/VVA	

AFDELING PELAGISCHE SYSTEMEN

Fransz H.G. *Dr. ir.*		afdelingshoofd	
Baars M.A. *Dr.*		senior onderzoeker	
Klein Breteler W.C.M. *Dr.*		senior onderzoeker	
Kuipers B.R. *Dr.*		onderzoeker	
Veldhuis M.J.W. *Dr.*		onderzoeker	
Hansen F.C. *Dr.*		post doc. NIOZ	
Wal P. van der *Dr.*		post doc. NWO/GOA	tot 01-03
Kraay G.W.		lab. hoofd assistent	
Oosterhuis S.S.		1e lab assistent	
Gonzalez S.R.		lab. assistent	
Witte H.J.		analist	
Schogt N.		analist	
Bleijswijk J.D.L. van *Drs.*		OIO NIOZ	tot 01-04
Stolte W. *Drs.*		OIO NIOZ (50% BEWON)	tot 01-08
Heemst J.D.H. van *Ir.*		OIO NWO/VVA	
Buitenhuis E.T. *Ir.*		OIO NWO/VVA	
Kempers E.S.	32.0 uur	analist (project-)	
Shimwell S.J. *Drs.*		onderzoeker (project-) BCRS/RWS	
Van Noort-Kooman J.A.	7.0 uur	analist (project-)	m.i.v. 01-05 tot 15-11

AFDELING BENTHISCHE SYSTEMEN

Wilde P.A.W.J. de *Prof. dr.*		afdelingshoofd	
Vosjan J.H. *Dr.*		senior onderzoeker	
Bak R.P.M. *Prof. dr.*		senior onderzoeker	
Duineveld G.C. *Drs.*		onderzoeker	
Pauptit E.		lab. hoofd assistent	
Kok A.		1e lab. assistent	
Berghuis E.M.		1e lab. assistent	
Nieuwland G.		1e lab. assistent	
Noort G.J. van		lab. assistent	
Gast G.J. *Drs.*		OIO NIOZ	
Hondeveld B.J.M. *Drs.*	34.2 uur	OIO NIOZ (50% BEWON)	
Witbaard R. *Drs.*	32.0 uur	OIO NIOZ	tot 01-12
Tahey T.M. *Drs.*		OIO EG	
Holtmann S.E. *Drs.*	28.0 uur	onderzoeker (project-)	m.i.v. 01-05

Belgers J.J.M.		analist (project-)	tot 01-09
	24.0 uur		m.i.v. 03-10
Klein R.	32.0 uur	lab. assistent (project-)	m.i.v.16-01 tot 31-12
Weele J.A. van der		gewetensbezwaarde	
Lavaleye M.S.S *Drs.*		onderzoeker (project-)	m.i.v. 01-08 tot 01-11
Boon A.R. *Ir.*		OIO NWO/VVA	
Kracht B. *Drs.*	19.0 uur	assistent	m.i.v. 13-06

AFDELING KUSTSYSTEMEN

Beukema J.J. *Dr.*		afdelingshoofd/hoofdredacteur	
Swennen C. *Dr.*		senior onderzoeker	tot 01-03
Fonds M. *Dr.*		senior onderzoeker	
Spaargaren D.H. *Dr.*		senior onderzoeker	
Cadée G.C. *Dr.*		senior onderzoeker	
Veer H.W. van der *Dr. ir.*		onderzoeker	
Piersma T. *Dr.*		onderzoeker	
Duiven P.		1e lab. assistent	
Bruin W. de		analist	
Puyl P. v.d.		analist	
Hegeman J.		1e lab assistent	
Zuidewind J.		analist	
Bolle L.J. *Drs.*	34.2 uur	OIO NIOZ (50% BEWON)	
Goeij P.J. de *Drs.*		OIO NIOZ	
Honkoop P.J.C. *Drs.*		OIO NOP	
Walker P.A. *Drs.*	36.0 uur	OIO NAM	
Dekker R. *Drs.*		onderzoeker (project-)	
Kwast D.		analist (project-)	tot 01-04 m.i.v. 01-05
Baltus C.A.M. *Drs.*		toegevoegd projectonderzoeker	m.i.v. 01-10 tot 31-12

