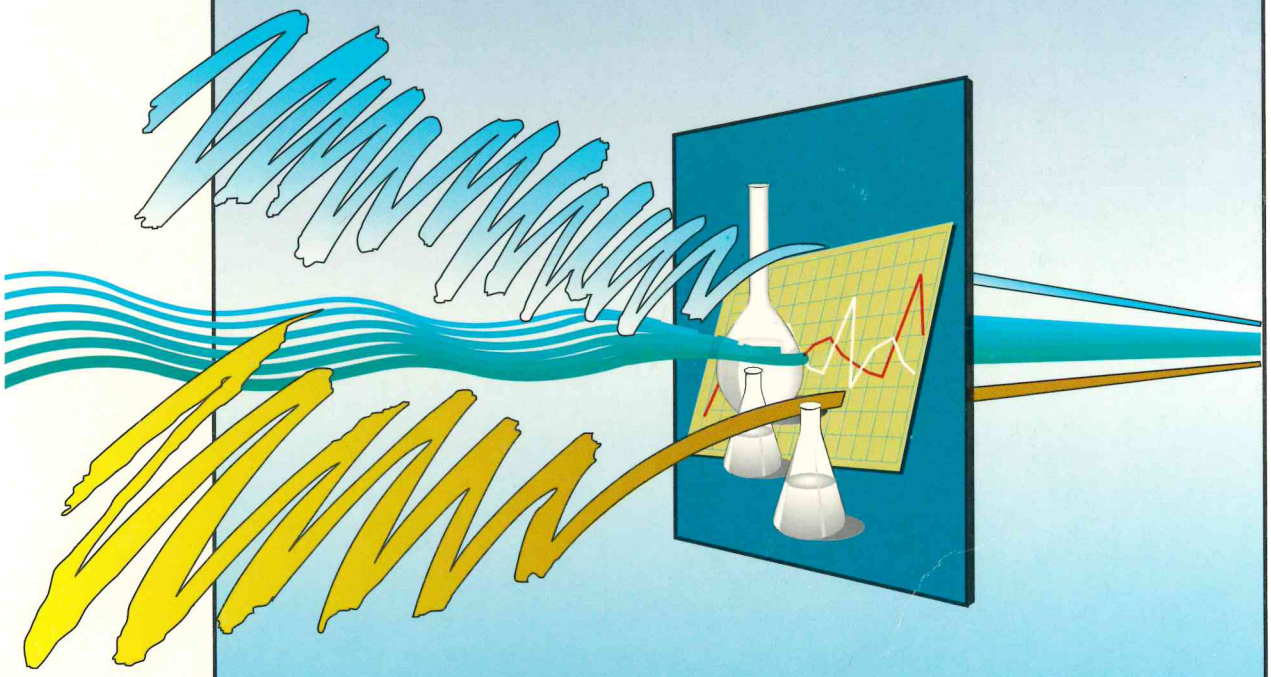
# ANNUAL Report 1996

Netherlands Institute for Sea Research
P.O. BOX 59, TEXEL
HOLLAND



NETHERLANDS INSTITUTE FOR SEA RESEARCH ( NIOZ )

NETHERLANDS INSTITUTE FOR SEA RESEARCH
ANNUAL REPORT 1996

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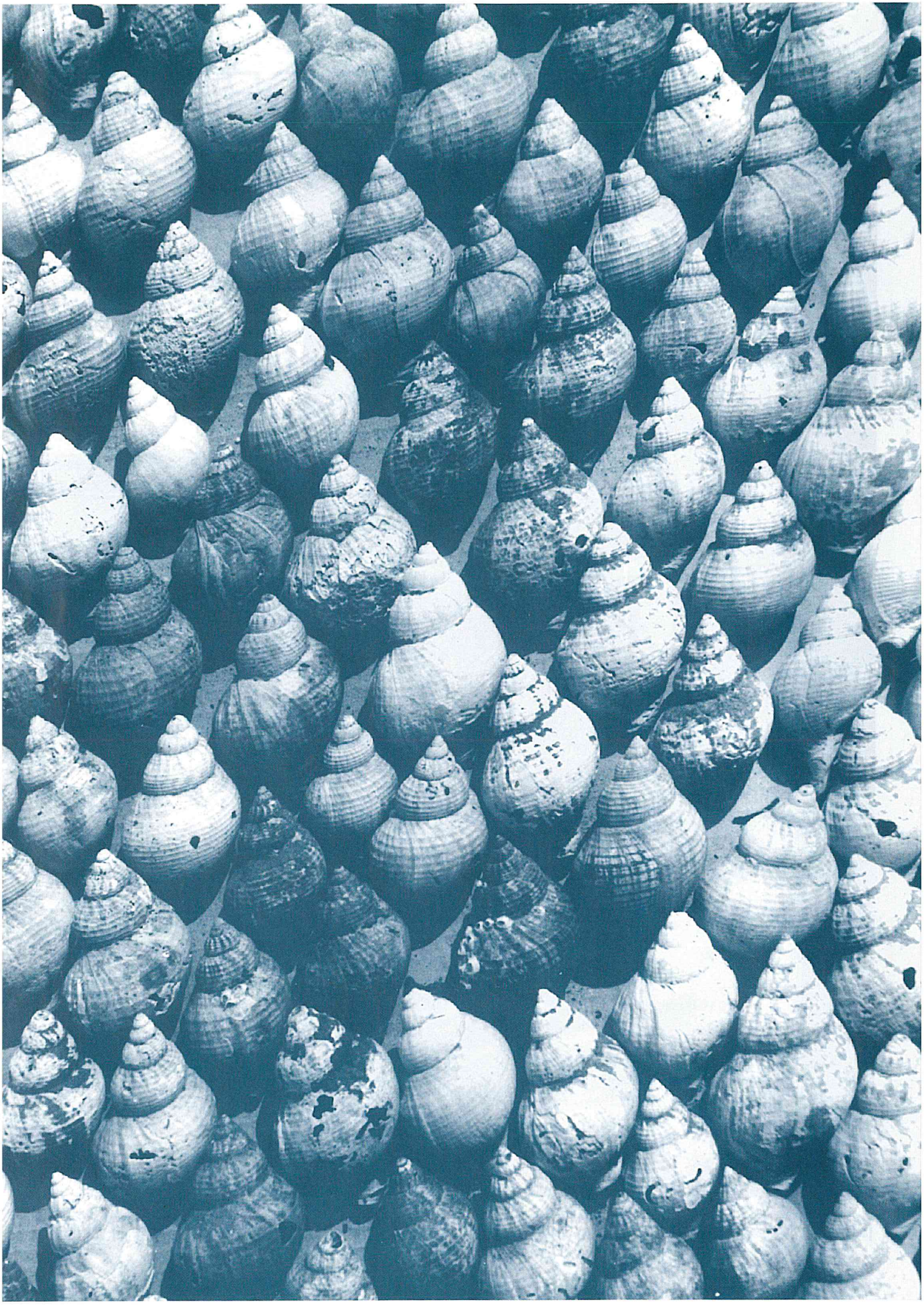
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Overfishing and tributyltin exterminated the whelk in the Wadden Sea, only empty shells remained.

The year 1996 has been a turbulent year, scientifically, financially, socially and in terms of management.

The second phase of the reorganization aiming at a significant decrease of the costs of exploitation on a structural base, could be carried out thanks to a major financial injection of NWO. The reorganisation has resulted in the termination of labour contracts of six technical staff members, the privatization of the cantine, the sale of the Journal of Sea Research to Elsevier Science BV (the editorial office remains at NIOZ, however), the privatization of the guest centre early 1997, a restructuring of several technical departments, an increase of the quality and efficiency of administrative and financial affairs and procedures and many other measurements aiming to reduce costs of exploitation. On the other hand financial room was created to attract young scientists, i.e. pre- and post-docs, and new staff members in the years to come to refresh and counterbalance the relatively old scientific staff.

The realisation of all these renewing activities has taken much energy and time. The efforts of a part-time consultant, Eelke Hemrica, have helped significantly to straighten out financial affairs. A full-time financial controller/manager will start work early 1997.

A business plan and an already updated version thereof have been presented to NWO and summarizes the financial and personnel budgets in the years to come. Although the severe deficits built up over the last years are felt as a heavy burden it is foreseen that these deficits are compensated before 1999 thanks to rigid budget cuts in 1996, 1997 and 1998.

Scientifically 1996 has been a good year, despite the impact of the reorganisation. In the first few months of this year the five department heads and the director produced a new science plan: Marine Science at NIOZ, Embedding, Organization, research topics and Future (1996-2000). It was decided to focus the major streams of research on two prioritized research items: Processes determining the transport of energy and matter in coastal, continental slope and oceanic systems and Marine system variability through time. Three scientific tools will be strenghtened: molecular biology, data management and modelling.

During the summer we were pleasantly surprised by the assignment of a second PIONIER grant, this time to Dr. Theunis Piersma. This significant funding will catalyse a major step forward in evolutionary research by studies at NIOZ and at the Univ. of Groningen related to predator-prey relationships of waderbirds and benthic macrofauna and on physiological and other effects of long-distance bird migration. This research will also benefit substantially from a newly-built unique waderbird facility (see figures) which opens unprecedented possibilities to study waderbird/benthic macrofauna relationships under simulated field conditions year-round.

Sea-going research was undertaken through expeditions with the RV Pelagia to study benthic processes a.o. in relation with effects of fishery activities, pelagic benthic coupling, variations in sediment transport during glacials and interglacials, palaeoclimatological phenomena, the role of currents along the eastern boundary of the north Atlantic gyres and to study toxicological effects on macrofauna. These programs were sponsored by the EC, GOA and BEON. GOA also sponsored a major expedition performed with the naval ship Tydeman in the Atlantic dealing with deep chlorophyll maximum phenomena. The success of this expedition was at least partly due to the excellent co-operation between the naval crew and the scientists. In the beginning of this year NIOZ scientists also participated largely in an Antarctic cruise with the Polarstern, a.o. to study $CO_2$ budgets, thanks to a grant from GOA.

After a visit of the Dutch Minister of Education and Science Dr. Ir. J.M.M. Ritzen and Senatorin B. Kahrs from Land Bremen of the FRG to NIOZ on 13 May, a proposal document has been prepared by researchers from NIOZ and the four Bremen institutes (University of Bremen, Institute for Tropical Ecology, the Alfred Wegener Institute and the Max Planck Institute for Microbiology) aiming to intensify the scientific, technical and logistic co-operation between the Netherlands and Germany in marine research. This major future co-operation will be beneficial for all institutes and may concentrate top research in oceanography in Europe. A major funding for this co-operation is expected for the next five years. In parallel and also based on a stimulus of Minister Ritzen concerning Dutch-German co-operation, funding was obtained by NIOZ and the research school of Sedimentology (NSG) on the Dutch side, and the Fachbereich Geowissenschaften of the Bremen University on the German side, to deepen palaeo-oceanographic research.

Within the Netherlands the co-operation with five research schools (Functional Ecology, Sedimentary Geology, Environmental Chemistry and Toxicology, School of Atmospheric and Marine Science, Biodiversity) has been intensified and co-operation contracts exist or will be realized with all of them. Initiatives have been taken to bundle the forces in Oceanography in the Netherlands through meetings concerning scientific and logistic affairs with NIOO-CEMO, the Geological Survey (RGD) (now operating under TNO) and the appropriate research schools.

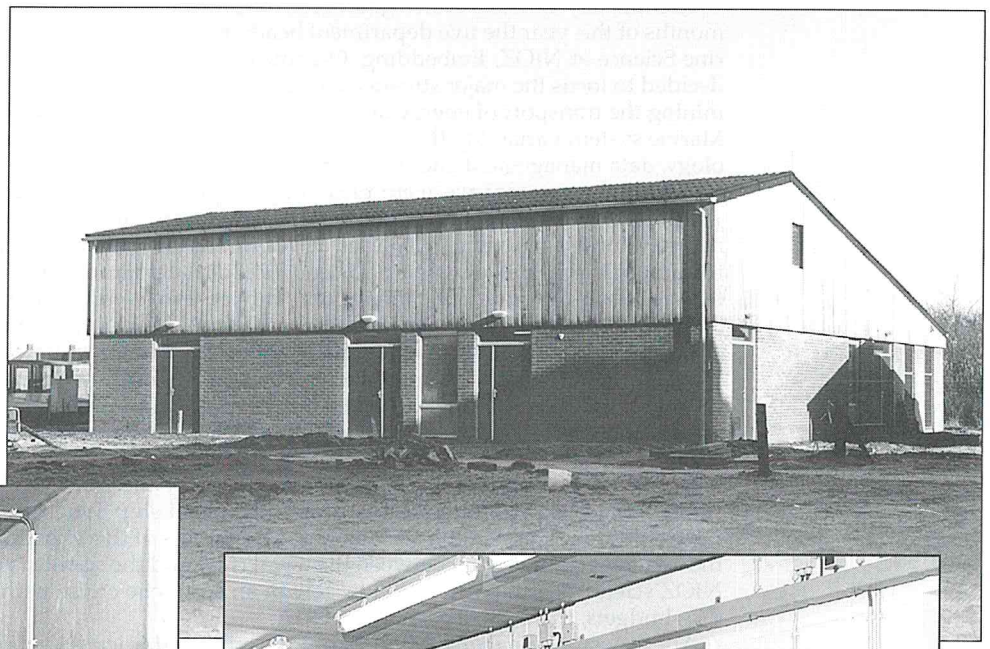
The new department head of the Department of Biological Oceanography, Dr. Gerhard Herndl, has been appointed and will start work at NIOZ by March 1, 1997. The position for the department head of the Department of Biogeochemistry and Toxicology will be advertised early 1997.

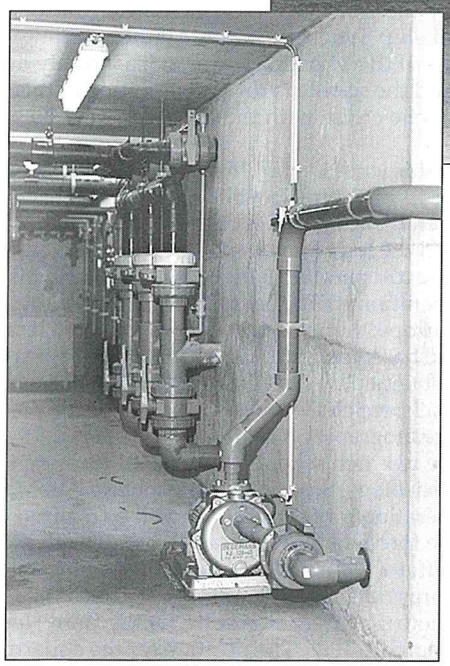
This annual report differs from the foregoing. No longer reports are provided on every project, only those completed in 1996 are dealt with and three multidisciplinary projects are given some more space. This change hopefully improves the readability of the report. In this new setup most NIOZ projects will be highlighted once in a period of 3-5 years. In addition lists of publications and other activities will as before give insight into the full range of scientific activities of NIOZ. In this way the annual report still provides the necessary data on the history of the institute as it did since its first issue in 1876.

It is remarkable and worthy of note that despite the managerial and financial constraints the output has been large: 125 peer-reviewed papers, 82 non-refereed papers, 12 reports, 61 posters and 243 oral presentations. 9 Ph.D Students received their degree in 1996.

At the conclusion of 1996 NIOZ is ready for the years to come having restructured itself. In particular the foreseen close Dutch-German co-operation is promising and may help NIOZ and the Bremen institutes to increase their quality of marine research through major international and multidisciplinary studies based on the integration of biological, chemical, geological and physical data on phenomena and mechanisms present in the sea.

Jan W. de Leeuw
Director







# 1. Scientific Activity

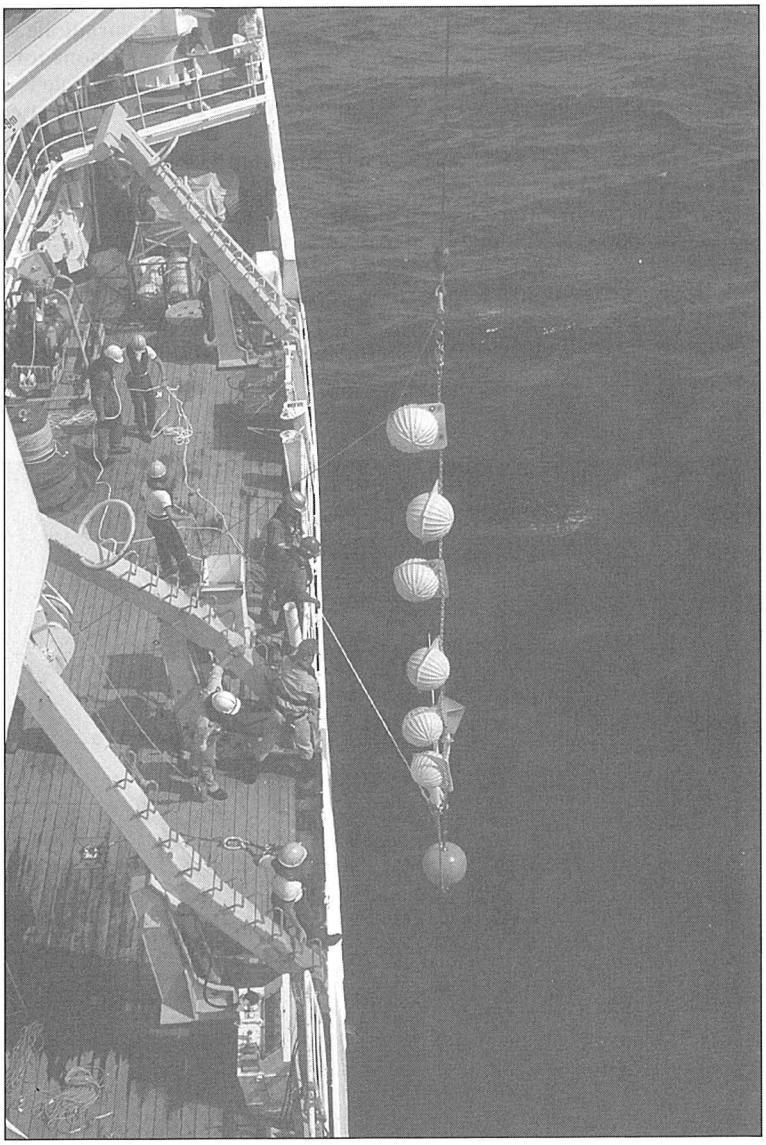


Photo: Taco de Bruin

# MULTIDISCIPLINARY PROGRAMMES

## THE DEEP CHLOROPHYLL MAXIMUM

**Contributors:** *H.G. Fransz and M.J.W. Veldhuis*

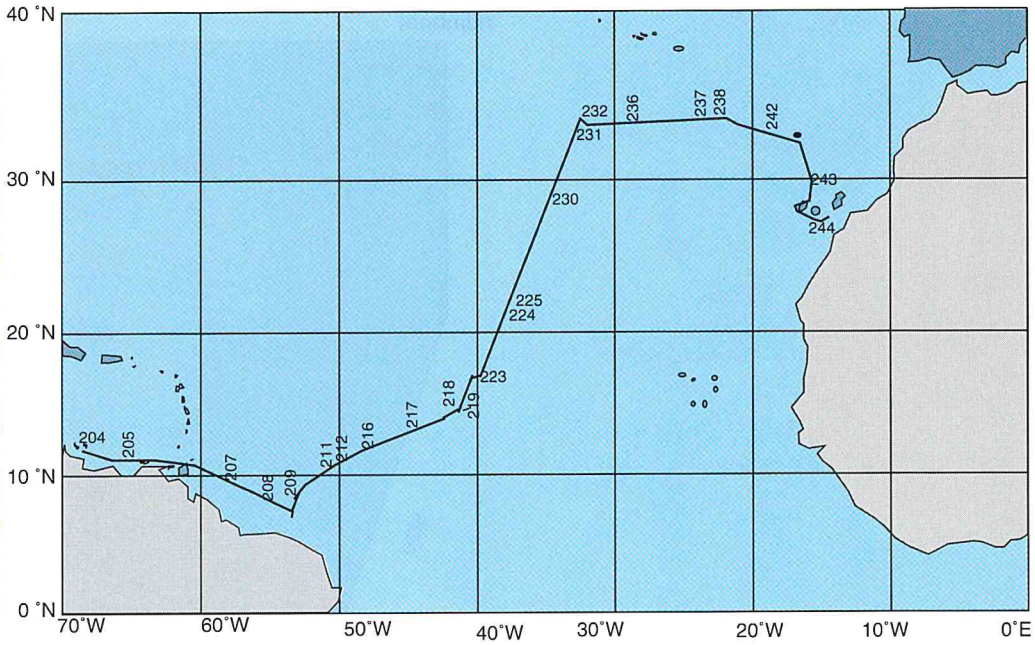
The cruise of the RV Tydeman was devoted to study permanently stratified plankton systems. In general these features are found in the tropical regions of all open oceans. These oceans' regimes show a strong vertical physical (thermal) and chemical (nutrients) gradient in the upper part of water column (less than 100 m). The strong stratification combined with the light gradient strongly affects the vertical distribution of phytoplankton. Due to the low nutrient concentrations at the surface the abundance of autotrophic algae is low. With depth, increasing nutrients and sufficient light give rise to phytoplankton biomass increases. A peak in chlorophyll can be found between 80 and 150 m depth and is usually called Deep Chlorophyll Maximum (DCM). Although the existence of the Deep Chlorophyll Maximum has been known for nearly half a century, its biology shows some remarkable characteristics not known until recent years. The 'discovery' of picophytoplankton (phytoplankton <2 µm) altered the view of the classical food web structure. The picoplankters *Synechococcus* spp. and *Prochlorococcus* spp. numerically dominate the DCM and, like bacteria, are prokaryotes. The phytoplankton primary productivity of these permanently stratified regimes is high. Concurrently, a high level of heterotrophic activity is responsible for the rapid regeneration of nutrients and organic carbon. Primary production and regeneration are in balance and, as a result, day-to-day variations in the chemical structure and biology are minimal.

The world-wide presence of the DCM under rather stable environmental conditions in (sub)tropical oceans and their apparent low temporal and spatial variations suggest an important role in the global oceanic ecosystems. Once we understand the reasons for this stability, we are able to predict its response to global environmental changes and the role it plays with respect to carbon cycling in the ocean. Based on this general concept the following aspects were studied in more detail:

1. What is the effect of the vertical light and nutrient gradients on species diversity and adaptive properties within a single species in the euphotic zone?
2. What is the nature of the interactions between the different trophical groups (phytoplankton, micro- and mesozooplankton and bacteria), and how do these interactions affect the global carbon and nitrogen mass balance?
3. How much of the organic carbon produced is exported to the aphotic zone?
4. If there are no significant day-to-day variations can there be diurnal variation in biological (growth/grazing) activity, and does this rhythm induce temporal variation in the different components?




RV Tydeman at the port of Willemstad, Curaçao, the Netherlands Antilles. Photo: Taco de Bruin.




Cruisetrack DCM 1996 Cruise. To minimise the effects by horizontal transport of nutrients and organic matter from river outflow and upwelling regions, stations were selected in the middle of the North Atlantic Ocean between the continents of America and Africa. (5 - 35° N and 50 - 15° W). Hr. Ms. Tydeman left Willemstad, Curaçao on 22 July 1996 and, after conducting a test series of seagoing instruments on 25 July, a transect of CTD casts was carried out on the continental slope of Guyana on 26 and 27 July to study inorganic carbon exchange between the southern and northern Atlantic ocean at different water depths. A detailed study of the DCM was conducted at 5 main stations.

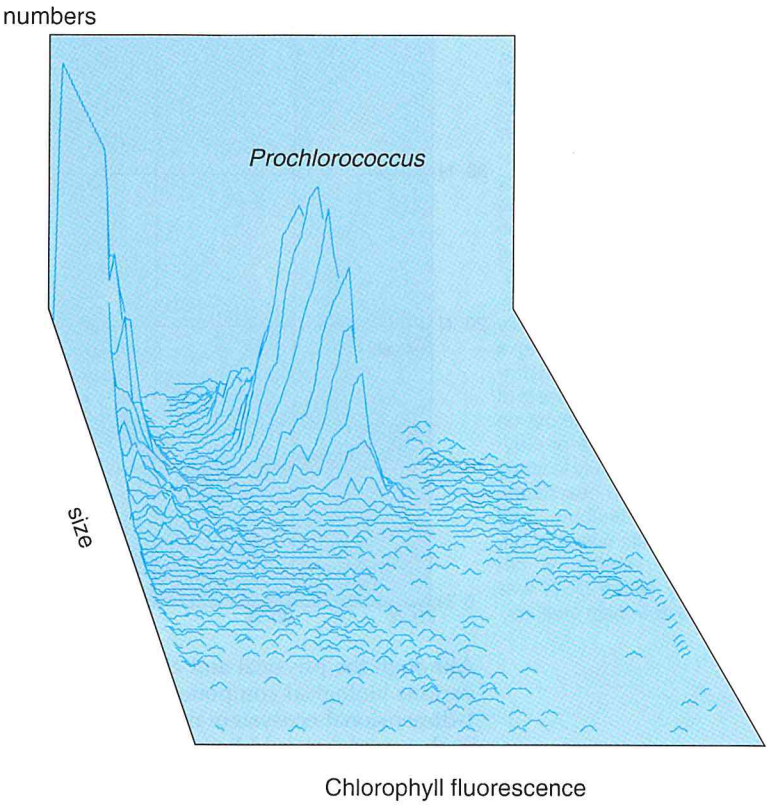
Although the physical and chemical structure of the DCM is well known our knowledge of the various biological components shows considerable gaps, which prevent us from constructing a 1-dimensional ecosystem model for the equilibrium and a mass balance of carbon and nitrogen. Such a model should be based on the trophic interactions and adaptive properties of the major biological components.

Briefly the following biological components are present in the euphotic zone. The primary producers include (large) nano- and (small) picophytoplankton. Both groups differ in their role within the microbial food-web. Primary grazers are mainly micro-organisms such as heterotrophic nanoflagellates and ciliates, which feed on small algae and bacteria. Heterotrophic bacteria can outnumber the autotrophic algae, because their number is related to the substrate pools of dissolved and particulate dead organic matter. These DOC and detritus pools reach equilibrium at a concentration where the rate of their production (proportional to algal biomass) equals their mineralisation and sinking rate (proportional to the concentration and weight of POC and detritus). At a relatively low value of the weight-specific loss rates, the equilibrium concentration of these carbon pools and their load of bacteria can be high. The bacterial productivity is proportional to the mineralisation rate, which in a steady state can never be higher than the rate of primary production. Hence the ratio in turnover rate of bacteria and autotrophs tends to be reciprocally proportional to their biomass ratio.

In a microbial food web, carbon and nutrients circulate between inorganic pools, autotrophs, bacteria, DOC and detritus, and the grazing microzooplankton. In (sub)tropical ecosystems changes in biomass tend to be small, but fluxes of carbon and nutrients between the various components can be high. Bacteria can stimulate primary production by mineralisation of DOC and detritus, but they also compete with the primary producers for nutrients. The microzooplankton reduce the number of algae and bacteria, but enhance their growth by regeneration of nutrients. This component can, however, induce instability by grazing down the algae to low levels and causing predator-prey oscillations.

The nutrient -algae-POC-detritus-bacteria complex by itself can reach a steady state when production and consumption of carbon and nutrients are in balance on a long term. In general these components, and changes therein, are considered to be mainly affected by the inverse light/nutrient gradient (depth). However, evidence is increasing that the microbial food web shows diel production cycles as a consequence of diurnal fluctuations in light conditions (12light :12dark). But in a system with only nutrient limitation of production there can be no over-exploitation of resources. Where grazing keeps the algae below an equilibrium level, the system is potentially unstable. Stability increases as the grazing pressure on algae is reduced. This can be the case when either the microzooplankton feeds mainly on bacteria and detritus, or when it is kept low by larger predators in the mesozooplankton.

The mesozooplankton forms the link between macrozooplankton and large marine invertebrates and vertebrates such as squids and fishes, which rise mainly at night to the euphotic zone to consume the secondary production. Mesozooplankton can feed on phytoplankton, microzooplankton and the detritus/bacteria complex. Macro- and mesozooplankton are the only plankton components capable of active vertical migration. By predator-prey control at different trophic levels mesozooplankton can affect the stability of the system.




Deep chlorophyll maximum.

**Preliminary results**

A pronounced DCM was found at all 5 main stations but each of them could be characterized by typical features (physical, chemical or biological) not present at the others. The first three stations showed the DCM layer at a depth of 80, 100 and 130 m, respectively. Concurrently, the peak layer showed a decrease in the fluorescence signal and a broadening of the peak. In the following two stations sharp DCM peaks were found at a depth of 100 m.

With respect to the physical structure two processes were weakening the stability of the upper water column. The first was double diffusion prominently present at the first two stations. Internal waves, on the other hand, with an amplitude of over 30 meters were also found. Both these processes will affect the vertical flux of matter as well as the daily amount of solar radiation received by the phytoplankton growing in the area of the critical depth (lower part of the DCM).

The optical profiles showed a pattern typical for open ocean water with verifying depth of the DCM (depth-range with only 1% to 0.1% of the incident irradiance). The highest abundance of particles however, was found above the fluorescence peak. Analysis of the particle distribution carried out with flow-cytometry confirmed this observation. Below a depth of 200 m the water column was extremely transparent indicating a low particle content.

As far as the nutrient distribution in the surface water layer is concerned, down to the peak of DCM, $NO_3$ was depleted. Over the same depth-range $PO_4$ and $NH_4$ were present in low but detectable concentrations. With depth the nutrient concentrations increased, however, the pattern was different for each station. Next to differences in absolute values the N/P ratio also varied. In the two Western Atlantic stations and the last station the N/P ratio was around 16. In the other two the ratio varied between 20 and 24.

The phytoplankton abundance, as examined with flow-cytometry, showed a numerical abundance of the prokaryotic phytoplankter *Prochlorococcus* in numbers up to 100,000 cells per ml. In terms of total phytoplankton biomass this species is responsible for 40 to 60% of the total chlorophyll concentration. Remarkably enough this species could be traced from the surface down to a depth of 180 m. The presence of *Prochlorococcus* over the whole euphotic zone indicates that this species must be capable of adapting to extreme light and nutrient conditions. At the surface nutrient concentrations are low but the light intensity is high. At the peak of the DCM and deeper sufficient nutrients are present but cells are existing in extremely low light levels. Cells adapt to these low light conditions by increasing their chlorophyll concentration thereby increasing the light capture properties of the cell. This process of increasing chlorophyll (> 10 fold increase) compensates for the decrease in light intensity.

Other phytoplankton species (i.e. *Synechococcus* spp. and small eukaryotic algae) were only ob-

served at shallow depths and are probably much more limited in their ability to adapt to the prevailing light and nutrient conditions.

A high frequency sampling programme (1.5 h interval for 30 h) showed that *Prochlorococcus* cell numbers increased at the end of the day indicative of a diel rhythm. Apparently during most of the day phytoplankton cells are actively producing new organic cell material by photosynthesis, but the actual onset of DNA synthesis and cell division is postponed till the end of the light period.

Diel patterns of the physiological activity were not restricted to phytoplankton. Bacteria also showed daily changes in activity and growth characteristics. Time course measurements of bacteria grown on different mixtures of organic carbon and nutrients (N and P) showed different growth curves. The organic carbon source stimulated particularly bacteria growth in samples collected in the morning. This observation was supported by the fact that the DNA synthesis rate was pronounced in the early morning (04:00 AM to 07:30 AM). On the other hand the highest protein synthesis rate was around noon. The different rates of DNA and protein synthesis in phytoplankton suggest a synchronization in activity and growth in the bacterial community. This observation is supported by the fact that even under high nutrient concentrations bacteria stopped assimilating nutrient for several hours, but resumed later. This daily shift in time of growth and physiological activity seems indicative for the synchronisation of bacterial activity.

Phytoplankton acts as a food source for microzooplankton (<200 µm in size) and this grazing activity can selectively be studied in specially designed experiments. Initial results from these grazing experiments showed not only moderate grazing activity of microzooplankton but also that it was limited to the upper part of the DCM (range 0.1 to 0.2 per day). The same region (surface to the upper part of the DCM) is also the zone with the highest primary production. Below, at the peak and bottom of the DCM, virtually no grazing activity took place. This gives the impression of an area with minimal biological activity and a slow turnover of organic carbon and nutrients.

An initial inventory of the larger organisms present (>50 µm) showed low numbers of net phytoplankton (with only a few long diatom chains) but a relatively high number of mesozooplankton (200 to 1000 µm size class). These large grazers were mainly copepods in the upper 200 m (mean abundance about 0.2 per l). Other experiments suggest that the smallest types of phytoplankton (picophytoplankton < 2 µm) were not a significant food source for these grazers but most likely microzooplankton.

## THE INTEGRATED NORTH SEA PROGRAMME (INP)

**Contributors:** *Hans van Haren, Wim van Raaphorst, Piet Ruardij, Fleur C. van Duyl, Herman Ridderinkhof, Kees Veth* and RWS-DNZ, RIKZ, MAFF (UK), Univ. Uppsala (S)

### The project

The North Sea is claimed to be one of the most intensively studied marine ecosystems, but detailed descriptions of the seasonal cycle of phytoplankton are of limited value. The available studies are based on sampling frequencies insufficient to resolve even the main features of the annual cycle, or on measurements in coastal stations close to marine laboratories and therefore not representative for the offshore environment. Since the end of the 1980's, the technology of oceanographic instrumentation allows a construction of a comprehensive data set, because moorable instruments capable of measuring biological parameters became available.

In July 1991 the Integrated North Sea Programme (INP) was launched to carry out an extensive field study to establish properly the variability of phytoplankton abundance in the central North Sea (water depth ~ 50 m) covering a full annual cycle. In contrast with shallower parts of the North Sea, which are well-mixed from surface to bottom throughout the year, this part of the North Sea becomes stratified in spring, after a period of sufficient insolation, and remains so through the summer (Fig. 1). In this area the water depth exceeds the sum of the depth of a wind mixed near-surface layer (typically 10-15 m) and that of a tidally mixed near-bottom layer (typically 10-30 m, depending on the current speed).

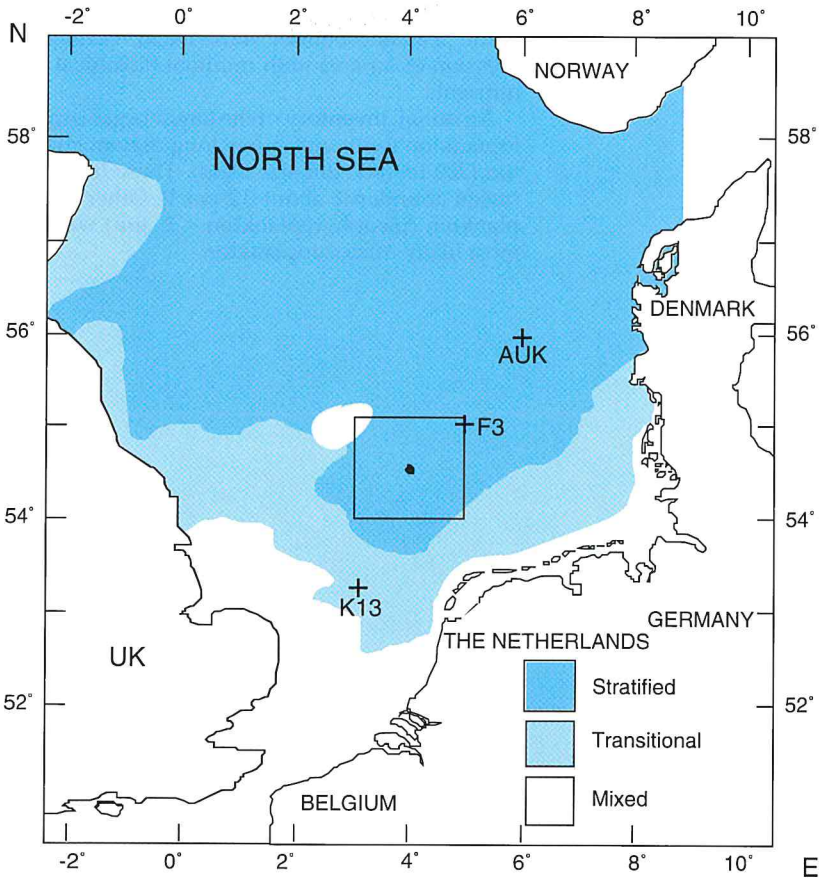



Fig. 1. Map of the INP research area (rectangle), the mooring site (●) and the platforms for meteorological data superposed on a general indication of the summer stratification extent.

At the start of the project, the idea was that the onset of a large phytoplankton bloom in spring will not occur before stratification is established and the surface mixed layer is shallower than the critical optical depth. For the open ocean on the other hand, some researchers predicted a spring bloom prior to, and even advancing in time, the onset of stratification. For the summer one assumed that in the central North Sea the two well-mixed layers are separated by a sharp and thin density jump (pycnocline), which acts as a barrier for vertical exchange of solutes. As nutrients are to be supplied mainly from the bottom in addition to local regeneration, such a physical system implies, under the assumption that the critical optical depth is not larger than the local water depth, a near-bottom mixed layer which is relatively light limited and a near-surface mixed layer which is relatively nutrient limited. Then, the maximum amount of phytoplankton is to be found

not in the photic zone proper, but rather near the pycnocline, i.e. roughly in the middle of the water column.

These concepts were verified during INP by studying the influence of atmospheric disturbances on the vertical exchange across the pycnocline. It was expected that such diapycnal mixing events and the associated short-term bursts of fluxes of nutrients (and perhaps phytoplankton) between the near-bottom and the near-surface mixed layers would happen irregularly in time, and might have longer-term impact on the pelagic biology, especially the phytoplankton species composition, abundance, productivity and sedimentation.

Newly developed moorable instruments were used to sample the relevant physical, biological and chemical data over long periods of time (up to a year) and at a sufficiently high rate (at least once an hour). This provided a test for future long-term unmanned oceanographic monitoring. Finally, the data were used to initiate and calibrate a new coupled model for the lower trophic levels in the pelagic system.

Initiated at NIOZ, the project has been partially financed by the institutes indicated above and by the Dutch governmental agency NWO (VvA and GOA), the national BEON programme and the EC-MAST programme (ERSEM-II).

## Logistics and technology

The INP mooring site is located in the central North Sea, Oyster Grounds, at 54° 25' N and 04° 02' E, where the waterdepth is about 45 m (Fig. 1). The location is well within the region of seasonal (thermal) stratification. Although the site has been chosen with care to be well away from frontal zones marking the transition between stratified and totally mixed waters, frontal meandering and the advection of patches of phytoplankton and suspended matter were detected at times during the study, thereby complicating the analysis. Sedimentologically, the area may be characterised by temporal deposition with sedimentation during periods of calm weather and erosion during stormy periods, especially in winter.

The site has been studied between July 1991 and February 1995, with instruments in place during about 29 months. In 1991 the summer period has been covered, in 1992 the late winter and summer periods, in 1993 the spring period (with bad data return) and from November 1993 onward the site has been occupied for fifteen consecutive months. During 18 days in July 1994 an extensive study of the pelagic-benthic coupling was performed under the separate code name STED (Short TErm Dynamics).

In 1991 every two weeks, and, in later years, at least once a month the mooring site was visited by the R.V. Pelagia (NIOZ) or the R.V. Holland (RWS-DNZ) for instrument servicing and additional sampling for calibration and hydrographic purposes. During STED extensive sediment sampling was performed using ship-borne instrumentation in addition to moored sediment traps. Through very careful ship handling by the crew of the R.V. Pelagia, a grid of 17 benthic stations was sampled within 500 m of the moorings at different phases of the tidal cycle.

Moored self-contained instruments were to sample physical parameters (current, density (temperature), radiation and meteorological parameters) and bio-geochemical parameters (chlorophyll-a, nutrients, suspended matter). This data acquisition required some techniques recently developed (especially for bio-optical and acoustic instruments) and technology development (in-situ nutrient auto analyzers). Adopting the two-layer model for the stratified water column, the mooring of two instruments of every type is at minimum, when one instrument is moored in the near-surface layer and the other in the near-bottom mixed layer.

During the full period of the study the water temperature was monitored at every 2 m from surface to bottom using coupled thermistor strings suspended from a surface buoy (Fig. 2). All other

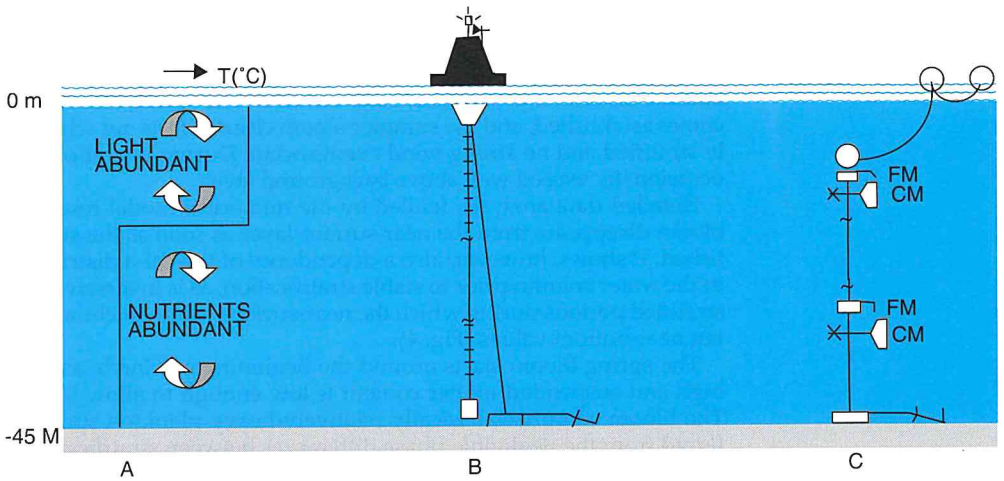



Fig. 2. Diagram of the types of mooring used during INP (B,C), and the "classic" two-layer stratification, indicated by the temperature profile as a function of depth (A). B/ Surface mooring with meteorological data buoy and thermistor strings. C/ General mooring with current meters (CM) and fluorometers (FM).

moorings contained a sub-surface buoy that became moored at a depth of about 10 m to avoid too severe wind-induced current and wave action, typical for the North Sea, thereby omitting the monitoring of the upper 12 m of the water column. From early 1994 onward, after a grant from NWO, the instrumentation became more suitable for the aim of the study as it was supplemented, a.o., by acoustic Doppler current profilers (ADCP) which can sample all three velocity components every 0.5 m between 3 m above the bottom and about 7 m from the surface, a wave-tide recorder, moorable transmissometers, additional fluorometers and *in-situ* nutrient (NOx) auto analyzers.

The sampling rate varied from once per minute (ADCP) to once per hour (optical instruments), so that a hitherto unachieved detailed set of data was obtained spanning long periods of time. Although relevant biological time scales typically are about one day, and largest forcing is expected on synoptic scales of one to five days, the relatively high sampling rate was needed to resolve (internal) tidal effects. The fast sampling of the ADCP was used in an attempt to estimate directly vertical fluxes of matter and momentum, but due to the problems with this instrument only a limited span of time became covered with good data.

Similarly, the additional development and the many troubles, which needed to be solved during the study, resulted in little good data harvest from the *in-situ* nutrient auto analyzers. Overall, the loss of data amounted for the moored instruments to about 30%, of which some 10% was due to complete mooring and/or instrument loss. Due to bad weather conditions about half of the hydrographic surveys scheduled could not be completed.

The general conclusion after the field study was that such sophisticated moorings are not yet adequate for long-term, routine oceanographic monitoring purposes, as most instruments need too much attendance by regular in-situ calibration and servicing. Instruments measuring physical parameters may remain unattended for a period of a year (thermistor string, ADCP) or three months (current meters, meteorological instruments). Biological parameters can be obtained without servicing and *in-situ* calibration data for two to four weeks (bio-optical instruments), whereas almost permanent attendance is, still, needed for instruments measuring chemical parameters such as nutrients.