AFDELING BEWON

Lindeboom H.J. *Dr.*		afdelingshoofd	
Bol-den Heijer A.C.	28.2 uur	secretaresse	
Berg A.J. van den *Drs.*	24.0 uur	onderzoeker	
Bergman M.J.N. *Ir.*		onderzoeker	
Boon J.P. *Dr.*		onderzoeker	
Daan R. *Dr.*		onderzoeker (project-)	
Duyl F.C. van *Dr.*		onderzoeker	
Raaphorst W. van *Dr. ir.*		onderzoeker	
Ridderinkhof H.J. *Dr.*		onderzoeker	
Riegman R. *Dr.*		onderzoeker	
Ruardij P. *Drs.*		modelleur	
Kop A.J. *Ing.*		1e lab. assistent	
Malschaert H. *Ing.*		1e lab. assistent	
Mulder M.		1e lab. assistent	
Lewis W.E.	28.0 uur	analist	
Noordeloos A.A.M.		analist	
Embsen E.G.M. *Ing.*		techn. wet. progr. (EG)	
Brussaard C.P.D. *Drs.*		OIO EU	
Osinga R. *Drs.*		OIO NOP	
Slomp C.P. *Ir.*		OIO NOP	
Mensink B.P. *Ir.*		OIO VROM/RIKZ/NIOZ	
Sleiderink H.M. *Ir.*		OIO NIOZ (50%)	
Bolle L.J. *Drs.*		OIO NIOZ (50%)	
Stolte W. *Drs.*		OIO NIOZ (50%)	tot 01-08
Hondeveld B.J.M. *Drs.*	34.2 uur	OIO NIOZ (50%)	
Santbrink J.W. van *Drs.*		toegevoegd projectonderzoeker	m.i.v. 01-04
Camphuysen C.J.		wet. assistent (project-)	
Hoek J. van der		analist (project-)	m.i.v. 17-01 tot 20-04
Jong J.J.M. de		erk. gewetensbezwaarde	tot 03-08
Philippart C.J.M. *Drs.*		onderzoeker (project-)	m.i.v. 01-01
Zuur A.F. *Drs.*		onderzoeker (project-)	m.i.v. 17-05 tot 17-11
Winter C.		assistent (project-)	m.i.v. 21-03
Leeuwen A. van *Drs.*	30.0 uur	onderzoeker (project-)	tot 01-03
Loos C.G.M.		adm. medewerkster	m.i.v. 25-07 tot 25-09
Damme C.J.G.		assistent (project-)	m.i.v. 01-06 tot 15-09

ONDERZOEK ONDERSTEUNENDE AFDELINGEN

STATISTIEK	Meer J. van der *Drs.*	statisticus	

CENTRUM VOOR INFORMATIEVERWERKING EN AUTOMATISERING

	Dapper R.		automatiseringsdeskundige
	Eijgenraam F.		automatiseringsdeskundige
	Manshanden G.M.	30.4 uur	automatiseringsdeskundige

REPROGRAFISCHE AFDELING

	Aggenbach R.P.D.		wnd. hoofd
	Verschuur B.	35.15 uur	medewerker
	Nichols R.C.		medewerker
	Graaf A.C. de	30.0 uur	medewerker

REDACTIE

	Beukema J.J. *Dr.*		hoofdredacteur
	Bak-Gade B.	19.0 uur	assistent redacteur
	Mulder-Starreveld J.P.	28.5 uur	redactie-assistente
	Barten-Krijgsman N.	15.2 uur	redactie-assistente
	Hobbelink H.		grafisch ontwerper

BIBLIOTHEEK

	Brouwer A.		hoofd	m.i.v. 01-09
	Bruining-du Porto M.	33.25 uur	bibliotheekassistent	

ALGEMENE DIENST

	Nieuwenhuizen J.M.		hoofd

RECEPTIE

	Zonnenberg G.	35.15 uur	telefoniste/receptioniste	
	Zoetelief H.	8.0 uur	telefoniste/receptioniste	tot 18-03
	Kikkert A.	20.0 uur	telefoniste/receptioniste	
	Starink J.M.	13.42 uur	telefoniste/receptioniste	m.i.v. 01-02

KANTINE

	Spigt H.		hoofd
	Jourdan M.T.		medewerkster

LOGEERGEBOUW 'IN DEN POTVIS'