## Modelling

A reduced set of daily averaged observations has been invoked to initiate and calibrate a one-dimensional integrated ecosystem model, which was forced with meteorological and current data measured at the INP site. The purpose of the modeling was to further unravel the relevant factors contributing to phytoplankton dynamics during the annual cycle.

In the physical submodel an integrated mixed layer model is used in which the exchange between the surface and bottom layers and the (initially non-turbulent) pycnocline is governed by en-/detrainment. After calibration some background diffusivity had to be invoked for the pycnocline in order to simulate the gradual increase of temperature in the near-bottom mixed layer. By its one-dimensional nature, horizontal advection is not accounted for in the model.

The rather sophisticated ecosystem component, which has been based upon the ERSEM model, describes biological and chemical processes in the water column as well as in the sediment and consists of nine functional groups to describe pelagic biology, ranging from bacteria to carnivorous zooplankton. The dynamics of chemical variables like nutrients are fully coupled to the biologically driven processes. Early diagenetic transformations and fluxes of organic matter and nutrients in the sediment and across the sediment-water interface are included explicitly.

## Results

The 1994 yearlong series of near-surface chlorophyll-a (chl-a), as extracted from fluorescence observations is shown in Fig. 3, along with the variation with time of the thermal stratification and the wind speed (cubed). The familiar two phytoplankton blooms per year are seen, one in spring and the other in late summer/early autumn. The spring bloom develops before stratification becomes established, and the summer bloom clearly starts out while the water column is still strongly stratified and no strong wind events occur. During winter observed and modelled chl-a levels occasionally exceed well above background level.

Detailed data analysis, fuelled by the numerical model results, shows that indeed the spring bloom disappears from the near-surface layer as soon as the stratification becomes solidly established. It shows, however, also a dependence of the chl-a distribution on the turbulence intensity in the water column prior to stable stratification, as is inversely inferred from, short-lived, weakly stratified periods during which the near-surface values of chl-a decrease at the expense of increasing near-bottom values (Fig. 4).

The spring bloom starts around the beginning of March, as soon as irradiation is sufficiently high and suspended matter content is low enough to allow light to penetrate sufficiently deep. The bloom comprises basically relatively heavy plankton species, i.e. mainly diatoms, as is inferred from the negligible phase differences between stratification rate and the rate of chl-a variation with time. The full use of available nutrients and the extent of the bloom in this time of the

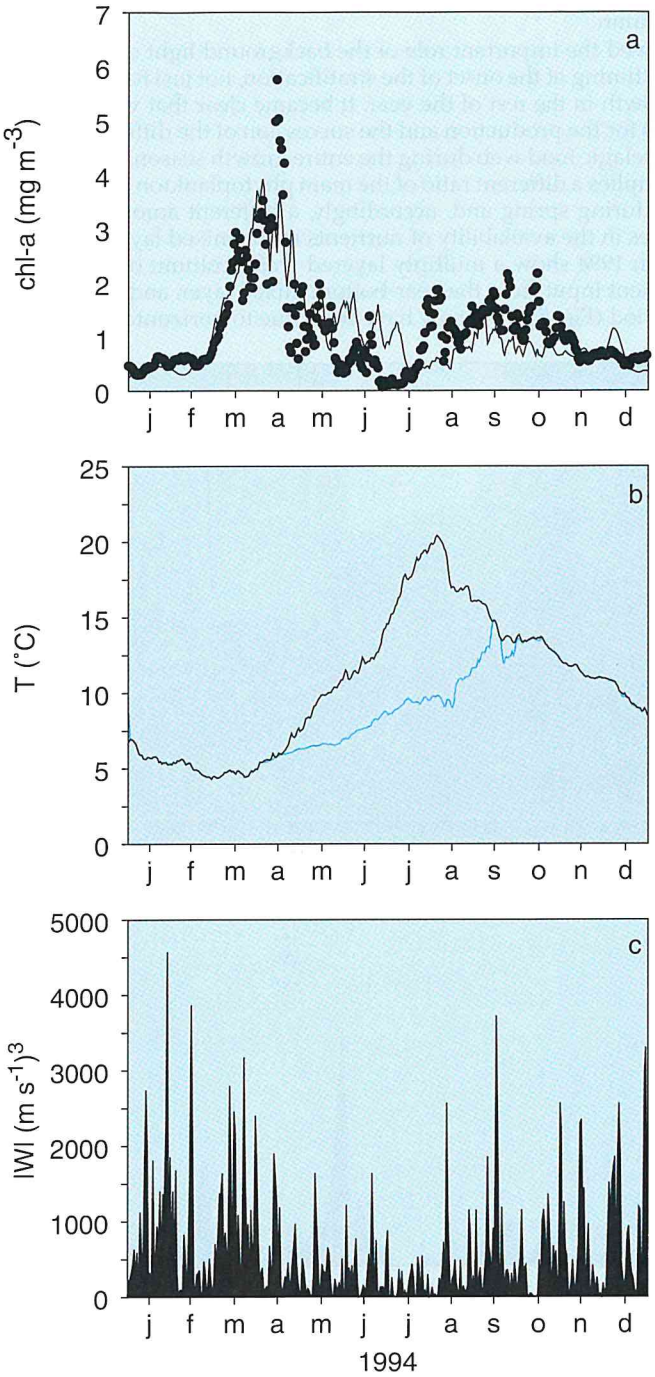



Fig. 3. A selection from the 1994 data. a. Chlorophyll-a (chl-a) at 13 m depth derived from fluorescence data (dots) and from the numerical model (solid line). b. Temperature measured at 2 m from the surface (solid line) and at 2 m from the bottom (dashed line). c/ Wind speed (cubed) measured at AUK.

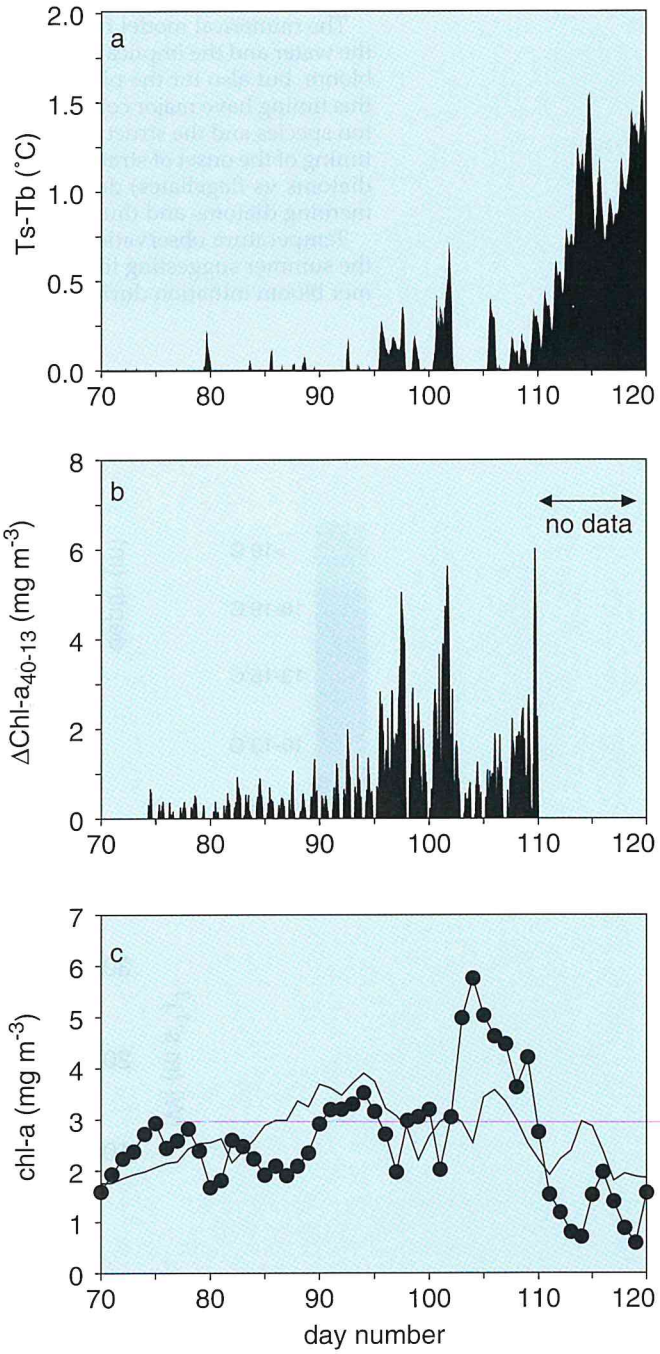



Fig. 4. Spring 1994. a. Hourly averaged observed water temperature difference between 2 and 43 m depth. b. Hourly averaged observed chl-a difference between 40 and 13 m depth. c. Daily averaged chl-a at 13 m as observed (dots) and modelled (thin solid line).

year thus depend on subtle variations in time between short periods of stratification, when diatoms and suspended matter sink to the bottom and the water column becomes clearer, and short periods of mixing, by which diatoms are brought back into the photic zone.

No observational evidence has been found for the spring bloom to enhance the (onset of) stratification, which seems typical for the open ocean. No evidence has also been found for the opposite situation, in which the stratification favours the spring bloom, which seems typical for shallow seas like the central North Sea. The analysis does show that the turbulence intensity critically influences the growth and that the spring bloom declines as soon as the stratification be-

comes well established. Curiously, one thus could use the phytoplankton as an indicator for the turbulence intensity in the water column.

The numerical model further showed the important role of the background light extinction in the water and the implications of the timing of the onset of the stratification, not just for the spring bloom, but also for the plankton growth in the rest of the year. It became clear that variations in this timing have major consequences for the production and the succession of the different plankton species and the structure of the pelagic food web during the entire growth season. A different timing of the onset of stratification implies a different ratio of the main phytoplankton groups (e.g. diatoms vs flagellates) developing during spring and, accordingly, a different amount of sedimenting diatoms and thus differences in the availability of nutrients in the mixed layers.

Temperature observations made in 1994 show a multiply layered water column over most of the summer suggesting limited nutrient input from the near-bottom mixed layer, and yet, a summer bloom initiation during that period (Fig. 5). This may have been due to horizontal advection

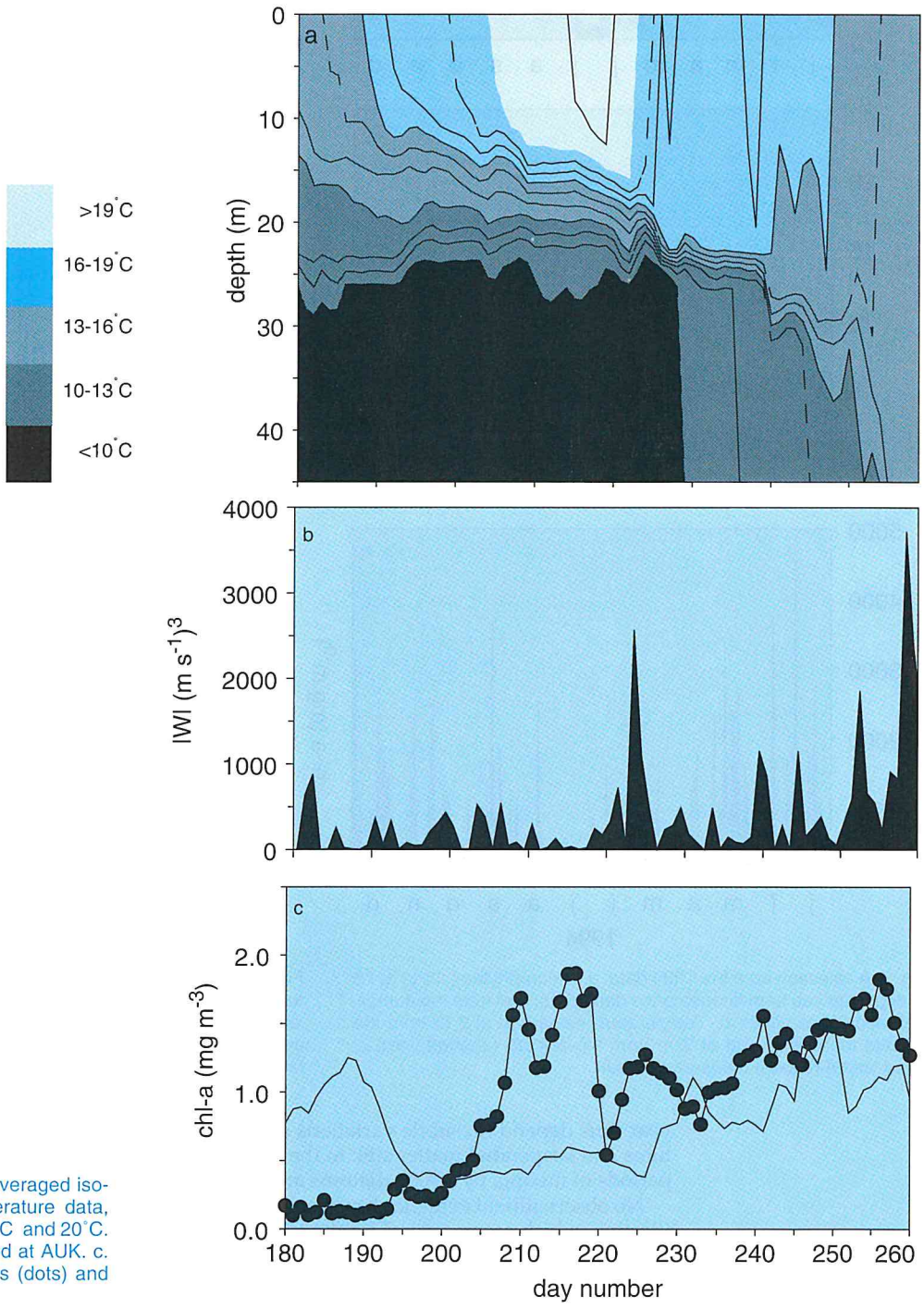



Fig. 5. Summer 1994. a. Daily averaged isotherms, as inferred from temperature data, and drawn every 1°C between 9°C and 20°C. b/ Wind speed (cubed) measured at AUK. c. Chl-a at 13 m from observations (dots) and the model (thin solid line).

as the hydrographic survey at the time showed strong frontal activity. On the other hand, from the ADCP data it became clear that the stability of the water column in terms of Richardson number frequently became critical during that period, due to strong current shear across the pycnocline induced by indirect atmospheric effects, i.e. inertial oscillations. Some support for exchange across the pycnocline, though statistically barely significant, was provided by the observations of periods of enhanced vertical matter fluxes as directly estimated from the ADCP data.

The early summer bloom was not confirmed by the numerical model, which simulated only a late summer bloom some three weeks later, when after a strong wind event the multiple layers reduced to a sharp and thin pycnocline and the classic two-layer system became established (Fig. 5c). This discrepancy between model and observations is explained by the lack of the physical mechanism, causing increased vertical mixing in the model, and possibly, by the role of horizontal advection. Nonetheless, from both the model and the observations atmospherically induced exchange has been inferred across the pycnocline during late summer. The development of the late summer bloom is more strongly governed by convective mixing rather than wind mixing, as has been found after examination of the 1991 and 1992 observations.

From the 1994 observations it was also concluded that light is not entirely limiting production in the near-bottom layer during summer. At the INP location no, or just weak, sub-surface maxima in chl-a content are found near the pycnocline. Prior to the onset of the late summer bloom, the highest concentrations of chl-a are found evenly distributed over the entire near-bottom mixed layer. This has been supported by the outcome of the numerical model (Fig. 6).

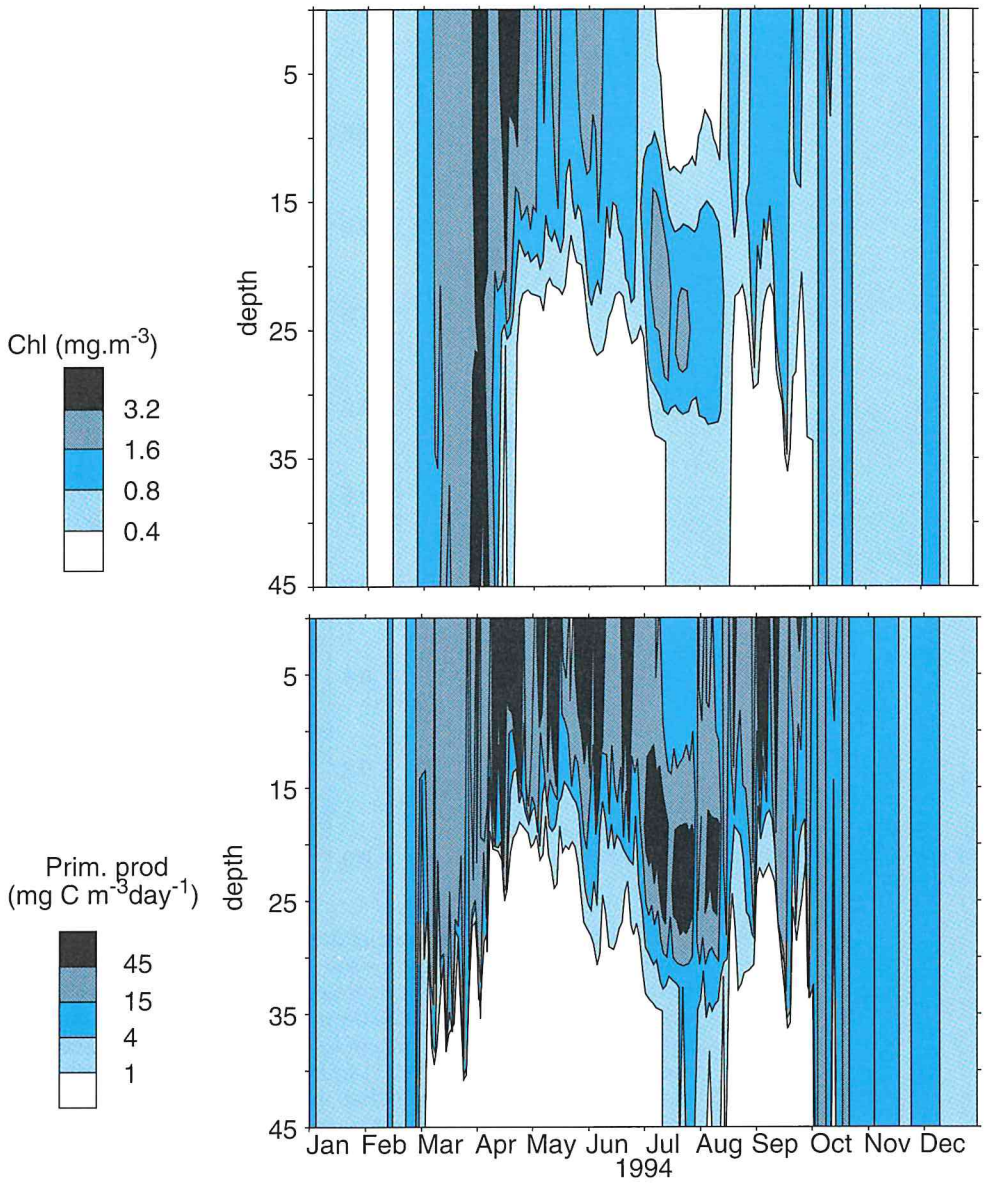



Fig. 6. (top) Simulated vertical distribution of chl-a in 1994. (bottom) Simulated vertical distribution of primary production in 1994.

During July 1994 an extensive study has been made of the particle accumulation on the sediment and resuspension and the response of microbenthos upon changes in net sedimentation of organic matter/ phytodetritus. The study on the pelagic-benthic coupling revealed that, indeed, the INP site functions as an area where sediment is accumulated in summer, but most likely re-eroded during severe storms in autumn and winter. Although the full period of measurements was undisturbed by any severe weather, resuspension of bottom fluff material occurred at maximum current during spring tide. This fluff was strongly enriched with organic carbon compared to the bulk sediment and, as has been inferred from the C/N ratio, it contained fresh plankton material at some occasions. Mass fluxes in the sediment trap moored a few meters above the bottom almost completely consisted of resuspended fluff that resettled to the bottom. These trap fluxes showed a distinct tidal cycle with highest fluxes directly after low water slack tide, when low current speeds and high concentrations of suspended matter and phytoplankton stimulated floc formation.

The deposition fluxes did not bring about measurable responses of the microbenthos, probably because variations in benthic bacterial production due to the heterogeneity of the bottom exceeded all other variations. The input of the phytopigments chloropyll-a and fucoxanthin (which are indicators for fresh phytodetritus) to the sediment was less than the degradation of these pigments in the sediment. Thus, phytopigments disappeared from the sediment during the STED period at a rate of ~0.06 $d^{-1}$ corresponding to a turnover period of ~17 days. The fact that this decrease in phytopigments was not reflected by a decrease in benthic bacterial production, implies that the turnover of total available bacterial food must have been slower than that of the phytopigments (Fig. 7). It is concluded that phytopigments may be good spatial indicators of food for bacteria, but rather poor indicators of the quantity of food available for bacterial uptake in sediments.

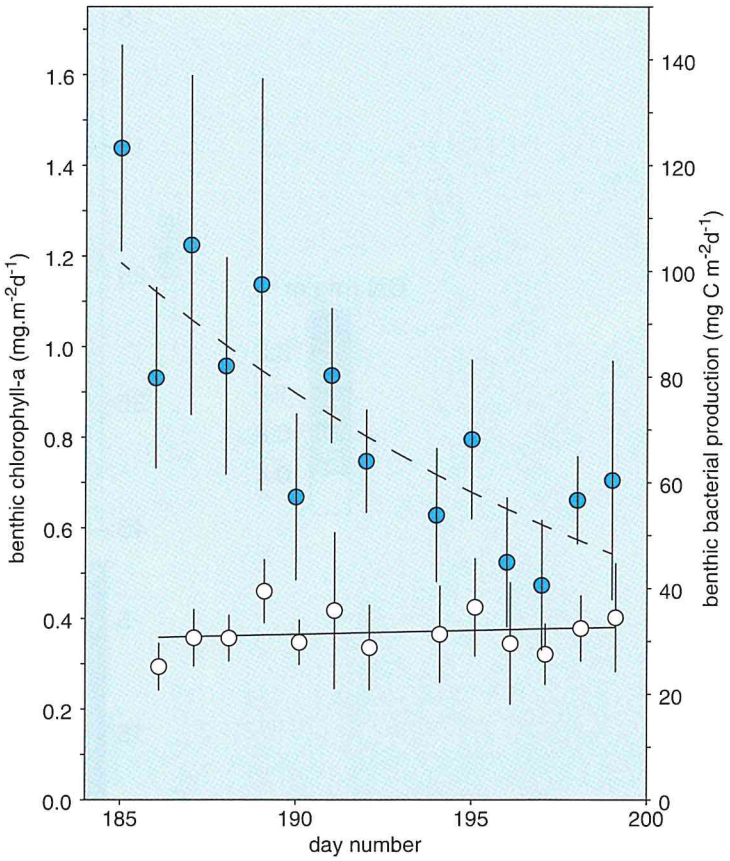



Fig. 7. Summer 1994. Daily averaged chl-a concentrations and benthic bacterial production in the 3 mm sediment surface layer.

The deposition of total suspended matter (TSM) and organic carbon has been further analysed with a simple advection-deposition-resuspension model (Fig. 8). From the model, a net accumulation of 75 g $m^{-2}$ has been calculated for a two weeks period, corresponding to a sediment accretion rate of 1.5 mm $year^{-1}$. The input of organic carbon associated with this accumulation was 115 mgC $m^{-2}$ $d^{-1}$ , which is sufficient to fuel the benthic bacterial production as measured in the surface sediment (32 mgC $m^{-2}$ $d^{-1}$) and probably also the production of the other benthos. It has been also inferred from the model that, in addition to the net accumulation, material is deposited temporarily on the sediment and resuspended again after 1-2 weeks. During this retention in the sediment, organic matter may provide an additional source of food to the benthic community, and thus may be decomposed substantially before resuspension and further transport across the North Sea.

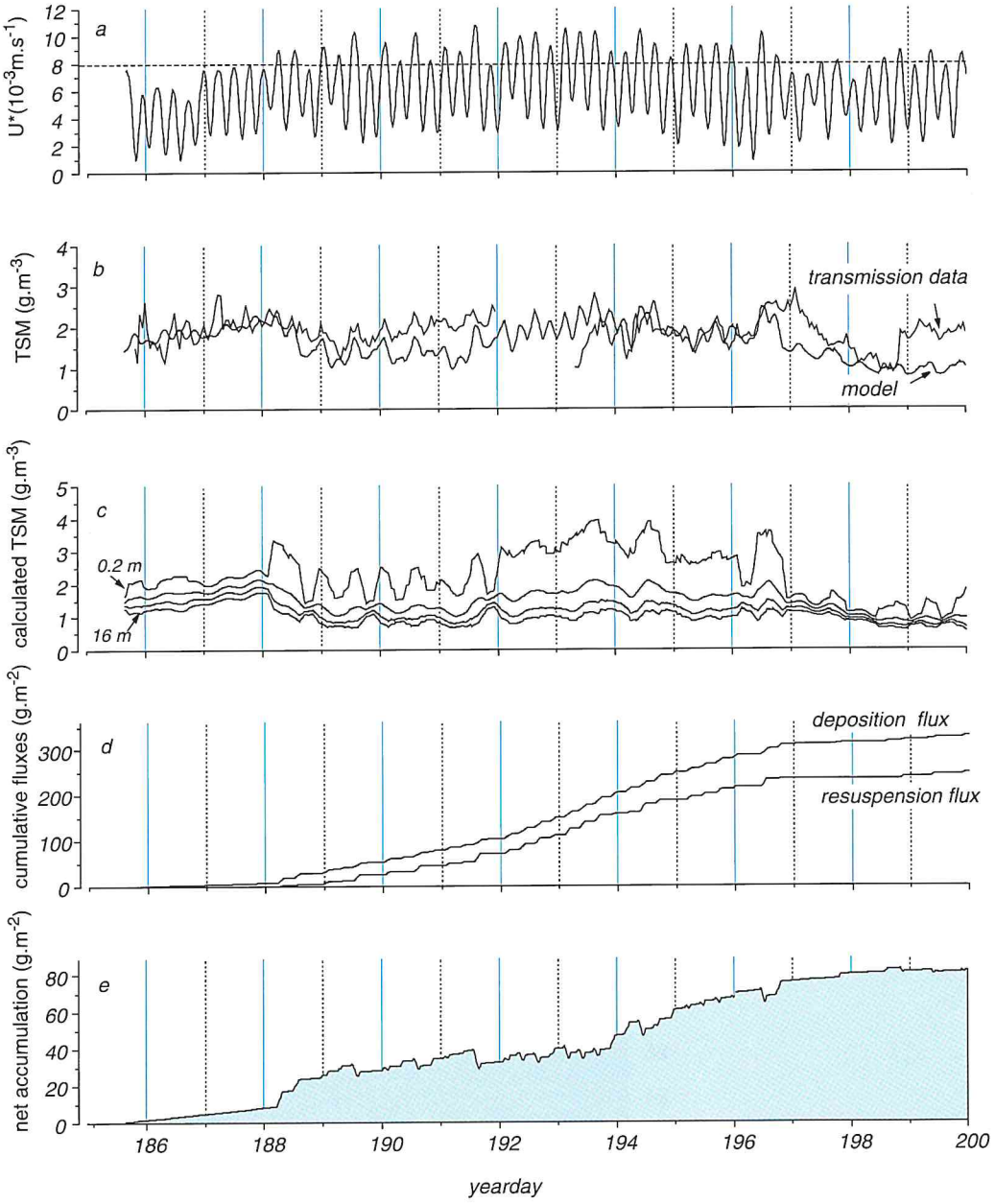



Fig. 8. Results from the advection-deposition-resuspension model calculations for Total Suspended Matter (TSM) in July 1994. a. Friction velocity U* at the seabed, calculated from current meter data at 1.5 m above the seabed (mab). b. TSM at 4.5 mab as calculated (thick line; 3 h averages) and measured (thin line; hourly data). c. TSM calculated for different depths (0.2, 6, 11 and 16 mab). d. Calculated cumulative fluxes of deposition and resuspension. e. Calculated cumulative net accumulation of particulate matter on the sea bed.

## Conclusions

- Sophisticated moorings are not yet adequate for long-term, routine oceanographic monitoring purposes, as the instruments generally need too much attendance by regular in-situ calibration and servicing.
- No observational evidence has been found for the phytoplankton spring bloom to enhance the (onset of) stratification or (vice versa) for the stratification to favour the spring bloom. Instead, a spring bloom is found before the stratification becomes well established and, prior to that, a subtle dependence of the evolution of the spring bloom has been found on the turbulence intensity in the water column. The timing of the onset of stratification is critical for the entire growth season.
- In summer no clear sub-surface maximum in chl-a was observed at INP, because sufficient irradiation reached to the bottom. Despite the strong stratification, a bloom developed after a strong (convective) mixing event in late summer, and another one also prior to that, probably after internal mixing events induced by strong current shear across the pycnocline, although the role of horizontal advection could not be ruled out entirely.
- Given the fact that the period of measurements on pelagic-benthic coupling was undisturbed by any severe weather, the bottom at the INP location has been found to accumulate suspended material during summer. The input of organic carbon provides sufficient food to sustain the benthic fauna. Phytopigments have been found good spatial indicators of food for bacteria but rather poor indicators of the quantity of food available for bacterial uptake in sediments.

## SWIRLING SEAS: TEMPORAL DYNAMICS IN MARINE ECOSYSTEMS

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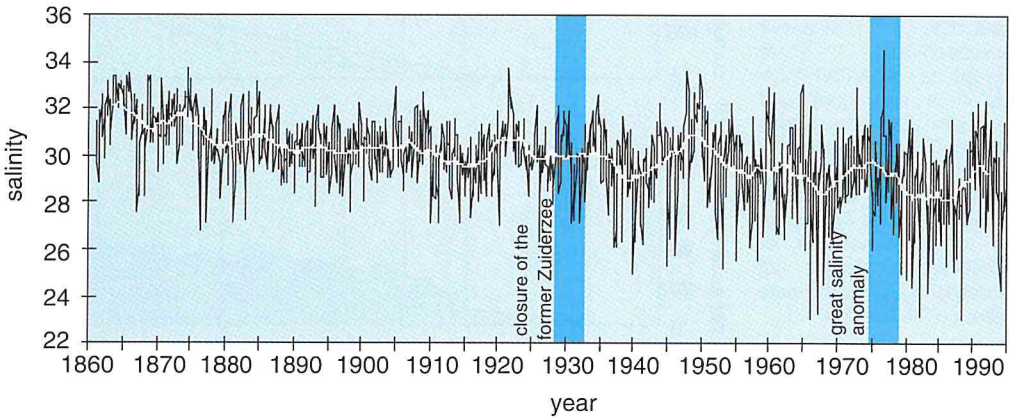
### Muddy waters

The NIOZ is located amidst the turbid and turbulent waters between the Wadden Sea and the North Sea. The physical conditions governing these marine ecosystems are far from constant. Tides and wind mix the ingredients of coastal waters originating from the ocean and rivers. Water temperature varies between ice-covered -2°C during severe winters and almost 20°C in warm summers.

Within this ever-changing world, marine plants and animals survive and reproduce. During their lifetime, they must deal with the fluctuations in the physical environment but also with variable densities of prey, competitors, predators and parasites. This entire coastal ecosystem is furthermore influenced by human activities such as fishing, land reclamation, eutrophication and pollution. Long-term observations on the temporal and spatial scales of the variations in abundance of marine plants and animals may reveal key-factors that govern the ecosystems of our surrounding waters.

### A long history

Salinity and temperature in the Marsdiep were daily measured by scientists of the Netherlands Institute for Fisheries Research (between 1861 and 1875) and the Zoological Station in Den Helder (from 1876 onwards), to examine, amongst other things, the possible relationship between these parameters and the varying numbers in fish recruits. The measurements were extended by an additional series on the northern site of the Marsdiep in 1947. From 1930 onwards, fish and invertebrates that were bycaught by commercial fishermen were delivered to the Zoological Station. This activity was ended as a result of the closure of the marine research facilities on the mainland in 1991. Most surveys of marine organisms, however, did not start before the change of the Zoological Station into NIOZ in 1960, and several series were initiated only after the institute moved to Texel in 1969.

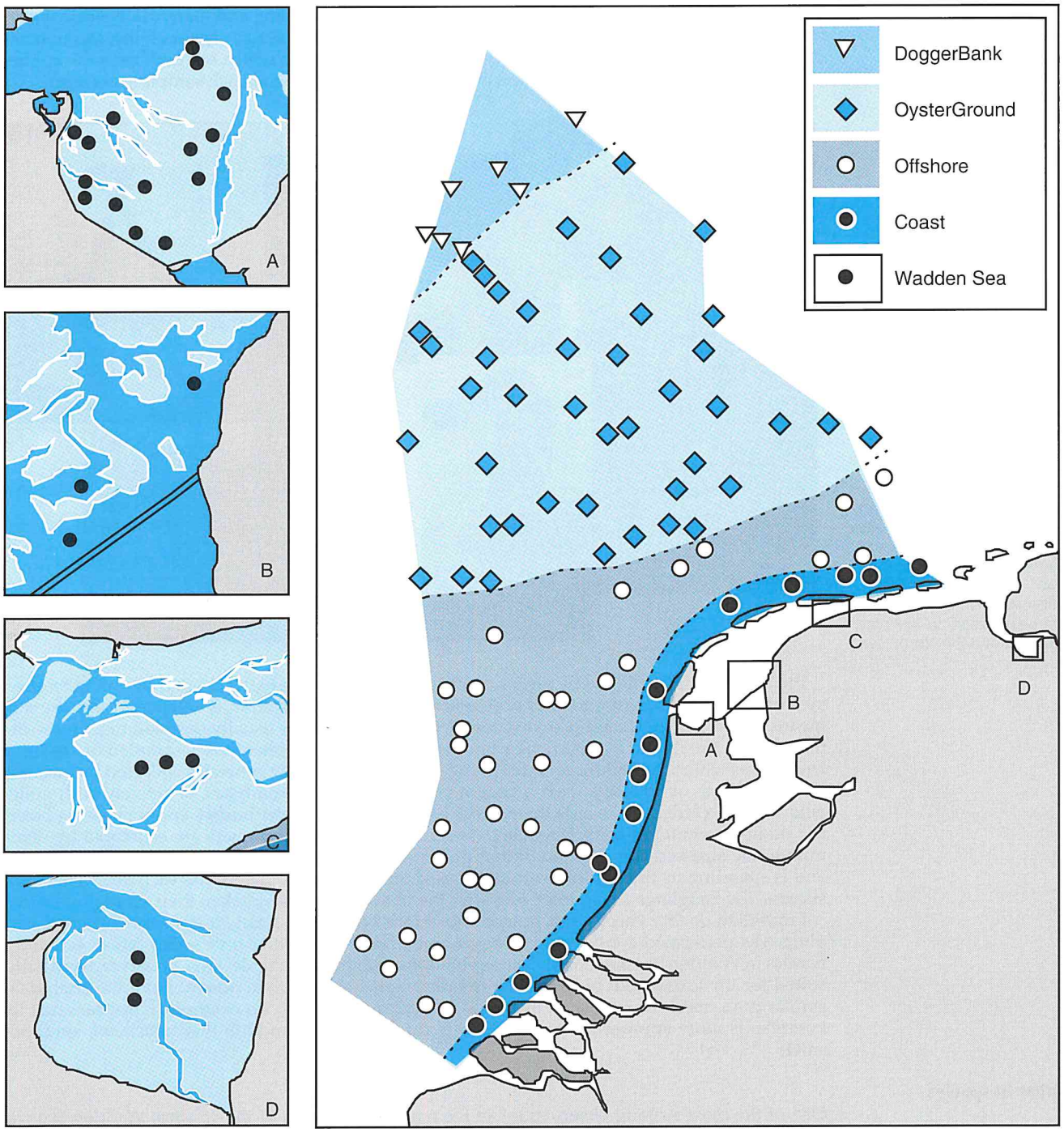



Monthly means and running averages (n = 60 months) of salinity in the Marsdiep tidal inlet near Den Helder between 1860 and 1995. The increase in variation in salinity from the 1930s onwards was probably caused by the closure of the former Zuiderzee around 1932 and a subsequent change in the management of river runoff. In former years, the freshwater entered the sea from the river IJssel near Kampen. Nowadays, fresh water is extensively flushed during winter time from the sluices in the Afsluitdijk whilst water is kept in the IJsselmeer in summer. Effects of the Great Salinity Anomaly, i.e. a mass of water with abnormally low salinity and temperature that moved in an anti-clockwise direction around the sub-Arctic gyre between 1961 and 1981, were not observed in the Dutch coastal zone.

The (bi-) weekly sampling of Marsdiep phytoplankton to determine algal production, species composition and biomass started in the late 1960s as part of an international programme which aimed at comparing primary production in a variety of ecosystems. Quantitative research on zooplankton dynamics in the North Sea and Wadden Sea started in 1972 within the framework of foodweb and productivity studies. Also since the late 1960s, the year-to-year variation in biomass and species composition of zoobenthos living on tidal flats in the Wadden Sea has been studied at least annually by sampling 15 permanent stations in late winter/ early spring. More recently, this work was extended by studying the degree and nature of the interannual variation in subtidal zoobenthic populations in the Wadden Sea (since 1989) and the Dutch part of the North Sea (since 1991). Two other long-term sampling programmes started in the early 1960s. Seasonal and inter-

annual variations of fish and invertebrates were studied in the Marsdiep tidal inlet and variation in numbers and breeding success of eider ducks have been examined on the neighbouring island of Vlieland. Between 1974 and 1982, a standard fishing survey was carried out yearly to examine the processes and periods in early life that determine the year-class strength of flatfish species. This Wadden Sea survey has been resumed in 1991.

The temporal variability in numbers of marine organisms and their environment has obviously been an important research topic of the institute for a long time and resulted in long-term observations on the abundance of many marine plants and animals. Although several series have end-

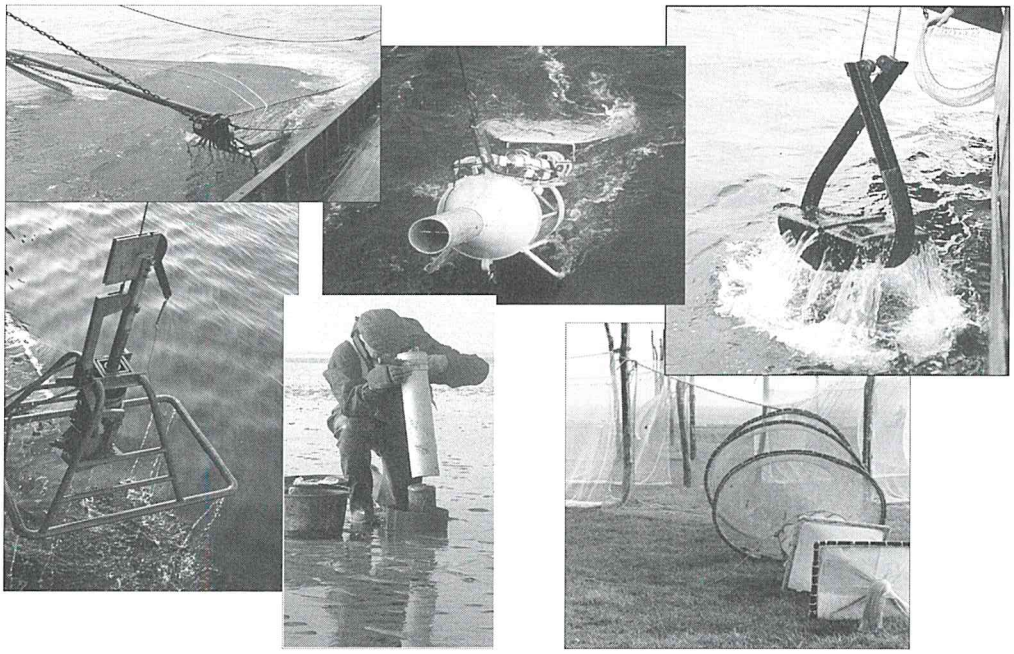



Intertidal and subtidal zoobenthos sampling stations in the Wadden Sea (A-D) and the North Sea. Note the stratified random sampling design for North Sea zoobenthos. To this end, the study area was divided into a number of homogeneous compartments in terms of sediment composition and water depth, assuming that the distribution of the zoobenthos is related to these environmental parameters. The zoobenthic studies are partly financed by the Dutch Ministry of Transport and Public Works. A: Balgzand, B: Kornwerderzand, C: Piet Scheveplaat, D: Dollard.

ed (e.g. bycatch species) or were interrupted for some years (e.g. flatfish recruits), most time series continued until the present day (e.g. temperature, salinity, phytoplankton, zoobenthos, fish and eider ducks).

## Caught in action

One of the main problems in studying densities of marine plants and animals is that they must be caught before they can be counted. Many organisms are mobile and swim actively or drift passively with the currents. Even species that are considered to be more or less sessile do not stay at exactly the same spot during their entire life. Bivalves move up and down in the sediment during the year, juvenile lugworms migrate downwards over the tidal flat, and many zoobenthic species are characterised by a pelagic phase during their lifecycle. The actual size, mobility, location and density of the marine organism under consideration determine which method has to be applied to catch on average a constant fraction of the studied population at each sampling occasion.



Selection of sampling gear that is used to collect zooplankton (plankton tow nets), zoobenthos (sampling core, Van Veen grab, Reineck boxcore) and fish (komfyke, 4m beam trawl) in the Wadden Sea and the North Sea.

Phytoplankton is sampled by means of a bucket from a jetty at high tide, and sampling frequency is intensified during periods of high algal densities. Zooplankton is collected from ships by means of specially designed plankton tow nets. Benthic fauna is usually sampled together with a fixed layer of sediment at a particular time of the year. Tidal zoobenthos is sampled by means of small cores whilst the benthic animals living in deeper waters are generally collected by means of Van Veen grabs or boxcores. Fish is caught either passively in komfykes, or actively with pulled nets. Breeding eider ducks hide themselves in long grass or under bushes and censussing breeding numbers would be very labour-intensive. Therefore, their numbers are estimated by determining the size and composition of that part of the population that is not involved in breeding and is spending its time in the surroundings of the colonies. To determine each year's breeding success, the fledglings are counted just after the female eiders have taken their young to the sea.

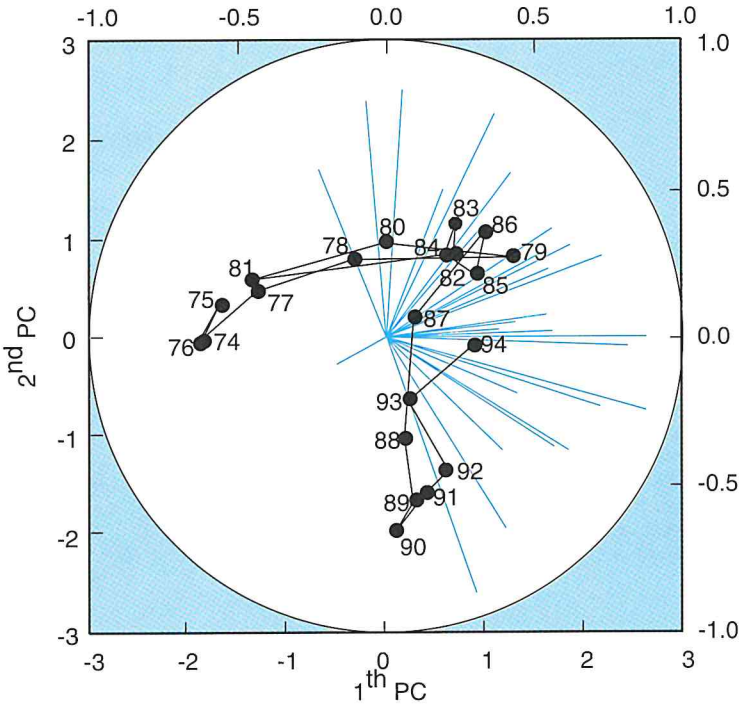
From data quality checks and from comparisons with other series, it appears that most sampling was performed consistently through time and that resulting time series reflect actual dynamics in Wadden Sea and North Sea populations. Some sampling designs, however, were better suited for the assessment of long-term trends in some species than others. From the analysis of similarity in trends of catches of intertidal fish traps over years, for example, it appears that the komfyke is more appropriate to consistently catch cod, bass and bib than mackerel, sprat and smelt.