	Steenhuizen G.H.		huismeester
	Borkulo T.C. van	19.0 uur	medewerkster Potvis

AUDIOVISUELE AFDELING

	Hart W.	24.0 uur	medewerker

FINANCIEEL ECONOMISCHE DIENST

	Luursema C.W. *Drs.*		hoofd	m.i.v. 15-10
	Arkel M.A. van *Drs.*		projectmanager	
	Wernand-Godee I.		medewerker project-administratie	

ADMINISTRATIE

Bruin D.J.		medewerker salarisadministratie
Keijser A.		medewerker financiële administratie
Spel M.M.	19.0 uur	medewerker financiële administratie
Porto S.W. de		medewerker inventarisatieadministratie

DIENST GOEDERENONTVANGST EN MAGAZIJN

Ran A.	hoofd	
Gieles S.J.M.	medewerker	

TECHNISCHE DIENSTEN

Bakker C.L.	hoofd	
Bonne E.	medewerker (detachering)	

DIENST ZEETECHNIEK

Porto H.H. de	hoofd	
Schilling J.	plv. hoofd	
Bos E.B.M.	1e 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

DIENST VAARTUIGEN & LOGISTIEK

Buisman T.C.J.	hoofd	
Zwieten C. van	med. naut. zaken	
Visser A.J.	chauffeur	
Gerssen C.	gezagvoerder Pelagia	tot 01-02
Souwer A.J.	gezagvoerder Pelagia	
Groot J.C.	stuurman Pelagia	
Pieterse J.M.	hoofdwerktuigkundige Pelagia	
Seepma J.	1e werktuigkundige Pelagia	
Kalf J.J.	2e werktuigkundige Pelagia	
Koomen W.J.M.	scheepskok Pelagia	
Grisnicht P.W.	scheepstechnicus Pelagia	
Saalmink P.W.	scheepstechnicus Pelagia	
Stevens C.T.	scheepstechnicus Pelagia	
Star C. van der	schipper Navicula	
Anthonijsz R.J.R.	machinist Navicula	tot 01-07
Tuntelder J.C.	matroos/kok Navicula	
Adriaans E.J.	schipper Griend	
Jongejan W.P.	komvisser	
Eelman A.	chauffeur (detachering)	
Schagen P.J.	machinist Navicula	m.i.v. 24-01

DIENST INSTRUMENTMAKEN

Boekel H.J.	hoofd
Heerwaarden J. van	medewerker
Keijzer E.J.H.	medewerker
Kuiken N.E.	medewerker

DIENST 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	

DIENST GEBOUWEN & INSTALLATIES

Schilling F.J.		hoofd	
Alkema P.R.		med. werktuigbouw	
Groot S.P.	30.4 uur	med. werktuigbouw	
Kuip T.		med. werktuigbouw	
Lakeman R.	20.0 uur	med. werktuigbouw	
Heerschap L.	34.2 uur	med. houtbewerking	tot 01-04
Daalder R.M.		med. houtbewerking	
Witte R.J.C.		med. houtbewerking	
Brondsema A.		med. energietechniek	