## Shifts in species

One of the most striking observations in the marine ecosystem of the western Wadden Sea was the significant increase in biomass and production of both phytoplankton and intertidal zoobenthos in the late seventies. In the Marsdiep, the westernmost tidal inlet of the Wadden Sea, phytoplankton biomass almost doubled at the end of the 1970s from less than 6 to more than 12 mg chlorophyll-a·m$^{-3}$ and remained high until the present day. On the Balgzand tidal flat, the biomass of zoobenthos increased from less than 19 to almost 30 gAFDW·m$^{-2}$ between the 1970s and the 1980s. The time series on species compositions showed that the increase was due to a shift of spe-

cies composition and biomass within the communities rather than an overall doubling of the biomass of the marine species already present.

Analysis of the 32 most abundant marine algae species or taxa (which together contributed more than 99.9% to the total numbers of algae in the Marsdiep) revealed that most species were relatively scarce during the first few years of the study period, i.e. between 1974 and 1994. A few species declined in the Marsdiep samples from this period onwards such as *Nitzschia closterium* and pennate diatoms. Several species were mainly found between the end of the seventies and the mid eighties, e.g. diatoms such as *Skeletonema costatum*, *Plagiogramma vanheurckii* and small *Chaetoceros* species. Other species generally became more abundant during the study period, e.g. *Ditylum brightwellii*, *Nitzschia longissima* and large *Chaetoceros* species. The major part of the increase in phytoplankton biomass, however, can be assigned to three phytoplankton species, i.e. the large diatoms *Rhizosolenia delicatula* and *R. shrubsolei*, and small flagellates of the *Phaeocystis* group.




Covariance biplot of the abundance of algae (32 in numbers most dominant species; blue lines) between 1974 and 1994 (black dots connected with grey lines). Note the clockwise shift in species composition of phytoplankton within this period.

The doubling in intertidal zoobenthic biomass during the late seventies resulted from an increase of the biomass of all species present. However, significant shifts in species numbers were observed. The abundance of polychaetes increased more than those of molluscs and crustaceans, small-sized species became more numerous than large-sized ones, and deposit-feeding species became numerically more dominant than carnivores. A more recent change in the species composition of the Balgzand tidal flat is the invasion of two American species, i.e. the large razorclam *Ensis americanus* and the 5-10 cm long deposit-feeding polychaete *Marenzelleria viridis*. Both species originate from the eastcoast of the USA and were probably transported to our waters in ship's ballast water. At present, the clam ranks 5th in biomass of the bivalves in the Wadden Sea and is the dominant species in some parts. In most intertidal areas of the Wadden Sea, the American polychaete does not contribute significantly to the total biomass. Only in the Ems estuary where the animal was first observed in the Netherlands, this worm presently dominates the zoobenthos.

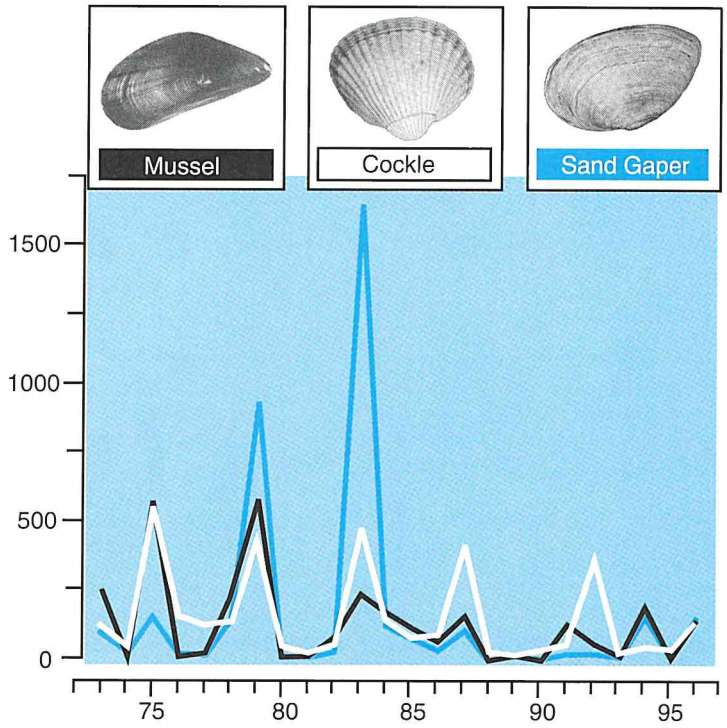
Such detailed information on the nature of observed changes facilitates further research on causes and consequences of temporal dynamics in marine ecosystems. Laboratory or field studies on the response of the three most dominant algae to fluctuations in environmental factors (e.g. nutrients, light conditions, temperature, grazing) will give insight in the causes of the doubling of production and biomass of phytoplankton in the Marsdiep tidal inlet. The observed shifts in species composition of zoobenthos may have had consequences for predating fish and birds which are not only species- but also size-selective feeders.

## The riddle of recruitment

Benthic animals in the Dutch coastal zone are relatively short-lived and most of the observed year-to-year variation in their total biomass and numbers is caused by varying settling numbers in offspring. Variation in recruitment may result from varying gamete production (i.e. related to abundance and fecundity of adults) or from changes in events between gamete production and the arrival of recruits at the site of interest (e.g. related to climate, predation, food supply). Both

aspects may vary strongly from year to year. For many marine species, however, the factors actually controlling the observed interannual variability in recruitment are still hardly known.

Experimental work showed that bivalves such as the Baltic tellin and the cockle produce more eggs after cold than after mild winters. However, the relationship between winter temperature and fecundity only partly explains the observed high numbers of spat of these species after severe winters on the tidal flats of the Wadden Sea. Other events that occur between egg production and the actual settlement of these young shellfish on the tidal flats, such as predation by shrimps and crabs, may additionally affect recruits but the relative contribution of all these controlling factors to the observed interannual variation in bivalve numbers is not known.




Abundance of spat of three important bivalve species in the Wadden Sea, i.e. the Mussel (*Mytilus edulis*), the Cockle (*Cerastoderma edule*) and the Sand Gaper (*Mya arenaria*), on the Balgzand tidal flats during summertime between 1973 and 1996. Note the coinciding patterns in abundance with high values in 1975, 1979, 1983 and 1987, and the low values between 1988 and 1990. Highest recruit numbers in 1979 occurred after the most severe winter during the study period, whilst lowest values at the three successive years 1988-1990 coincided with a series of the three mildest winters in this area.

Fish recruit numbers are also widely fluctuating, and this has been puzzling to man as long failing fisheries occur. The shallow coastal areas are extremely important as nursery areas for a number of fish species, in particular flatfish such as plaice and sole. The number of plaice recruits is determined during early life and inversely related to the winter temperature at the spawning area. Also recruits of flounder, sole, herring and whiting were found to be abundant in years following severe winters. Temperature, however, seems to be rather reflecting the prevailing weather system involved in the transport of young fish to the nurseries than being the actual cause of this relationship.

Breeding success of eiders was highly variable during the last 35 years. Although the number of breeding pairs remained fairly constant, the number of fledglings ranged between 0 and 3000 per year in the colony of Vlieland. Almost all eggs that are laid will hatch, but many chicks die before they are four weeks old. Predating herring gulls, rainy days, parasites and particularly food limitations take their toll, but the relative effects of these factors remain unclear.

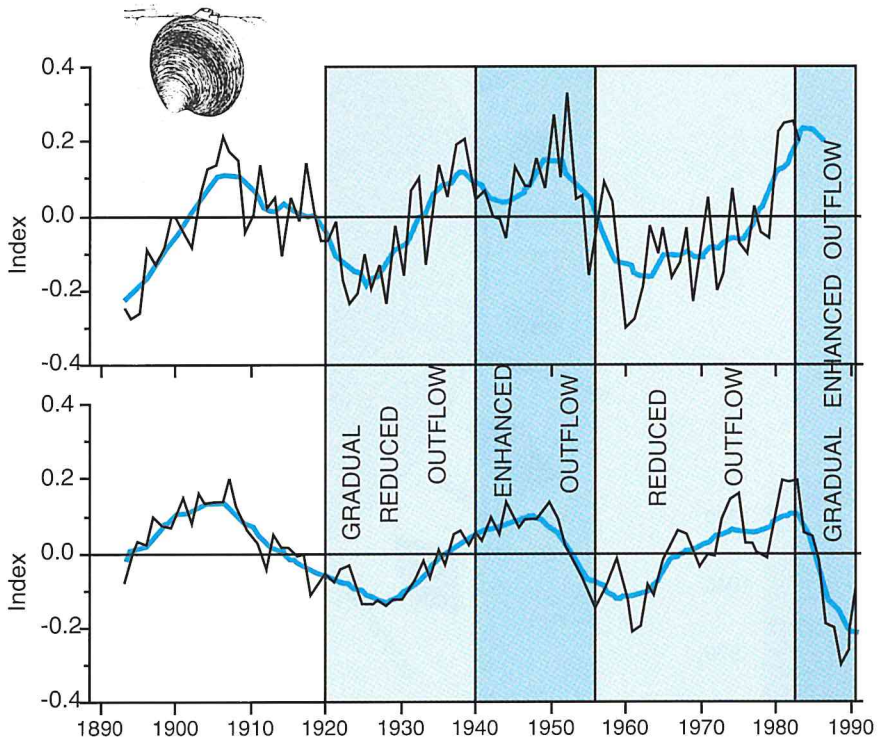
If the riddle is ever to be solved, it will be done by means of a combination of theoretical, experimental and field work. Information could be integrated into a recruitment model, and recruitment hypotheses tested on selected species at relevant locations to pinpoint the main controlling factors. Information derived from time series have to be used to examine if predictions on recruitment numbers hold under new circumstances that occur from year to year.

### Signals in shells and sediments

Although most biological series took approximately a scientist's life-time to compose, they are still relatively short when considered in relation to real long-term trends as induced by changes in effort and gear of fishing vessels during the past 100 years or climatic variations during the last 1000 years. It can be necessary, therefore, to have information on temporal dynamics in marine ecosystems for such long periods as well.

Fortunately, changes in marine ecosystems are recorded in shells of long-lived bivalves and in undisturbed sediments. The width of the internal growth lines of ocean quahog *Arctica islandica*

shells provide information on temporal and spatial differences in growth rates and possibly on the factors that determine shell growth such as hydrographic conditions or food supply. Furthermore, the introduction of new heavy fishing gear in Dutch waters is conserved in the frequency of scars in these shells. Also the shells of the whelk show obvious signs of damage by demersal fishing gear. Recently, the institute started to examine the possibility of extracting information on long-term variation of marine animals from sediment cores. The preliminary analysis of piston cores that were sampled in the Skagerrak and German Bight was promising; it revealed the presence of variable numbers of scales of fish, stickles of sea urchins, and shells of bivalves and ostracods over depth.



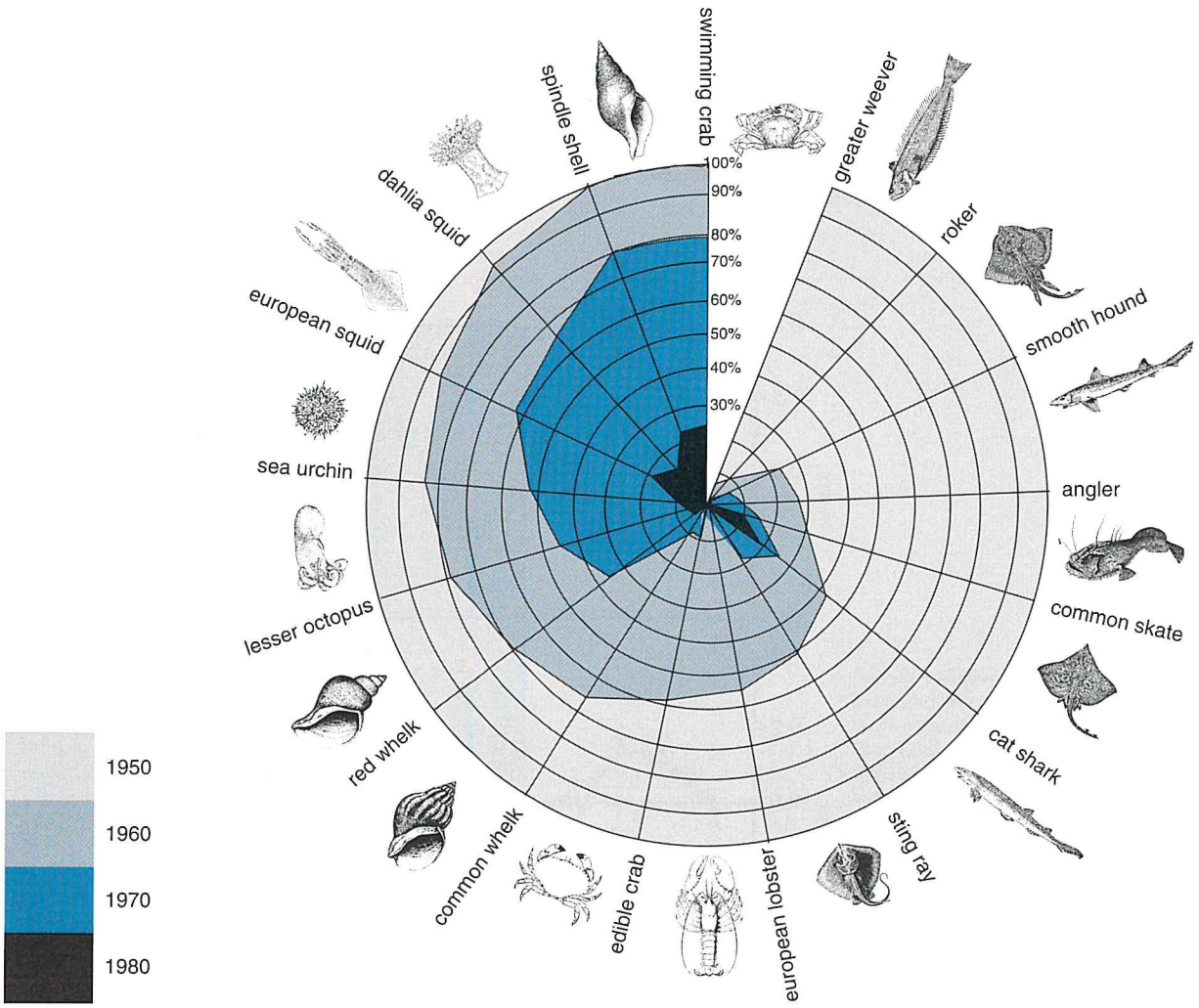

Mean chronologies of standardised growth variations in shells of the long-living bivalve *Arctica islandica* which were collected from the northern Fladen Ground in 1983 and 1991. As in other shells collected here, the periods 1900-1915, 1937-1954 and 1979-1987 have predominantly positive index values whilst the intermediate periods have negative values. A significant part of the observed variation in growth is explained by the fluctuations in fluxes of Atlantic water into and out of the northern North Sea.

The reliability of the information on long-term dynamics in marine ecosystems as derived from shells and sediments can be checked by comparing them with the short-term variation in directly measured biological variables (e.g. phytoplankton abundance, zoobenthos biomass, sizes of fish stocks) for the period that both series overlap (ca. 10-100 years). If the derived series indeed prove to be indicative for short-term trends in marine populations, they can be used to reconstruct the long-term variability of the animals in the past.

**In the long run**

During the last 30 years, we witnessed major shifts in production, biomass and species composition, both in the Wadden Sea and North Sea. Thanks to the existence of detailed time series, it was possible to hypothesise on causes of these changes. Plausible processes that underlie the observed patterns have to be analysed by experimental work carried out both in the lab and the field, e.g. the relationship between nutrient concentrations and primary production, winter temperature and shellfish recruitment, and bottom fishing effort and abundance of demersal fish and benthic invertebrates.

Because no two years are exactly the same, continuous measurements of the state of our surrounding waters will supply additional information on the temporal dynamics of marine ecosystems, in particular in combination with exploration of the information hidden in shells and sediments. Not only to examine the nature and amplitude of long-term and short-term periodic and/or non-periodic variations in marine ecosystems over time spans of tens, hundreds and thousands of years, but also to attempt to distinguish natural variations from man-induced ones.




Long-term change in relative abundance of bycatch species of demersal fish and benthic invertebrates in the southeastern North Sea between 1950 and 1980 as estimated by means of a dynamic catchability model. The model was applied to bycaugth animals which were delivered to the Zoological Station in Den Helder. The time series were corrected for the long-term change in fishing gear and effort within the Dutch demersal fleet. Model results indicate that otter trawlers already caught many bycatch fish species such as sharks, rays and skates between 1950 and 1960. Furthermore, the introduction of beam trawling in 1960 appears to have increased fisheries mortality of fish and in particular of invertebrates such as whelks, urchins, squids and crabs. Although the model was based on many assumptions, its results were in agreement with the long-term trends in those few species for which actual field data were available, i.e. roker, common skate, whelk and greater weever.

# DEPARTMENT OF PHYSICAL OCEANOGRAPHY

**The department continued to work under the following main themes:**
**1. water circulation and hydrography of the North Atlantic**
**2. dynamics of (non)linear marine processes**
**3. physical aspects of marine ecosystems**

**As a part of theme 1) the TripleB (Bay of Biscay Boundary) programme was continued with a 4 weeks hydrographic survey with RV Pelagia in the Bay of Biscay in the summer of 1996. Most of the results of the previous sea-going programme, DUTCH-WARP, have been analysed. A short summary of the results of this project is presented below.**

**Within theme 2) projects concerning the study of the thermohaline circulation, oceanic monopolar vortices, chaotic mixing and internal wave focussing were continued. A theoretical study on tides in basins with a sloping bottom was finished and a summary of the results is presented in this annual report.**

**Multidisciplinary projects in which the department was involved under theme 3) were the study of the behaviour of cohesive sediments in the Dollard, the INP-mooring project in the central North Sea, the JGOFS/Southern Ocean project, the Deep Chlorophyll Maximum (DCM) project and the application of marine optics.**

## THE HYDROGRAPHY AND THROUGH-FLOW OF THE NORTH-EASTERN NORTH ATLANTIC OCEAN: PROJECT DUTCH-WARP

**Contributors:** *H.M. van Aken, C. de Boer, J.C. de Munck, L. Otto* (ocean hydrography), *S. Ober* (instrumentation and standards), *M. Manuels* (oxygen determinations), *R.X. de Koster* (data base management)

In 1989 the DUTCH-WARP project was initiated by the NIOZ department of physical oceanography. In this project the hydrography and circulation in the Iceland Basin was studied. The goals were to understand qualitatively and quantitatively (1) the near-surface flow of Sub-Polar Mode Water (SPMW) from the North Atlantic Current (NAC) to the Norwegian Sea, (2) the transport of Iceland-Scotland Overflow Water (ISOW) through the Iceland Basin, from the ridges near the Faeroe Islands to the Charlie-Gibbs Fracture Zone in the Mid-Atlantic Ridge at 52°30'N, 35°W and to the Porcupine Abyssal Plain, and (3) the interaction between the different water types in the Iceland Basin like Labrador Sea Water (LSW) at intermediate levels, and Lower Deep Water (LDW) originating from the near bottom layer over the Porcupine Abyssal Plain. The programme also contributed to WOCE, by surveying twice the WOCE Hydrographic Programme (WHP) repeat section AR7E between Ireland and Greenland. These latter data have been submitted to the WHP Data Assimilation Centre and are now available from the WHP Special Analysis Centre in Hamburg. The data from the other hydrographic surveys have been submitted to the ICES oceanographic data centre in Copenhagen. Until now DUTCH-WARP data have contributed to 5 data reports, 13 scientific publications and one PhD thesis.

In 1989 a hydrographic section along the 20°W meridian was surveyed by RV Tyro, while in 1990 and 1991 more extensive high resolution hydrographic surveys and XBT surveys were carried out in the Iceland Basin as well as the surveys of WHP section AR7E. On each station in these surveys a CTDO profile was measured and water samples were taken for the determination of salinity, dissolved oxygen, nitrate, nitrite, phosphate and silica. In 1990 tritium concentrations were measured also for samples from a limited number of hydrographic stations. In 1989 and 1990 a total of 5 current meter moorings were deployed in the Iceland Basin, while 19 Lagrangean ARGOS surface drifters were deployed between 1990 and 1993. Additional to the DUTCH-WARP data hydrographic data became available from other cruises of RV Tyro, and from surveys of RV Oceanus, RV Gauss, and RV Tydeman, as well as from the ICES hydrographic data centre.

SPMW is formed in successive winters by convective cooling and deepening of the surface mixed layer. The permanent thermocline forms the lower boundary of this water type at 500 to 1000 m depth. In the resulting low stability SPMW core large lateral gradients in potential temperature, $\Theta$ (Fig. 1), salinity, and nutrients were observed. The coldest variety of SPMW is found just west of the Reykjanes Ridge, while the warmest and most saline SPMW is found south-west of Ireland. From the surface drifters, deployed in the central Iceland Basin, a mean north-eastward surface velocity of 2.4 $cm \cdot s^{-1}$ was measured. This suggests a through-flow of the SPMW from the NAC to the Norwegian Sea near the Faeroe Islands with a residence time of about 2.5 years. The surface drifters show a north-westward retroflexion of the surface flow near 53°N, 20°W which also can be seen in the isotherms of the SPMW (figure 1). With a residence time of the SPMW of about 2.5 years, the SPMW is expected to cool about 2°C between 51°N and the region near the Faeroe Islands, due to the annual mean heat loss to the atmosphere. Given the minimum temper-

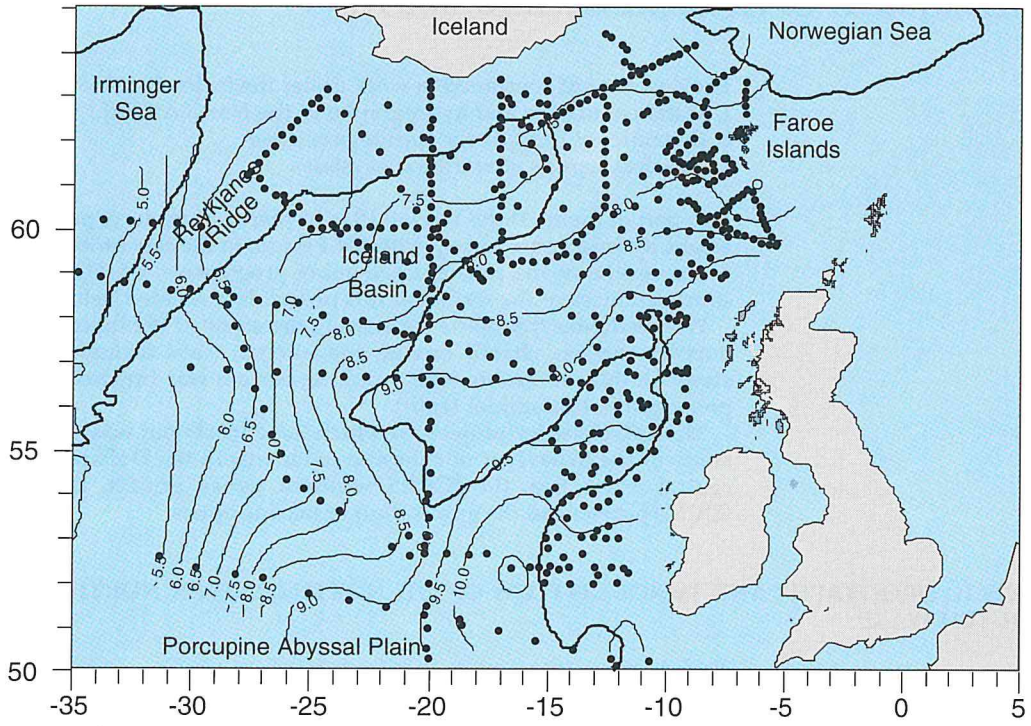



Fig. 1. Potential temperature Θ in the core of the Sub-Polar Mode Water, based on the DUTCH-WARP CTD profiles, extended with data from RV Gauss, RV Oceanus, RV Tyro, RV Tydeman, and data from the ICES oceanographic data centre. The thick line indicates the 2000 m depth contour. The dots indicate the positions of the 846 hydrographic stations used in this analysis.

ature in the SPMW between Iceland and Scotland of slightly over 7°C one can conclude that only SPMW with a potential temperature over 9°C near 51°N will be transported towards the Norwegian Sea. The colder SPMW in the southern part of the research area therefore is assumed to cross the Reykjanes Ridge westwards and to contribute to the Irminger Current and the Irminger Sea cyclonic gyre. The cold SPMW found west of the Reykjanes Ridge originates from this current branch. Geostrophic transports have been computed relative to a level of no motion in the potential density anomaly surface $\gamma_\Theta$=27.725 kg/m$^3$. This level of no motion has been found from an empirical search method which is optimized with respect to mass conservation. The level of no motion also agrees with long term current observations. The resulting geostrophic surface velocities agree in zonal structure and in magnitude with the surface flow derived from the surface drifters. From the geostrophic calculations three main current branches can be discerned for the transport of SPMW (Fig. 2). About 3 Sv (1 Sv=10$^6$ m$^3$·s$^{-1}$) of warm and saline SPMW flows along the European continent towards the Iceland-Scotland Ridge while 7 Sv flows towards this ridge via the retroflexion and through the Iceland Basin. A 13 Sv current branch is found to transport relatively cold SPMW from the western Porcupine Abyssal Plain across the Reykjanes Ridge towards the Irminger gyre. Near the Iceland-Scotland Ridge a significant convergence of the SPMW transport is found, indicating that there about 3 Sv SPMW is removed from the surface layers to deeper levels, probably by entrainment into the fast flowing Norwegian Sea Deep Water (NSDW) which flows across sills in the Faeroe Bank Channel and on the Iceland-Faeroe Ridge. This transport scheme leaves a net transport of 7 Sv SPMW entering the Norwegian Sea between Iceland and Scotland.

At intermediate levels the low salinity LSW is the most prominent water type, while saline cores, typical for water originating from the Mediterranean Sea, although present south of Porcupine Bank, are virtually absent in the Iceland Basin. No indication has been found that any LSW is transported across the Iceland-Scotland Ridge. Over the south Icelandic slope a saline water mass is observed at intermediate density levels, resulting from mixing of ISOW with entrained SPMW.

The highest potential densities in the Iceland Basin have been found in the ISOW. This water type originates from mixing of the cold NSDW with warmer and more saline SPMW, entrained over the sills on the Iceland-Scotland Ridge (warm entrainment). Lower Deep water, found over the Porcupine Abyssal plain, has a high dissolved silica concentration because Antarctic Bottom Water (AABW) is a main constituent of this water type. From geostrophic transport estimates (Fig. 3) as well as from water mass analysis, it is derived that 1.4 Sv NSDW and 1.1 Sv entrained SPMW combine to an inflow of 2.5 Sv ISOW into the Iceland Basin. From hydrography and current measurements it is found that at slightly smaller densities LDW with high dissolved silica concentrations and relatively low salinity as well as more saline North East Atlantic Deep Water (NEADW), which overlies LDW, recirculate in a cyclonic way through the Iceland Basin. Due to its lower density this recirculating water mass overlies the near bottom ISOW core in the Iceland Basin. It is

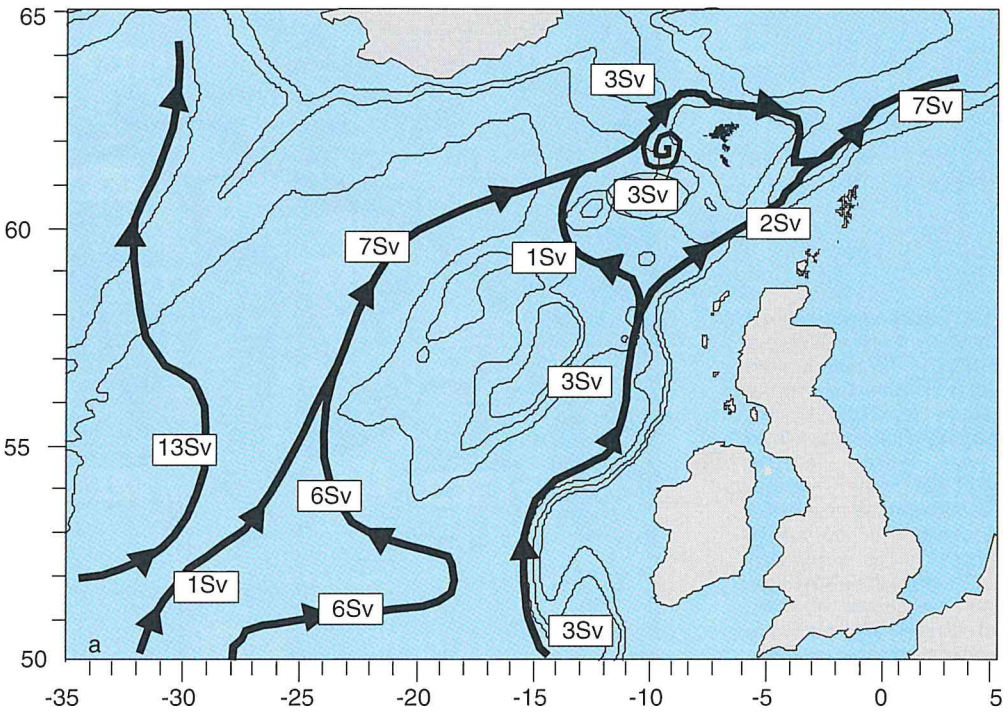



Fig. 2. Geostrophic transport of near surface Sub-Polar Mode Water with potential density anomaly $\gamma_\Theta$<27.70 kg·m-$^3$, determined relative to a level of no motion in the $\gamma_\Theta$=27.725 kg·m-$^3$ surface. The values in the boxes give the transport in the current branches in Sv (1 Sv=$10^6$ $m^3 \cdot s^{-1}$), while the spiral indicates the loss of SPMW due to entrainment into the cold overflowing NSDW.

incorporated into the ISOW core by (cold) entrainment, which thereby increases its transport to 3.6 Sv south of Iceland. This geostrophic transport is confirmed by current measurements. A long term mean velocity in this ISOW core has been measured to be over 19 cm/s south of Iceland, at 40 m above the bottom. Further downstream, along the eastern slope of the Reykjanes Ridge, ISOW mixes with the overlying LSW which reduces its salinity and lowers the density of the ISOW core to values below those of LDW. This causes the ISOW core to leave the near bottom layer and to overly the LDW over the Porcupine Abyssal Plain. Hereby ISOW is transformed to NEADW, which is characterized by a salinity maximum, relative to the underlying LDW and the overlying LSW. Next to the overflow of NSDW into the Iceland Basin, a small overflow of 0.4 Sv NSDW across the Wyville-Thomson Ridge into the Rockall Channel was determined, which also contribute to the formation of NEADW.

The circulation of LDW and NEADW through the Iceland basin is part of a larger scale cyclonic recirculation in the eastern North Atlantic. South of the Iceland Basin another 3.1 Sv LDW and NEADW contributes to this recirculation, which forms, together with the ISOW, a Deep Northern Boundary Current of 6.7 Sv. The AABW contribution to the recirculation which enters the eastern Atlantic basin (2 Sv) will leave this basin together with the NSDW flow (1.8 Sv) and the entrained SPMW (1.1 Sv) through the Charlie-Gibbs Fracture Zone near 52°30'N. This makes up a total of 4.9 Sv deep water which should leave the north-eastern Atlantic basins. However, Saunders derived from current meter observations in both deep zonal channels of the Charlie-Gibbs Fracture Zone a net westward transport of only 2.4 (±0.5) Sv. This indicates that a major part of the south-westward flowing deep water near the Reykjanes Ridge recirculates further in the eastern Atlantic Basin. This recirculation will maintain the salinity maximum in the NEADW core near 2600 dbar, which can be traced southwards to 41°N, south of the Charlie-Gibbs Fracture Zone (52°30'N). But at least part of the ISOW will pass westwards through the Charlie-Gibbs Fracture Zone. It can be recognized in a deep S>34.95 core in the Irminger Basin west of the Reykjanes Ridge near 2000 dbar and contributes, together with Denmark Strait Overflow water and Labrador Sea Water to the formation of the North Atlantic deep water Complex in the western Atlantic Ocean. The residual 2.4 Sv NSDW, SPMW and AABW is assumed to leave the deep layers in the eastern Atlantic basins by mixing and large scale upwelling.

In the DUTCH-WARP programme a consistent picture of the circulation and water mass modification in the north-eastern North Atlantic Ocean has emerged. The total transport of SPMW towards the Norwegian Sea agrees with some of the earlier estimates. But the main course of this transport in the late 1980's and early 1990's appears to be through the Iceland Basin, and north-west of the Faeroe Islands. In previous circulation schemes the main transport route of SPMW was assumed to lie more to the east and between the Faeroe Islands and Scotland. This difference may reflect inter-annual to inter-decennial variability of the ocean circulation. From the convergence of the near surface transport the loss of SPMW to intermediate and deep layers due to entrainment into the deep water mass near the Faeroe Islands was determined. In the near bottom layers the contribution of warm entrainment of NSDW to the formation of ISOW was estab-

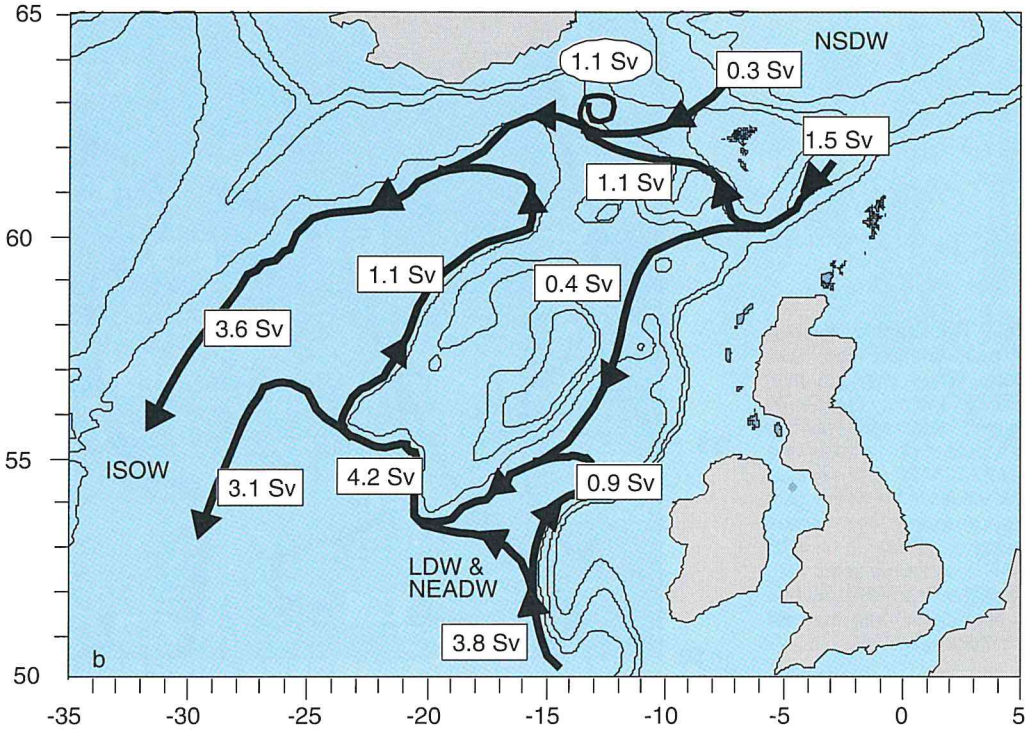



Fig. 3. Geostrophic transport of NSDW, ISOW, LDW and NEADW in the near bottom layer with potential density anomaly $\gamma_\Theta$>27.80 kg·m-$^3$, determined relative to a level of no motion in the $\gamma_\Theta$=27.725 kg·m-$^3$ surface. The values in the boxes give the transport in the current branches in Sv (1 Sv=10$^6$ m$^3$.s$^{-1}$), while the ellipse indicates the source of warm and saline SPMW due to entrainment into the overflowing NSDW.

lished. By determining the role and magnitude of cold entrainment of LDW into ISOW and subsequent mixing with LSW, the mechanism of the transformation of ISOW to NEADW was described.

## TIDES IN BASINS WITH A SLOPING BOTTOM

**Contributor:** *L.R.M.Maas*

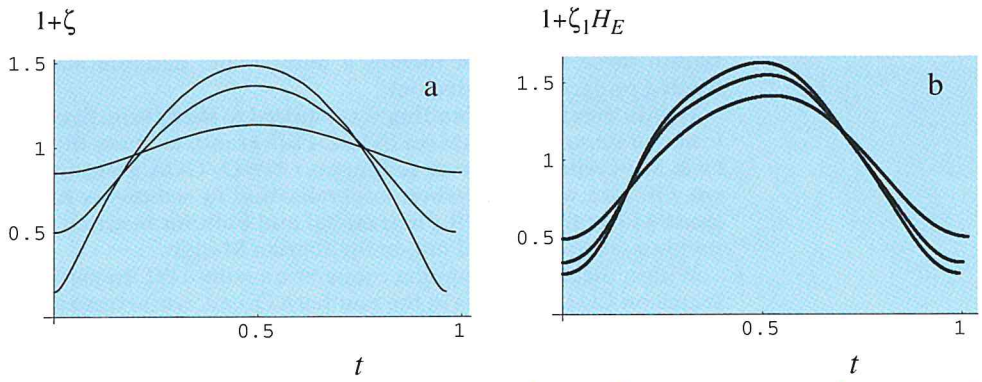
This project concerned a theoretical study on tides in basins with a sloping bottom.

An enclosed basin like an estuary or fjord, has certain (eigen) modes which are all characterised by the fact that they necessarily conserve mass. Thus there will always be a zero-elevation line somewhere in the basin, separating regions with opposite phases. The sole mode added to this system when the basin communicates with a sea through a narrow strait is the 'pumping' or Helmholtz-mode, characterised by a periodic mass-exchange through the narrows and by a uniform elevation change within the basin.

A basin with vertical side-walls responds linearly to a change in volume transport through the entrance, a change that may be due either to the natural variability in the tides (e.g. the fortnightly cycle), or to wind effects. The tidal elevation within this so-called Helmholtz resonator may thus change its amplitude and phase, but it will remain sinusoidal in time. If the observed tidal elevation is not sinusoidal (as, for instance, in certain basins of the Wadden Sea) then the response is nonlinear. There may be several reasons for this nonlinearity. Firstly, it may be due to the essentially nonlinear nature of bottom-friction in the narrows. Secondly, it may be due to the slope of the bottom.

A basin with sloping boundaries leads to a nonlinear response with prolonged periods of high water and short periods of low water. This can be explained from the consideration that, given the same flux of water through the entrance, it takes more time to change the water level when the water is already high (and the immersed area is large) than when the water is low (and the immersed area is small). It was shown in this project that without forcing, a model, capturing this can be solved analytically. In natural circumstances, however, tidal forcing can not be neglected and numerical methods have been applied. These models suggest the occurrence of several novel features. Firstly, for a constant forcing (tidal current) the amplitude of the tidal oscillation in the basin may be varying on a long timescale. Tidal levels are increasing due to the (near-) resonancy of the basin. However, since the eigen frequency of the basin is a function of the amplitude, the system is brought out of resonance and, as a consequence, the tidal amplitude drops. From this point the cycle starts again. This mechanism acts even in the absence of friction. Secondly, if friction is included, the amplitude response curve exhibits multi valuedness if the system is close to resonance. This means that, for the same values of the 'parameters of the sytem' (forcing and fric-

tional magnitudes) the basin may respond with either a small or large amplitude oscillation. More dramatically, however, one of these modes may cease to exist for slightly different parameter values. Thus if this parameter changes slowly and passes a threshold value it may force the system to quickly change its state of oscillation to the only remaining state, thereby creating a strong response. Changes like these may perhaps be triggered by the changing contribution due to winds. Evidence of such changes may be hidden in observed sedimentological zonation-patterns in tidal estuaries.




a. Theoretical, free response of the surface area A=1+ζ, where ζ is sealevel elevation, for initial conditions varying from linear to (large amplitude) fully nonlinear. Time is scaled with the period of a linear wave: 2π.
b. Observed, average spring, mean and neap tidal elevation ($\zeta_i$) over one tidal period (T), as observed by Rijkswaterstaat in Lauwersoog at the S-end of Zoutkamperlaag basin in the Dutch Wadden Sea. Displayed is $1+\zeta_i/H_E$ , a scaled and off-set version of the observed elevations, so as to be comparable with the free-mode. Equivalent depth has been taken as 12 percent of maximum depth, $H_E$ =1.9 m. Time is scaled with the lunar, semidiurnal tidal period.

## EXTERNAL PROJECTS OF THE DEPARTMENT OF PHYSICAL OCEANOGRAPHY

- The morpho-dynamic and bio-dynamic behaviour of mud in tidal areas (NWO-BOA)
  *H. Ridderinkhof, M. Wilpshaar, J.T.F. Zimmerman*
- Non-linear dynamics in physical oceanography (NWO-GOA)
  *J.T.F. Zimmerman, G. Schramkowski, G. van der Schrier, L.R.M. Maas, H. Ridderinkhof*
- Bay of Biscay Boundary (Triple B) (NWO-GOA)
  *H.M. van Aken, C.Veth, J.J.M. van Haren, S. Ober, R. de Koster, R. Manuels*
- Integrated North-Sea program (INP-mooring) (NWO-VvA)
  *J.J.M. van Haren, R.Manuels, H.Ridderinkhof*
- Concertations on European Validation Experiments for coastal/shelf water remote sensing (CEVEx) (EEG)
  *M. Wernand*
- Dynamics of Internal Waves in Moving and Rotating Fluids (INTAS) (EEG)
  *L.R.M. Maas*

# DEPARTMENT OF MARINE CHEMISTRY AND GEOLOGY

**The department of Marine Chemistry & Geology continued to work within four general research themes:**
**1: Biogeochemistry of carbon, nitrogen , phosphorus, silica, and sulphur in marine systems.**
**2: Carbon and trace metals in the oceanic watercolumn.**
**3: Palaeoceanography.**
**4: Sedimentation and sediment transport processes.**

**Within these four main themes a number of national and international (a.o. EC-MAST) funded projects are carried out.**

**Within theme 1 new funding was aquired to study selective desorption-adsorption of organic matter on mineral matrices (NIOZ-PhD grant), to study the mechanisms and importance of Fe & Mn-cycling in marine sediments ( NWO- GOA grant for a PhD). In the next three years we will also work on carbon mineralisation in sediments from the Adriatic Sea (EC-MAST grant within the MATER programme) and both for research themes 1 & 4 within the OMEX programme to be carried out on the Iberian Margin.**

**Within theme 2 the ongoing cooperation with AWI Bremerhaven has been continued for research on CO2 dynamics in the Southern Ocean, while research on the role of trace metals and CO2 in phytoplankton dynamics was studied in the EC-MAST project MERLIM.**

**Within Theme 3 an internal NIOZ project on the applicability of biogenic Si as a palaeotracer was initiated and work on the palaeocenography of the South East Atlantic can be continued thanks to external funding from 1997 onwards.**

**Studies in the framework of Theme 4 (ENAM and OMEX) will be finished in beginning 1997. Both projects will be continued based on new funding by EC-MAST.**

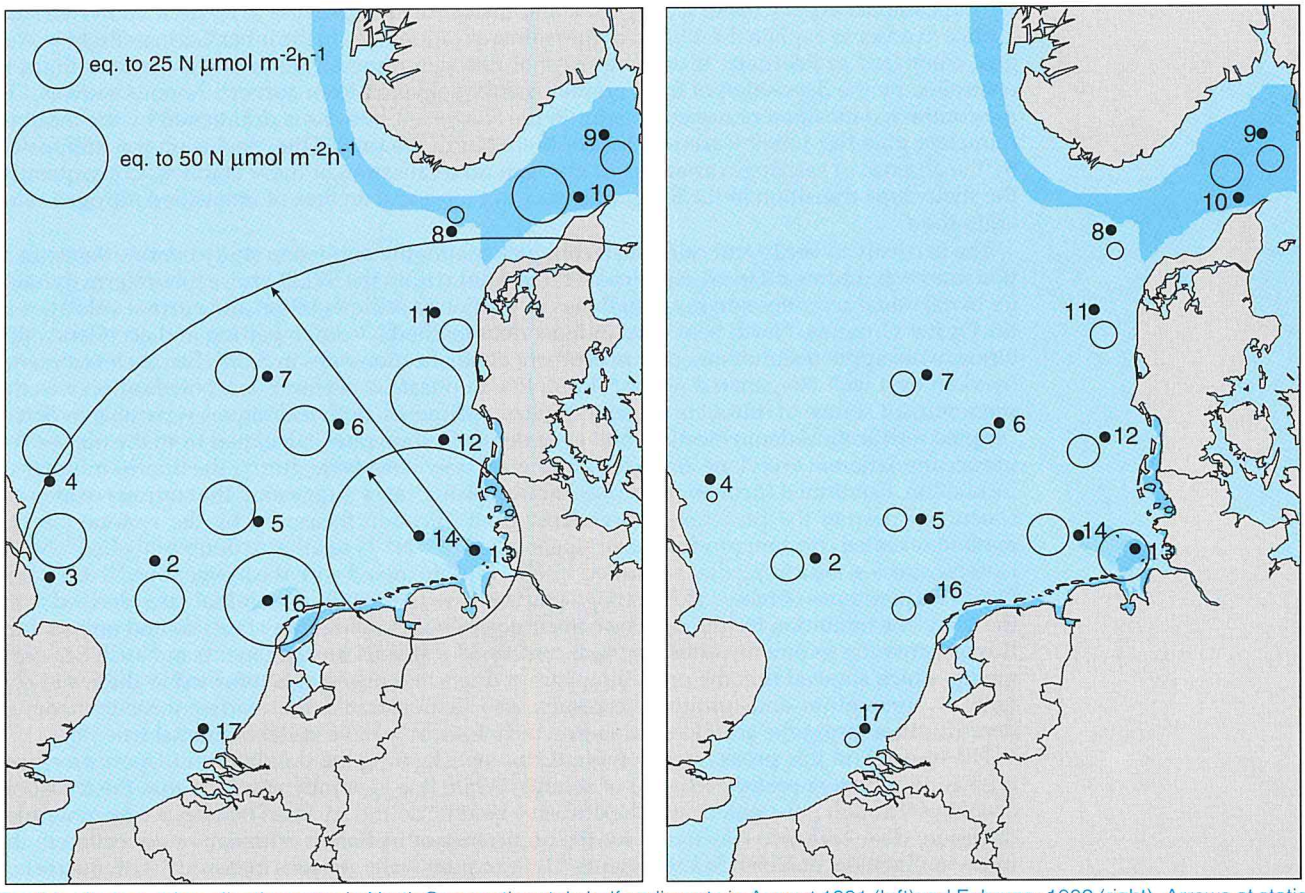
## SEDIMENT-WATER EXCHANGE OF NITROGEN COMPOUNDS AND OXYGEN IN THE NORTH SEA

**Contributor:** *L. Lohse*

On a global scale, the importance of continental margins in biogeochemical cycles is large, despite the relatively small area they occupy. Although their area comprises only 8% of the ocean, between 18% and 33% of the global primary production takes place on the shelves. The shallow depth of continental shelf seas ensures that a substantial part of the primary production reaches the sea floor. There, intensive chemical and biological processes modify the composition of the organic material settled. The degradation of particulate organic matter produces a variety of dissolved organic and inorganic compounds, which may be further mineralised, sorbed to the sediment matrix, or diffuse out of the sediment. The current debate focusses on the question whether benthic processes along the continental margin can affect the amount of elements participating in global biogeochemical cycles.

Recent literature compilations on global nitrogen fluxes revealed a pronounced imbalance of the present-day ocean. It was demonstrated that the nitrogen-loss (175 to 418) Tg N $yr^{-1}$ strongly exceeded the nitrogen supply (90 to 293 Tg N $yr^{-1}$). This imbalance was primarily caused by an up-ward revision of denitrification rates in shelf-and deep-ocean sediments, which accounted for 101 and 185 Tg N $yr^{-1}$ of the global sedimentary denitrification rate, respectively. Given the small surface area occupied by shelf sediments the validation of benthic denitrification rates as well as the associated fluxes of other inorganic nitrogen compounds is indispensable. These fluxes are subject to considerable seasonal and spatial variation, since production and deposition of biogenic material on the continental shelf affect benthic nitrogen biogeochemistry. The coupling of denitrification and nitrification received particular attention in this project, since a tight coupling between both processes may lead to a removal of fixed nitrogen from the shelf, thereby counterbalancing eutrophication effects.

Initial studies carried out within the INP-BELS project (Integrated North Sea Programme-Benthic Links and Sinks in North Sea nutrient cycling) revealed a pronounced seasonal variation in the coupling of both processes and the accompanying sediment-water fluxes of inorganic nitrogen compounds. The thickness of the oxic layer appeared to be the predominating factor controlling inorganic nitrogen cycling. Increased carbon and nitrogen mineralisation in summer caused that this layer was 2 to 3 fold thinner in August compared to February. Nitrification was clearly stimulated by the enhanced ammonium availability in August, despite the decreased thickness of the oxic layer. This suggested that the zone of maximum nitrification activity was located close to the oxic-anoxic boundary, where ammonium concentrations were highest. Except in the mud deposition area in the inner German Bight, nitrate pore water concentrations peaked in the oxic layer of the sediment and sediment-water fluxes unequivocally showed the release of nitrate to the overlying water. Hence, nitrification in the sediment rather than the overlying water was the predominant source of nitrate for denitrification in North Sea sediments. The most striking result of the




Benthic nitrogen mineralisation rates in North Sea continental shelf sediments in August 1991 (left)and February 1992 (right). Arrows at station 13 and 14 in August indicate corresponding circles. Note that the rate at st. 13 in the German Bight in August is an order of magnitude higher than at other stations.

investigations was the apparent de-coupling between nitrification and denitrification due to the very steep nitrate concentration gradients between the nitrification zone and the overlying water. Although nitrification rates were higher in August compared to February, most of the produced nitrate (i. e. ~ 95%) diffused along the steepest concentration gradient to the overlying water instead of becoming denitrified in anoxic layers. In February, nitrification rates had decreased and the zone of maximum activity had moved deeper into the sediment. At the same time, nitrate concentrations in the overlying water had increased, thereby diminishing the concentration gradient between the nitrification zone and the overlying water. As a result, coupled nitrification-denitrification became more efficient, although even then not more than 25% of the produced nitrate was denitrified. It was postulated that this weak coupling of both processes may be representative for continental shelf sediments overlain by a well-oxygenated water column low in nitrate concentrations. In conclusion, the thickness of the oxic layer and the nitrate concentration in the overlying water were the most important factors controlling the efficiency of coupled nitrification-denitrification. Further, it was ascertained that non-accumulating North Sea sediments regenerate nitrogen compounds to the overlying water, rather than being a sink.

Futher studies included a detailed examination of benthic nitrogen biogeochemistry in relation to production, advection and deposition of organic matter on the North Sea shelf. The location of sampling stations was chosen along the prevailing transport route of water masses and suspended material in the North Sea. The major depositional areas (i. e. the inner German Bight and the Skagerrak) as well as areas characterised by temporal deposition were included. Analysis of the grain size spectrum and the organic carbon content of the bottom deposits corroborated with the hydrodynamic regime of the North Sea. Three clusters were distinguished: I) depositional areas with a median grain size < 50 µm; II) transition areas characterised by temporal deposition and grain size between 80 and 180 µm, and III) non-depositional areas characterised by a medium grain size of > 280 µm. Pore water profiles of oxygen, nitrate and ammonium as well as total nitrogen mineralisation corresponded to this clustering. In February 1992, i. e. just before the onset of the spring phytoplankton bloom, the spatial differences in nitrogen mineralisation between these three clusters were much less pronounced than in August 1991, when benthic processes were stimulated by deposition of preceding plankton blooms. In August, nitrogen mineralisation rates at stations belonging to cluster II and III were 2 to 3-fold higher than in February. Stations in

the depositional areas (cluster I, Skagerrak and the German Bight) had to be divided in two subgroups in order to explain the 40-fold higher mineralisation rates in the inner German Bight in August compared to February. It was argued that nitrogen mineralisation in the German Bight is controlled by the deposition of fresh organic matter delivered from authochthonous sources. On the contrary, deposition of organic matter in the Skagerrak stations is dominated by the input of refractory material, winnowed from the southern North Sea shelf. This conclusion was supported by the absence of seasonal variations in nitrogen mineralisation at those stations. Consequently, the shelf-slope transition in the Skagerrak does not represent an area of intensified nitrogen mineralisation.

The necessity to verify and calibrate techniques commonly applied to study benthic denitrification rates was addressed in an experiment carried out within the STED-cruise (Short term dynamics in microbial activities and nutrient fluxes in relation to sedimentation and current velocities in the Oyster Grounds, North Sea). Two independent methods, isotope pairing and acetylene inhibition, were applied simultaneously to estimate denitrification rates in North Sea shelf sediments overlain by a well-oxygenated water column low in nitrate concentrations. Nitrification was the predominant source of nitrate in the investigated sediments. Both techniques were able to detect coupled nitrification-denitrification, however, denitrification rates calculated from the nitrous oxide accumulation in acetylene amended cores were only detectable during the first 60 minutes of incubation. Continued incubation resulted in decreasing rates, suggesting that nitrous oxide was consumed despite the presence of acetylene. Denitrification measured by the isotope pairing method revealed constant production of single-labelled $^{14}N^{15}N$ relative to double labelled $^{15}N^{15}N$ isotopic species, indicating that the added $^{15}NO_3^-$ rapidly mixed with the indigenous $^{14}NO_3^-$ pool. Denitrification rates obtained from isotope pairing were twice as high as initial rates derived from the acetylene inhibition technique. The contemporaneous examination of nitrate and ammonium fluxes across the sediment-water interface confirmed previous measurements in North Sea sediments, which showed that the prevailing part of deposited nitrogen is returned to the water column as ammonium and nitrate. The results also demonstrated that earlier measurements of denitrification using the acetylene inhibition technique may have underestimated true rates.

The research in this project was completed by investigating the dominant transport processes mediating sediment-water exchange of solutes. While it is generally assumed that the transport of solutes through pore waters and the diffusive benthic boundary layer takes place by molecular diffusion, clear evidence was found for the occurrence of turbulent diffusion or advection in the upper millimeters of North Sea sediments. Oxygen pore water profiles measured with microelectrodes in sandy sediments revealed the presence of a subsurface layer characterised by enhanced diffusive transport. In general, enhanced diffusivity was shown in coarse, permeable sediments intrinsically characterised by relatively low oxygen consumptions. These sediments were predominantly located on the southern North Sea shelf, while silty, impermeable sediments as found in the depositional area of the Skagerrak did not seem to be influenced by enhanced diffusion. Additionally, enhanced diffusive transport was more pronounced in periods characterised by low oxygen uptake of the sediment. Quantitative evaluation of the pore water profiles by a diffusion-reaction model revealed that the effective diffusion coefficient in the subsurface layer had to be 1.5 to >100 times higher than the molecular diffusion coefficient in order to account for the observed curvature of the oxygen profiles. The time-depending adaptation of oxygen pore water profiles to changes in bottom friction velocity suggested that bottom currents generated by diurnal tidal motion may induce an oscillating oxic-anoxic interface in sandy North Sea sediments. Repeated shifts from anoxic to oxic conditions may promote organic carbon mineralisation and minimise burial of organic carbon, thereby offering an additional explanation for the low organic carbon contents in North Sea sediments.

A theoretical examination of transient steady-state oxygen profiles adapting to a new flow regime above the sediment surface demonstrated the implications of confined benthic chambers in studying sediment-water exchange in sandy, permeable sediments. The decrease of effective diffusivity in the sub-surface layers of the sediment and the re-establishment of molecular diffusion as the dominant transport mechanism inside benthic chambers may lead to an underestimation of the true oxygen flux between 30 and 60%. As a consequence, previous measurements of benthic oxygen consumption in permeable, sandy shelf sediments may have severely underestimated the benthic oxygen consumption.

## THE NORTH-WEST EUROPEAN SHELF PROGRAMME (NOWESP)

**Contributors:** *Wim van Raaphorst, Katja Philippart*

Shelf seas are a vital part of the global marine system. The NW European shelf, which consists of the North Sea, the Irish Sea, the Celtic Sea, the shallow part of the Bay of Biscay, the English Channel and the Skagerrak, is a transit area for energy and mass between the European continent and the Atlantic Ocean. Its central part, the North Sea, is one of the best studied marine systems. During past decades, many seagoing expeditions have been carried out on the shelf by many research institutes and regular monitoring programmes were executed by national authorities in the coastal waters. Thus, a large amount of data should, in principle, be available.

Within the NOWESP project, which was funded by the EC MAST 2 programme and coordinated by the RIKZ, 18 research institutes from 7 European countries worked together to exploit the large amount of data existing for the NW European shelf. NIOZ participated in NOWESP as the coordinator of one of the 5 main task-groups in which the project was divided, and as a member of the overall steering committee. The project was started in 1993 and finished in December 1996. The objective of NOWESP was to determine the level of variability of the NW European shelf system in terms of physical (e.g. salinity, temperature, currents), geochemical (e.g. suspended solids, nutrients, carbon) and biological parameters (e.g. chlorophyll, zooplankton, primary production) on the basis of existing data. Therefore 3 issues were addressed:

1 the identification and acquisition of relevant data sets;
2 the provision of these data sets to the NOWESP partners in a uniform format;
3 the analysis of the data by jointly agreed statistical techniques.

The first two years of the project were almost completely devoted to the issues 1 and 2. Apart from data sets available from the institutes participating in NOWESP, additional sets were identified using the information provided by the EDMED files (European Directory on Marine Environmental Data) and ICES. The originators of these sets were contacted and asked to make their data available to NOWESP. Part of the data sets, particularly the older ones, were present in hand written form only and had to be digitalised. At the end of project more than 3 million data records were stored in the research data base at the 'Institut für Meereskunde' (IfM) in Hamburg and made available to the participating institutes via the server on the electronic net system.

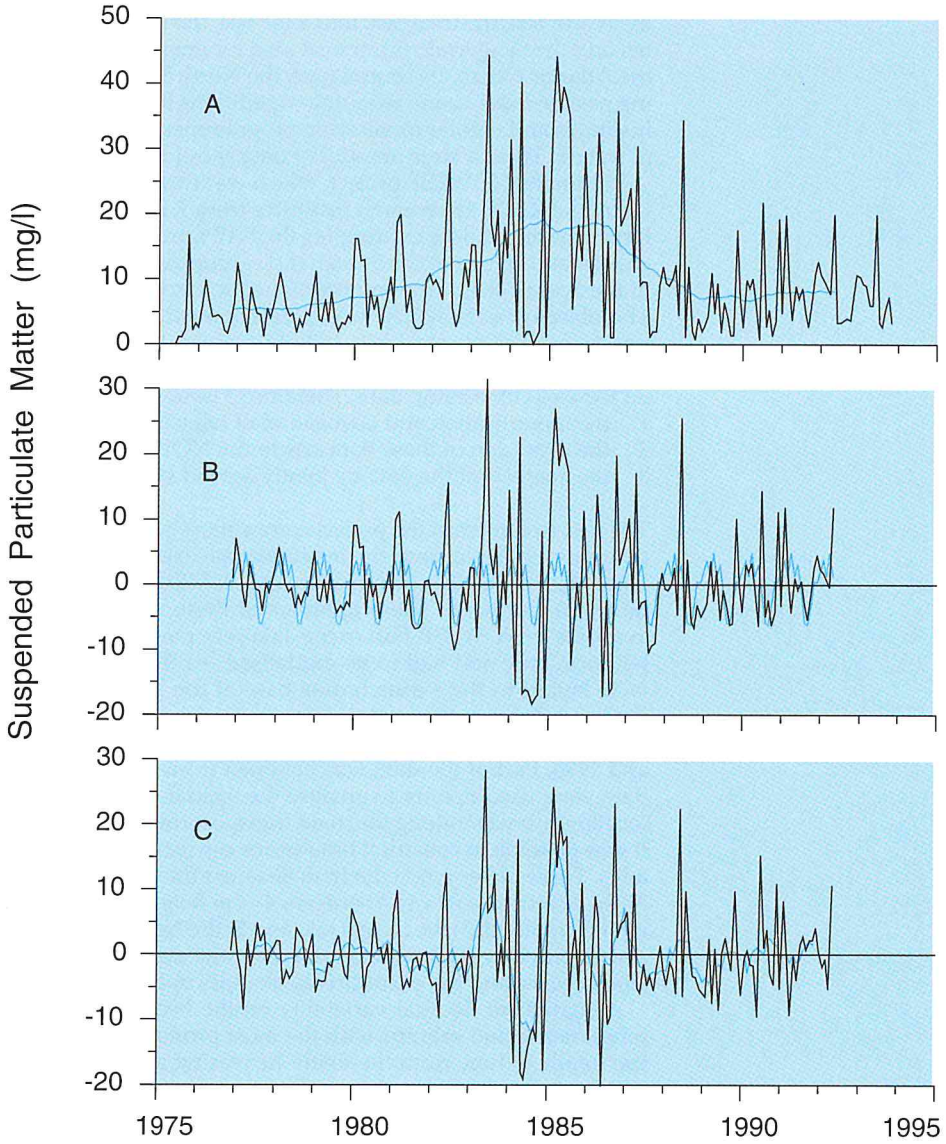
The data sets span the period between 1960 and 1993 with the densest coverage between 1975 and 1990. Part of the data was obtained from cruises which were not repeated over time. These data were used mainly to analyse the spatial distributions of the parameters on the shelf. For 8 locations ('boxes') along the main transport route of water and suspended particles over the shelf, it was possible to construct time-series consisting of monthly mean values and spanning 2-3 decades. These boxes are 1) the Irish Sea near the Isle of Man, 2) The English Channel off Plymouth, 3) the Scottish coast off Aberdeen, 4) the Belgian coast, 5) the Dutch coast, 6) the German Bight near Helgoland, 7) the Skagerrak, and 8) the Norwegian Channel off Bergen. The analysis of these time-series was done in three different time-domains to determine the decadal variability, the seasonal cycles, and the event driven changes and other short-term fluctuations, respectively.

A significant decadal variability on the NW European shelf was identified for at least water temperature and salinity, with the most prominent periods around 8 and 17 years. For nutrients the trends in time from the firstly increasing and more recently decreasing river discharges was clearly visible, and, together with a strong seasonal cycle, these trends obscured any longer-term cyclic signals. Still, also for the geochemical and biological parameters a low frequency variability could not be excluded. The long-term anomalies observed in salinity and temperature occurred simultaneously on the whole shelf, indicating a synoptic climatological forcing. Indeed, the decadal patterns of these two parameters were strongly correlated to the atmospheric heat fluxes, the precipitation in NW Europe and the North Atlantic Oscillation Index (NAO I).

Comparison of the mean seasonal cycles at the 8 locations on the shelf showed the classical patterns of chlorophyll with the main peak occurring in spring and a second, but smaller peak in autumn. The timing of these peaks in the year, however, differed between the stations. The earliest spring bloom occurred in the Skagerrak (February-March) and the latest in the English Channel and the Irish Sea (May). At these latter two stations the autumn bloom was hardly visible in the data. Considerable differences were also observed in the length of the period in which the N:P ratio was below the well known Redfield ratio of 16:1. In both the Irish Sea and the English Channel this period was more than 10 months per year between 1960 and 1994, thus suggesting an almost continuous N-limitation for the growth of phytoplankton at these stations. Along the Dutch and Belgian coast the period with N:P less than 16 varied between 4 and 10 months per year, while near Helgoland this period suddenly changed from 4-10 months per year before the early eighties to less than 3 months per year after 1985.

Short term fluctuations were present in the time-series of all parameters at all stations, but the cross-correlations between the different stations were non-significant in almost all cases. Thus, although the stations were situated along the route of the mean residual current over the shelf, the data did not suggest some sort of tele-connection by which an anomaly at one station can be trans-

ferred to another. Apparently, the lateral transports on the shelf are so variable and the internal processes which modify the short-term anomalies are so strong, that the transfer of such signals is obscured.



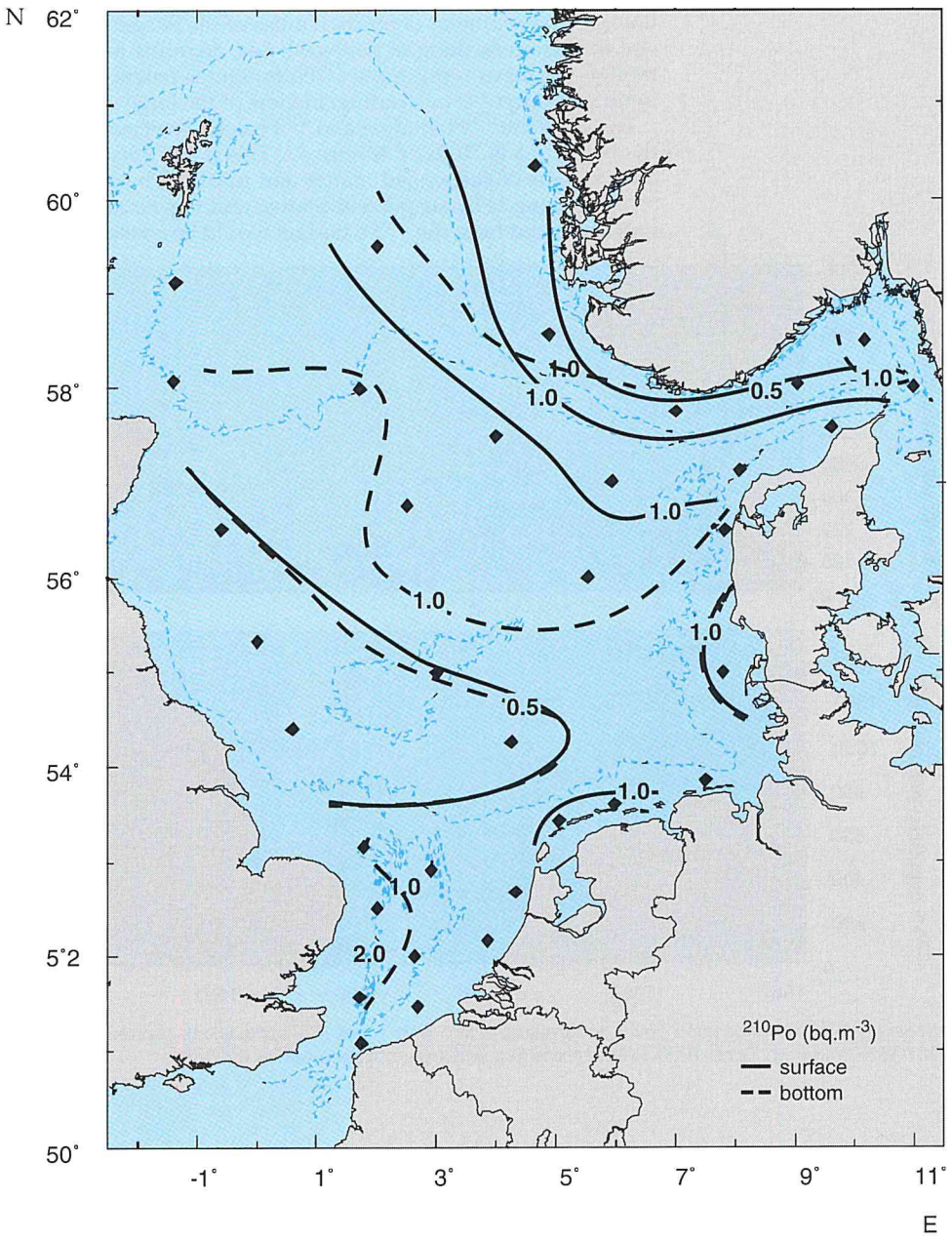

Among the data sets which were stored in the NOWESP research data base were also the concentrations of suspended particulate matter (SPM) measured about 50 km off the Belgian coast between 1975 and 1993 and delivered to NOWESP by the Management Unit of the Mathematical Models of the North Sea (MUMM) in Brussels. These SPM data were evaluated at NIOZ. Panel A shows the time-series of monthly mean concentrations (thin line); the thick line is the 36 months moving average from which an increasing trend is apparent until the mid eighties, followed by a decrease back to about 10 $mg.l^{-1}$ in the early nineties. The variability of the concentrations is, however, considerable and maximum monthly mean values were as high as 45 $mg.l^{-1}$. In panel B the trend is subtracted from the original signal (thin line) thus showing the annual and inter-annual variability. The apparent mean annual cycle which is part of this variability is indicated by the thick line. This analysis clearly demonstrates that before 1983 and after 1988 the short term variability is mainly of seasonal nature. In panel C both the mean annual cycle and the decadal trend are subtracted from the original data, thus yielding the so-called residuals (thin line). The thick line in C is the 12 month moving average of these residuals and shows that the years 1983, 1985 and, to a lesser extent, in 1986 had exceptionally high SPM concentrations that can not be explained by the long-term trend or the seasonal cycle, in 1984 the concentrations were relatively low.

## ON THE CYCLING OF $^{210}$PB AND $^{210}$PO IN THE NORTH SEA

**Contributor:** *J.P. Beks.*

The natural radioisotopes $^{210}$Pb and $^{210}$Po are widely used in marine research. Their presence in the entire marine system, halflives suitable for research on timescales of a few months to a few years, and a relatively easy detection in low concentrations are the major properties. Main topics of concern for a marine $^{210}$Pb budget in a shelf sea are the exchange with the atmosphere and the sediment, and processes in the seawater.

Atmospheric deposition is one of the main sources of $^{210}$Pb in the North Sea water. The depositional flux of (total) atmospheric $^{210}$Pb was sampled every week in the Netherlands: in Groningen (53°18'N 6°35'E) and on Texel (53°01'N 4°48'E) from 1987-1994. With the predominant westerly oceanic winds the annual $^{210}$Pb flux is relatively low, as $^{222}$Rn (the source for atmospheric $^{210}$Pb) is mainly exhaled by the continents. The daily fluctuations in $^{210}$Pb deposition are determined by the almost random daily fluctuations in precipitation and concentration in groundlevel air; the variations in the annual $^{210}$Pb flux appear to be mainly correlated with the number of heavy rain/thunder storms. Changes in the mesoscale weather system induces changes in $^{210}$Pb deposition at an annual or even decadal timescale. Annual variations of this flux are large in the Netherlands, up to a 100%. Translated to the North Sea area the average atmospheric deposition is estimated at about 42 Bq.m$^{-2}$.a$^{-1}$.



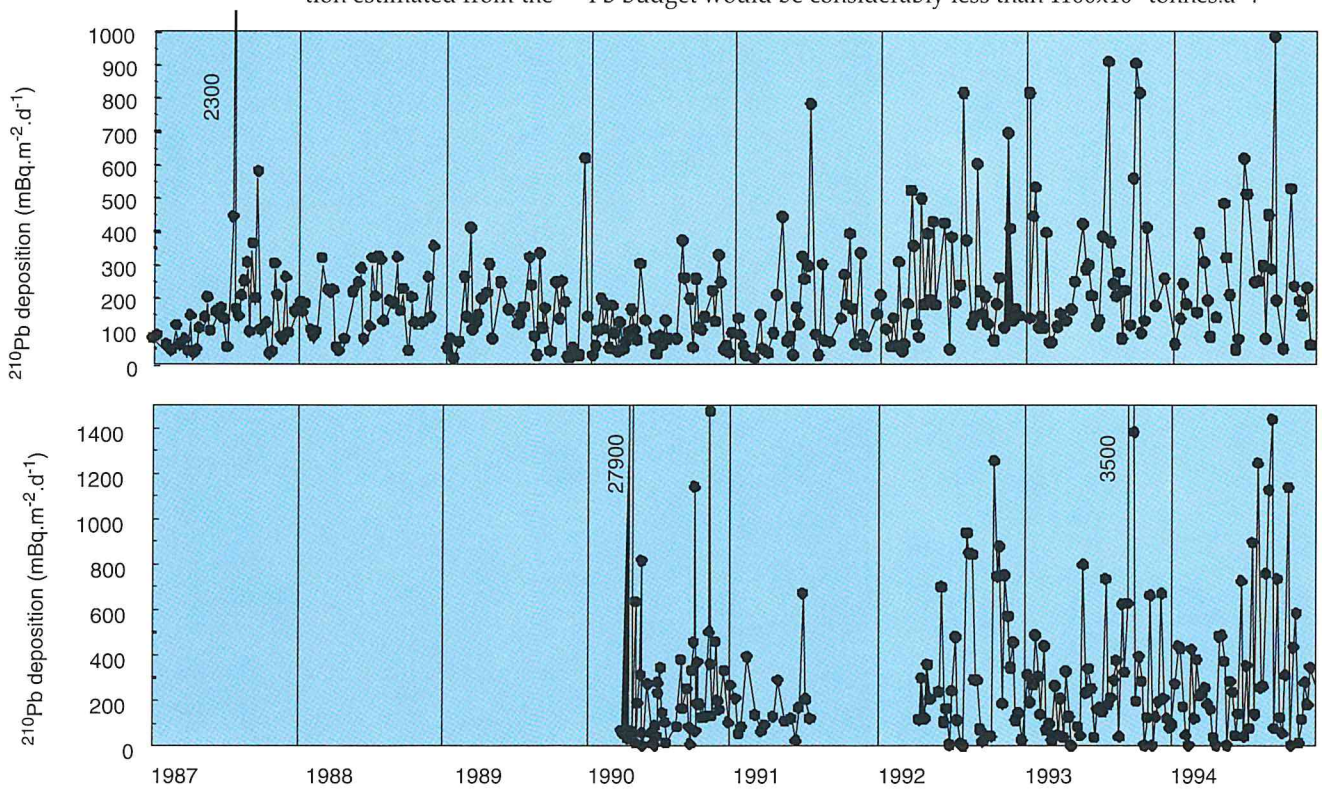

Total $^{210}$Po activity concentration in surface and bottom water of the North Sea. Diamonds represent 36 sampling stations in April 1993. High $^{210}$Po activities occur in the Thames area, along the Duch and Danish coast, and in bottom waters of the central North Sea. Low activities were found in the western North Sea, the Dogger Bank area, and the surface water of the Skagerrak.

The $^{210}Pb/^{210}Po$ system in the seawater was monitored during a 4 seasons programme at 38 stations throughout the North Sea. Dissolved and particulate samples for $^{210}Pb$ and $^{210}Po$ measurements were collected in surface and bottom waters. Summer (total) $^{210}Po$ values in 1993 ranged from 0.4 $mBq.kg^{-1}$ south of the Dogger Bank to 2.4 $mBq.kg^{-1}$ in bottom waters on the west slope of the Norwegian Trench. The 1993 spring season pattern of the $^{210}Po$ distribution was similar. The contribution of dissolved and particulate $^{210}Po$ changes with the seasons. While in summer most $^{210}Po$ was in the dissolved phase, the particulate contribution increased during autumn and winter. In spring most $^{210}Po$ was particulate. Bottom waters at all seasons and stations normally were richer in $^{210}Po$ than surface waters. North Sea water samples from July 1993 and August 1994 had comparable $^{210}Po/^{210}Pb$ ratios in the particulate as well as the dissolved phase. Particulate activities in August 1994 were two times the activities in July 1993, whereas the dissolved activities in August 1994 were only half the July 1993 activities. The ratio (total) $^{210}Po/^{210}Pb$ in bottom waters was mostly greater than 1, irrespective of the quantity of suspended matter or organic matter. This points to effective scavenging of $^{210}Pb$.

From 36 boxcores in the entire North Sea excess $^{210}Pb$ inventories were measured. On this basis the total $^{210}Pb$ flux to the sediment is estimated 150 $Bq.m^{-2}.a^{-1}$. The (excess) $^{210}Pb$ and $^{137}Cs$ inventories have a similar distribution: high in fine-grained areas, low in sandy areas.

In the $^{210}Pb$ budget of the North Sea, the input is determined by the supply by rivers, as artificial supply by power plants and fertilizer plants does not play a major role. Fishery activities only extract a minor part of total $^{210}Pb$ from the seawater. $^{210}Pb$ fluxes to the sediment smaller than 10% of the atmospheric deposition occur in the sandy areas of the Southern Bight and the Dogger Bank. Large fluxes to the sediment, up to 50 times the atmospheric flux, mainly occur in the fine-grained sediment deposition areas of the Skagerrak and the Norwegian Trench. The net lateral flux, from flushing of the North Sea, accounts for 1/3 of the $^{210}Pb$ flux to the sediment. Although the input term in the $^{210}Pb$ budget is balanced by the output term, the match between input and output is misleading, in view of the large errors in both terms.

Based on the $^{210}Pb$ budget and $^{210}Pb$ activity of suspended matter, total mass accumulation in the North Sea is $1100x10^6$ $tonnes.a^{-1}$. This is an order of magnitude higher than estimates based on transport of suspended matter and from $^{210}Pb$ sedimentation rates. Only when we consider $^{210}Pb$ scavenged by suspended matter, and regenerated after particle break-up, mass accumulation estimated from the $^{210}Pb$ budget would be considerably less than $1100x10^6$ $tonnes.a^{-1}$.




Atmospheric $^{210}Pb$ deposition fluxes in Groningen (A) and Texel (B), sampled at approximately weekly intervals. Fluxes from Groningen 1987-1988 and from Texel 1990-1991 were measured and published earlier by Z. Zuo.

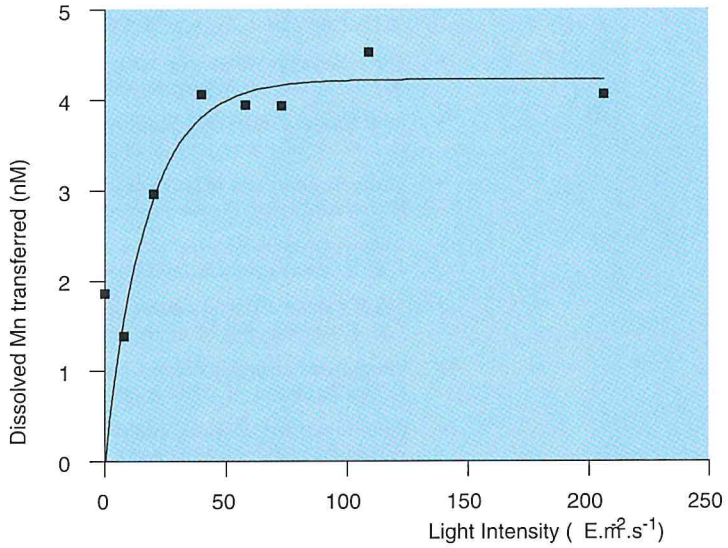
## MECHANISMS OF MN/FE SEQUESTRATION BY *PHAEOCYSTIS* COLONIES

**Contributor:** *V. Schoemann*

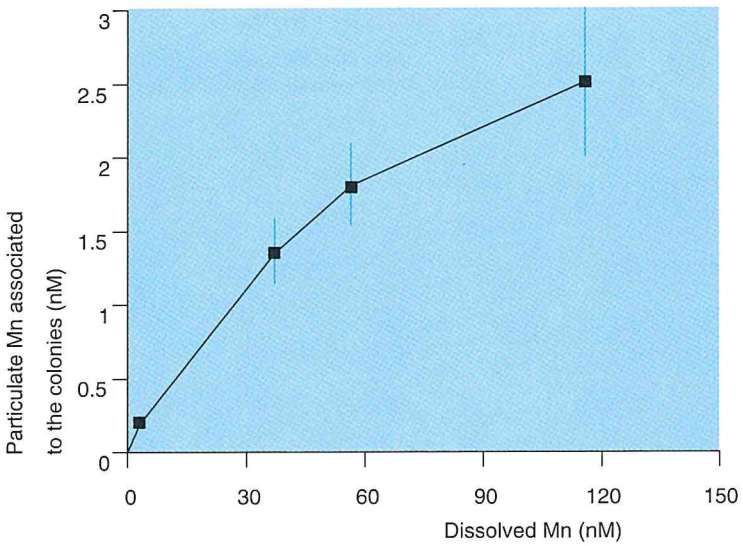
In the frame of the EC project on the 'Biogeochemistry of *Phaeocystis* colonies and their derived aggregates' which started in April 1994 and ended in April this year, in collaboration with C. Lancelot (ULB, Brussels) and U. Riebesell (AWI, Bremerhaven), the mechanisms of Mn/Fe sequestration by *Phaeocystis* colonies were investigated.

Previous work on cultivated *Phaeocystis* colonies suggested that high pH and $O_2$ concentrations reached within the colonies when colony cells are photosynthezing, are leading to precipitates of ferromanganese oxyhydroxides within the colony matrix, thus affecting the geochemical cycle of these trace elements. The mechanisms behind Mn/Fe sequestration by *Phaeocystis* colonies were investigated on cultured and field *Phaeocystis* colonies using radiotracer techniques ($^{54}Mn$, $^{59}Fe$, $^{14}C$) in combination with different chemical treatments. For instance, pre-incubation of *Phaeocystis* colonies with DCMU (dichloromethylurea, a photosynthesis inhibitor) allowed to distinguish between uptake of Mn/Fe due to the photosynthetic activity of the cells and sorption of trace metals on cell surfaces in absence of photosyntyhesis. Furthermore, post-incubation washing of radioactive *Phaeocystis* colonies with the reductive solution of Ti complexed by citrate and EDTA was used to isolate specifically dissolved Mn/Fe actually assimilated by the cells through elimination of amorphous Mn/Fe oxyhydroxides and extracellular Fe/Mn.

The results obtained show that the mechanisms regulating trace element transfers by *Phaeocystis* colonies are not equivalent for Mn and Fe. Transfers independent of photosynthetic activity, represent the largest part of total Fe uptake by *Phaeocystis* colonies. Contrasting, photosynthetic Mn precipitation and accumulation are the most important Mn uptake processes by *Phaeocystis* colonies. Also, Mn uptake by *Phaeocystis* colonies is strongly regulated by ambient light and available dissolved Mn.




Relationship between Mn uptake by *Phaeocystis* colonies and light intensity.




Relationship between Mn accumulation by colonies and ambient dissolved Mn.

## EXTERNAL PROJECTS OF THE DEPARTMENT OF MARINE CHEMISTRY AND GEOLOGY

- Autonomous Lander Instrument Packages for Oceanographic Research (ALIPOR;EC-MAST)
  *W. Helder, T.C.E. van Weering, L. Lohse, H. Franken, B. Koster*
- Ocean Margin Exchanges (OMEX; EC-MAST)
  *W.Helder, T.C.E. van Weering, W. van Raaphorst, H. T. Kloosterhuis, L. Lohse, H. de Stigter, W. Boer, J. van Ooijen, K. Bakker*
- Biogases in European Estuaries (BIOGEST; EC -ENVIRONMENT)
  *W. Helder, H. P. J. de Wilde*
- Mass Transfer and Ecosystem Response (MATER; EC-MAST)
  *W. Helder, E. Koning, J. van Ooijen, K. Bakker*
- European North Atlantic Margins ( ENAM; EC-MAST)
  *T.C. E. van Weering, H. de Haas, W. Boer*
- Marine Ecosystem Regulation: Trace Metals and carbondioxide regulation ( MERLIM; EC-MAST)
  *K. Timmermans, H. J. W. de Baar, R. Nolting, J. de Jong , J. van Ooijen*
- North West European Shelf programme (NOWESP; EC-MAST)
  *W. van Raaphorst, H. Malschaert*
- Biogeochemistry of Phaeocystis colonies (EC-MAST)
  *V. Schumann, H. J. W. de Baar, J. de Jong*
- Air-Sea gas exchange of MAGE (EC-MAST)
  *H.J. W. de Baar, M. Stoll, E. de Jong*
- Transfer of DOC in the oceans (NWO-VvA Theme 9)
  *H. J. W. de Baar, C. Wiebinga*
- Air - sea carbondioxide fluxes (NWO-NOP II)
  *H. J. W. de Baar, E.de Jong, M. Stoll*
- Trace elements -Phytoplankton interactions (NWO-NAAP)
  *H. J. W. de Baar, J. de Jong, R. Nolting*
- Joint Global Ocean Flux Studies in the Southern Ocean (NWO- NAAP)
  *H. J. W. de Baar, J. de Jong, E. de Jong, M. Stoll*
- Mineralisation and regeneration of org. carbon in the North Sea (NWO-VvA Theme 4)
  *W. Helder, W. van Raaphorst, H. de Heij.*
- Recent sediment accumulation and mixing in depositional sinks in the North - Sea (NWO-VvA Theme 4)
  *T. C. E. van Weering, H. de Haas, W. Boer*
- Teluk Banten: Coastal marine sediments and sedimentation (NWO)
  *T. C. E. van Weering, H. de Haas, W. Boer*
- Integrated North Sea Project: Mooring (BEON)
  *W. van Raaphorst, H. Malschaert, H. van Haren, F. van Duyl*
- Remote sensing of water quality (RESTWAQ; BCRS)
  *W. van Raaphorst, H. Malschaert, P. Ruardij.*
- Integrated Data Application (SRON)
  *W. van Raaphorst, H. Malschaert*
- Xenobiotic substances (Rhodamines) as tracers for watermass transport (XTRANS; RWS)
  *W. Helder, J. den Das*
- Carbondioxide in the Southern Ocean (AWI)
  *H. J. W. de Baar, M. Stoll, E. de Jong*

# DEPARTMENT OF MARINE BIOGEOCHEMISTRY AND TOXICOLOGY

**In this department, both natural and anthropogenic organic compounds are investigated. The major research topics are:**

**The investigation of the short and long term variations in the preservation of resistant bio-macromolecules and the mechanisms of oil genesis.**

**Examination of molecular indicators in palaeo environments to decipher conditions favouring organic matter preservation in sediments and to discriminate between natural (e.g. astronomically induced) changes, and man-induced variations in the present climate (NWO-PIONIER project).**

**The study of the environmental chemistry and toxic effects of polyaromatic hydrocarbons (PAHs), organochlorines, organobromines, and organotin compounds.**

**The projects which were finished this year, are highlighted.**

## DIAGENETIC AND CATAGENETIC TRANSFORMATIONS OF SEQUESTERED BIOMARKERS

**Contributor:** *M.P. Koopmans*

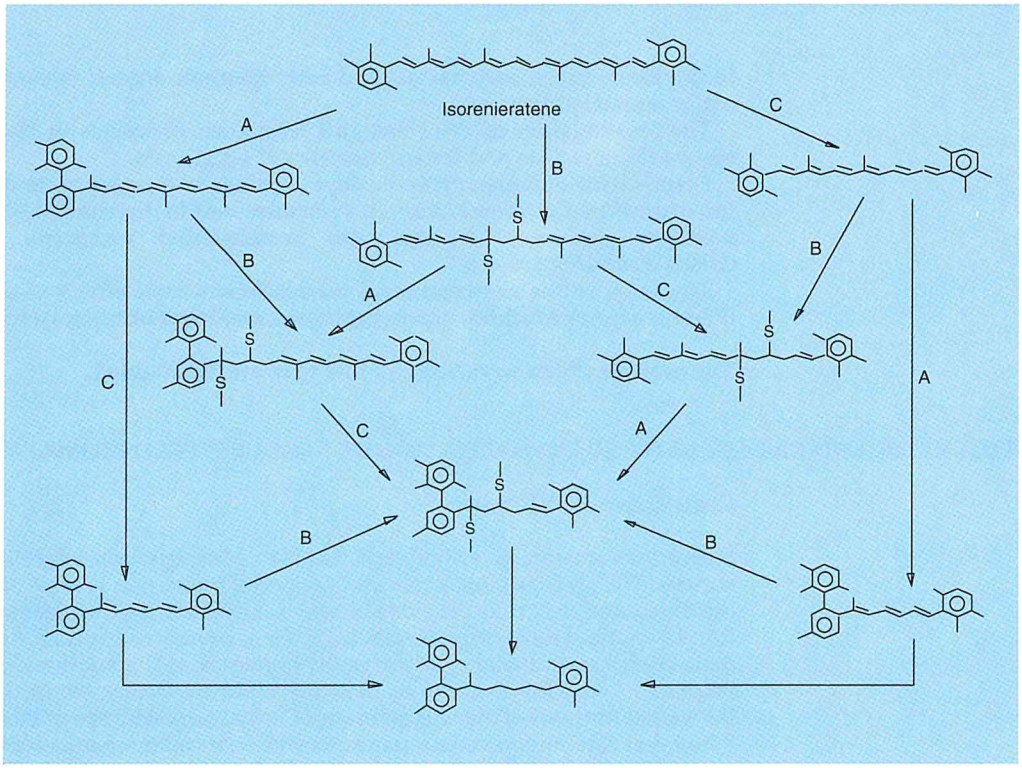
Biomarkers are organic compounds that are unambiguously related to specific biochemical precursors. The precursor molecule of a particular biomarker is biosynthesised by a certain source organism, and may thus provide valuable information on chemical (*e.g.* redox conditions), physical (*e.g.* water temperature) and biological (*e.g.* presence of specific organisms) aspects of ancient depositional environments. In thermally immature sedimentary rocks, the information stored in biomarkers may be obscured as their precursor molecules are incorporated into high-molecular-weight fractions of the organic matter. Compounds with specific functional groups (*e.g.* double bonds and carbonyl moieties) may react with reduced inorganic sulphur species during early diagenesis to form S-rich macromolecules. Alternatively, precursor molecules may be linked by oxygen bonds to become part of high-molecular-weight fractions of the organic matter, although the reactions by which these bonds are formed are not well understood. In order to investigate how the information stored in sequestered biomarkers is affected by the chemical transformations occurring during diagenesis and catagenesis, the geological fate of two classes of biomarkers (organic sulphur compounds and carotenoids) was studied in detail.