STAGIAIRES 1994

Naam:	Periode:	Afdeling:	Opleidings Instituut:
B.J. Tijhuis	01/01/94 - 15/01/94	Bewon	Hog.Inform.Onderwijs
M.C.J. Schop	01/01/94 - 15/01/94	Bewon	Hogesch.Noorderhaaks
E.R. Stobbelaar	01/04/94 - 01/07/94	Bewon	Hogesch.Enschede
P. van Baal	01/04/94 - 01/07/94	Bewon	Hogesch.Enschede
F. Bos	01/08/94 - 31/12/94	Bewon	Hogesch.Enschede
M.M.P. Huibers	08/08/94 - 31/12/94	Bewon	Hogesch.W-Brabant
A.E.M. Slot	01/01/94 - 01/03/94	Chem.Oceanogr.	Hogesch.Midden Ned.
I. Loonstra	01/01/94 - 01/04/94	Chem.Oceanogr.	IJmond College
T.J.P. Happee	01/01/94 - 01/07/94	Chem.Ocenaogr.	Hogesch. Alkmaar
D.M. Zuurbier	01/01/94 - 01/07/94	Chem.Ocenaogr.	Hogesch. Alkmaar
E. de Vries	24/01/94 - 27/05/94	Chem.Oceanogr.	Hogesch.IJsselland
S. van Wieren	07/02/94 - 30/05/94	Chem.Oceanogr.	Hogesch.Amsterdam
A. van Roon	01/09/94 - 31/12/94	Chem.Oceanogr.	HLO-Alkmaar
H.J.M. Swagerman	20/09/94 - 01/07/94	Chem.Oceanogr.	HLO-Alkmaar
N. van Bruinisse	01/01/94 - 28/01/94	Electronica	MTS-Alkwaard
A. van der Gracht	01/01/94 - 14/01/94	Electronica	MTS-Noorderhooft
A. Witte	17/01/94 - 17/06/94	Electronica	MTS-Noorderhooft
A. Kooistra	24/01/94 - 24/06/94	Electronica	MTS-Alkwaard
S. Wijnker	15/08/94 - 31/12/94	Electronica	MTS-Alkwaard
J. Bosschaart	01/09/94 - 31/12/94	Electronica	MTS-Noorderhooft
E. Heidinga	22/08/94 - 31/12/94	Fys.Oceanografie	Hogesch.Leeuwarden
D. Ypma	01/01/94 - 28/01/94	Gebouw.& Inst.	MTS-Alkwaard
D. de Wildt	17/01/94 - 24/06/94	Gebouw.& Inst.	MTS-Alkwaard
H. Rosier	01/12/94 - 28/02/94	Gebouw.& Inst.	MTS-Noorderhooft
D.F. Broeren	17/01/94 - 10/06/94	Geologie	Hogesch.W-Brabant
D.A.F. Bosman	09/05/94 - 26/08/94	Geologie	Van Hall Instituut
M. Visser	14/11/94 - 31/12/94	Hav.& Vaartuig.	HTS
S. Dam	07/02/94 - 30/04/94	Kustsystemen	Hogesch.Amsterdam
A.M. Helbig	21/07/94 - 15/11/94	Kustsystemen	Van Hall Inst.
A. Hofman	21/07/94 - 15/11/94	Kustsystemen	Van Hall Inst.
E. Bontes	01/09/94 - 31/12/94	Kustsystemen	IJmond College
S. Klos	01/09/94 - 31/12/94	Kustsystemen	IJmond College
R. van Malderen	01/01/94 - 31/05/94	Mar.Biogeochem.	Hogesch.Rotterdam
J. Jellema	01/01/94 - 31/06/94	Mar.Biogeochem.	HLO-Leiderdorp
D. Buchner	01/09/94 - 31/12/94	Mar.Biogeochem.	MLO-Delft
I.A.L. Boogers	01/09/94 - 31/12/94	Mar.Biogeochem.	HLO-Delft
M.M. Klapwijk	01/11/94 - 31/12/94	Mar.Biogeochem.	Hogesch.Rotterdam
S.F. Kip	03/01/94 - 03/07/94	Pel.Systemen	Agrarische School
P.H. van Zutphen	14/11/94 - 31/12/94	Pel.Systemen	Hogesch.IJsselland
W. Noordzij	01/01/94 - 25/02/94	Zeetechniek	MTS-Noorderhooft
L. Boom	18/07/94 - 25/09/94	Zeetechniek	MTS-Noorderhooft
N. Alles	01/09/94 - 31/12/94	Zeetechniek	MTS-Noorderhooft

ARBEIDSVOORWAARDEN

Primaire arbeidsvoorwaarden

Het in 1993 bereikte accoord tussen de centrales van overheidspersoneel en de Minister van Onderwijs, Cultuur en Wetenschappen inzake het pakket arbeidsvoorwaarden, heeft een looptijd tot 1 april 1995. Dit houdt in dat er in 1994 geen veranderingen zijn opgetreden in de primaire arbeidsvoorwaarden voor het personeel werkzaam in de sector Onderwijs en Onderzoek.

Wachtgeldregeling

De aanspraken bij onvrijwillige werkloosheid zijn in 1994 wel veranderd. Per 1 april is in werking getreden het Besluit Werkloosheid Onderwijs- en Onderzoekpersoneel (BWOO). Het BWOO vervangt de Uitkeringsregeling 1966 en het Rijkswachtgeldbesluit. Met name de duur van de uitkering is in sommige gevallen volgens de nieuwe regeling verkort.

Voor degenen die voor 1 april 1994 een uitkering genoten krachtens één van de twee laatstgenoemde regelingen, geldt een overgangsregeling.

Decentrale arbeidsvoorwaardenmaatregelen
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. Twee medewerkers hebben in de loop van dit jaar van deze regeling gebruik gemaakt.

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 vijf medewerkers ouderschapsverlof genoten.

Kinderopvang

Tot 1 januari 1994 subsidieerde het NIOZ de Stichting Kinderdagverblijf Texel. Deze subsidie is per deze datum vervallen door de koop van een kindplaats. Hierdoor heeft het NIOZ de beschikking over tien dagdelen 'kinderopvang' en krijgen NIOZ-medewerkers voorrang bij een verzoek tot plaatsing van hun kind.

FORMATIE-ONDERZOEK

Het was de bedoeling het formatie-onderzoek bij de wetenschappelijke en de overige ondersteunende afdelingen in de maand september af te ronden. Het ingestelde onderzoek naar de organisatiestructuur van het NIOZ (zie **Algemeen**) leidde er echter toe, dat, na advies van het onderzoekbureau &AEF, de vaststelling van de formatie voorlopig werd geparkeerd, voor zolang het organisatie-onderzoek nog niet was afgesloten en besluitvorming hierover had plaatsgevonden.

ARBEIDSOMSTANDIGHEDEN

ARBO

Door het Nederlands Instituut voor Arbeidsomstandigheden (NIA) is in 1994 een onderzoek uitgevoerd naar de stand van de ARBO-zorg binnen de NWO instituten en stichtingen. Uit dit onderzoek kwam naar voren dat bij vrijwel alle instellingen het wettelijk verplichte ARBO-beleidsdocument ontbrak. Hoewel bij alle organisaties aandacht werd besteed aan ARBO-zaken, was deze voor verbetering vatbaar.

De adviezen die door het NIA zijn uitgebracht, hebben er toe geleid dat voor het NIOZ een Inspectie Plus Pakket (IPP) wordt aangeschaft met behulp waarvan de (verplichte) jaarlijkse risico-inventarisatie en -evaluatie kan worden uitgevoerd. Hiervoor zal door het NIA begin 1995 een cursus worden gegeven.

Tevens zal door het NIA in het voorjaar van 1995 een ARBO beleidsconferentie worden georganiseerd, voornamelijk gericht op het opstellen van het hierboven genoemde beleidsdocument. Binnen het NIOZ heeft overleg plaatsgevonden over het instellen van een ARBO-werkgroep. In deze werkgroep zullen vertegenwoordigers van verschillende geledingen zitting nemen teneinde ARBO-aandachtspunten en -acties beter op elkaar af te stemmen.

In 1994 is er een instructiefilm vervaardigd over het veilig werken aan boord van schepen. Deze film wordt, voor de aanvang van een vaartocht, vertoond aan de 'opstappers' die niet regelmatig op onderzoekvaartuigen vertoeven.

Bedrijfsgezondheidszorg

In het contract dat met de Bedrijfsgezondheidsdienst Den Helder is gesloten, is opgenomen dat medewerkers zich periodiek geneeskundig kunnen laten onderzoeken. Deelname aan dit onderzoek geschiedt op basis van vrijwilligheid.

Het periodiek geneeskundig onderzoek richt zich op de relatie tussen de gezondheidstoestand en het werk (en de werkomstandigheden) van de medewerker. In het laatste kwartaal heeft de beroepscategorie laboratoriumpersoneel zich aan dit onderzoek kunnen onderwerpen. De belangstelling voor dit onderzoek was zeer groot.

Ziekteverzuim

Het totale ziekteverzuim ten opzichte van 1993 is iets gestegen, te weten 4,4% (1993: 4,01%).

Deze geringe stijging doet zich zowel bij het wetenschappelijk (2,4% tegen 2,03% in 1993) als bij het niet wetenschappelijk personeel voor (5,4% tegen 5,11% in 1993).

Opgemerkt dient te worden dat de verzuimpercentages enigszins nadelig worden beïnvloed door een aantal langdurig zieke personeelsleden.

OVERLEG

Uitvoeringsregelingen

Ingevolge de Collectieve Arbeidsvoorwaardenregeling (CAR) kunnen per werkgever afzonderlijke Uitvoeringsregelingen worden opgesteld die nadere uitwerking geven aan de arbeidsvoorwaarden zoals die zijn opgenomen in de CAR. In 1994 zijn in overleg met de Ondernemingsraad twaalf regelingen in gewijzigde of nieuwe vorm tot stand gekomen waaronder de overwerkregeling 'Zeegaande expedities' die apart deel uitmaakt van de CAR. In deze regeling is het onderscheid vervallen tussen Wadden/Noordzee- en Oceaan expedities.