Thermally immature sedimentary rocks from the Gessoso-solfifera Formation (Messinian), northern Italy, and from the Ghareb Formation (Upper Cretaceous), Jordan, were artificially matured in the laboratory at temperatures ranging from 160 to 330°C to induce the diagenetic and catagenetic transformations occurring in the natural system. Aliphatic hydrocarbons, organic sulphur compounds, and compounds released after chemical degradation of high-molecular-weight fractions of the organic matter (*e.g.* polar fractions and kerogens) were analysed quantitatively. This combined thermal and chemical degradation approach provided detailed molecular information on the diagenetic and catagenetic fate of sequestered biomarkers.

In the sample from the Gessoso-solfifera Formation, S-bound carbon skeletons (*e.g.* phytane and steranes) in the polar fraction are released at low maturation temperatures (< 260°C), and the amounts of the corresponding free hydrocarbons increase simultaneously. Alkylthiophenes are also generated as stable thermal degradation products of S-bound carbon skeletons. The specific isomer distribution of several alkylthiophenes, *e.g.* 2,5-di-*n*-alkylthiophenes with an $n$-$C_{38}$ carbon skeleton thought to originate from $n$-$C_{38}$ unsaturated ketones biosynthesised by several prymnesiophyte algae, remains constant so that these alkylthiophenes can be used as biomarkers at increased levels of thermal maturity. O-bound carbon skeletons (*e.g.* $n$-$C_{29\text{-}31,37,38}$) are released as saturated ketones, which are also regarded as stable thermal degradation products. At T > 300°C, free hydrocarbons with increasingly shorter chain length are generated in high amounts, probably from C-C bond cleavage of macromolecules sequestered in high-molecular-weight fractions of the organic matter (*e.g.* algaenans, the non-hydrolysable macromolecular components of marine algae).

In the sample from the Ghareb Formation, a similar early generation of S-bound carbon skeletons is observed. However, the relative amount of alkylthiophenes generated is much larger than in the sample from the Gessoso-solfifera Formation. This can be explained by the larger amount of C-S bonds per carbon skeleton in the sample from the Ghareb Formation, which will consequently generate larger amounts of S-containing stable thermal degradation products (*i.e.* alkylthiophenes).

In the course of these studies, a whole new range of diagenetic and catagenetic products of the diaromatic carotenoid isorenieratene was discovered. This carotenoid is uniquely biosynthesised by photosynthetic green sulphur bacteria (Chlorobiaceae), organisms that need both light and free $H_2S$, and it is therefore an excellent biomarker for the occurrence of photic zone anoxia in ancient depositional environments. The newly discovered compounds were formed by (i) cyclisation and




Possible reaction pathways of isorenieratene, including (A) cyclisation, (B) sulphurisation and (C) expulsion reactions.

subsequent aromatisation of the polyene isoprenoid chain, (ii) expulsion of toluene and *m*-xylene resulting in $C_{32}$ and $C_{33}$ 'carotenoids', (iii) sulphurisation, (iv) reduction of the double bonds in the polyene chain, and (v) C-C bond cleavage. The interplay of these reactions can lead to formation of specific isorenieratene derivatives *via* several different reaction pathways. Derivatives of isorenieratene were identified in a suite of rock samples covering the Phanerozoic, indicating that photic zone anoxia has been relatively common in the past. The only present day marine setting in which Chlorobiaceae thrive is the Black Sea. The presence of isorenieratene derivatives in some well known petroleum source rocks (*e.g.* from the Duvernay, Exshaw, Schistes Cartons, Kimmeridge Clay and Menilite Formations) suggests that photic zone anoxia is an important environmental parameter for the formation of petroleum source rocks.

Because the reactions occurring with isorenieratene only involve the polyene isoprenoid chain, it can be expected that similar reactions can occur with other carotenoids, since carotenoids contain by definition a polyene isoprenoid chain. Indeed, diagenetic and catagenetic products of the ubiquitous carotenoid β-carotene, that were formed by the same reactions as the derivatives of isorenieratene, were identified in a rock sample from the Green River Shale and in a North Sea oil.

## ORIGIN AND MOLECULAR CHARACTERIZATION OF THE INSOLUBLE ORGANIC MATTER IN MARINE SEDIMENTS

**Contributor:** *François Gelin*

Kerogen, the insoluble and macromolecular fraction of sedimentary organic matter constitutes the largest reservoir of organic carbon on Earth. For this reason, it has been studied extensively over the past decades as the appropriate analytical tools enabling its investigation were developed. The origin of kerogen, in particular the marine ones, is still a matter of debate. The work performed during this project was dedicated to the investigation of the chemical structure of kerogen to understand its formation. The main method used for that purpose was analytical pyrolysis which involves the thermal fragmentation in an inert atmosphere of the macromolecular material, followed by separation and identification of the products released.

The project initially focused on the understanding of mechanisms of pyrolysis of well-known high-molecular-weight compounds. Ether lipids isolated from the green microalga *Botryococcus braunii* were pyrolysed. The pyrolysis products were identified as alkenes, alkanes and mid-chain ketones. The position of the carbonyl group in the ketones corresponded to the position of the ether bond in the lipids. This clearly indicated that pyrolytic cleavage of secondary ether bonds generates both mid-chain ketones and alkanes or alkenes. Moreover, cleavage of the ether bond appeared to be the initial step and triggered the formation of other pyrolysis products. Based on the mechanisms of pyrolysis described above, the structure of the insoluble aliphatic biomacromolecule (algaenan) from *B. braunii* race L was identified as a polymer composed of long-chain isoprenoid units, comprising 40 carbon atoms, linked together with oxygen bonds (ether bridges) at very specific positions of the carbon skeleton. More information was obtained by subjecting a soluble biopolymer isolated from *B. braunii* race A to flash pyrolysis. Its very complex pyrolysate (representation of the products of pyrolysis) was compared with the pyrolysate of the insoluble algaenan produced by the same algal species, revealing very close structural similarities. Hence, it was concluded that the insoluble biomacromolecule, *i.e.* the algaenan, was a more condensed and/or reticulated form of the soluble aliphatic polyaldehyde.

Evidence for the occurrence of algaenans in the marine environment was obtained by the discovery of resistant biomacromolecules produced by five out of seven marine microalgal species investigated. The chemical structure of the algaenan biosynthesized by the eustigmatophyte *Nannochloropsis salina* was studied by solid state $^{13}C$ NMR, chemical degradations using hydroiodic acid (HI) and ruthenium tetroxide ($RuO_4$), and flash pyrolysis. It appeared from these investigations that the *N. salina* algaenan was composed of linear alkyl chains, containing 28 to 34 carbon atoms, linked by ether bridges. A second eustigmatophyte, *Nannochloropsis* sp., was shown to produce an algaenan very similar to that produced by *N. salina*. It was also suggested that diols and alkenols, lipids also produced by the eustigmatophytes, are the biosynthetic precursors and building blocks of the algaenans.

No evident precursor could be established for the algaenans of the three algaenan-producing green microalgae *Chlorella spaerckii*, *Chlorococcum* sp. and *Nannochloris* sp. These algaenans are comprised of mixtures of structurally different macromolecules, partly aliphatic for the two former algae and fully aromatic for the latter one. It was concluded, based on the occurrence of algaenans in these marine algal species that a significant part of marine kerogens consists of selectively preserved algaenans. Therefore, these type of biomacromolecules are thought to be potential precursors of marine crude oils.

The importance of algaenans in the marine ecosystem was further demonstrated with the pyrolysis studies of kerogens isolated from an immature Miocene sediment (Vena del Gesso, Messinian, Italy). The nature, abundance and origin of the pyrolysis products were studied. It appeared that the nine kerogens studied were essentially composed of homogenous macromolecular components, *i.e.* presumably algaenans, and sulfur-bound lipids incorporated into the insoluble matrix during the early diagenesis. These kerogens were ultimately treated with the chemical reagents $CrCl_2$ and $Li/EtNH_2$ to remove most of the components which were (poly)sulfur-linked to the macromolecular network. As shown by the flash pyrolysis of the residue obtained, these degradation reactions led to an enrichment in algaenan-derived macromolecules.

In summary, algaenans (non-hydrolysable macromolecules), such as those biosynthesized by contemporary marine algae, must have been produced in ancient marine environments as well and represent a significant component of the organic matter present in marine sediments. The chemical properties, such as the resistance against bacterial attack, of these algaenans can contribute to their relative enrichment upon burial in sediments, via a process called the Selective Preservation Pathway.

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## ASSESSMENT OF CYTOCHROME P450 1A IN DAB AS AN EFFECT BIOMARKER FOR EXPOSURE TO POLYCHLORINATED BIPHENYLS AND RELATED COMPOUNDS

**Contributor:** *H.M. Sleiderink*

The toxic effect of polyhalogenated aromatic hydrocarbons such as polychlorinated biphenyls (PCBs), dibenzo-*p*-dioxins (PCDDs) and dibenzofurans (PCDFs) is mediated through a common mode of action, finally resulting in the induction of the enzyme cytochrome P450 1A (CYP1A). Because of its wide distribution, the flatfish dab (*Limanda limanda*) is an important species in international contamination monitoring programmes in the North Sea, such as the Joint Assessment and Monitoring Programme of the Oslo and Paris Commission, and the North Sea Task Force. As a bottom-dwelling flatfish dab is often in close contact with sediment. The objective of this project was to provide the necessary mechanistic support for the inclusion of measurements of CYP1A activity in dab liver as an effect-biomarker for exposure to polyhalogenated aromatic compounds in these international monitoring programmes.

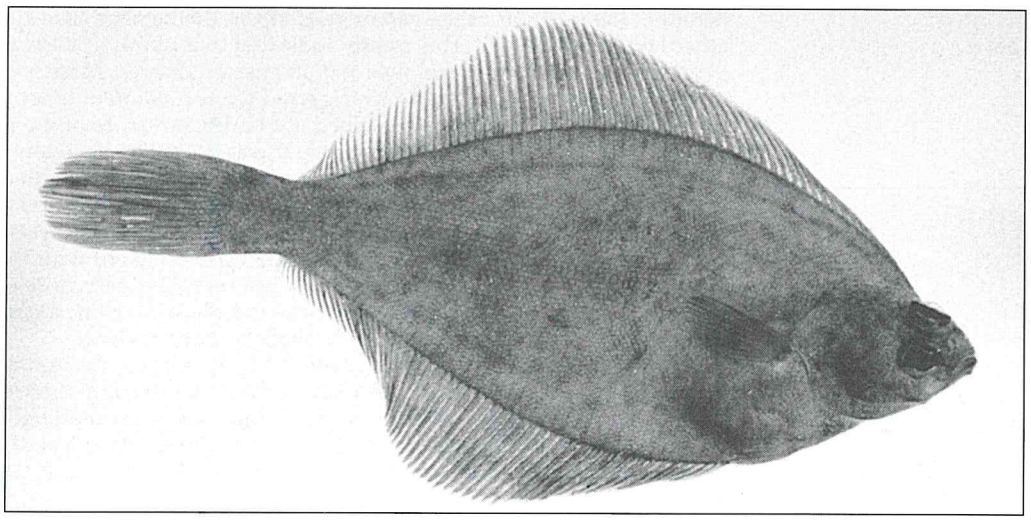


Fig. 1. the flatfish dab *Limanda limanda* is an important species in international contamination monitoring programmes in the North Sea Photo H. Hobbelink

During several cruises and laboratory experiments PCBs were selected as model compounds, since they were shown to be the most important class of contaminants capable of inducing CYP1A in the southern North Sea. The levels of CYP1A were measured in two ways: the enzyme activity was measured as the conversion rate of a model substrate to a fluorescent metabolite (EROD-activity), and the enzyme concentrations were measured immuno-chemically (by ELISA). The project has benefited much from the international co-operation set up within the theme microcontaminants of the Integrated North Sea Programme (INP), of which the cruises were carried out in 1991 and 1992. Colleagues of the Laboratory of Marine Molecular Biology of the University of Bergen (Norway) and the Netherlands Institute of Ecology, Centre for Estuarine and Coastal Ecology in Yerseke (the Netherlands), contributed as co-authors to some of the publications.

A number of laboratory experiments utilizing a technical PCB mixture and single chlorobiphenyl congeners showed that PCBs were indeed able to induce CYP1A in the liver of dab. Congeners not substituted with chlorine atoms in the *ortho*-positions with respect to the C-C inter-ring bond ('planar CBs') showed the strongest induction potential, whereas the induction potential of some mono-*ortho* substituted congeners in dab was relatively low compared to mammals. Similar observations have been reported in the literature for other fish species.

Besides exposure to environmental contaminants, several natural factors were shown to influence CYP1A expression too. Since such variations have nothing to do with exposure to contaminants, it is of crucial importance to know these factors and establish the magnitude of their impact on CYP1A levels. The most surprising result of this project was the very strong influence of sea-water temperature on CYP1A expression in dab. This effect is not only relevant when comparing CYP1A levels between different seasons, but also in a single season when differences in bottom water temperature of up to 10°C can occur between well-mixed and stratified areas of the North Sea. Statistical analyses of the data indicated that water temperature was inversely related to CYP1A levels, whereas PCB concentrations showed, as expected, a positive correlation. In dab from off-shore stations with low bottom water temperatures due to stratification, highly elevated CYP1A levels were observed in mature male dab collected in August/September, albeit the levels of PCBs at these stations were low .

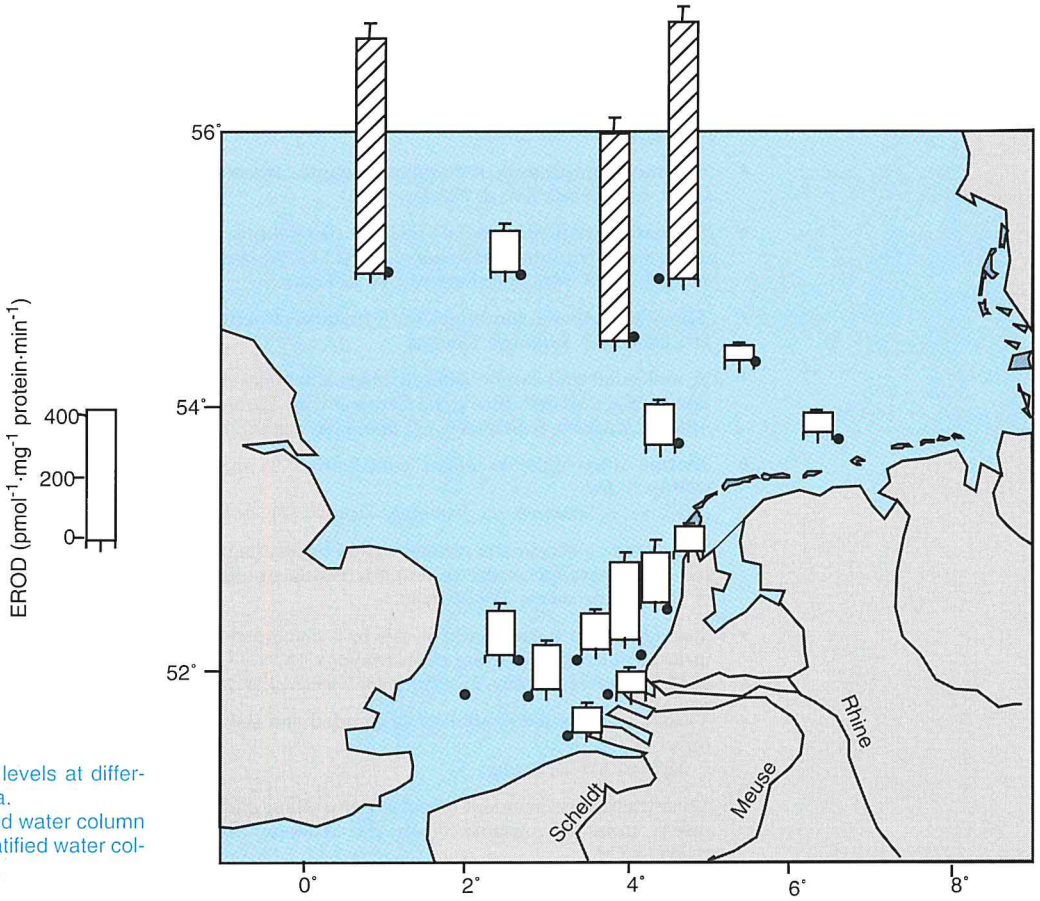



Fig. 2. Cytochrome P4501A levels at different locations in the North Sea.
Open bars are vertically mixed water column (T≥°C). Hatched bars are stratified water column (bottom water ≥12.5°C).

The occurrence of the temperature effect on CYP1A expression was confirmed in a laboratory acclimation experiment. Sea water temperature also had an effect on the dose - effect relationship when fish were induced with 3,3',4,4'-tetrachlorobiphenyl (CB-77), one of the most potent inducers of CYP1A. Although the maximum responses at low (10°C) and high (16°C) temperature were similar, the induction response occurred faster at the higher temperature. Thus, at low temperature the basic activity is higher, but the induction response after exposure to increased levels of contaminants is slower.

A comparison of CYP1A expression in juvenile and adult stages of both sexes showed that adult males of 15-20 cm were most suitable. Like in other species, gravid females showed a lowered expression of CYP1A compared to males. Outside the breeding season, no significant differences between the sexes were observed.

A cruise on the North Sea in early November was undertaken to test whether this is the optimal sampling period for application of these biomarkers in monitoring programmes. Sea water temperatures were within 1°C at this time of year and spawning related migration is reported not to start before December. The results showed that the enzyme responded to the increased levels of contaminants in the coastal area compared to three off-shore locations. Between these more pristine off-shore areas, PCB levels and CYP1A expression were similarly low. The rather high basic level of CYP1A activity that was found in dab has also been reported for other flatfish species.

It is concluded that dab can be used for monitoring of CYP1A activity only when a number of factors other than exposure to PCBs and related compounds are taken into account when designing the sampling scheme and when interpreting the data. With other flatfish species dab seems to have a rather high basal activity of CYP1A in common, which lowers the induction response expressed as a ratio of high-exposed to low-exposed fish.

## EXTERNAL PROJECTS OF THE DEPARTMENT OF MARINE BIOGEOCHEMISTRY AND TOXICOLOGY

- 'Molecular palaeontology of marine sediments' (PIONIER project NWO-BOA)
  *J.S. Sinninghe Damsté, M. Baas, W.I.C. Rijpstra, M. Dekker, M. Kok, I, Höld, S. Schouten, K. Grice.*
- 'Environmental changes at the time of the Permian/Triassic biotic crisis' (NWO-GOA).
  *M. Sephton, J.W. de Leeuw.*
- 'Chemical composition of dissolved organic carbon' (NWO-NOP)
  *J.D.H. van Heemst, J.W. de Leeuw.*
- 'High resolution continental - marine correlations: Reconstruction of Mediterranean late Neogene climatic and environmental history.' (NWO-GOA; main contractor University of Utrecht)
  *H.J. Bosch, J.S. Sinninghe Damsté, J.W. de Leeuw.*
- 'The role of euxinic conditions for formation of petroleum source rocks' (Shell)
  *D. Clifford, J.S. Sinninghe Damsté.*
- 'A molecular and carbon isotopic biogeochemical study of environmental conditions leading to deposition of 'black shales' during the Cenomanian/Turonian oceanic anoxic event' (NWO-GOA)
  *M.M.M. Kuypers, S. Schouten, J.S. Sinninghe Damsté.*
- 'Marine microalgae as major contributors to marine sedimentary organic matter and crude oils' (NWO-GOA)
  *P.Blokker, S. Schouten, J.S. Sinninghe Damsté, J.W. de Leeuw.*
- 'Improved palaeoclimate reconstruction by an integrated compound-specific stable carbon isotopic, flash pyrolysis mass spectrometric and micro-palaeontological approach' (NWO-GOA)
  *A. Boom, S. Schouten, J.W. de Leeuw.*
- 'Recognition of palaeobiochemicals by a combined organic sulphur and isotope geochemical approach: its application in molecular palaeontology' (NWO-GOA)
  *H.M.E. van Kaam-Peters, J.S. Sinninghe Damsté, J.W. de Leeuw.*
- 'Origin and characterization of suspended and sedimental organic matter by means of carbon isotopes' (NWO-GOA)
  *L. Megens, J.W. de Leeuw.*
- 'Quantitative assessement of palaeo-upwelling and palaeo-river input: a high resolution study of sediments from the Angola Basin (SE Atlantic) using Uk37 and compound-specific isotopic data' (NWO-GOA)
  *G.J.M. Versteegh, J.W. de Leeuw, F.J.H. Jansen.*
- '*In vitro* biotransformation, residue analysis and genotoxicity of lipophilic organohalogens in marine mammals and birds' (BEON).
  *J.P. Boon, M.J. Greve, J. Bouma, C. van Hezik, W.E. Lewis, M.T.J. Hillebrand.*
- 'Effects of tributyltin exposure on the sexual development of the common whelk (*Buccinum undatum*)' (RIKZ).
  *B.P. Mensink, J.P. Boon, C.C. ten Hallers-Tjabbes, C.V. Fischer, H. Kralt.*
- 'Occurrence of imposex in common whelks from the Eastern Scheldt in relation to concentrations of butyltin and phenyltin compounds' (RIVM)
  *B.P. Mensink, J.P. Boon, C.C. ten Hallers-Tjabbes, C.V. Fischer.*
- 'Contaminants in the Marine Environment: Their fate in the abiotic and biotic compartments with emphasis on biological responses (biomarkers) of organisms'. (EU-DG-XIIB).
  *J.M. Everaarts, E.M. van Weerlee, C.V. Fischer.*
- 'Teluk Banten: chemical boundary conditions and sources of major contaminants' (NWO).
  *K. Booij, M.Th.J.Hillebrand, J. van Ooijen, R.F. Nolting.*
- 'Time-integrated sampling of organic contaminants in the water phase' (RIKZ)
  *K. Booij, H.M. Sleiderink, E.M. van Weerlee*
- 'Time integrated sampling using solid phase micro extraction and empore disks' (RIKZ)
  *J.L.M. Hermens, K. Booij, W. Mulder.*

# DEPARTMENT OF BIOLOGICAL OCEANOGRAPHY



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

## SEDIMENTATION AND DEGRADATION OF ORGANIC MATTER PRODUCED BY MARINE PHYTOPLANKTON

**Contributors:** *R. Osinga, F.C. van Duyl, A.J. Kop, W.E. Lewis*

Production of organic matter by photosynthesis and its mineralization to carbon dioxide are the two major processes in the marine carbon cycle. In the sea, most organic matter is produced by phytoplankton. This project concerns some aspects of the fate of the organic matter produced by marine phytoplankton in general, and the fate of β-dimethylsulfoniopropionate (DMSP) in particular. DMSP is biogeochemically important as a precursor for dimethylsulfide (DMS), which plays a role in atmospheric chemistry. The project focused on the colony-forming phytoplankton genus Phaeocystis in the southern North Sea

Experiments with the alga *Emiliania huxleyi* showed that accumulation of DMSP containing algae on the sediment could lead to rapid formation of DMS, especially under anoxic conditions. In pelagic mesocosm experiments with a bloom of *Phaeocystis* sp., sedimentation of the algae was studied in relation to DMS-release. Sedimentation was related to the phytoplankton standing stock in the water column. Formation of DMS occurred in short peaks, which were not necessarily related with sedimentation events, nor with the termination of the *Phaeocystis* bloom, as had previously been suggested.

Aerobic degradation experiments with phytoplankton debris dominated by *Phaeocystis* sp. showed that the algal material consisted of a labile and a refractory fraction, each comprising ca. 50% of the total organic carbon. The labile fraction was completely degraded within one week, while some refractory material was still left after 100 days. Relatively more refractory compounds were produced during the early growth phase of *Phaeocystis* sp.

In benthic degradation experiments with similar *Phaeocystis*-dominated phytoplankton detritus, the effects of the sea urchin *Echinocardium cordatum* on several benthic processes were studied under various organic loads. After pulse-additions of organic matter, benthic oxygen uptake, benthic bacterial production, transport of organic matter into the sediment and sulphate reduction rates in deeper sediment layers were all higher in the presence of the sea urchins than in systems without. When more organic matter was added, the magnitude of the effects of the sea urchins did not change significantly, except for oxygen uptake rates, which were further stimulated under higher organic loads. This could be explained by an enhanced oxygen transport into the sediment, leading both to higher aerobic metabolic activity and to an increased reoxidation of reduced inorganic compounds.

*In situ* benthic mineralization rates were measured at two locations in the southern North Sea. At the Broad Fourteens, an area experiencing high current velocities, oxygen uptake, sulfate reduction and benthic bacterial production showed a clear seasonal pattern. At the deeper, less turbulent Oyster Grounds the seasonal pattern was less regular. Events as storms and fishery-related beam-trawl activities may have considerable effects on benthic mineralization in this area. At both locations, aerobic respiration was the most important benthic metabolic pathway, although sulphate reduction rates were higher than suggested in the literature.

## SIZE DEPENDENT RESTRICTIONS ON COMPETITION FOR NUTRIENTS BY MARINE PHYTOPLANKTON.

**Contributor:** *Willem Stolte*

Phytoplankton cell size varies a few orders of magnitude and is an important factor in determining the carbon and energy fluxes in the marine environment. As phytoplankton growth in marine ecosystems is often nitrogen-controlled, knowledge of the effect of enhanced nitrogen availability on marine algae is essential for predicting effects of increased nitrogen loads on local and global carbon fixation and sedimentation. Therefore, the goal of this study was to investigate the role of different nitrogen supply regimes on the size distribution within phytoplankton populations. The effect of different amplitudes and frequencies of pulses on competitive ability were investigated as well as the effect of nitrate vs. ammonium as the source of nitrogen.

The maximum specific growth rate of a variety of organisms is negatively related to body size. This allometric relationship is often satisfactory described with the power function:

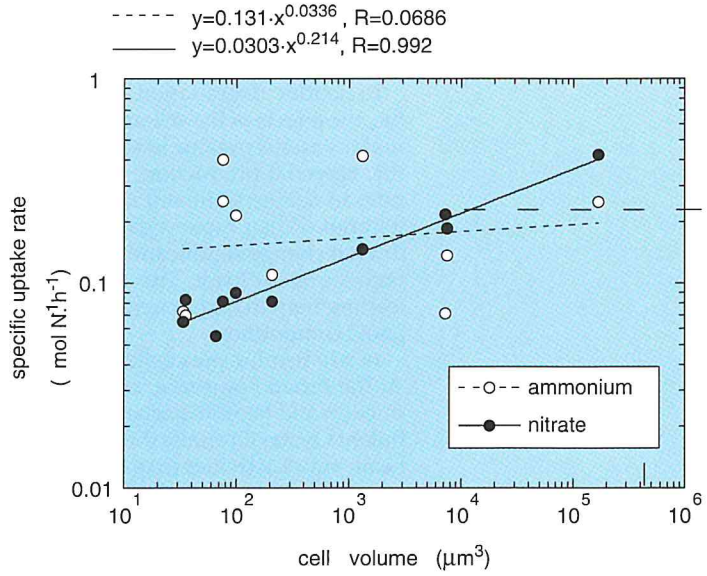
$$V = a \cdot W^b$$

where $a$ is a proportionality constant dependent on the used units and $b$ describes the size dependence of $V$ (a specific rate). $W$ is a measure for body weight, for unicellular organisms often represented by cell volume. For a variety of heterotrophic organisms $b$ = - 0.25. For unicellular phytoplankton, $b$ is often less negative.

In this study, a size-dependence of growth rate was derived on the basis of the cell surface to biomass ratio. Based on this ratio it was hypothesised that the size dependence would be less strong when the specific growth rate is limited by nitrogen. Large cells reduce their nutrient quota to a greater extent relative to their volume than small algae, in a way that nitrogen quota of nitrogen-limited cells is more related to the square rather than to the cube of the cell radius. Since the surface related uptake rate of nutrients is also proportional to the square of the cell radius, the size dependence of phytoplankton growth rate is negligible under severe nitrogen limitation at a constant supply rate of nitrogen, but the higher cell volume to biomass ratio of large phytoplankton makes them potential storage specialists.

Experiments with an axenic strain of the marine diatom *Ditylum brightwellii* showed that the initial specific nitrate uptake rate was not correlated to cell volume. However, larger cells were able to sustain this uptake rate for a longer period and thus depleted the external pool of nitrate in less time than did smaller cells of the same species. Intracellular pools of nitrate could be detected and the specific intracellular concentration of nitrate was highest in the larger cells, as hypothesised. Upon ammonium addition, ammonium did not accumulate in the cell to a measurable amount. Concurrently, ammonium was not faster depleted in the large cell culture.

In addition to the hypothesis that a variable nutrient supply can select for larger species compared to a more continuous supply, it could be shown to be more complex for nitrogen controlled environments. The response of phytoplankton to variable supplies of ammonium differed principally from that of nitrate. In an experiment with monoalgal cultures of different taxa, net specific ammonium uptake rate was not correlated to cell volume, but specific nitrate uptake rate was positively correlated with phytoplankton cell volume, independent of taxonomy within the group of species tested. According to the nutrient uptake rates, a large cell volume was expected to be a




Specific uptake rates in nitrate or ammonium pulsed monocultures, plotted against cell volume of the cultured algae. Straight lines are power fits.

selective advantage under variable supplies of nitrate. Indeed, in continuous culture competition experiments under the same nutrient regime, selection for large cells occurred when nitrate was the only nitrogen source, whereas no selection for cell size occurred when nitrogen was supplied in the form of ammonium.

Nitrate use is hypothesised to be limited by the availability of iron in certain areas of the oceans. During the Bloom-93 cruise in the northern part of the North Sea and the adjacent part of the Atlantic Ocean, nitrate uptake and assimilation by phytoplankton was studied. In this area, high nitrate concentrations co-occurred with extremely low concentrations of dissolved iron. Upon addition of iron, the enzyme nitrate reductase of the phytoplankton population increased on a per cell basis while nitrate uptake was not influenced. Because the potential nitrate reduction rate was higher than the measured nitrate uptake rates, it is not clear whether iron was limiting nitrate use in this area. The effect of iron limitation on nitrate assimilation complicates the results of size dependent nitrogen competition. If nitrate reduction is strongly inhibited, the advantage of larger cells using nitrate as an alternative nitrogen source disappears. At moderate inhibition of nitrate reduction it can be an additional advantage to store nitrate intracellularly before it is reduced. Whether iron limitation affects phytoplankton production via nitrate reductase needs more research.

Considering the large taxonomic diversity in phytoplankton, it is not a surprise that taxonomic differences play an important role. However, the size of a cell causes particular restrictions to nutrient uptake, storage (because nitrogen is not stored as a polymer) and growth. Small algae can rapidly respond numerically upon nutrient addition. On the other hand, storage of nitrate is a strategy which is restricted to large algae with a high vacuole volume to biomass ratio.

To construct predictive ecosystem models it is necessary to understand the composition and growth of all trophic levels. Our results will help future work on ecosystem studies because it provides key factors which determine the size spectrum of phytoplankton production with respect to nitrogen source and frequency and amplitude of fluctuations. In the end, this will hopefully lead to better understanding of the functioning of whole ecosytems.

## ECOPHYSIOLOGY OF THE CALCIFYING MARINE ALGA *EMILIANIA HUXLEYI*

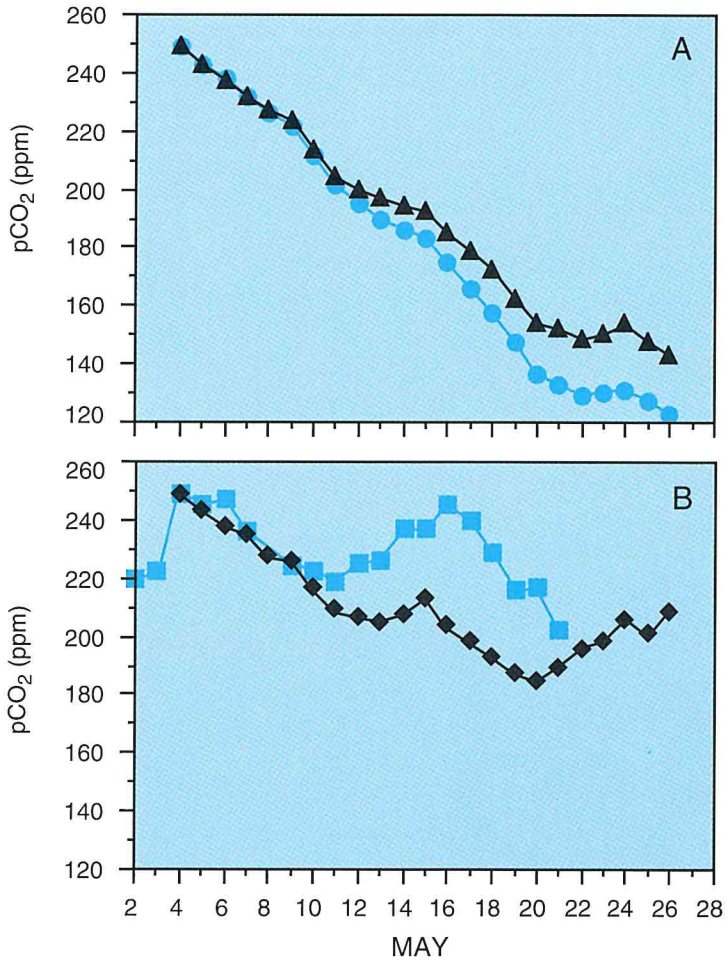
**Contributors:** *J.D.L. van Bleijswijk, M.J.W. Veldhuis, P. van der Wal, E.S. Kempers, G.W. Kraaij*

Light limitated growth of the calcifying marine alga *Emiliania huxleyi* is a net sink for carbon dioxide. In contrast, growth under phosphate str$^{e}$ss produces carbon dioxide. The formation of an *E. huxleyi* bloom of 30 million cells $l^{-1}$ decreased the partial pressure of carbon dioxide with 20 ppm less than bloom formation of a non-calcifying phytoplankton community reaching the same biomass. The succes of *E. huxleyi* blooming was primarily determined by the strength of loss factors. These are the main conclusions of the PhD project *Ecophysiology of the marine calcifying alga Emiliania huxleyi* which ended on 2 Februari 1996 with the promotion of Van Bleijswijk.

The research project was dedicated to the effect of blooms of the calcifying alga *E. huxleyi* on the inorganic carbon system of marine surface waters and, vice versa, to the effect of surface water characteristics, including photon flux density, temperature, and nutrient concentrations, on *E. huxleyi* bloom formation. Cell division, photosynthesis and calcification, were studied on timescales of hours, days and weeks. Attention was paid to intraspecific variability within the cosmopolitan *E. huxleyi*.

On the basis of measurements in semi-continuous laboratory cultures, it was calculated that light limited growth of *E. huxleyi* is a sink for carbon dioxide, whereas growth under phosphate stress produces carbon dioxide. These results imply that growth of natural *E. huxleyi* populations (typical densities between 0.5 and 50 million cells $l^{-1}$) under phosphate stress may increase the carbon dioxide concentration of surface water with 0.05-0.5 µmol $l^{-1}$ $d^{-1}$.

Calculations based on the daily net changes in biomass and calcium carbonate in a large outdoor enclosure (11 $m^3$) revealed that the phytoplankton community, including an *E. huxleyi* bloom of 30 million cells $l^{-1}$, had decreased the partial pressure of carbon dioxide ($pCO_2$) from 250 to 150 ppm. In comparison, a non-calcifying phytoplankton community reaching the same biomass (about 0.8 g C $m^{-3}$) would have reduced $pCO_2$ from 250 to 130 ppm. Clearly, *E. huxleyi* decreases the concentration of carbon dioxide in surface waters to a smaller extent than non-calcifying phytoplankters.




Calculated effects of phytoplankton growth and temperature increase on $pCO_2$ in an outdoor enclosure. Calculations were done with the programme pH-$CO_2$ (courtesy M.M. Rutgers van der Loeff (AWI) and M.C.H. Stoll). A: calculated $pCO_2$ for phytoplankton community including calcifying *Emiliania huxleyi* population ( ▲ ) compared to $pCO_2$ for a non-calcifying phytoplankton community ( ● ). B: calculated $pCO_2$ for a phytoplankton community including the calcifying *Emiliania huxleyi* population corrected for temperature increases during the course of the experiment, ( ◆ ) compared to $pCO_2$ measured ( ■ ) by Purdie and Finch (1994).

Experiments in the laboratory, in enclosures and in the field demonstrated significant net dissolution of coccolith calcite in the dark period (>10% of standing stock in 8 h) despite the fact that the ambient seawater was supersaturated with calcium carbonate. Dissolution of calcite consumes $CO_2$ and bacterial activity, cell division and cell lysis may all contribute to the dissolution process.

On the other hand, it was shown that calcification can continue in the dark and that phosphate limitation stimulates this dark calcification. The results imply that calcification measurements should extent over a complete L:D cycle (24 h). Detachment of coccoliths from the *E. huxleyi* cell was found to occur mainly during cell division. Numbers of detached coccoliths also increased during the decline of an *E. huxleyi* population due to grazing activity or lysis of cells.

Using a combined morphological and immunological approach, it was found that two major calcified types of *E. huxleyi* are unequally distributed over the oceans. The smallest, type A (coccosphere diameter 3-5 µm), was widespread in the Atlantic region. For reasons yet unknown, the larger type B (coccosphere diameter 5-8 µm) had a far more restricted distribution; this type was only encountered in the North Sea. Recent experiments indicate that type B is a polyploid of type A.

*E. huxleyi* types A and B showed considerable differences in cell and growth characteristics. Type B grew faster than type A at low photon flux densities (PFD <20 µmol photons $m^{-2}$ $s^{-1}$) in the laboratory. Type B cells had higher calcium carbonate and organic contents, higher chlorophyll fluorescence and higher light-scatter properties. Considering the effects of PFD, temperature and phosphate concentration on cell and growth characteristics, the diel variability in these parameters, induced by the L:D cycle, was significant.

In large outdoor enclosures with low and intermediate phosphate loadings, intense blooms of *E. huxleyi* type A developed. In contrast, *E. huxleyi* numbers stayed low in enclosures with high phosphate concentrations and in unfertilized enclosures.

In order to find out whether the formation of *E. huxleyi* blooms in the enclosures was controlled by nutrients (bottom-up) or by predators (top-down), the *in situ* gross growth rate of *E. huxleyi* was determined on the basis of diel changes in cellular DNA content. The gross growth rates of *E. huxleyi* did not differ between enclosures. In contrast, the loss rates of *E. huxleyi* differed significantly. In enclosures with low and intermediate phosphate concentrations loss rates were low, allowing extensive blooming of *E. huxleyi*, whereas in the enclosure with high phosphate concentrations and in the unfertilized oligotrophic enclosure losses were high, preventing blooming of *E. huxleyi*. Clearly, losses, or rather the lack of such, determined the succes of *E. huxleyi* blooming and nutrient conditions affected the *E. huxleyi* loss rates, probably because they affected the growth rates of other phytoplankton species.

Cell cycle studies of *E. huxleyi* showed that PFD exerts control only on the $G_1$ phase and not on the S and $G_2M$ phases of the DNA synthesis cycle. Temperature affects the $G_2M$ phase (and probably also the other phases). In addition to environmental control, an internal *E. huxleyi* clock seems involved in the regulation of cell cycle processes.

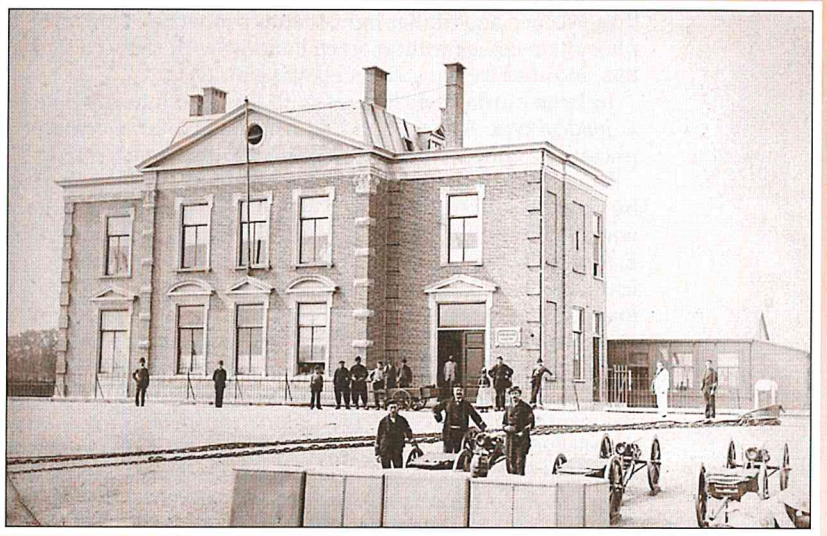
(*Overdruk uit: Tijdschrift der Ned. Dierk. Ver.* (2). *V.* 2).

# HET ZOÖLOGISCH STATION

DER

# NEDERLANDSCHE DIERKUNDIGE VEREENIGING

in 1896



Dezelfde bediende die sedert 1889 in het station werkzaam is, bleef ook in 1896 weer aan die inrichting verbonden; daarnaast stond der instelling gedurende de zomermaanden een jong maatje ten dienste, dat echter niet aan de verwachtingen, die men omtrent zijn geschiktheid gekoesterd had, voldeed.

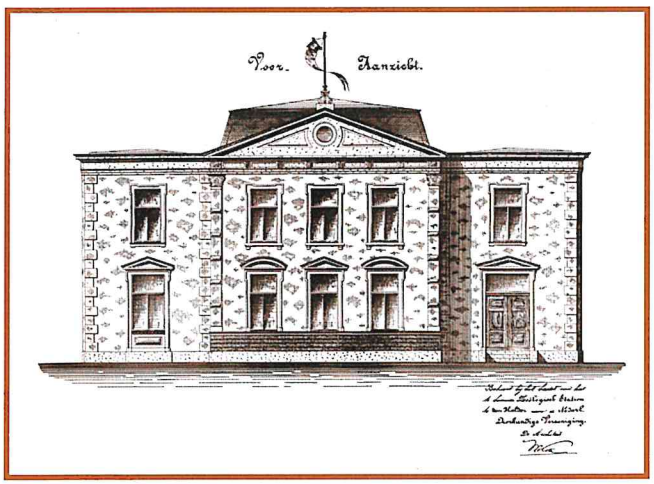
Ik stel mij voor in dit jaar, bij wijze van proef, een visschersjongen tijdelijk in dienst te nemen.

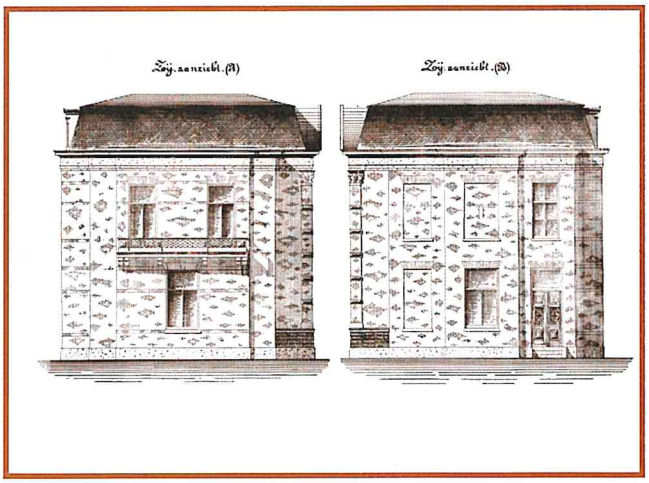
Met het oog op de uitbreiding, die mijne werkzaamheden als adviseur allengs ondergaan hebben, vergunde de Minister van Waterstaat mij, toen de schrijver, die mij tot nog toe ter zijde had gestaan, door een ander vervangen moest worden, in zijn plaats iemand, die een academische opleiding genoten had tot mijnen assistent te benoemen. Tijdelijk, om te beginnen voor de vier maanden Juli—October 1896, engageerde ik daarop als zoodanig den Heer H. C. Redeke, phil. candidatus van de Amsterdamsche universiteit. De wintermaanden bracht de Heer R. tot voortzetting van zijn academische studiën wederom in Amsterdam door, sedert 1 April is hij echter opnieuw bij mij in functie getreden. In zijne vrije uren assisteert hij mij natuurlijk ook bij de directie van het station: van zijne tegenwoordigheid in die instelling ondervindt uit den aard der zaak elkeen voordeel, die van het station gebruik maakt — en dit natuurlijk in hooge mate op die dagen, die vele zijn, die ik voor ambtsbezigheden buiten Helder doorbreng.

Een zeer belangrijke tak van werkzaamheid voor ons Station wordt allengs de levering en verzending van zoölogisch materiaal aan instellingen en partikulieren. Uit gebrek aan middelen en personeel moet ik er echter — en dat wel zeer tot mijn leedwezen — op bedacht zijn aan dezen tak van dienst geen al te groote uitbreiding te geven. De visschers moeten — zal men werkelijk veel van hen verkrijgen — nageloopen worden, er telkens aan herinnerd worden, dat hunne aanbrengsten welkom zijn; bij hen vangt men kabeljauw niet met een schelvischje, maar door een goudvischje, klein of groot, uit te werpen of toe te zeggen. »Alles" koopen, wat op dit gebied aangeboden wordt, en als marktvisch geen waarde heeft, zou eigenlijk het beste middel zijn, om »wat" te verkrijgen van hetgeen men werkelijk noodig heeft — daartegen verzetten zich echter de eischen, die ook overigens aan de werkelijk niet rijkelijk gevulde stations-kas gesteld worden.

De rekening en verantwoording van de gelden, die in 1896 voor het Station beschikbaar zijn geweest, toont tegenover een bedrag van twee duizend drie en tachtig gulden en vijfentachtig cent aan inkomsten, een bedrag aan uitgaven $f\,0{,}49^1/_2$ beneden dat der ontvangsten. Uit de hieronder volgende specificatie blijkt, dat op de rekening van 1896 komt een bedrag van $f\,85{,}02$, dat nog te betalen was voor op den dienst van 1895 betrekking hebbende rekeningen.

Ik acht mij gelukkig U te kunnen mededeelen, dat ik er in geslaagd ben de verschillende voor het jaar '96 komende uitgaven uit de voor dat jaar beschikbare middelen volkomen te bestrijden. Daartoe was het echter noodig met groote zuinigheid te werk te gaan. Met name voor den post dienstpersoneel had ik mij gaarne een grootere uitgaaf veroorloofd — daarvoor was echter in '96 geen geld beschikbaar.



## TRENDS AND VARIATIONS IN DNA SIGNATURES OF MARINE PHYTOPLANKTON: TAXONOMICAL AND ECOLOGICAL IMPLICATIONS OF THE DYES PICOGREEN AND SYTOX GREEN

**Contributors:** *M.J.W. Veldhuis, T.L. Cucci, M.E. Sierack*i (at Bigelow Laboratory for Ocean Sciences)

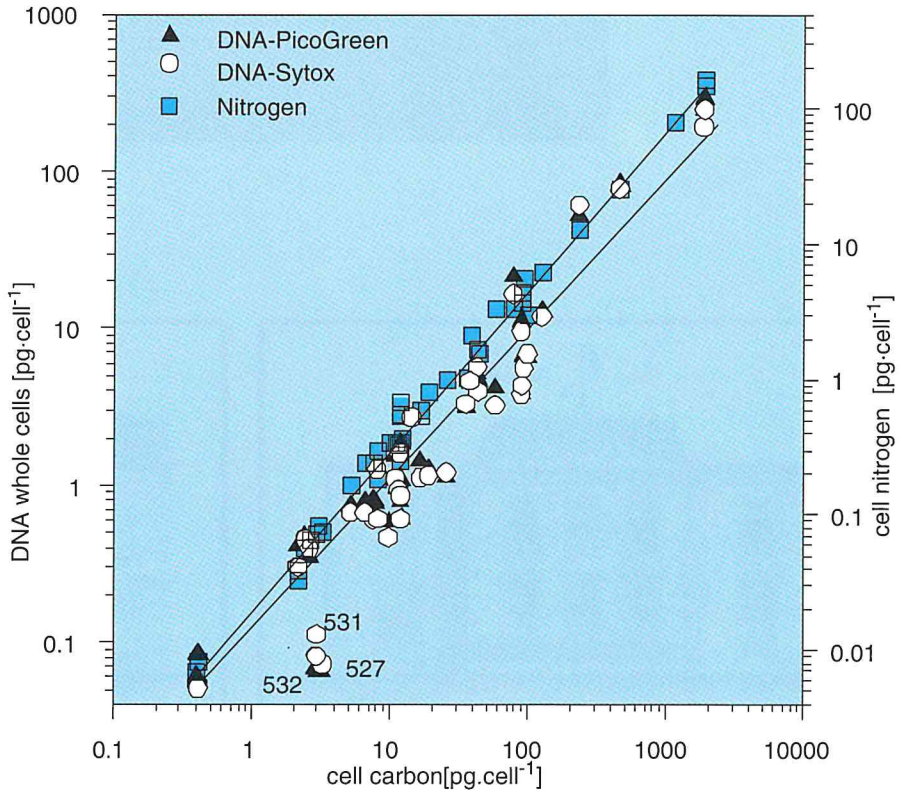
Over the past decade there has been a renewed interest in the DNA of phytoplankton. This interest mainly originates from molecular biologists using the encoded genetic information as a new tool for taxonomical purposes. Determining the genome size also turns out to be a successful tool to assess variations between species and strains using base-pair specific staining of the nuclear dsDNA. In combination with plant-pigment-finger-printing the genome size and variations in base composition are a good alternative or can be used in conjunction with other molecular techniques.

In eco-physiological studies the DNA cell-cycle has been found to be a useful tool to estimate *in situ* phytoplankton growth rates. This can be achieved even on the level of individual phytoplankton species by applying flow- or image cytometry to study the wax and wane of key-phytoplankton species.

These and other studies clearly indicate that the cellular DNA content can be estimated in a whole range of microplankton species, including not only phytoplankton, but also pelagic bacteria and even particles as small as viruses. Despite the variety of dyes available it is still far from easy to measure the DNA of the smaller sized phytoplankton particles. A more universal procedure for staining DNA in unicellular planktonic marine organisms was still lacking.

An inventory of marine unicellular phytoplankton shows however, that in addition to the taxonomical variation there is a great variability in size-classes ranging over 4 orders of magnitude (0.7 µm to > 1 mm in diameter). The variety in cell size, shape and cellular composition is great. However, all phytoplankton species contain chlorophyll *a*, but this is a scaleable cell component, ranging from <1 to 50,000 fg chlor *a* .cell$^{-1}$. It is probably because of the great variation in sizes that phytoplankton biomass and fluxes are based either on total chlorophyll concentration or fluorescence. In complex marine ecosystems plant pigment is still one of the easiest parameters for discerning phytoplankton from other functional groups of organisms present. The major disadvantage of chlorophyll is that the concentration fluctuates highly with changing environmental conditions including macro- and micro nutrients as well as the light climate. The nutrient status, but in particularly the photon flux density, strongly affect the pigmentation of the phytoplankton, causing changes in the pigment concentrations or fluorescence signals over more than one order of magnitude within a single species.

Similar to the chlorophyll concentration the size of the genome increases with cell size despite the fact that the nuclear DNA concentration should be considered to be a non-scaleable cell component. There have been several attempts to use bulk DNA in whole or size fractionated seawater




Total DNA concentrations in 90 algal species (> 121 strains) as measured in whole cells varied by a factor of 20,000 from ca. 0.010 pg.cell$^{-1}$ in *Prochlorococcus* to 278 pg.cell$^{-1}$ in the large dinoflagellate (*Prorocentrum micans*). The cellular DNA appears to be a scaleable cell component co-varying with the cellular carbon and nitrogen concentration of the phytoplankton cell. This co-variation allows the total DNA content to be used as an accurate and independent estimate of total cell carbon biomass in unicellular pelagic phytoplankton.

samples as an estimate for microbial biomass or growth rate of the algal population but this approach was never widely applied. This is because DNA measurement of bulk samples confounded the multiple taxonomic and trophic groups in the plankton. With a DNA content in the order of 5% of total cell carbon relative large volumes are required for the analysis. Remarkably, DNA measurements applying flow-cytometry have hardly been used in this context, whereas it is one of the most used and therefore probably best developed application in the medical field. Even in phytoplankton, of all intracellular components the amount of dsDNA remains most constant. The cell nucleus, the major source of dsDNA within the cell, is hardly affected by the nutrient status of the cell or the prevailing light conditions. Extranuclear DNA can be found in mitochondria and chloroplasts of the eukaryotic species but their contribution to the total DNA concentration is small, on the order of 3%. The only other significant source of DNA is in plasmids, which can be up to 11%.

Two new dyes -PicoGreen® reagent and SYTOX Green™ stain have been tested for their general use to assess the DNA content of different classes of marine phytoplankton. Secondly, the DNA versus total cell carbon has been estimated to examine the co-variation between these two parameters. The use of particulate DNA to asses plankton biomass would benefit from a further refinement of assessing the DNA signature on the level of taxonomical groups/species and the separation between phytoplankton, bacteria and heterotrophic protists as achieved with flow-cytometry.

The basic instrumental configuration of modern low power flow-cytometers (15 mW, 488 nm excitation) appeared to be sensitive enough to detect the DNA signal in nearly all 121 strains (12 taxonomical classes) examined. Only the class of Eustigmatophyceae (*Nannochloropsis* spp.) showed a poor staining, probably because of the thick impermeable cell wall.

The major advantages of the dyes tested over other dyes are: 1) suitability for direct use in seawater; 2) emission of the DNA-dye complex in the green wavelength band (525 nm ±15 nm) showing no overlap with the autofluorescence of the pankton pigments in the red band; 3) high fluorescence yield of the DNA-dye complex with an increase in fluorescence > 100 fold. In particular the high increase in dye fluorescence allowed the detection of the DNA signature of the smallest known phytoplankter (*Prochlorococcus*, 0.7 µm). But also small bacteria concomitant in some of the algal cultures could easily be detected. The new dyes are therefore useful as a general method to determine the DNA content in a marine phytoplankton. Unlike other dyes the method needs little preparation and presence of chlorophyll allows phytoplankton to be discriminated from other particles.

## EXTERNAL PROJECTS OF THE DEPARTMENT OF BIOLOGICAL OCEANOGRAPHY

- 'European Regional Sea Ecosystem Models II' (MAS-II project)
  *P. Ruardij, E. Embsen*
- The coccolithophote *Emiliania huxley* as a model system of quantiying oceanS biological control on global climate change.
  *M.Veldhuis, G. Kraay*
- 'Role and significance of biological processes in DMS release from ocean to atmosphere: a close examination of the black box' (EU-Envionment project)
  *F.C. van Duyl, R Osinga, A.J. Kop , A. van den Berg , P. Ruardij*
- 'Giftige Algen en Reductie van Nutrient belastingen' RKZ-402 (RIKZ-BEON)
  *R. Riegman, A. Noordeloos.*
- ' model system approach to biological climate forcing: the example of Emiliania huxely' (NWO-NOP II)
  *W. Stolte, J, Snoek*
- 'De invloed van EUtrofiering op de PROductiviteit van mariene ecosystemen' (RIKZ-BEON)
  *R. Riegman , A. Noordeloos*
- 'Deep Chlorophyl Maximum in the oceans: persistence of the plankton community, its biodiversity and its implication for carbon cycling' (GOA)
  *H.G. Fransz, W.W. Gieskes, M .J.W. Veldhuis*
- 'The role of ultraviolet B radiation in the functioning of heterotrophic bacteria in coral reefs and adjacent tropical ocean waters off Curaçao , Netherlands Antillen' (WOTRO)
  F.C. van Duijl, P Visser.
- 'Baltic Sea System Study' (EU-MAS-III project)
  *P. Ruardij, E. Embsen*
- Mass transfer and ecosystem response (MATER EU-MAST)
  *P. Ruardij , E. Embsen*

# DEPARTMENT OF MARINE ECOLOGY

**The department of Marine Ecology studies (1) population ecology, (2) structure and dynamics of benthic systems and (3) long-term changes in marine ecosystems.**

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

## WINTER TEMPERATURE, IMMERSION TIME AND BIVALVE REPRODUCTION.

**Contributor:** *P.J.C. Honkoop*

This project was partly funded by the National Research Program (NOP-I), and is now in its final phase. It deals with the effects of the water temperature during the winter months and immersion time of tidal flats on the reproductive output and recruitment of three important bivalve species in the Dutch Wadden Sea, the cockle *Cerastoderma edule*, the mussel *Mytilus edulis* and the Baltic tellin *Macoma balthica*.

Nowadays, one of the topics of science is the possible climate change as caused by enhanced concentrations of greenhouse gasses. Today it is generally accepted that the emission of greenhouse gasses will cause a global raise of air temperature, and as a consequence the heating of sea water, accompanied by a sea-level rise. Possible effects of these changes are the disappearance of the lowest parts of the tidal flats in coastal areas, thus decreasing the space for intertidal animals and their predators, and a shift from cold-minded species to higher latitudes. This means that such species living in the Dutch Wadden Sea may disappear to be replaced by species living at warmer latitudes now. Therefore, the aim of this project was to find experimental evidence for temperature effects on bivalve recruitment.

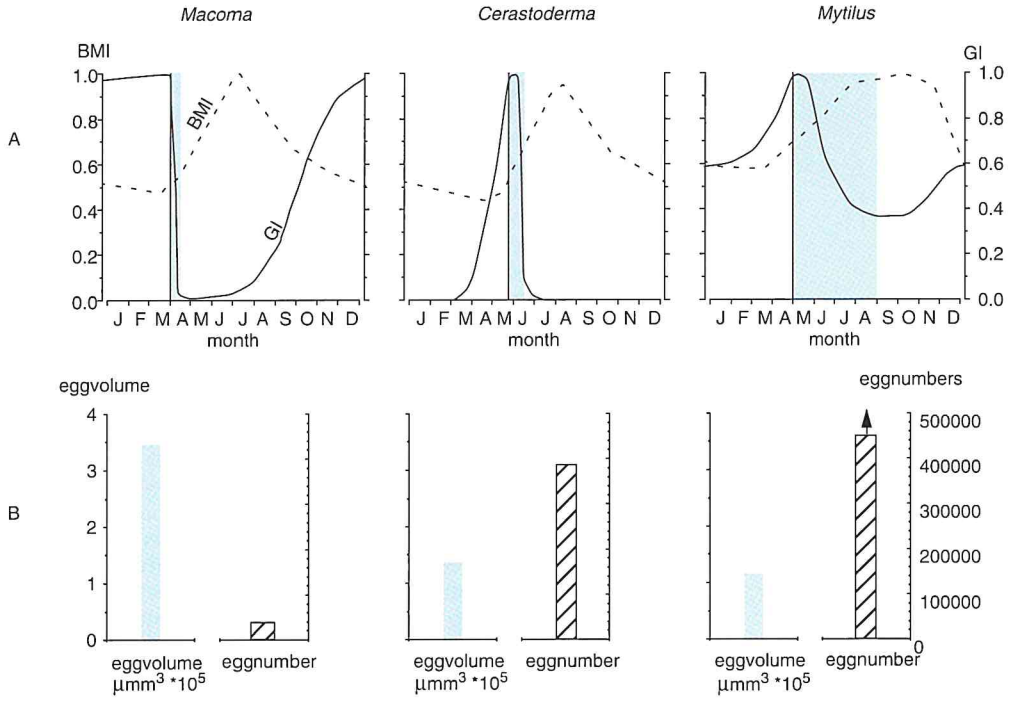
At the Balgzand, a tidal flat area in the southwestern part of the Dutch Wadden Sea, the abundance of benthic species was estimated at least twice per year since 1969. These data showed that several species are sensitive to winter temperature. For 12 out of the 29 species studied it was shown that they were cold-sensitive, resulting in low abundance after severe winters and relatively high numbers and biomasses after mild winters. On the other hand, the recruitment of some species (measured as the juvenile density in August) was relatively high after cold winters and low after mild winters. Among this cold-winter-favoured group are four important bivalve species with relatively high shares of the total benthic biomass (up to 60 %): *M. arenaria*, *M. edulis*, *C. edule* and *M. balthica*.

Year-to-year variations in bivalve recruitment can be very large, 2 - 3 orders of magnitude are not uncommon. So far, the causes of these large variations are not clear. Although it was thought that winter temperature could be a major cause of this variation, when the project was started, experimental evidence and further insight into possible underlying mechanisms was lacking.

To prove the hypothesis that winter temperature but also the immersion time of the tidal flats can affect bivalve recruitment, three bivalve species, *M. balthica*, *C. edule* and *M. edulis* were kept during the winter months in an experimental set-up in which we could manipulate temperature as well as immersion time. Two different temperatures were maintained, simulating either a mild or a cold winter, and two tidal levels, a subtidal and a tidal level (submersion 100 % and 60 % of the time, respectively), to create differences in feeding time. At regular time intervals, the ash-free dry body mass was determined. During the spawning period animals were placed individually in beakers containing seawater of appropriate temperature, and initiated to spawn by means of a temperature shock. Because it was thought that more eggs can result in a higher number of offspring and that larger eggs can increase juvenile survival, all eggs released by an individual female were counted and their diameters were measured.

It was found that changes in body mass were similar for the three species. During winter the animals lost part of their body mass until the start of the growing season early April. Due to the relatively high metabolic rates at higher temperatures, mass losses were most pronounced at the highest water temperature (particularly at the tidal level) and lowest or absent at the lower temperature (particularly at the subtidal level). This means that just prior to spawning the body mass was highest in the cold-subtidal groups and lowest in the mild-tidal groups.

For both *Macoma* and *Cerastoderma*, the number of eggs was related to body mass just before spawning. This means that the egg production per adult female was highest at the lowest temper-




Annual courses based on literature in (A) body mass (BMI, broken lines) and gonadal index-cycles (GI, solid lines) and (B) measured egg sizes and numbers in the three species studied: *Macoma*, *Cerastoderma*, and *Mytilus*. Body mass and gonadal index values are divided by the maximum BMI and GI values. The shaded area indicate the spawning periods. Because of the prolonged spawning period of *Mytilus*, we could not reliably quantify the egg numbers for this species.

ature. Immersion time positively affected egg production. Thus the largest egg production per female occurred at the lowest temperature at the subtidal level (70 000 and 700 000 eggs) and the lowest production occurred at the highest water temperature (20 000 eggs in *Macoma* and 200 000 eggs in *Cerastoderma*). For *Macoma* the relationship between body mass just prior to spawning and the numbers of produced eggs was highly significant and provided a tool to predict egg numbers from the easily measurable body mass.

For *Macoma* we did not succeed to influence the mean egg size. Even manipulation of the immersion time during part of the autumn (from the end of October on) did not cause any effect on egg size, which remained constant with a diameter of about 105 µm.. However, in field populations differences in egg size were observed. *Macoma* living at a lower tidal level produced significantly larger eggs with a diameter of 108 µm, 8 µm larger than the egg size of a population living at the highest tidal level. After combining field results with the experimental data, it was concluded that egg size may be determined before October. In *Cerastoderma* significant larger eggs were produced at the lower than at the higher water temperature, 80 µm and 75 µm, respectively. In *Mytilus* only a small but significant immersion time effect was observed, 72 µm and 73 µm m at the tidal and subtidal level, respectively.

Differences between species can be explained by differences in timing of gametogenesis described in literature and presented graphically as the gonadal index cycle. In *Macoma* gametogenesis starts soon after spawning and is completed before the winter and, according to our results, possibly before October. This means that egg size cannot be affected during winter, whereas egg numbers can decrease during periods of high energy demands. In *Cerastoderma* gametogenesis takes place only a few weeks prior to spawning and both egg size and egg numbers can be influenced by manipulation of temperature or feeding regime during winter. Gametogenesis in *Mytilus* starts in late summer, ceases at low temperatures (no temperature effects on egg size were observed) and continues at higher water temperatures, as food becomes available (only an immersion time effect on egg size was observed), until spawning.

In conclusion, both winter temperature and immersion time can affect egg size and egg numbers in the species studied, probably via changes in adult body mass. The most pronounced effects were observed in egg numbers and thus, this could be a factor causing variation in recruitment.

## SHOREBIRD FLYWAYS AND INTERTIDAL BENTHIC COMMUNITIES

**Contributor:** *Th. Piersma*

In 1996 a joint enterprise between two partners within the Research School "Functional Ecology", the Netherlands Institute for Sea Research (NIOZ) and the Centre for Ecological and Evolutionary Studies of the University of Groningen, was recognized by NWO, and received funding. The programme involves substantial investments in terms of manpower and facilities, including the final development of artificial and eventually climatized intertidal flat units at NIOZ. Briefly, the programme centres around the role of shorebirds, and especially Knots (*Calidris canutus*), as size and species selective predators of buried bivalves on the intertidal flats of the Wadden Sea and coastal areas elsewhere, and hopes to elucidate aspects of community organization from detailed knowledge of specific predator-prey interactions.

Shorebirds are highly visible and abundant predators of benthic organisms in intertidal soft-sediment communities worldwide. During bouts of intense predation, shorebirds of a kind can effectively deplete particular size- and age-classes of benthic organisms. The seasonal removal of entire cohorts implies competitive release prior to resettlement of the sediment, and suggests that intra- and interspecific competitive processes between resident benthic populations are less predictable in structuring soft-sediment communities than they are on rocky shores. The large fluctuations in bivalve prey abundance, at least in the Wadden Sea, puts high demands on the migratory flexibility and capacities of the predators that are dependent on this resource. In addition, the specific and highly directional selection pressures exerted by shorebirds are likely to leave their imprints on the life-history strategies of the benthic prey organisms, thus affecting soft-sediment community structure in evolutionarily dynamic ways.

This project proposes to analyse experimentally evolutionary aspects of trophic interactions between shorebirds and intertidal invertebrate organisms, in the belief that general organising principles of intertidal soft-sediment benthic communities can be deduced from the relevant details. The approach is based on the realisation that unravelling of evolutionarily dynamic systems such as animal communities requires deep insights in the key interacting mechanisms, in this case the habitat- and prey-selection criteria of avian predators and the predator-avoidance mechanisms (a large part of a life-history strategy) of their benthic invertebrate prey. The "genetic wiring" of life-history strategic aspects (for example, the degree to which growth rate and deep burying by bivalves are under direct genetic control, or rather phenotypically dependent on environmental conditions, and the variability of the genetics underlying these behaviours) are critical for the prediction of community-wide effects of changes in presence or absence of specific components of the intertidal foodweb, of the repercussions of manmade alterations to the natural environment, and of changes in climate affecting seasonality and range boundaries of component species.

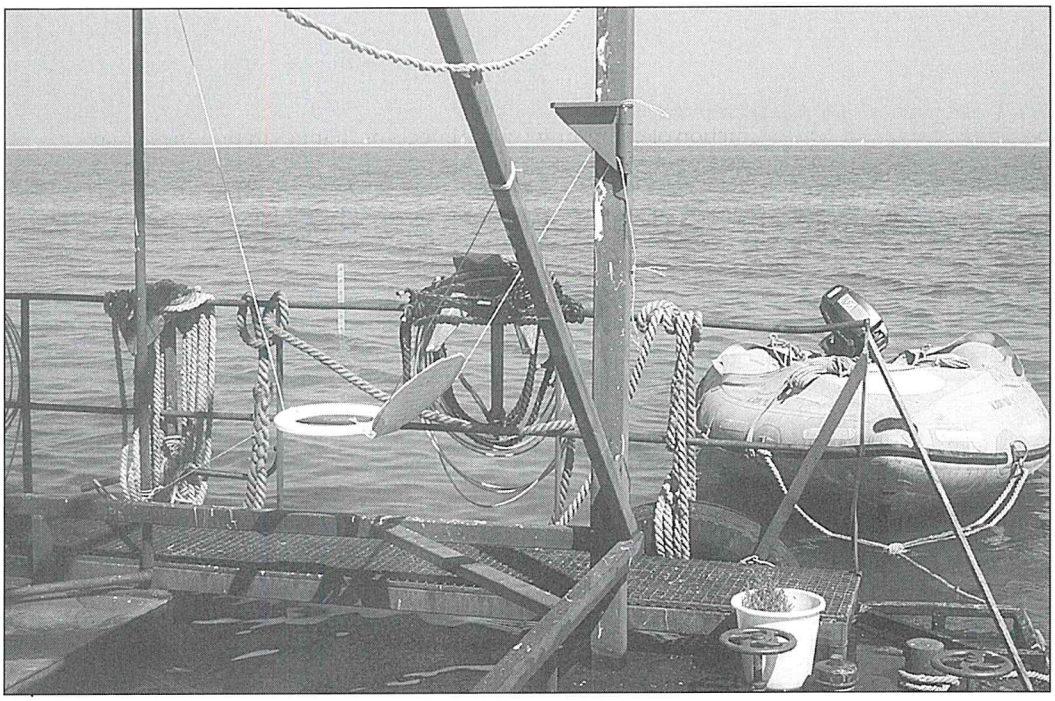
The project builds on several promising theoretical and practical developments. A critical practical tool is the ability to assemble small-scale copies of intertidal soft sediment communities that can be exposed to various (combinations of) predation pressure, a feature unique to this particular marine environment. By varying the tidal and climatic conditions of experimental areas of soft-sediment, both the characteristics of the predation and the behaviour of the prey can be manipulated. It is thus possible to deduce the predators' habitat- and diet-selection rules that determine the likelihood and severity of predation. We can also directly measure the selective effects of different predatory regimes on the invertebrate prey populations. The possibility to breed and cross-breed benthic invertebrates originating from field populations with different predatory regimes under different predator pressures in the laboratory, in combination with the latest molecular genetic techniques, should allow us to disentangle the population genetic structure underlying the behavioural adaptations (life-history characteristics) relevant for understanding the evolutionary arms race between shorebird predators and benthic invertebrate prey. Theoretical tools, such as life-history theory, game theory and dynamic programming, will enable a generalisation, and an exploration of the repercussions of our empirical findings.

The ambitious emphasis on predator-prey interaction mechanisms, population processes and evolutionary dynamics, means that we must devote this project to a well-known and observationally and experimentally tractable part of soft-sediment communities. We have chosen the interactions between the most important bivalve-eating shorebirds and their main bivalve prey species. The focus will be on the situation in the Wadden Sea, where Knots are important predators of the bivalves Baltic tellin (*Macoma balthica*) and edible cockle (*Cerastoderma edule*). Even though most of our work will conveniently take place in the Wadden Sea and the newly built experimental facilities at NIOZ, the choice for Knot, a world-wide long-distance migrant shorebird uniquely found on intertidal soft sediments (when not breeding on arctic tundra), affords many opportunities for large-scale comparisons of shorebird predation, benthic invertebrate prey avoidance and community structure, and the role that a single class of predation can play in geographically distant and biologically diverse communities. Much of this work is already underway, by our foreign colleagues and collaborators. Together, these studies should enable an appreciation of the extent to which shorebird flyways are evolutionarily moulded and constrained by the distribution and life-history characteristics of the major prey species.

From early 1997 onwards a team consisting of one full-time and three part-time senior scientists based on Texel and in Groningen, two full-time and two part-time reasearch assistants and three graduate students linked to the research groups Marine Biology, Population Genetics and Animal Ecology of the University of Groningen respectively, with enthusiastic support from the two home institutions and NWO, will try to make this programme into a success.



View of Richel from the (floating) observation hide. Photo: Th. Piersma.



View of the observation hide from Richel. Photo: J. v.d. Kam©.

## SENSITIVE SKATES OR RESILIENT RAYS?

**contributor:** *Paddy Walker*

Studies have been carried out on the population dynamics of skate and ray (*Raja*) species in the North Sea, including tag-and-release experiments throughout the North Sea, laboratory experiments on growth and ageing and observations on the reproductive cycle and food consumption. Temporal and spatial trends in abundance and distribution have also been studied. The research was supported financially by the Netherlands Petroleum Company (NAM bv).

Rays and skates are cartilaginous fish and have a benthic distribution, occupying the same spatial niche as flatfish. The skate and ray species in the North Sea are considered to be sensitive to fisheries as they mature at a relatively high age and large size, and have a low fecundity. Some species (the common skate and the thornback ray) have declined in abundance in the past decades, whilst the starry ray has increased in abundance. The species specific variations in life histories play a key role in determining the sensitivity or resilience of the species to exploitation.

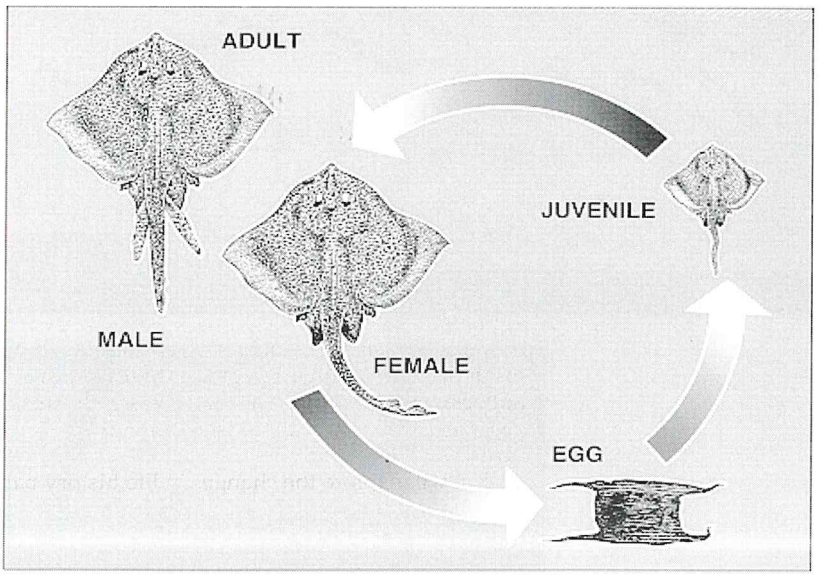



Fig. 1. Life cycle of rays and skates. Mating occurs in spring and females lay fertilised eggs in capsules throughout the year. The young are replica's of the adults and hatch after several months when fully developed.

Skates and rays are a bycatch of the present demersal fisheries in the North Sea and have traditionally been landed for consumption. Although only the largest individuals are landed, most length and age classes are caught in trawls due to their large size at hatching (9-24 cm) and morphology (large 'wings' and presence of sturdy spines), leading to low gear selectivity. Since only mature individuals can contribute to the next generation, survival during the juvenile period is a key factor in ray population dynamics. Therefore, it is to be expected that those species with the lowest length and/or age at maturity have the highest chance of survival at increasing levels of exploitation. Demographic methods were chosen to study the expected species specific response to enhanced mortality.

Demographic analysis of populations assumes constant age-specific rates of birth and death and a stable age distribution, with the population growing exponentially at an instantaneous rate *r*. Life tables are a way of keeping track of births and deaths. An age-structured life table can be used to estimate the rate of change of the population (*r*) at a given combination of year-class survival, fecundity and age at maturity. Conversely, setting the level of population change to 0 enables the estimation of the level of mortality above which the population will, in theory, start to decline. These levels of mortality have been estimated for four species, in combination with their specific age at maturity and fecundity. The starry ray (*Raja radiata*) appears able to 'withstand' the highest mortality (0.8, which represents a 55% decline in numbers annually), whilst the skate (*R. batis*) population should go into a decline if the mortality goes above 0.4 (representing a 30% annual decline in numbers). Both the cuckoo (*R. naevus*) and thornback (*R. clavata*) rays will decline above a total mortality of 0.6 (45% annual decline) or 0.5 (40% annual decline), respectively.

Scottish survey data from the North Sea for the periods 1929-1956 and 1980-1995 have been analysed. The observed shifts in species composition (taking the four most abundant species into account) correspond well to what would be expected based on the above. The common skate is now only found in the extreme north of the North Sea, the thornback ray is much less abundant than it used to be, and the starry ray has increased in abundance.

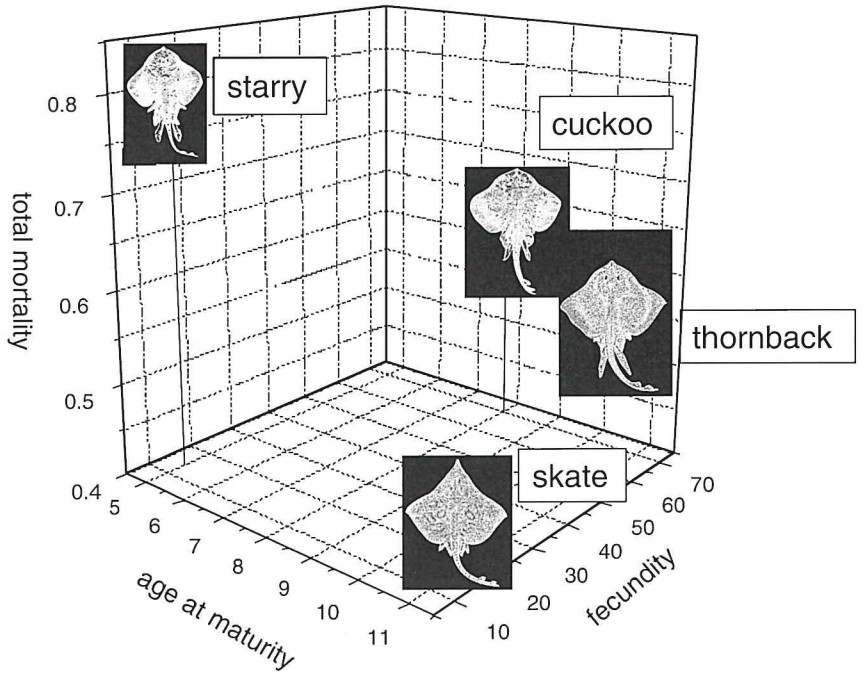



Fig. 2. Estimates of total mortality at species specific combinations of age at maturity and fecundity if the rate of increase of the population is set at 0.

Although the simple method described above appears to predict quite well the order of sensitivity of species to enhanced mortality, it does not take into account any changes in the population as a result of exploitation. It is possible that there are density-dependent processes operating that have not been made explicit. For example, the thornback ray has decreased in abundance in the past 50 years, but appears to grow faster now than 30 years ago. This has resulted in a lower age at maturity which compensates in part for the higher level of mortality. The completion of this research project will explore the changes in life history parameters and the possible link to fisheries.

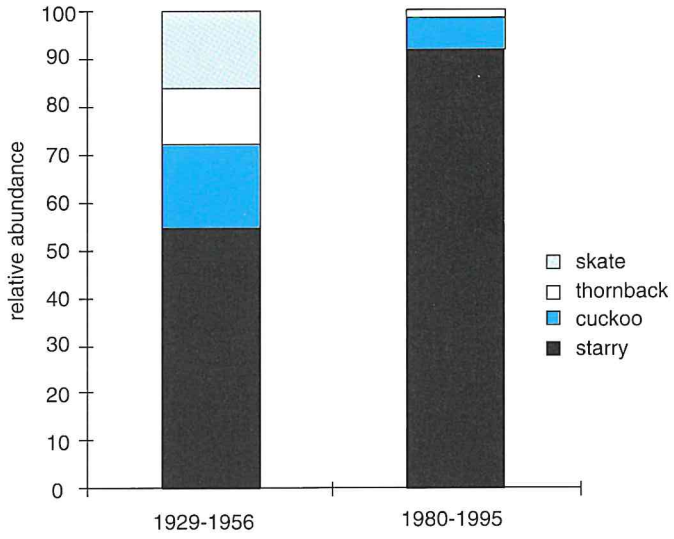



Fig. 3. Relative abundance of four skate and ray species in the central and north-western North Sea during two time periods, based on Scottish survey data.

## ENVIRONMENTAL EFFECTS OF OFFSHORE DRILLING ACTIVITIES

**Contributors:** *R. Daan, M. Mulder*

There has been an extensive use of oil based drilling muds (OBM) during drilling activities in the North Sea in the 80's and early 90's. Drill cuttings from wells drilled with OBM were discharged on the seabed and considerable amounts of OBM base oil adhering to drill cuttings have contaminated the seabed around well sites. Field studies on the environmental effects of these discharges have been carried out on the Dutch Continental Shelf (DCS) since 1985. The majority of these studies were initiated by RWS (North Sea Directorate) and carried out by NIOZ in cooperation with MT-TNO Den Helder.

Initially the attention focused on short-term effects. However, from 1993, when a ban was introduced on the offshore discharges of oil contaminated drill cuttings, the research has shifted to the long-term effects of the former discharges. Three platforms, in the northern deposition area, the southern erosion area and the transition zone, respectively, received particular attention. After repeated field surveys during the first years after drilling had ceased at these locations, extensive long-term surveys were carried out at each of them, to assess the intensity and spatial extent of pollution and associated biological effects 6 to 8 years after drilling. Additionally, in 1994 and 1995, a compendious sampling programme was executed covering 12 well sites in different areas of the DCS and including actual production platforms but also a few abandoned well sites. At each of these locations one or more wells had been drilled with OBM 7 to 13 years ago. Discharge loads were variable and ranged from 10 to 400 tonnes of base oil per location. Each survey comprised benthos sampling of a few stations within 2000 m from the discharge site. In order to describe the long-term impact of the former OBM cutting discharges on the DCS, information is available now from 15 well sites with a wide variation in drilling history.

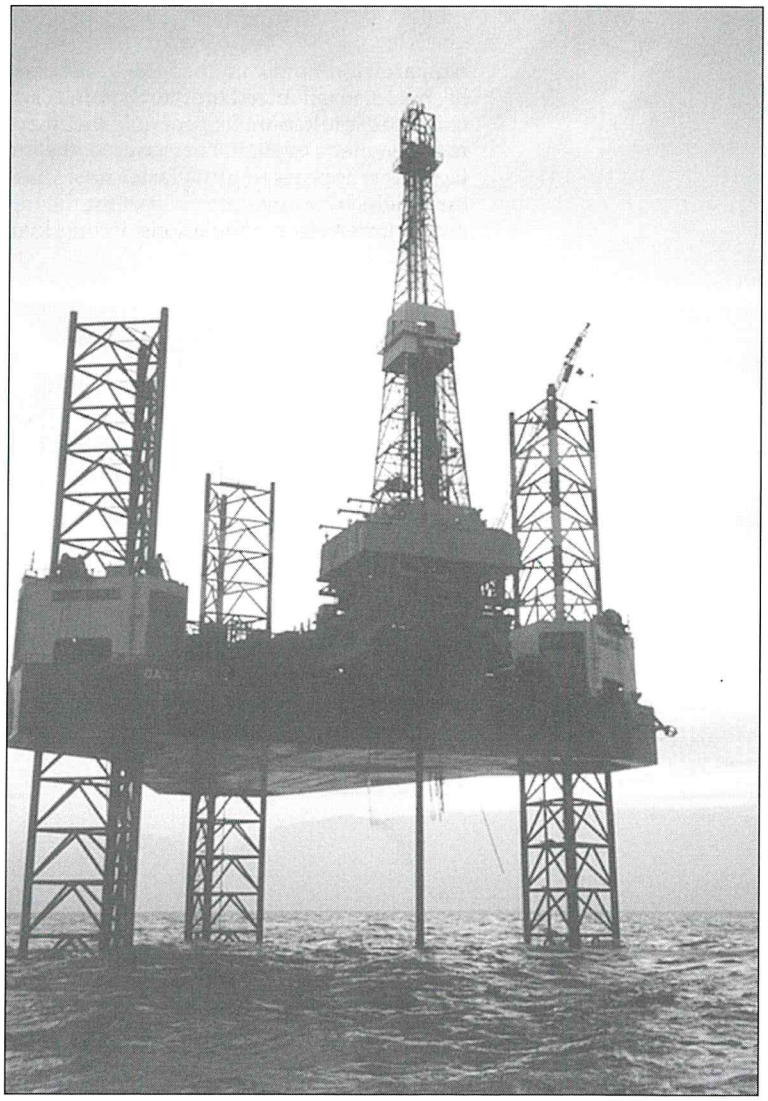


Photo: M. Mulder.