In het najaar is met de Ondernemingsraad het overleg gestart over de in 1995 in te voeren regelingen personeelsbeoordeling en 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

Na veel uitstel kwam in maart eindelijk de 'Comedia de la NIOZ' met de 'jaarlijkse' toneeluitvoering. Gespeeld werd 'The Real Inspector Hound' van de controversiële Engelse schrijver Tom Stoppard. Twee uiterst succesvolle opvoeringen (zie Texelsche Courant maart 1994) waren het resultaat van oefening baart kunst. Tijdens het hierop volgende feest speelde de Belgische band 'Crazy Date'.

In september werd door het personeel een bezoek gebracht aan een natuurgebied in wording: de Blauwe Kamer te Rhenen. 's Middags werd het nabijgelegen Ouwehands Dierenpark bezocht waar ons een blik achter de schermen gegund werd. In Muiden werd deze dag besloten met een Franse maaltijd.

De cabaretgroep 'Crème Fraîche', winnaars van het Groningse Studenten Cabaret Festival, lieten in november voor een volle zaal hun kwaliteiten zien.

ACRONYMS USED IN THIS ANNUAL REPORT

ACS	American Chemical Society
AGU	American Geophysical Union-3
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
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
CZCS	Coastal Zone Colour Scanner
DMS	Dimethylsulphide
DNZ-RWS	Dienst Noordzee-Rijkswaterstaat Directorate North Sea, Ministry of Transport and Public Works
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
ECOWASP	Ecosysteem Model Waddenzee
EGS	European Geophysical Society
EMBS	European Marine Biology Symposium
ENAM	European North Atlantic Margin
EPOS	European Polarstern Study
EROS-2000	European River Ocean System-2000
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
GEM	Global *Emiliania* Modelling
GEOMAR	Forschungszentrum für Marine Geowissenschaften (Kiel)
GIUB	Geological Institute, University of Oslo, Norway
GLOBEC	Global Ocean Ecosystem Dynamics
GOA	Geologie, Oceanografie, Aardwetenschappen Geosciences Foundation
IAEA	International Atomic Energy Agency
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
ICPF	International Conference on nonlinear dynamics and Pattern Formation
ICSF	International Conference on Stratified Flows
ICSU	International Council of Scientific Unions
IFREMER	Institut Français de Recherche pour l'Exploration de la Mer
IGBP	International Geosphere Biosphere Program (under ICSU)
IIOE	International Indian Ocean Expedition, 1959-1965
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
INDEX	Indian Ocean Experiment, 1979
INP	Integrated North Sea Programme
INQUA	International Quaternary Association
IUCN	International Union for the Conservation of Nature
IOC	Intergovernmental Oceanographic Commission
JGOFS	Joint Global Ocean Flux Study

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
MAFF	Ministry of Agriculture, Fishery and Food (UK)
MAST	Marine Science and Technology programme
MATURE	Biogeochemistry of the maximum turbidity zone in estuaries
MILZON	Inventariserend Macrobenthos Onderzoek in de Milieu Zonering op het Nederlands Continentaal Plat (Dir. Noordzee, RWS)
NAM	Nederlandse Aardolie Maatschappij Dutch Oil Company
NATO	North Atlantic Treaty Organization
NERC	Natural Environment Research Council (UK)
NIOP	Netherlands Indian Ocean Programme
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
NMI	Netherlands Measurements Institute
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 Atmosperic 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
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 Fishery Investigations
RUG	Rijksuniversiteit Groningen University of Groningen
RUU	Rijksuniversiteit Utrecht University of Utrecht
RWS	Rijkswaterstaat Department of the Ministry of Transport and Public Works
SEAS	Study of the European Arctic Shelf
SeaWIFS	Sea Viewing Wide-Field of view Sensor
SCOR	Scientific Committee on Oceanic Research
SETAC	Society of Environmental Toxicology and Chemistry
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
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
UGGI	Union Geodesique et Geophysique Internationale International Union of Geodesy and Geophysics
VU	Vrije Universiteit Amsterdam Free University Amsterdam
VUB	Vrije Universiteit Brussel Free University Brussels
WCRP	World Climate Research Programme
WOCE	World Ocean Circulation Experiment
WSG	Wader Study Group
XRD	X-Ray Diffraction
XRF	X-Ray Fluorescence