Clearly elevated oil concentrations in surface sediments (10 cm top layer) were found at 10 of the 15 well sites investigated. Maximum concentrations were generally in the order of 10 to 50 $mg.kg^{-1}$ dry sediment, but in a few cases over 100 $mg.kg^{-1}$. Oil was not only found at the location with the most recent and relatively high discharge load (300 tonnes of base oil 6 years ago), but also at the station with the smallest and oldest discharge (13 tonnes of oil 13 years ago). Furthermore, there were no indications for consistent differences between locations with a different hydrographic regime or between platform locations and abandoned well sites. Based on these findings it was unlikely that oil contamination of the sediments has completely disappeared at any of the locations. This was supported by the results of visual inspection of sediment samples which always showed that oil was extremely patchy distributed in sediments. This patchy distribution may have caused that the presence of oil in sediments is not always demonstrated by chemical analyses of subsamples. At most locations oil was found only within 100 m from the well, but at three locations up to 250 m and at one location up to 500 m. Nevertheless, the oil concentrations in the surface sediments generally seemed to be lower than measured in the first years after drilling, suggesting a decrease by biodegradation and/or redistribution of contaminated sediments. However, at the few locations where deeper sediment layers (10-30 cm) in the vicinity of the platform were analysed, these deeper layers consistently showed substantially elevated oil concentrations, always higher than in the surficial layer. This indicates that oil is persistently present particularly in deeper sediments, which are hardly subject to redistribution and where anoxic conditions may prevent bacterial degradation.

Clear evidence for persistent biological effects was obtained at 11 of the 15 locations investigated. The effects became manifest by significantly reduced densities of a number of benthic species, including those known as most sensitive to OBM contamination of sediments, in particular the sea urchin *Echinocardium cordatum*. This species was used in all surveys as an indicator species to detect environmental response. *E. cordatum* appeared to occur in reduced densities not only at locations where elevated oil concentrations were detected, but also at 2 locations where no oil was found. This may indicate that there is a long-lasting impact of the former discharges, even when oil has (or seems to have) disappeared from the sediment. Effects on *E. cordatum* were found not only at locations with the largest and relatively recent discharges, but also at a location where 'only' 26 tonnes of oil had been discharged 13 years ago. The occurrence of reduced population densities of *E. cordatum* was generally limited to an area within a radius of ~200 m from the well, but in a few cases there seemed to be an effect up to at least 500 m distance. However, it does not seem likely that remnants of the former discharges are still the actual cause of the depressed population densities at this distance. Even when sediment conditions have completely recovered, it may take a long time before populations of long living species like *E. cordatum* have recovered. Nevertheless, the consistent response of *E. cordatum* shows its particular value as a sensitive indicator of environmental stress caused by the former discharges.

## EXTERNAL PROJECTS OF THE DEPARTMENT OF MARINE ECOLOGY

- Autonomous Lander Instruments Packages for Oceanographic Research (EU)
  *G.C.A. Duineveld, P.A.W.J. de Wilde, E. Berghuis, R. Witbaard*
- Beach Bird Survey (CSR consultancy)
  *J. van der Meer*
- Benthic Biology and Geochimistry of a north-eastern Atlantic Abyssal locality (EU)
  *G.C.A. Duineveld, R. Witbaard, J. van der Weele, E. Berghuis, A. Kok*
- Benthos Atlas (DNZ)
  *G.C.A. Duineveld, S.E. Holtmann*
- Mapping of epibenthos in the North Sea and comparison of more or less fished areas (BEON, NIOZ)
  *M.J.N. Bergman, J. van Santbrink*
- Mapping of habitat characteristics in the Wadden Sea (BEON, NIOZ)
  *H.W. van der Veer*
- Relationship between RNA and bacterial growth (GOA/2'GS)
  *S. Mwangi* (Kenia), *G. Nieuwland*
- Long-term effects of oil based drilling muds on the macrofauna in the North Sea (DNZ, EZ, VROM)
  *R. Daan, M. Mulder*
- Pelagic-benthic coupling in the oligotrophic Cretan Sea (EU)
  *G.C.A. Duineveld, R. Witbaard, J. van der Weele, E. Berghuis, A. Kok, G. NIeuwland*
- Coral reef restoration and life history characteristics of the reef coral *Madracis mirafilis* (EU)
  *R.P.M. Bak, G. Nieuwland, I. Nagelkerken, N. Epstein*
- Dynamics through natural and anthropogenic causes of marine organisms (EU)
  *H.J. Lindeboom, C.J.M. Philippart, C. Winter, J.W. de Leeuw, J.J. Beukema, J. van der Meer*
- Ecoprofiel eidereend (RIKZ)
  *C.J. Camphuysen*
- Ecoprofiel roggen (RIKZ)
  *P.A. Walker*
- Griend: schelpdieren vogel relatie (Natuurmonumenten, Vogelbescherming)
  *Th. Piersma, A. Koolhaas, C.J. Camphuysen*
- Effects of fisheries on the benthic fauna of the North Sea and Irish Sea (EU)
  *H.J. Lindeboom, M.J.N. Bergman, M. Fonds, C.J.M. Philippart, S. Groenewold, J. van Santbrink, P. van de Puyl*
- Effects of dumping of dredge material on Loswal Noord and a baseline study of a new dumping location (RIKZ)
  *M.J.N. Bergman, R. Daan, J. van Santbrink, M. Mulder*
- Mass transfer and ecosystem response (EU)
  *G.C.A. Duineveld, J. van der Weele, E. Berghuis, A. Kok*
- Monitoring bodemfauna Noordzee (RIKZ)
  *S.E. Holtmann, R. Daan, G.C.A. Duineveld, M. Mulder, B. Kracht, J.J.M. Belgers*
- Monitoring Waddenzee (RIKZ)
  *R. Dekker, W. de Bruin, J. Zuidewind*
- NAM Bodemdaling (NAM)
  *J.J. Beukema*
- Long-term research in population ecology of rays (NAM)
  *P.A. Walker, H.W. van der Veer*
- Pinkegat/Plaatgat, baseline study (NAM)
  *R. Daan, M. Mulder, H.J. Lindeboom*
- Effects of drilling in the Wadden Sea-NAM-MER rapport (NAM)
  *H.J. Lindeboom, M.J.N. Bergman*
- Reproductive success of bivalves in the western Wadden Sea after mild and cold winters (NOP-VROM)
  *P. Honkoop, J.J. Beukema*
- Climatological effects on macrobenthos in the Wadden Sea (NOP-VROM)
  *J.J. Beukema, J. Drent*
- Ocean Margin Exchange Benthos (EU)
  *G.C.A. Duineveld, E. Berghuis, A. Kok, J. van der Weele, M. Lavaleye, P.A.W.J. de Wilde*
- Ocean Margin Exchange Bridging (EU)
  *G.C.A. Duineveld, E. Berghuis, A. Kok, J. van der Weele, M. Lavaleye, P.A.W.J. de Wilde*
- A study of predator-prey relationships of waderbirds and benthic macrofauna (PIONIER)
  *Th. Piersma*
- A pilot study of corals, seagrasses, macrofauna, fishes and birds in Teluk Banten (Indonesia) (NWO/2'GS)
  *H.J. Lindeboom, R. Daan, M. Mulder, R.P.M. Bak, J. van der Brugge*
- Consumption of discards by sea birds in the North Sea (EU)
  *C.J. Camphuysen, C. Winter*
- The fate of organic matter in benthic systems in the North Sea (VVA)
  *A. Boo*

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

**Contributors:** *P.R. Boudreau, R.C. Sidle.*

As one of eleven Core Programme Elements of The International Geosphere-Biosphere Programme (IGBP), LOICZ focuses on the area of the Earth's surface where land, ocean, and atmosphere meet and interact. The overall goals of this project are to determine at regional and global scales: the nature of that dynamic interaction; how changes in various components 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. Unlike many other Core Projects of IGBP, LOICZ functions within a more restrictive geographic area where horizontal fluxes of materials dominate.

Coastal zones are of critical importance to humanity from the varied perspectives of natural resources, transportation, subsistence, recreation, and habitat for humans, animals, and plants. Although coastal zones comprise a small proportion of the Earth's surface, they are the corridors through which water, carbon, nutrients, and sediments pass. As such, they are subject to the impacts of global change (particularly with respect to carbon cycling), both extensive and intensive land use, and other human impacts. Changes in coastal environments result in social and economic change, which in turn feedback to the natural environment. Understanding these feedback mechanisms is thus necessary to gain better insights into the processes involved in global change.

### Scientific Activities of the LOICZ Core Project Office during 1996

Because the main function of the LOICZ Core Project Office is to coordinate and promote the implementation and synthesis of global coastal zone research, much of the activities in 1996 related to assisting others in accomplishing these missions. Such activities were facilitated through a number of organisational arrangements. Three LOICZ Research Nodes operated in 1996:

- River Discharge Node - Professor John D. Milliman, School of Marine Sciences, College of William and Mary, Gloucester Point, Virginia, USA;
- Deltaic Research Node - Professor A. Sanchez-Arcilla, Maritime Engineering Laboratory (LIM/UPC), Catalonia University of Technology, Barcelona, Spain; and,
- Biogeochemical Modelling Node - Professor Stephen V. Smith, Department of Oceanography, University of Hawaii, Honolulu, Hawaii, USA and Professor Fredrick Wulff, Department of Systems Ecology, Stockholm University, Stockholm, Sweden.

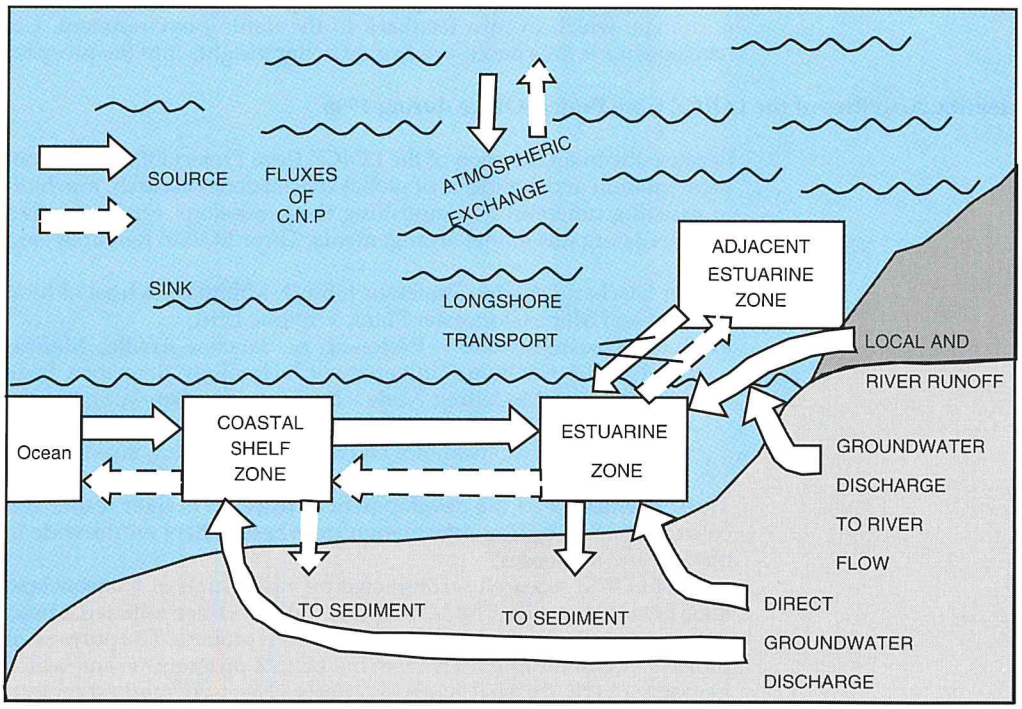
These scientists lead the development of research in their respective focal areas. In general, they collected and compiled information from researchers world-wide in an effort to develop global models and syntheses.

Most LOICZ research is conducted by individuals or teams of scientists who provide access to their data and results. The LOICZ Core Project Office initiated a process for accepting, reviewing, and approving proposals for LOICZ research projects. The purpose of this evaluation is to identify projects that fit the overall aims of the LOICZ programme and which can contribute useful information for LOICZ global synthesis efforts. Over two hundred project submissions have been evaluated and processed by the Core Project Office and Scientific Steering Committee of LOICZ. These contributions have resulted in recommended acceptance or acceptance of 10 Core Research Projects, about 20 Regional Research Projects, and numerous Local Research Projects during 1996. As a result of the contributions from The Netherlands National LOICZ Committee, many of these projects were from Dutch researchers. These approved projects cover the full scope of LOICZ research from biogeochemical studies to the integration of socio-economic and natural sciences.

Only a limited number of scientific initiatives are actually led by the staff at the LOICZ Core Project Office. Of particular note is the development of a coastal typology for describing coastal areas and the similarity among coastal areas. This work resulted in a coastal GIS classification system that identifies 400 coastal lowlands and has an associated database of parameters that can be used in statistical analysis. This activity is one of the primary scientific initiatives of the Core Project Office and it was supported in 1996 by a data analyst and a small workshop (in conjunction with Food and Agricultural Organisation of the United Nations and the Geological Survey of The Netherlands, RGD) that was held at the NIOZ. Typology efforts at the Core Project Office will continue in 1997 with an additional workshop scheduled at NIOZ. Attempts will be made to link the current typology system to biogeochemical modelling efforts in LOICZ and to address other needs and applications of the typology system —e.g., expanding the current typology to include more mountainous coastlines; susceptibility of coastal areas to natural hazards; evaluating human interaction in coastal zones; and assessing impacts of sea level rise due to global warming. Inherent in the entire typology exercise is the issue of scaling from local to regional to global data bases and models.

## Organisational Activities of the LOICZ CPO

Many of the coordination activities conducted at the LOICZ Core Project Office involve facilitation of scientific meetings. To ensure high quality products from such venues, the staff commits a significant portion of its time to preparing meeting documentation, arranging meetings and workshops, participating in the scientific discussions, and preparing high quality reports that provide a record of the meeting discussions for the participants, funding agencies, and future scientific initiatives. This work is both challenging and demanding due to the global scientific agenda and the requisite network of scientists world wide that are involved. It is necessary to organise workshops and meetings in diverse geographic regions to ensure necessary participation and focus on relevant regional issues that contribute to global syntheses. These diverse locations ensure that there is a good balance of researchers from developed and developing countries. This approach has been very successful in addressing such complex issues as groundwater discharge in the coastal zone (an international symposium held in Moscow, Russia), continental shelf fluxes of carbon, nitrogen and phosphorus (an international workshop held in Lagos, Nigeria), and integrated natural and socio-economic modelling (an international workshop held in Hanoi, Vietnam).




Schematic of the coastal zone, emphasising the different pathways of groundwater discharge abd the distinctions among the terrestrial compartment and the 'estuarine zone' and the 'open shelf zone' within the marine compartment (Buddemeier, 1996, LOICZ R&S No. 8, Moscow Symposium).

In addition to the scientific meetings, the Core Project Office organised and/or participated in a number of meetings required to ensure proper communication and interaction within the LOICZ Scientific Steering Committee and the other Programme Elements of the IGBP. Of significant note was the First IGBP Congress held in Germany in April. At this meeting and at subsequent interactions throughout the year, significant progress was made toward developing linkages among the LOICZ Project and the other Programme Elements, most importantly, Biospheric Aspects of the Hydrological Cycle (BAHC), IGBP Data and Information Systems (IGBP-DIS), Global Change and Terrestrial Ecosystems (GCTE), and Joint Global Ocean Flux Study (JGOFS). Late in 1996, discussions within IGBP were initiated related to the development of an Inter-Core Hydrology Project focused on nutrient fluxes.

## Research Agenda

The LOICZ Project is highly multidisciplinary and by mandate covers a vast array of geographic settings. The ultimate research products must be adaptable for inclusion into global models or syntheses. However, such synthesis efforts must develop in logical stages of progression and require keen insights into issues of spatial and temporal scaling. The role of the LOICZ Core Project Office at NIOZ is primarily to encourage and initiate these global research programmes and to advance collaborations and synthesis efforts to a stage where they can evolve with minimal support from LOICZ in terms of team building, conceptualisation, and internal operations. At this more

mature stage, the node structure of these LOICZ-related operations would become the dominant driving and functional mechanism. As these LOICZ projects develop, it is possible to implement new areas of high priority research. Implicit in the development of present and future research initiatives is the need for a co-ordinated effort within the greater IGBP-framework that addresses the major physical driving process in coastal environments such as the horizontal flux of water from land to the coastal zone and off the continental shelf. Such an inter-core hydrology project would facilitate many of the quantitative gaps in the LOICZ programme as well as other IGBP programmes.

**Staffing of the Office at NIOZ**

There was a significant turnover of staff at the LOICZ CPO during 1996. Ms. Sheila Lunter, the Office Administrator, left the LOICZ CPO in February 1996 to join the IGBP Secretariat in Stockholm. Ms. Cynthia Pattiruhu became the new Office Administrator in March 1996. Project Director Dr. John Pernetta accepted a position with UNEP/GEF and left the LOICZ CPO in May 1996. On December 1, 1996, Dr. Roy C. Sidle joined LOICZ as the new Executive Officer, on leave from his position as Senior Researcher with the Department of Quaternary and Marine Geology, Geological Survey of Denmark and Greenland. Dr. Robert Buddemeier came to CPO as Senior Visiting Scientist between June and December on leave from the Kansas Geological Survey, USA.

## THE NETHERLANDS MARINE RESEARCH FACILITIES (MRF)

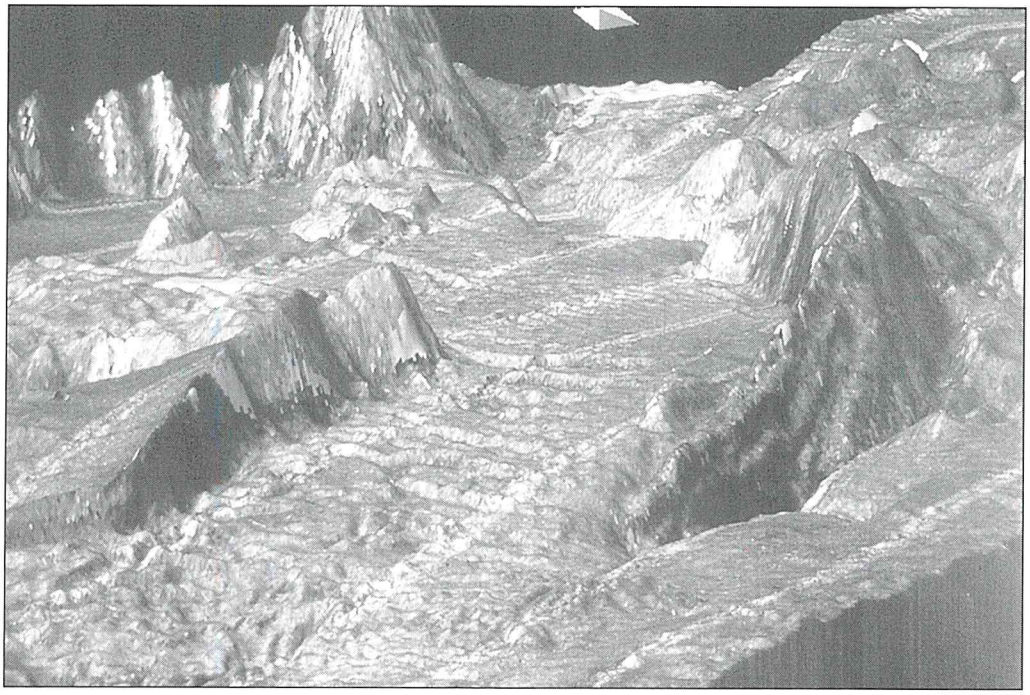
**Contributor:** *C.N. van Bergen Henegouw*

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

In 1996 the National Programme consisted of the following projects:

1. Triple B, hydrographic observations in WOCE Hydrographic Programme repeat area AR 12; project manager Dr. H.M. Van Aken (NIOZ). In a 29-days cruise in the Bay of Biscay with RV 'Pelagia' last years' programme was repeated.
2. Anaxiprobe 1996, a two-phased project to determine the geological origin and evolution of the actively developing Anaximander Mountains in the eastern Mediterranean Sea; project manager Dr. J.M. Woodside (VU). The first phase was executed last year. The second phase was executed on board the Russian RV Gelendzhik.
3. The Deep Chlorophyll Maximum of the oceans: persistence of the plankton community, its biodiversity and its implication for carbon cycling (DCM); project manager Dr. ir. H.G. Fransz (NIOZ). A scientific team of 23 people joined 'Tydeman' in Willemstad (Curaçao) for a 40 days long expedition on the Atlantic Ocean.

On request of the Alfred Wegener Institute (Germany) Auto analyser support was given by MRF, funded by the Netherlands Antarctic Committee. An analyst joined the German research vessel 'Polarstern' for a cruise of one month.



During Anaxiprobe 1996 sediment and rock samples were collected on specific locations based on the bathymetric maps made on board l'Atalante. A deep-towed seismo-acoustic system was used to have geometrically correct isometric images of sea floor back scatter variations and sub-bottom profiles on specific tracks through the area. This picture shows a 3D Bathymetric image of the Anaximander Mountains (courtesy IFREMER)

- Advice to GOA for ships of opportunity and programme 1997 and 1998 :

For the execution of the 1997 programme of Triple B MRF advised the use of RV 'Pelagia'. MRF advised project manager Dr. S.R. Troelstra to execute 'Late Quaternary paleoceanography of the Denmark Strait Overflow Pathway (SE Greenland margin)' in two parts. The Danish research vessel 'Dana' is planned to execute the seismic part of the project in co-operation with a Danish seismic survey in an area north of the Dutch project and for the coring programme of the project another research vessel will be chartered. The Russian RV Gelendzhik was proposed for the Training through Research Cruise (project manager Dr. J.M. Woodside). Dependent on GOA funding 'Actuofluxen' (project manager Dr. G. de Lange) will be executed on board the Italian research vessel 'Urania' to deploy long term deep sea moorings.

For the 1998 programme, MRF advised GOA on requests for two ships of opportunity (one Univ. of Amsterdam and one Univ. of Utrecht) and on seven sea-going applications (three NIOZ, one Univ. of Amsterdam, one Univ. of Utrecht, one Univ. of Groningen en one NIOO-CEMO).

M.J. Rietveld and C.N. Van Bergen Henegouw took part in the 10th meeting of the International Ship Operators, at the Southampton Oceanography Centre, Southampton, UK. Adjacent to this meeting the first bi-annual marine technician workshop - training, funded by the European Commission, was held. Eight marine technicians of NIOZ participated in this workshop.

Based on the advice of a GOA working group and a NIOZ advisory committee GOA and NIOZ approved the formation of a data management group (DMG). The DMG 'hot' core is a national facility (MRF) and consists of four people (data specialist T.F. de Bruin, data base manager R.X. de Koster, CTD data processing specialist M.A. Hiehle and shipboard data specialist J.D.J. Derksen). To enforce and include NIOZ data management, data specialists of the five scientific departments cooperate with the DMG. H. Ridderinkhof and C.N. van Bergen Henegouw are leading the DMG. The DMG will be part of the national oceanographic data commission (NODC) to be officially created in 1997. In this NODC all major organisations active in marine research will be involved.

The total effort of MRF in terms of cruise, ship days and personnel involved for 1996 is given in the table.

| Project | ship days | scientists | students | MRF |
|---|---|---|---|---|
| 1 | 29 | 8 | 3 | 4 |
| 2 | 18 | 8 | 7 | - |
| 3 | 40 | 17 | - | 6 |

# 2. Publications and presentations

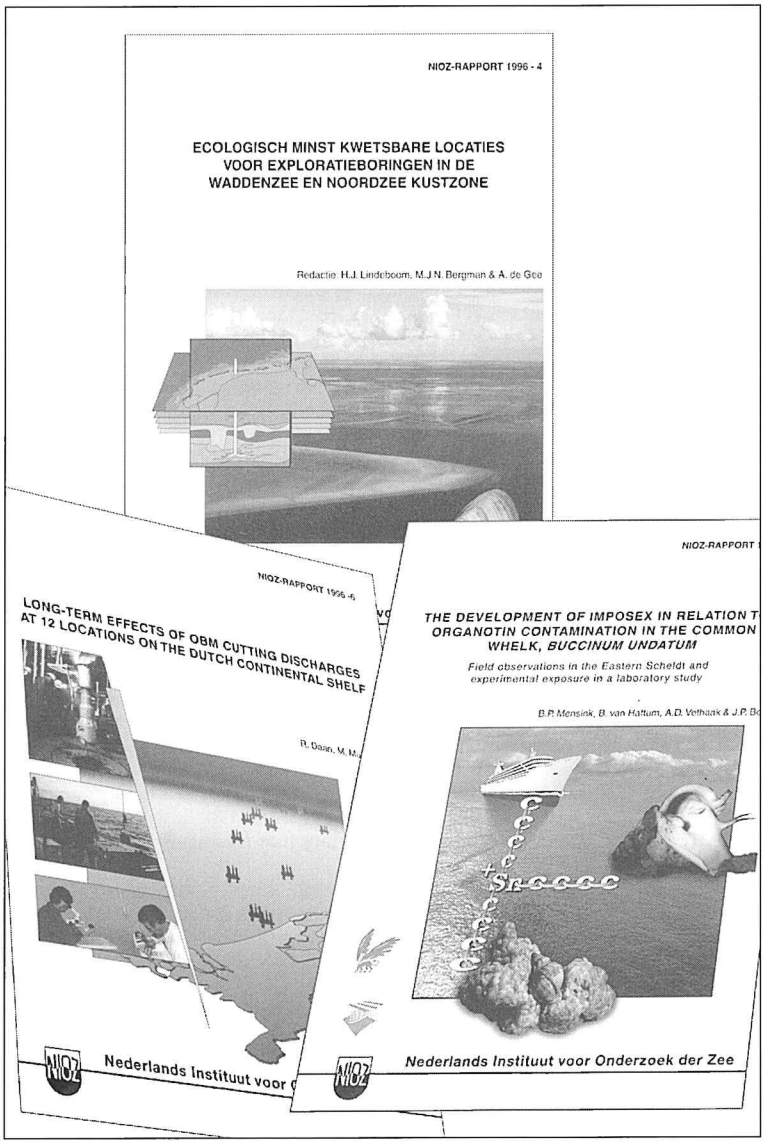



Photo: Henk Hobbelink

## PUBLICATIONS

## JOURNAL OF SEA RESEARCH AND OTHER SERIES ISSUED

In 1996, volumes 35 and 36 of the Journal of Sea Research (former Netherlands Journal of Sea Research) appeared and no 24 of the NIOZ Publication Series (the Annual Report 1995). The Annual Report was edited by B. Bak, G.C. Cadée, P. de Wolf and W. Van Raaphorst.

These two volumes of JSR contained two special issues, viz. 35 (1-3), which was devoted to the Swedish West Coast Project and edited by R. Rosenberg, and 36 (1-2), which contained a number of papers on *in situ* measurements of suspended particle size and settling velocity and was edited by D. Eisma. The no 4 of vol. 35 and the no 3-4 of vol. 36 were regular numbers and contained 13 and 14 papers, respectively.

Starting from mid 1996, C.J.M. Philippart joined the Editors.

Within the framework of the recent reorganization of NIOZ, including termination of non-core activities, negotiations were carried out with commercial publishers, resulting in an agreement to publish the Journal of Sea Research by Elsevier Science (Earth Sciences Department) in collaboration with the Netherlands Institute for Sea Research. Starting from vol. 37 (early 1997), Elsevier Science will take care of type setting, printing, distribution, and subscriber administration. The editorial office will stay at NIOZ.

The publication of the NIOZ Publication Series has been discontinued. NIOZ continues publication of its Annual Report, which is available free of charge or on an exchange base.

### NIOZ 1996

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Kiswara, W. & H.J. Lindeboom. Teluk Banten: Biotic Programme Studies, Field report NIOZ/LIPI. 1-27.

T.C.E. Van Weering. ENAM Cruise Pelagia, August 2-23,1996, 1-20.

## POSTERS

Baars, M.A. Zooplankton biomass in the upper 200 m in and outside the seasonal upwelling areas of the western Arabian Sea. AGU ASLO Ocean Sciences Meeting, San Diego, USA, 12-16 February.

Bakker, D.C.E, U.V. Bathmann & H.J.W. De Baar. Surface water $fCO_2$ changes during spring from 47° to 60°S, at 6°W. Antarctisch Symposium, Veldhoven, 1 May.

Bakker, D.C.E, U.V. Bathmann & H.J.W. De Baar. Surface water fCO2 changes during spring from 47( to 60(S, at 6(W. The Oceanography Society congress, Amsterdam, 8-11 July.

Berghuis, E., G.C. Duineveld, P.A.W.J. De Wilde, A. Noordeloos, W.I.C. Rijpstra, J.S. Sinninghe Damsté & J.W. De Leeuw. Short term epipelagic-abyssopelagic coupling as revealed by pigment and steroid profiles. 1996 Gordon Conference on Organic Chemistry, Holderness School, New Hampshire, USA, 11-16 August.

Boon, A.R. Relationships between benthic activity and the annual phytopigment cycle in near-bottom water and sediments in the southern North Sea. Benguela Dynamics: Impacts of variability on shelf-sea environments and their living resources, Cape Town, Africa, 25-27 November.

Boon, A.R. The quality of near-bottom particulate organic matter in the North Sea as revealed by fatty acids and phytopigments. The Oceanographic Society, Amsterdam, 8-11 July.

Bosch, H-J. & J.W. De Leeuw. Reconstruction of Mediterranean Late Neogene climatic and environmental history: molecular biogeochemistry of lacustrine rhytmites of the Florina-Kozani basin, NW Greece. 3e Nederlands Aardwetenschappelijk Congress, Veldhoven, the Netherlands, 2-3 May.

Bosch, H-J. & J.W. De Leeuw. Reconstruction of Mediterranean Late Neogene climatic and environmental history: molecular biogeochemistry of lacustrine rhytmites of the Florina-Kozani basin, NW Greece. 3rd annual symposium of the Netherlands Research School of Sedimentary Geology, Amsterdam, the Netherlands. 4 October.

Buitenhuis, E.T. The response of photosynthesis and calcification in *Emiliania huxleyi* to speciation of the dissolved inorganic carbon system. Verwey dagen, Texel, 29 January- 2 February.

Cadée, G.C. Shell preservation in Recent environments. Is Antarctica different? Antarctica Symposium, Veldhoven, 1 May.

Camphuysen, C. & C.J.N. De Winter. Roost formation of Guillemots, Razorbills and Kittiwakes in the central North Sea in winter. Intern. ICES Symp. Seabirds in the marine Environment, Glasgow, UK, 22-24 November.

De Bruin, T.F., L. Otto, S. Ober, R.X. de Koster & H.M. Van Aken. Repeated XBT sectors in the Framework of WOCE, 1st International Euro GOOS Conference, The Hague, 7-10 October 1996.

Fransz, H.G. & F. Carlotti. Koud Onderzocht. Onderzoeksdag Arctische en Antarctische Studiën. Biologisch Centrum, Haren 30 October.

Fransz, H.G. & F. Carlotti. Models of annual life cycles of Antarctic copepods. 6th Int. Conference on Copepoda, Oldenburg, Germany 29 July-3 August.

Gast, G.J., P.J. Jonkers, F.C. Van Duyl & R.P.M. Bak. Effects of anthropogenic eutrophication on micro-organisms and nutrients in coral reef waters. Conference Science, use and management of the Great Barrier Reef, James Cook University, Queensland, Australia, 25-29 November.

Gast, G.J. & R.P.M. Bak. Effects of antropogenic eutrophication on microbes and nutrients in coral reef waters. Symposium Great Barrier Reef: Science, use and management, Townsville, Australia, 25-29 december.

Gelin, F., J.S. Sinninghe Damsté & J.W. De Leeuw. Refractory macromolecules in marine microalgae. 7th Plant Taphonomy Meeting, NIOZ, 11 November, 1995, Texel, the Netherlands.

Grice, K., S. Schouten, J.S. Sinninghe Damsté, A. Nissenbaum & J.A. Charach. Freshwater algae *Botryococcus braunii* in an ancient hypersaline euxinic environment. Informal European Stable Isotope Meeting III, CRPG-Nancy- France, 30 September-1 October.

Groenewold, S. & M. Fonds. Effects of beam trawl fishery on the food uptake of scavenging benthic predators in the southern North Sea. Third Intern. Symp. on flatfish ecology, NIOZ, 2-8 November.

Jansen, J.H.F., E. Ufkes & R.R. Schneider. Other times, other glacials: a Milankovic approach of the paleoceanography of the South Atlantic and equatorial oceans. Third Dutch Geosciences conference, Veldhoven, 2-3 May.

Kenig, F., J.S. Sinninghe Damsté, B. Popp & R.E.B. Summons. Palaeoenvironmental reconstruction of the Oxford Clay Sea: Geochemical fossils and their isotopic composition. Gordon Conference on Organic Geochemistry, New Hampshire, USA, August 11-15.

Kok, M.D., R. Osinga, S. Schouten & J.S. Sinninghe Damsté. Abiotic Incorporation of Sulphur into Algal Biomass. 6th V.M. Goldschmidt conference, Heidelberg, Germany. 31 March- 4 April.

Koning, E., G.J.A.Brummer, J. Van Iperen, W. Helder & A.J. Van Bennekom. Biogenic silica production, its transfer through the water column and its burial in the sediments of the north-west Indian Ocean. OPALEO Symposium, Brest, France, 3-7 June.

Köster, J., M.P. Koopmans, H.M.E. Van Kaam-Peters, J.W. De Leeuw & J.S. Sinninghe Damsté. Effect of speciation of organic sulphur in homohopanoids on side chain preservation and 22R/22S epimer ratios. Gordon Conference on Organic Geochemistry, New Hampshire, USA, 11-15 August

Köster, J., S. Schouten, J.S. Sinninghe Damsté & J. W. De Leeuw. Reconstruction of the depositional environment of Toarcian marlstones (Allgäu Formation, Tyrol/Austria): contributions from biomarkers and compound specific carbon isotope analysis, Sediment '96, University of Vienna, Austria, Vienna, 9-15 May.

Lam, F.P. Extraordinary tidal currents at the Greenland shelf edge. Tidal Science 1996, Royal Society of London, 21-22 October.

Lavaleye, M.S.S. Megabenthos as an indicator for food-availability and foodtransport in the OMEX-regi. Workshop Ocean Margin Exchange (OMEX), Brussels, Belgium, 20-22 May.

Löscher, B.M., J. T.M. De Jong & H.J.W. de Baar. The distribution of Cd and phosphate at the 6°W meridian in the Southern Ocean. Scientific Meeting of The Oceanography Society congress, Amsterdam, 8 - 11 July.

Mensink, B.P., J.M. Everaarts, H. Kralt, C.C. Ten Hallers-Tjabbes & J.P. Boon. Tributyltin (TBT) exposure in early life stages induces the development of male sexual characteristics in common whelks, *Buccinum undatum*. Studiedag 'Oestrogeen actieve stoffen in het milieu', RIKZ, Den Haag, 23 Februari.

Montaudo, G., C. Puglisi, F. Samperi, J.W. De Leeuw, W.A. Hartgers, K. Kishore & K. Ganesh. Thermal degradation processes in poly(xylylenesulphides) investigated by comparative direct pyrolysis-MS and flash pyrolysis-GC/MS experiments. Pyrolysis '96, Venice, Italy, 14-18 October.

Pool W.G., J.W. De Leeuw & B. Van de Graaf. Automated processing of GC/MS data by a repetitive backfolding of the first differential. 3e Nederlands Aardwetenschappelijk Congres, Veldhoven, the Netherlands, 2-3 May.

Ruardij, P., H. Van Haren & H. Ridderinkhof. Integrated North Sea Program (INP). Mooring at the Oystergrounds. Coupled physical-biological model. EURO-GOOS, the Hague, 7-10 October.

Ruardij, P., H. Van Haren & H. Ridderinkhof. Integrated North Sea Program (INP). Mooring at the Oystergrounds. Coupled physical-biological model. RvO-Symposium, the Hague, 5 June.

Schoemann, V., H.J.W. De Baar, J.T.M. De Jong & C. Lancelot. Controlling mechanisms of Mn seasonal distribution in the continental coastal zone of the North Sea. Progress in Belgian Oceanographic Research, Academy, Brussels, Belgium, 8-9 January 1996.

Schouten, S. & J.S. Sinninghe Damsté. Stable isotope analyses of molecular fossils. Voorjaarsbijeenkomst Nederlandse Vereniging voor Massaspectrometrie, Vrije Universiteit, Amsterdam, 25 April.

Schouten, S., J.S. Sinninghe Damsté. Novel thiophenes with C-3 alkylated steroid carbon skeletons. Gordon Conference on Organic Geochemistry, New Hampshire, USA, 11-15 August.

Schouten S., A. Dijkhuizen, J.S. Sinninghe Damsté, F. Wagner, H.J. Visscher & J.W. De Leeuw. Stable carbon isotope analyses of lipids in recent and fossil leaves of the birch *Betula pubescens*. Informal European Stable Isotope Meeting III. Nancy, France, 30 September.

Shimwell, S.J. & M. R. Wernand. Calculation of the Q factor in Case 2 waters. Ocean Optics XIII, SPIE, Halifax, Canada, 22-25 October.

Timmermans, K.R., M.A. Van Leeuwe, J.T.M. De Jong, H.J. Witte, J. Van Ooyen & H.J.W. De Baar. Iron addition experiments in the southern region of the Pacific Ocean during ANT XII/4. Antarctica Symposium, Veldhoven, 1 May.

Timmermans, K.R., M.A. Van Leeuwe, J.T.M. De Jong, H.J. Witte, J. Van Ooyen & H.J.W. de Baar. Iron addition experiments in the southern Pacific Ocean. The Oceanography Society congress, Amsterdam, 8-11 July.

Ufkes, E., J.H.F. Jansen & R.R. Schneider. Changes in winter surface-water temperature as recorded by test size variations in *G. bulloides*: a case study from Walvis Ridge, SE Atlantic. Third Dutch Geosciences conference, Veldhoven, 2-3 May.

Van Bennekom, A.J. Variability of bottom water renewal in the Norwegian Basin. The Oceanographic Society, Amsterdam 8-11 July.

Van Bergen Henegouw, C.N., T.F. De Bruin & H. Ridderinkhof. Future academic marine research data management in the Netherlands. EUROGOOS, The Hague, The Netherlands, 7-10 October.

Van der Geest, H.G., M. Hoetmer, M. Langevoord, A.J. Schrier, J.IJ. Witte & H.W. Van der Veer. Flatfish on the reefs of Curaçao, Dutch Antilles, a baseline study. Third Intern. Symp. on flatfish ecology, NIOZ, 2-8 November.

Van der Schrier, G. & L.R.M. Maas. Bifurcation analysis of the thermohaline ocean circulation. European Geophysical Society XXI General Assembly 6-May.

Van der Schrier, G. & L.R.M. Maas. Bifurcation analysis of the thermohaline ocean circulation. Geophysical and Environmental Fluid Dynamics (GEFD) summer school,

Van der Veer, H.W., C.J.G. Van Damme & M.F. Leopold. Impact of cormorant predation on juvenile flatfish stocks in the Dutch Wadden Sea. Third Intern. Symp. on flatfish ecology, NIOZ, 2-8 November.

Van der Veer, H.W., J.IJ. Witte & B. Bies. Meristic variability in 0-group plaice (*Pleuronectes platessa*) in the western Wadden Sea and consequences for growth and mortailty. Third Intern. Symp. on flatfish ecology, NIOZ, 2-8 November.
Van Gils, J., T. Piersma & M.W. Dietz. Telemetric tracking of shorebirds as a method to study predator-prey interactions on intertidal flats. Fifth European Conference on Wildlife Telemetry, Strasbourg, 25-30 August.
Van Haren, H. & D. Mills. Integrated North Sea Program (INP). Mooring at the Oystergrounds. Observations. Euro-GOOS, the Hague, 7-10 october 1996.
Van Heemst, J.D.H. & J.W. De Leeuw. Molecular characterisation of North Sea dissolved organic matter. 3e Nederlands Aardwetenschappelijk Congres, Veldhoven, the Netherlands, 2-3 May.
Van Heemst, J.D.H. & L. Megens. Characterisation of organic matter from the Ems-Dollart estuary. Verwey-Symposium 1996, NIOZ, Texel, the Netherlands, 29-31 January.
Van Iperen, G.J.A. Brummer & A.J. Van Bennekom. Diatoms from the upwelling areas of the NW Indian Ocean: acomparison of sediment trap and surface sediments records. Tokyo, Japan 6-13 September
Van Kaam-Peters, H.M.E., S. Schouten, J.W. De Leeuw & J.S. Sinninghe Damsté. The Kimmeridge Clay Formation: New insights into its depositional environment. 3e Nederlands Aardwetenschappelijk Congres, Veldhoven, the Netherlands, 2-3 May.
Versteegh, G.J.M, R. Riegman, J.W. De Leeuw & J.H.F. Jansen. Effects of growth limitation on the Uk'37 alkenone ratio as revealed by culture studies of *Isochrysis galbana*. 3e Nederlands Aardwetenschappelijk Congres, Veldhoven, 1-3 May.
Veth, C. Dutch Oceanographic Research in Antarctica. Consultative Meeting Antarctic Treaty, Utrecht, The Netherlands, May 6-10.
Walker, P. 'Flatfish' fisheries and fitness, Third. Intern. Symp. on flatfish ecology, NIOZ, 2-8 November.
Wernand, M.R., S.J. Shimwell & J.C. De Munck. The generation of high resolution ocean colour information from 5 particular bands (a case 2 water approach) Ocean Optics XIII, SPIE, Halifax, Canada, 22-25 October.
Wiebinga, C.J. & H.J.W. De Baar. Distribution of total and dissolved organic carbon in the Indian sector of the Southern Ocean. The Oceanography Society, Amsterdam, 8-11 July.
Wiebinga, C.J. & H.J.W. De Baar. Vertical distribution of total and dissolved organic carbon in the Indian sector of the Southern Ocean (ANTARES 2, summer 1994). Antarctica symposium, Veldhoven, 1 May.
Wilpshaar, M. Field measurements on cohesive sediment transport. Physics of Estuaries and Coastal Seas (PECS), Den Haag, 9-12 September.

## ORAL PRESENTATIONS

Baars, M.A. Introduction to heterotrophic plankton, with special reference to mesozooplankton. Lecture Series Marine Ecosystems, University of Groningen, Haren, 7 June.
Baars, M.A. Productivity and plankton of the Arabian Sea. Lecture Series Marine Ecosystems, University of Groningen, Haren, 7 June.
Baars, M.A. The Arabian Sea: a different kind of tropical ocean ecosystem. The Oceanography Society Meeting. Amsterdam, 8 July.
Bak, R.P.M. Coral reefs. Marine Biology. Lecture series University of Groningen, June.
Bak, R.P.M. Biogeography, coral reefs. Lecture series University of Groningen, 16 January.
Bak, R.P.M. Community composition on a Caribbean coral reef; do changes in the benthos relate to human activity? University of Marseille II, 16 October.
Bak, R.P.M. Coral reefs and pollution. University of Groningen, 7 May.
Bak, R.P.M. From overfishing to climate change: man and coral reefs. Station marine d'Endoume Marseille, 2 April.
Bak, R.P.M. Long-term change in coral reefs and the role of eutrophication. European Oceanology Observatory Monaco, 4 October.
Bak, R.P.M. The coral reefs of Teluk Banten. Indonesia. NWO workshop Jakarta, 5-7 November.
Bak, R.P.M. The use of Fluorescently Labelled Bacteria (FLB) in studying change in coral reef benthos filter-feeding conditions. 8th Int. Coral reef Symposium, Panama, 24-29 June.
Bak, R.P.M. Tropical Marine Biology. Lecture series, University of Amsterdam, February.
Bakker, D.C.E. Surface water $fCO_2$ changes in spring between 47° and 60°S along 6°W. Laboratoire d'Océanographie et de Climatologie, Université de Pierre et Marie Curie, Paris, France, 26 March.
Bakker, D.C.E., U.V. Bathmann & H.J.W. De Baar. The fugacity of $CO_2$ in (South) Atlantic surface waters and related air-sea exchange of $CO_2$. European Geophysical Society, Den Haag, 8 May.
Beks, J.P. The $^{210}Pb$ budget of the North Sea. Atmospheric inpus *vs.* sediment flux. Symposium 'Radionuclides in the oceans' (RADOC 96-97). Cherbourg, 7-11 October.
Benielli, D., J. Sommeria, F.-P.A. Lam & L.R.M. Maas. Observation of an internal wave attractor. European Geophysical Society (EGS). Den Haag, 6-10 May.
Benielli, D., J. Sommeria, L. Maas & F.-P. Lam. Laboratory confirmation of internal wave focusing in a container with sloping side wall. Fifth IMA conference on stratified flows: Mixing and dispersion in stably stratified flows. Dundee, 24-27th September.
Bergman, M.J.N. A new benthos dredge ('Triple-D') for quantitative sampling of infauna species of low abundance. INMARTECH-1996, Southampton, 1 October.
Bergman, M.J.N. A study on the effects of beam trawl fishery on the ecosystem of the North Sea. Lecture for students from developing countries, NIOZ, 28 August.
Bergman, M.J.N. Experimental set-up to study effects of beam trawl fishery on the benthic ecosystem. Course van Hall Instituut at NIOZ, 9 July.
Bergman, M.J.N. How to enhance the selectivity of bottom trawls. Workshop BEON, Den Haag, 19 January.
Bergman, M.J.N. How to study effects of beam trawl fishery on the ecosystem? Course van Hall Instituut at NIOZ, 9 July.
Bergman, M.J.N. Measures for management of beam trawl fishery with respect to the effects on the North Sea ecosystem. Workshop BEON preparatory to IMM '97, Wageningen, 3-4 April.

Bergman, M.J.N. Results of the IMPACT-II field studies in 1995. Annual meeting EC-project IMPACT-II, Kiel, 10 January.

Bergman, M.J.N. The use of beam trawls with respect to a sustainable management of the North Sea ecosystem. Workshop 'Milieugebruiksruimte' UV - IvM, Delft, 30 January.

Beukema, J.J. What can we learn from two large-scale 'experiments' in the Dutch Wadden Sea? 9th Int. Sci. Wadden Sea Symposium, Norderney, 4-8 November.

Booij, K. Sediments and SPMDs as extractors of environmental toxicity. Workshop 'Extraction of environmental toxicity', Bilthoven, 26 September 1996.

Booij, K., M.Th.J. Hillebrand & J. Van Ooijen. Nutrients and organic contaminants in Teluk Banten. Workshop 'Teluk Banten', Noordwijkerhout, 11-12 June 1996.

Boon, J.P. Environmental chemistry of PCBs and related compounds. University of Utrecht, 13 May.

Boon, J.P., B.P. Mensink, B.G.M. Van Hattum & C.C. Ten Hallers-Tjabbes. Sexual changes in marine gastropods upon exposure to tributyltin from anti-fouling paints on ships. (Lecture workshopdag 'Oestrogeen Actieve Stoffen in het Milieu', RIKZ-Rijkswaterstaat, Den Haag, 23 Feruary.

Boon, J.P., B.P. Mensink, B.G.M. Van Hattum & C.C. Ten Hallers-Tjabbes. Species differences in the development of imposex in marine snails after exposure to tributyltin. (Lecture presented at 29-02-'96 at the 'Winter School' of the Research School M&T (Environmental Chemistry & Toxicology). The role of differences in species sensitivity in ecotoxicology, NIOZ, Texel, 28 February - 01 March.

Boon, J.P. Biotransformation of anthropogenic compounds: a new or ancient phenomenon? (Mook-SymposiumRoyal Netherlands Academy of sciences, Amsterdam, 23 May.

Boon, J.P. Environmental chemistry of PCBs and related compounds. Lecture course Marine environment and at course ecotoxicology, RITOX, University Utrecht, 3 June.

Boon, A.R. An annual cycle of phytopigments in water and sediment in the North Sea. 3e Nederlands Aardwetenschappelijk Congres, Veldhoven, 2-3 May.

Boon, A.R. Relationships between benthic activity and the annual phytopigment cycle in near-bottom water and sediments in the southern North Sea. New Challenges for North Sea research, Hamburg, Germany, 21-23 October.

Boon, J.P., M. Helle, M.H.A. Dekker, H.M. Sleiderink, H.J. Klamer, B. Govers, P. Wester & J. De Boer. *In-vitro* biotransformation of chlorinated bornanes (toxaphene) in hepatic microsomes of marine mammals and birds. Influence on bioaccumulation and mutagenicity. Dioxin '96. 16th Annual Symposium on Dioxins and related compounds, 12-16 August 1996.

Brussaard, C.P.D. Autolysis of phytoplankton. International PELAG symposium: Eutrophication in planktonic ecosystems: Food web dynamics and elemental cycling. Helsinki, Finland, 26-30 August.

Brussaard, C.P.D. The effect of phytoplankton cell lysis on the microbial food web. Fifth European Marine Microbiology symposium, Bergen, Norway; August 11-15.

Buitenhuis, E.T. Culturing *Emiliania huxleyi* under carbon limitation. Alfred Wegener Institut, Bremerhaven, Germany, 13 May.

Buitenhuis, E.T. The response of photosynthesis and calcification in *Emiliania huxleyi* to speciation of the dissolved inorganic carbon system. MERLIM workshop, Bergen, Norway, 27 February.

Cadée, G.C. Shellfragments are more interesting than entire shells. Working Group Quaternary and Tertiary Geology, Haarlem, 16 March.

Camphuysen, C.J. & S. Garthe. The Northern Fulmar revisited: On the scavenging habits and spatial distribution of an abundant North Sea seabird. International ICES Symposium 'Seabirds in the Marine Environment', Glasgow, 22-24 November.

Camphuysen, C.J. Beached bird surveys in the Netherlands, methods and results. Onderzoek aan olieslachtoffers in Nederland: methodes en resultaten. Directoraat Generaal Scheepvaart & Maritieme Zaken, Rijswijk, 5 September.

Camphuysen, C.J. Possibilities and impossibilities in the study of the eider *Somateria mollissima* in the Netherlands. SOVON, Leeuwarden, 9 March.

Collinson, M.E., P.F. Van Bergen & J.W. De Leeuw. How do fossil fruits and seeds provide evidence of Angiosperm evolution ? 9th IOPC, California, June 30 - July 5, 1996, Santa Barbara, California, USA, 30 June - 5 July

De Baar, H.J.W. Determination of natural and pollutant concentrations of zinc in rivers and sediments, Advisory Committee on Zinc in Environment and Health of Netherlands Council for Public Health, Den Haag, 7 May.

De Baar, H.J.W. Distributions of dissolved Fe and $CO_2$ in the Polar Front during December-January 1996. Workshop Polarstern expedition ANT XIII/2, Bremerhaven, Germany, 27 June.

De Baar, H.J.W. Lecture 'Common concepts for speciation, diffusion and limitation for anyone element carbon, iron , zinc and cobalt. Workshop EU-MAST MERLIM Program, Bergen, Norway, 27 February.

De Baar, H.J.W. Lecture on Fe-$CO_2$ and Plankton in the Southern Ocean, visit of ministers J.M.M. Ritzen and Senatorin mrs. B. Kahrso to NIOZ, Co-operation AWI Bremen - NIOZ, 13 May.

De Baar, H.J.W. Lecture series Introductory Oceanography. Department of Marine Biology, University of Groningen, 5-14 February.

De Baar, H.J.W. Lecture series on air-sea gas exchange and the Oceanic $CO_2$ System in Climate Change. Introductory course on Oceanography for Graduate students, NIOZ, 20 November.

De Baar, H.J.W. Lecture series on Rare Earth elements and their isotopes in the oceans, course Isotope Geology, Free University, Amsterdam, 24 September.

De Baar, H.J.W. Light and iron limitation as controls of biological productivity in the Antarctic Ocean (1992-1996 findings). International Conference of the Oceanography Society, Amsterdam, 10 July.

De Baar, H.J.W. Physics and chemistry regulate algal blooms and carbondioxide uptake in the Antarctic Ocean, MOOK Symposium, Royal Netherlands Academy of Sciences, Amsterdam, 23 May.

De Baar, H.J.W. Pollutant metals; Greenhouse Gases. Lectures in course Marine Environment, University of Groningen, 9-10 May.

De Haas, H. & T.C.E. Van Weering. Recent sediment accumulation, organic carbon burial and transport in the North Sea. ENAM Meeting Geilo, Norway, 22-28 April.

De Haas, H. & T.C.E.Van Weering. Recent sediment accumulation, organic carbon burial and transport in the north eastern North Sea. Jubilee meeting Geological Society of Sweden/Marskat 6 Meeting, Stockholm, Sweden, 16-18 October.

De Haas, H.W. Boer, H.T. Kloosterhuis & T.C.E. Van Weering. Organic carbon in Teluk Banten Sediments. Workshop Indonesian/Netherlands Cooperation in Global Change Research, Teluk Banten project, Noordwijk, 11-12 June.

De Leeuw, J.W., Application of chemolysis techniques to the study of biopolymers. Ancient Biomolecules Initiative Workshop. Biopolymers and Lipids, School of Chemistry, University of Bristol, Bristol, UK, 19-20 June.

De Leeuw, J.W., J.S. Sinninghe Damsté, F. Gelin, H.M.E. Van Kaam-Peters & J.D.H. Van Heemst. Algal polyethers and polyphenols as well as sulfurized polysaccharides as major building blocks of marine kerogens. ACS Symposium: 'Organic Matter Preservation in Sediments and Soils', Orlando, USA, 25-29 August.

De Leeuw, J.W., P.F. Van Bergen, J. Van Heemst & S. Peulvé. Polyphenolic substances in DOM, POM and sediments: do they reflect a contribution from lignin? 212$^{th}$ ACS National Meeting, Orlando, USA, 25-29 August.

De Leeuw, J.W., Long chain alkenones asproxies for paleo-SST. Institute for Marine Atmospheric Research, Utrecht, 16 December.

Den Besten P.J., J.M. Everaarts & B.P. Mensink. Biomarkers in evertebrates. Symposium: 'Biomarkers, als koortsthermometer voor het milieu: toepassing door de waterbeheerder', RIKZ, Den Haag, 3 October.

De Wilde, P.A.W.J. Benthic Community Activity: Advanced course Estuarine Ecology, Yerseke, 7 May.

De Wilde, P.A.W.J. Estimates of benthic community respiration with bell-jars and benthic lander techniques. Alipor Workshop, Tjärnö, Sweden, 13-16 April.

De Wilde, P.A.W.J. Introduction into benthic biological research in OMEX. Observation of a phytodetritus deposition event along the continental margin SW of Ireland in August 1995. OMEX Workshop, Strenglin, Germany, 17-21 March.

De Wilde, P.A.W.J. Lecture series Marine Ecosystems. Department of Marine Biology, University of Groningen, Haren, 2-7 June.

De Wilde, P.A.W.J. The benthic system of the continental slope in the NE Atlantic Ocean. International course, NIOZ, Texel, 28 August.

Duineveld, G.C.A. Responses of benthic communities to seasonal food inputs in an oligotrophic system. Workshop Pelagic Benthic Coupling in the oligotrophic Cretan Sea (CINCS ), Genova, Italy, 1-4 April.

Duineveld, G.C.A. Seasonal and spatial fluctuation of phytodetritus in the sediment in the OMEX region. Workshop Ocean Margin Exchange (OMEX), Brussels, Belgium, 20-22 May.

Duineveld, G.C.A. Seasonal variation in benthic activity and biomass in the oligotrophic Cretan Sea. 2$^{nd}$ Workshop of the Mediterranean Targeted Project, Iraklio, Crete, 1-3 February.

Eglinton, T.I., O. Gustafsson, S. Schouten & J.S. Sinninghe Damsté. Isotopic evidence for common biological precursor(s) of long-chain diols and n-hydrocarbon pyrolysis products from Black Sea sediments. 212$^{th}$ ACS National Meeting, Orlando, U.S.A., 25-29 August.

Everaarts, J.M. Contamination of tropical marine envrionments. Chagos expedition. Diego Garcia, British Indian Ocean Territory, 27 February-17 March.

Everaarts, J.M. Toxicological aspects of the marine environment. Course marine environment. University of Groningen, 15 May.

Everaarts, J.M. Polychlorinated biphenyls and cyclic pesticides in sediments and macro invertebrates from coastal zones of different climatic regions. International Symposium on the base of Nuclear and Related Techniques for Studying Environmental Behaviour of Crop Protection Chemicals. International Atomic Energy Agency and Food and Agriculture Organisation of the United Nations, Vienna, Austria, 4 July.

Fonds, M. Research on the possibilities to decrease the production of discards in beam trawl sole fisheries. BEON meeting on fishery effects. RIKZ, The Hague, 19 January.

Fonds, M. Survival chances of discards in the beam trawl fishery. Course on 'Protection and utilization of the Ocean', organised by the Zentrum für Klimaforschung, Univ. Hamburg, NIOZ, 27 August.

Fonds, M., J.G.Hiddink & M.Wolters. Laboratory observations on the effect of winter temperature on reproduction of flatfish: flounder (*P. flesus*), dab (*L. limanda*) and plaice (*P. platessa*). Third Intern. Symp. on flatfish ecology, Texel, 4 November.

Fransz, H.G. Estuarine zooplankton. Estuarine Ecology course of the research school Functional Ecology, NIOO Yerseke, 6 May.

Furness, R.W. & C.J. Camphuysen. Seabirds as monitors of the marine environment. International ICES Symposium 'Seabirds in the Marine Environment', Glasgow, 22-24 November.

Gast, G.J. & R.P.M. Bak. Effects of anthropogenic eutrophication on microbes and nutrients in coral reef waters. Australian Institute for Marine Science, Townsville, 21 November; James Cook Universiy, Townsvill,e 9 December; Australian Museum for Natural History, Sidney, 12 December; School of Biological Sciences, University of Sidney, 13 December.

Gast, G.J., F.C. Van Duyl & R.P.M. Bak. Micro-organisms in coral reef water types: abundances and growth. 8th International Coral Reef Symposium, Panama, 24-29 June.

Gast, G.J., F.C. Van Duyl & R.P.M. Bak. Microbes in coral reef waters: variation in time and space along a eutrophication gradient. Verweydagen, NIOZ, The Netherlands, 29-31 Januari.

Gelin, F., J.S. Sinninghe Damsté & J.W De Leeuw. Contribution of microalgal macromolecules to marine sediments. 3$^{e}$ Nederlands Aardwetenschappelijk Congres, Veldhoven, The Netherlands, 2-3 May.

Gelin, F., J.S. Sinninghe Damsté & J.W. De Leeuw. Bacterial degradation of microalgal matter as a mechanism for selective preservation of aliphatic biomacromolecules in marine sediments. ACS Symposium: 'Role of Bacteria in Processing and Sourcing Sedimentary Organic Matter', New-Orleans , USA, 24-28 March.

Gelin, F., J.S. Sinninghe Damsté, M.D. Kok, J.R. Maxwell & J.W. De Leeuw. Sulfurization and occurrence of resistant microagal biomacromolecules as associated factors for a significant preservation of organic matter in marine sediments. ACS Symposium: 'Organic Matter Preservation in Sediments and Soils', Orlando, USA, 25-29 August.

Gelin, F., J.S. Sinninghe Damsté & J.W. De Leeuw. Structural elucidation of insoluble, aliphatic polyethers isolated from marine microalgae by combined flash pyrolysis and chemical degradation methods. Pyrolysis '96, Venice, Italy, 14-18 October.

Gipp, H.J.W. Benthic Foraminifera and their (pale)oceanographic applications: How do microhabitat preferences affect the (pale)oceanographic interpretation of marine sediment samples? Third Dutch Geosciences conference, Veldhoven, 2 May.

Grice, K., S. Schouten & J.S. Sinninghe Damsté. Stable carbon isotopes of biological markers from hypersaline environments. 3e Nederlands Aardwetenschappelijk Congres, Veldhoven, The Netherlands, 2-3 May.

Grice, K., S. Schouten, A. Nissenbaum, J. Charach & J.S. Sinninghe Damsté. Biological markers from hypersaline environments with unusually heavy $\delta^{13}C$ contents. V.M. Goldschmidt Conference. Heidelberg, Germany, 31 March-4 April.

Groenewold, S. Scavengers feeding on fishery discards in the North Sea. Intern. Course 'Protection and utilzation of the ocean', Zentrum für Klimaforschung Univ. Hamburg, NIOZ, 27 August.

Hoefs, M.J.L., J.S. Sinninghe Damsté, G.J. De Lange & J.W. De Leeuw, Changes in kerogen composition across an oxidation front in map turbidites as revealed by pyrolysis GC-MS. 212th ACS National Meeting, Orlando, USA, 25-29 August.

Hoefs, M.J.L., S. Schouten, J.S. Sinninghe Damsté & J.W. De Leeuw. Methanogenic bacterial lipids in marine sediments: paleoenvironmental implications. 3e Nederlands Aardwetenschappelijk Congres, Veldhoven, The Netherlands, 2-3 May.

Höld, I.M., S. Schouten & J.S. Sinninghe Damsté. A molecular level investigation of kerogens using stable carbon isotopic compositions of pyrolysis products. 6th V.M. Goldschmidt conference, Heidelberg, Germany, 31 March-4 April.

Höld, I.M., S. Schouten & J.S. Sinninghe Damsté. A molecular and stable carbon isotopic study on isoprenoid-rich marine kerogens. Stable carbon isotope analysis of pyrolysis products of kerogens. 212th ACS National Meeting, Orlando, USA, 25-29 August.

Honkoop, P.J.C. Effects of water temperature in winter on subsequent recruitment of the bivalves *Macoma balthica* and *Cerastoderma edule*. Verwey Symp., NIOZ, 29-31 January.

Jansen, J.H.F. Lowered sea-surface temperatures in the Arabian Sea: upwelling *versus* advection. Arabian Sea workshop, Institute for Palaeoenvironment and Palaeoclimate, University of Utrecht, Utrecht, 29 May.

Jansen, J.H.F. Milankovic and the surface circulation of the the South Atlantic Ocean during the late Quaternary and the next 80 000 years. Institut for Marine and Atmospheric Research, Utrecht University, 28 March.

Jansen, J.H.F. Palaeoceanography of the SE Atlantic Ocean en palaeoclimate of Africa. Course Institute for Palaeoenvironment and Palaeoclimate, Netherlands Research School of Sedimentary Geology, Utrecht, 26 November.

Jansen, J.H.F. Paleoceanography of the last deglaciation. Course Institute for Palaeoenvironment and Palaeoclimate, Netherlands Research School of Sedimentary Geology, Utrecht, 5 and 12 November.

Jansen, J.H.F. Paleoceanography of the last deglaciation. Third Dutch Geosciences conference, Veldhoven, 2 May.

Jansen, J.H.F., E. Ufkes & R.R. Schneider. Orbitally forced changes in the surface circulation of the SE Atlantic during the late Quaternary and the next 80 000 years. Symposium Prediction in Geology. Geologische Vereinigung e.V. & Koninklijk Nederlands Geologisch Mijnbouwkundig Genootschap. Amsterdam, 24 February.

Jansen, J.H.F., E. Ufkes & R.R. Schneider. Other times, other glacials: a Milankovic approach of the paleoceanography of the South Atlantic and equatorial oceans. Third Dutch Geosciences conference, Veldhoven, 3 May.

Jansen, J.H.F. Milankovic and palaeoceanography, or other times other glacials. Geoflex, Geologic Student Society, Free University, Amsterdam, 14 March.

Kenig, F., J.S. Sinninghe Damsté, B.N. Popp & R.E. Summons. Palaeoenvironmental reconstruction of Oxford Clay Sea: Geochemical fossils and their isotopic composition. Isotopic studies in Paleontology, Lyell Meeting, London, UK, 27 February.

Kok, M.D., R. Osinga, S. Schouten & J.S. Sinninghe Damsté. Abiotic incorporation of sulphur into algal biomass; A possible pathway to the formation of sulphur-rich kerogens. 3e Nederlands Aardwetenschappelijk Congres, Veldhoven, 2-3 May.

Kok, M.D., R. Osinga, S. Schouten & J.S. Sinninghe Damsté. Formation of macromolecular sulphur-rich organic material by the incorporation of inorganic sulphur species into carbohydrates. 212th ACS National Meeting, Orlando, U.S.A. 25-29 August.

Koopmans, M.P. & J.S. Sinninghe Damsté. Sedimentary derivatives of a carotenoid of green sulphur bacteria as a molecular proxy for photic zone anoxia. 6th Goldschmidt Conference, Heidelberg, Germany, 31 March.

Koopmans, M.P. Artificial maturation of sulfur-rich sedimentary rocks: Implications for the use of biomarkers in petroleum geochemistry. Mobil Exploration and Producing Technical Center, Dallas, TX, USA, 29 March.

Koopmans, M.P. Artificial maturation of sulfur-rich sedimentary rocks: Implications for the use of biomarkers in petroleum geochemistry. ARCO Exploration and Production Technology, Dallas,TX, USA, 28 March.

Koopmans, M.P., H.M.E. Van Kaam-Peters, S. Schouten, J.W. De Leeuw & J.S. Sinninghe Damsté. Novel dia- and catagenetic products of isorenieratene reveal input from Chlorobiaceae. ACS Symposium: 'Role of Bacteria in Processing and Sourcing Sedimentary Organic Matter', New Orleans, USA, 24-28 March.

Koopmans, M.P., J.S. Sinninghe Damsté & J.W. De Leeuw. Biodegradation of organic sulfur compounds in crude oils from Oman. ACS Symposium: 'Biodegradation of Petroleum', New Orleans, USA, 24-28 March.

Köster, J., M. Rospondek, A. Zubrzycki, J.W. De Leeuw & J.S. Sinninghe Damsté. Biological markers and stable carbon isotope ratios as tools in palaeoenvironmental reconstructions: examples from the Menilite Formation (Oligocene) of the Flysch carpatians of SE Poland. Sediment '96, University of Vienna, Vienna, Austria, 9-15 May.

Kuipers, B.R. Pelagic mesocosm research at NIOZ. NIOO Nieuwersluis, 4 April.

Lam, F.P. Reflections and geometric focusing of internal waves. Dept. of applied mathematics and theoretical physics. Univ. of Cambridge, 11 October.

Lam, F.P. Shelf waves with diurnal tidal frequency at the Greenland shelf edge. EGS, Den Haag, 8 May.

Lavaleye, M.S.S. Betekenis van bodemfauna in het ecosysteem van de Noordzee. Symposium bodemdieren van de Noordzee, ter gelegenheid van de publicatie van de 'Bodemdierenatlas Noordzee', RIKZ, The Hague, The Netherlands, 23 April.

Lavaleye, M.S.S. Benthos as an indicator for food-availability and foodtransport in the OMEX-region. Workshop Ocean Margin Exchange (OMEX), Strenglin, Germany, 18-21 March.
Lindeboom, H.J. Biological research in Teluk Banten, Indonesia. NWO Workshop, Noordwijk, 11-12 June.
Lindeboom, H.J. Biological research in Teluk Banten. Workshop on the research of integrated coastal zone management of Teluk Banten, Jakarta, 5-7 November.
Lindeboom, H.J. Effects of fisheries. Workshop on the future of fisheries, Vlissingen, 21 March.
Lindeboom, H.J. Interannual and decadal variability of marine ecosystems. Symposium 'New challenges for North Sea research', Hamburg, 21-23 October.
Lindeboom, H.J. Long-term changes in marine ecosystems. Platform for Marine Life Sciences, Amsterdam, 13 June.
Lindeboom, H.J. Natural variability of the marine ecosystem and the human impact. NIOO-CEMO, Yerseke, 8 May.
Lindeboom, H.J. Natural variability of the marine ecosystem and the human activities. University Groningen, 20 May.
Lindeboom, H.J. Natural variability of the marine ecosystem, phenomena and possible causes. MOOK Symposium, Amsterdam, 23 May.
Lindeboom, H.J. Natural variation of the marine ecosystem. Colloquium at the Biological Station Helgoland (BAH), Hamburg, 29 January.
Lohse, L. The role of the sea floor as a regenerator and sink in North Sea nutrient cycling: final results of the INP-BELS project, New Challenges for North Sea Research, Hamburg, Germany, 22 October.
Löscher, B.M. Cadmium versus phosphate. Verwey-Symposium, NIOZ, 29 - 31 January.
Löscher, B.M. Chances in the cadmium-phosphate ratio in response to primary production. Colloquium, NIOZ, 28 November.
Maas, L. & F.P. Lam. Multiple reflections and focusing of internal waves. University of Wales (UCES), Menai Bridge, Bangor, 1 October.
Maas, L.R.M The Poincare model: internal and inertial wave patterns in enclosed basins. ENSL, Lyon, 23 September.
Maas, L.R.M. Focusing of internal waves in uniformly stratified lakes. Workshop on 'Physical processes in natural waters', Kastanienbaum, Switzerland, 16-18 September.
Maas, L.R.M. J. Sommeria, D. Benielli & F.-P.A. Lam. Observation of an internal wave attractor. INTAS-meeting: Grenoble, 20 September.
Maas, L.R.M. Tidal estuaries with sloping bottom: forced, nonlinear Helmholtz resonators. Physics of Estuaries and Coastal Seas (PECS) Den Haag, 9-12 September.
Mélières, M.A., J. Guiot, J.H.F. Jansen & L. Tessier. Indicateurs des changements de l'environnement et chronologies. Symposium: Dynamique à long terme des Écosystèmes forestiers intertropicaux. Paris, France, 22 March.
Mensink, B.P. Environmental effects of tributyltin in antifouling paints : imposex. Lecture presented at the Short Intensive Programme: salt water problems in European perspective, NIOZ, 9 July.
Mensink, B.P., C.C. Ten Hallers-Tjabbes & J.P. Boon. Effects of tributyltin on the common whelk, *Buccinum undatum*. NWO/NVT symposium for Ph.D. students in Toxicology, Doorwerth, 14-15 November.
Ober, S. Developments of oceanthermometry INMARTECH-1996. Southampton, 30 September.
Osinga, R., Sedimentation of particulate DMSP and the release of DMS from the sediment. EU Workshop Rhodos, Greece, 19 February.
Philippart, C.J.M. & G.C. Cadée. Changes in phytoplankton in the Marsdiep, the westernmost tidal inlet of the Wadden Sea, between 1974 and 1994. 15th Anniversery of the Dutch-Flemish Society of Diatomists, Roermond, 31 May.
Philippart, C.J.M. & G.C. Cadée. Phytoplankton variation in the Marsdiep. 10th Anniversery of AquaSense, Wageningen, 17 December.
Philippart, C.J.M. Long-term impact of bottom fisheries on bycatch demersal fish and benthic invertebrate species. ICES Symposium on ecosystem effects of fisheries, Reykjavik, Iceland, 1 October.
Philippart, C.J.M., P.A. Henderson, T. Johannessen, A.D. Rijnsdorp & S.I. Rogers. Relationships between variation in fish recruit numbers and latitudal position along the north-western European coastline. Third Int. Symposium on flatfish ecology, NIOZ, 7 November
Piersma, T. An introduction to the lifes of Bar-tailed Godwits and Knots, and the role that Texel plays for them. Christelijke Plattelandsvrouwen, Texel, 28 October.
Piersma, T. Biology of migratory shorebirds. Symposium on shorebird conservation in the Asia-Pacific region. Brisbane, Australia, 16 March.
Piersma, T. Feeding adaptations in mollusc-eating waders. Internat. Workshop on cranial and cervical systems, University of Leiden, Leiden, 2 July.
Piersma, T. Introduction to a workshop on the morphology and ecology of feeding by waterbirds. NIOZ, Texel, 7 February.
Piersma, T. Selective predation by waders and the structure of benthic communities of intertidal mudflats. MOOK-symposium, KNAW, Amsterdam, 23 May.
Piersma, T. Shorebirds in intertidal communities. Presentation NIOZ/RUG/NWO Pionier-group, University of Groningen, Haren, 17 December.
Piersma, T. Studies on the migration of shorebirds along the East Atlantic flyway. The 1996-Northwest Australia Expedition of the Australasian Wader Studies Group, Broome, Australia, 8 March.
Piersma, T. The economics of bird migration. Pan-African Ornithological Conference, Accra, Ghana, 3 December.
Piersma, T., B.J. Ens & J. Van der Meer. Dynamics of migration in relation to flight energetics. International Workshop on Energetics of reproduction in birds, mammals and reptiles: exploring new techniques. CNRS, Chizé, Villiers en Bois, Beauvoir/Niort, France, 11 October.
Piersma, T., P. Wiersma & J. Van Gils. The many unknowns about plovers and sandpipers: an introduction to a world of research opportunities. Wader Study Group Annual Conference, Kasterlee, Belgium, 9 November.
Ridderinkhof, H. Chaotic advection in tidal current fields: mechanisms and quantification. European Geophysical Society (EGS), Den Haag, 6-10 May.
Ridderinkhof, H. The large scale transport and distribution of cohesive sediments in an idealised estuary: a modelling approach. Physics of Estuaries and Coastal Seas. Den Haag, 9-12 September.
Ridderinkhof, H., B. De Winder & B. Kornman. Physical and biological aspects of the transport, sedimentation and

erosion of mud in intertidal areas. Derde Nederlands Aardwetenschappelijk Congres. Veldhoven, 2-3 May.

Riegman, R. Macronutrient dynamics related to harmful algal blooms - NATO meeting The physiological ecology of harmful algal blooms. Bermuda Biological Research Station, 2 June.

Schoemann, V. Does *Phaeocystis* play a role in the biogeochemical cycle of manganese? NIOZ, 7 March.

Schoemann, V., V. Herzl, R. Wollast & C. Lancelot. On mechanisms of manganese sequestration by *Phaeocystis* colonies. Ocean Sciences Meeting, San Diego, USA, 12-16 February.

Schouten S. & J.S. Sinninghe Damsté. Trends in geosciences: Stable carbon isotope analyses of molecular fossils. 3e Nederlands Aardwetenschappelijk Congres, Veldhoven, 1-3 May.

Schouten S., M.J.L Hoefs, J.W. De Leeuw & J.S. Sinninghe Damsté. Palaeoenvironmental significance of methanogenic bacterial lipids in marine sediments. 6th Goldschmidt Conference, Heidelberg, Germany, 31 March-4 April.

Sinninghe Damsté, J.S. & M.P. Koopmans. The fate of carotenoids in sediments: An overview Invited lecture at the 11th International Symposium on Carotenoids, Leiden, 18-23 August.

Sinninghe Damsté, J.S. Is there evidence for a significant contribution of bacterial biomass to organic carbon in carbonaceous sediments? ACS Symposium: 'Role of Bacteria in Processing and Sourcing Sedimentary Organic Matter', New Orleans, USA, 24-28 March.

Sinninghe Damsté, J.S. Isorenieratene derivatives as indicators of photic zone anoxia: Applications in sediments from the Cenomanian/Turonian oceanic anoxic event. Amsterdam Free University, Amsterdam, June 25.

Sinninghe Damsté, J.S. Moleculaire fossielen als indicatoren voor palaeowaterkolomstratificatie. 'Mook'-Symposium, KNAW, Amsterdam, 23 May.

Sinninghe Damsté, J.S., S. Schouten, M.J.L. Hoefs & J.W. De Leeuw. Palaeoenvironmental significance of methanogenic bacterial lipids in sedimentary organic matter. ACS Symposium: 'Role of Bacteria in Processing and Sourcing Sedimentary Organic Matter', New Orleans, USA, 24-28 March.

Spaargaren, D.H. Lecture series on mariculture and marine resources. San Theodoro, Galapan, Oriental Mindoro, The Philippines, February.

Stoll, M.H.C. Partial pressure of $CO_2$ at the Polar front, Southern Ocean. ANTXIII/2 Workshop, AWI, Bremerhaven, Germany, 26-28 June.

Stoll, M.H.C. The importance of Delta-T for climate studies, CASOTS Workshop, Southampton Oceanography Centre, Southampton, UK, 20-21 June.

Stolte, W. Size-dependent restrictions on competition for nutrients by marine phytoplankton-Chisholm Massachussetts Institute for Technology, USA, 18 April.

Stolte, W. Size-dependent restrictions on competition for nutrients by marine phytoplankton. Bigelow Laboratory in West Boothbay Harbour (USA), 19 April.

Ten Hallers-Tjabbes. Lecture Course on environmental chemistry and biology. Lecture at Department of Chemistry, University of Groningne, 31 May.

Ten Hallers-Tjabbes, C.C. (for IUCN). Whelks and Dogwhelks and the confusion about the ban on TBT. London Convention Scientific Group 19th Meeting (LC/SG 19), Rio de Janeiro, Brazil, 14 May.

Ten Hallers-Tjabbes, C.C. Dumping of $CO_2$, the greenhouse gas, in the ocean. University of Groningen, Institute for Energy and Environment, Groningen, 27 February.

Ten Hallers-Tjabbes, C.C. Impact of organotin antifouling from from shipping in open sea, risk and ecological consequences and potential impact on humans. Malaysian Institute for Fisheries Research, Batu Maung, Penang, Malaysia, 28 March.

Ten Hallers-Tjabbes, C.C. Impact of organotin antifouling from shipping in open sea, risk and ecological consequences and potential impact on humans. Institute of Marine Sciences, Chulalongkorn University, Bangkok, Thailand, 2 April.

Ten Hallers-Tjabbes, C.C. Organotin: properties, uses, environmental effects and policy for the marine environment. Van Hall Institute, Groningen, 23 January.

Ten Hallers-Tjabbes, C.C. Organotin: properties, uses, environmental effects and policy for the marine environment. Van Hall Institute, Groningen, 26 April.

Ten Hallers-Tjabbes, C.C. The decline of the whelk and TBT - a case study. Lecture course Marine Environmental Biology, University of Groningen, Groningen, 2 May.

Ten Hallers-Tjabbes, C.C., B.P. Mensink, B. Van Hattum & J.P. Boon. Impact of traditional antifouling in open sea, risk and ecological consequences. Symposium 'The present Satus of TBT-Copolymer Antifouling Paints' (ORTEP-DGSM), 21 February .

Ten Hallers-Tjabbes, C.C. Ecological condition and future of the North East Atlantic. Seas at Risk (SAR) Assembly, Lisabon, Portugal, 27 September.

Ten Hallers-Tjabbes, C.C. Impact of TBT antifouling in open sea in Europe and Southeast Asia; risk and ecological consequences. Presented at IMAS96: shipping and the marine environment: is compromie inevitable? The Institute of Marine Engineers, London, 23 October

Timmermans, K.R. Physiological and molecular indices of trace metal limitation in marine phytoplankton. Mariene Levenswetenschappen Platform, Amsterdam, 13 June.

Ufkes, E., J.H.F. Jansen & R.R. Schneider. Paleoceanographic changes in the SE Atlantic: a 1.1 Ma record of planktonic Foraminifera. Third Dutch Geosciences conference, Veldhoven, 3 May.

Van Aken, H.M. Evidence for breaking internal waves below the permanent thermocline near the continental slope in the Bay of Biscay, European Geophysical Society, The Hague, 8 May.

Van Aken, H.M. Ocean circulation in the Northeast Atlantic Ocean. IMAU, University Utrecht, 10 October.

Van Aken, H.M. The conveyer belt in the North Atlantic Ocean. MOOK symposium, Royal Netherlands Academy of Sciences and Arts, Amsterdam, 23 May.

Van Aken, H.M. The hydrography and circulation of deep water in the north-eastern North Atlantic Ocean. Universität Hamburg, 18 January.

Van Bennekom, A.J. & J.E.E. Van Beusekom. Aluminium and Silica dynamics in the Southern Ocean. SCAR-CAO Antarctica Symposium, Veldhoven, 1 May.

Van Bennekom, A.J. Coupling of Aluminium and Silica Dynamics via Biogenic Silica in Water and Sediments. Biogenic Silica Workshop Brest, France, 3-7 June

Van Bergen, P.F., M.E. Collinson & J.W. De Leeuw Variations in macromolecular composition of fossil and extant monocotyledons: are they of any chemosystematic importance?, Palaeobotany and Palynology: Past, Present and Future, Linnaean Soc. Palaeobot. Palynol. Specialist Groups, Royal Holloway, University of London, 24-25 April.

van Bergen, P.F. , M.E. Collinson, H.A. Bland, R.P. Evershed & J.W. De Leeuw. Chemical transformations of lignin-cellulose complexes in morphologically well-defined plant remains. 212th ACS National Meeting, Orlando, U.S.A. 25-29 August.

Van den Berg, A. A modelling approach for DMS in the North Sea, including emission estimates using the FyFy model. EU Workshop Rhodos, Greece, 20 February.

Van der Meer, J. Interference and the spatial distribution of wintering waders, Lecture Series, State University of GroningenThe Netherlands, 18 Januari.

Van der Meer, J Secondary production. Lecture Series, IBN, Texel, The Netherlands, 13 Februari.

Van der Meer, J. Intra-specific competition on intertidal flats: what Volterra's coefficients do not tell. Symposium NEVECOL, NVAE, Wageningen, The Netherlands, 19 December.

Van der Schrier, G. & L.R.M. Maas. Chaos in a simple model of the 3-D thermohaline ocean circulation. SAMO, Texel 3-4 October.

Van der Veer, H.W. Recruitment variability in North Sea plaice. ICES Working Group on recruitment processes, Halifax, Canada, 17-20 June.

Van der Veer, H.W., P. Ruardij, A.J. Van den Berg & H. Ridderinkhof. Impact of interannual variability in hydrodynamic circulation in the southern North Sea during egg and larval transport on the year-class strength of plaice *Pleuronectes platessa* L. Third Intern. Symp. on flatfish ecology, NIOZ, 3 November.

Van Duyl, F.C. DMSP and DMS concentrations and bacterial degradation of DMS during the *Phaeocystis* spring bloom in the Marsdiep area. EU Workshop Rhodos, Greece, 19 February.

Van Duyl, F.C. Pelagic-benthic coupling in the North Sea: short-term dynamics in phytopigment sedimentation and the response of benthic bacteria. 5th European Marine Microbiology Symposium, Bergen, Norway, 14 August.

Van Haren, H. Suspended matter measurements using ADCP and the opportunity to estimate matter fluxes directly. Acoustic Doppler current profiler workshop, Delft, 20 November.

Van Kaam-Peters, H.M.E., T. Mongenot, W.I.C. Rijpstra, J.W. De Leeuw & J.S. Sinninghe Damsté. Palaeoenvironmental reconstruction of an Upper Jurassic lagoonal system using free and sulphur-bound biomarkers. 6th V.M. Goldschmidt Conference, Heidelberg, Germany. 31 March-4 April.

Van Kaam-Peters, H.M.E., S. Schouten, J.W. De Leeuw & J.S. Sinninghe Damsté. Environmental controls on the molecular and isotopic composition of organic matter deposited in a Kimmeridgian euxinic shelf sea. Gordon Research Conference, Plymouth NH, USA, 11-16 August.

Van Kaam-Peters, H.M.E., S. Schouten, J.W. De Leeuw & J.S. Sinninghe Damsté. Palaeoenvironmental control on the preservation of organic matter in the Kimmeridge Clay Formation. 3rd annual symposium of the Netherlands Research School of Sedimentary Geology, Amsterdam, the Netherlands, 4 October.

Van Kaam-Peters, H.M.E., S. Schouten, J.W. De Leeuw & J.S. Sinninghe Damsté. Compound-specific stable carbon isotope analysis of kerogen pyrolysates of the Kimmeridge Clay Formation (Dorset, U.K.). Pyrolysis '96, Venice, Italy, 14-18 October.

Van Raaphorst, W. Benthic processes in the North Sea. Resuspension and deposition of particulate matter. Symposium New Challenges for North Sea Research, Hamburg, Germany, 22 October .

Van Raaphorst, W. Eutrophication of the Wadden Sea and the North Sea. University of Groningen, Groningen, 14 May.

Van Raaphorst, W. Processes near the sediment-water interface and sediment-water exchange processes. OIO course, NIOZ, 20 November.

Van Raaphorst, W. What determines the early diagenesis of organic matter in the North Sea. Geochemische Kring, University of Utrecht, Utrecht, 10 May.

Van Weering, T.C.E. & H. De Stigter. Benthic Boundary Layer Dynamics And Sedimentation At Goban Spur. Omex I Final Meeting, Brussels, Belgium, 20-22 May.

Van Weering, T.C.E. Sedimentary processes in Teluk Banten. Workshop Indonesian / Netherlands Cooperation in Global Change Research, Teluk Banten project, Noordwijk , 11-12 June.

Van Weering, T.C.E. The sedimentary record of Teluk Banten. 2nd BPPT / NWO / LIPI Workshop on Marine and Coastal Research, Jakarta, Indonesia, 5-7 November.

Van Weering, T.C.E., T. Nielsen, N.H. Kenyon & K. Akentieva. Large submarine slides on the NE Faeroe margin. Applied Geosciences Meeting, Warwick, UK, 15-18 April.

Van Weering, T.C.E., T. Nielsen, T. Rasmussen, A. Kuijpers & N.Kenyon. Sedimentary processes and pathways at the NE Faeroe margin. ENAM Meeting Geilo, Norway, 22-28 April.

Van Weering,T.C.E. Benthic boundary layers at the Goban Spur. European Geophysical Society XXI General Assembly, Den Haag, 6-10 May.

Van Weering,T.C.E. Noorse zee diep water ventilatie; effect op Paleoceanografie en klimaat lezing. Symposium 'Mook' KNAW, Amsterdam, The Netherlands, 23 May.

Van Weering,T.C.E. & H. De Stigter. Recent sedimentation at Goban Spur. OMEX workshop, Strenglin, Germany, 17-21 March.

Veldhuis, M.J.W. University of Maine (USA). Seasonal and spatial variability in phytoplankton biomass, productivity and growth in the north-western Indian Ocean, March 15.

Versteegh, G.J.M., J.H.F. Jansen, J.W. De Leeuw, P. Muller, R. Schneider & G. Ruhland. A palaeoenvironmental reconstruction of the Angola Basin using biomarkers. 3e Nederlands Aardwetenschappelijk Congres, Veldhoven, 1-3 May.

Versteegh, G.J.M., R. Riegman, J.H.F. Jansen & J.W. De Leeuw. Prymnesiophyte molecular paleontology an overview. 7th Global *Emiliania* Modelling Initiative Workshop, Blagnac, France, 4-8 September.

Volkman, J.K., F. Gelin, J.W. De Leeuw, J.S. Sinninghe Damsté, C. Largeau & S. Derenne. Distribution of non-hydro-

lysable highly biopolymers in marine microalgae, Australian Organic Geochemistry Conference, Perth, Australia, 2-4 October.

Vosjan, J.H. Lecture series on Marine Bacteriology for the International Postgraduate Training course on Fundamental and Applied Marine Ecology of the Free University Brussels, Belgium, January.

Vosjan, J.H. Microbial biomass and light attenuation (PAR, UV-a, UV-b) in the Weddell Sea and the effect of UV-b on the ATP content of microbes. Antarctica Symposium, Veldhoven, 1 May.

Walker, P.A. Spatial and temporal shifts in ray species composition in the central and northwestern North Sea, ICES synposium Ecosystem efects of fisheries, Reykjavik, Iceland, 1 October.

Walker, P. Sensitive skates or resilient rays? 3rd Shark & Ray Workshop, Birmingham, UK, 25-27 October.

Walker, P. The sensitive skate and fisheries, Symposium on Biology of Skates, Annual Meeting of the American Elasmobranch Society, New Orleans, 12-20 June.

Walker, P. ICES Annual Science Meeting: Mini Symposium of Ecosystem Effects of Fisheries, 26 September-3 October.

Zimmerman, J.T.F. Chaotic stirring. Chigoku Industrial Research Institute, Kure, Japan; 27 March.

Zimmerman, J.T.F. Tidal asymmetry and sediment transport. Ehime University, Matsuyama, Japan, 28 March.

Zimmerman, J.T.F. The phenomenon Tide - 'Het getij en wij' 100 jarig jubileum van de 'Getijtafels voor Nederland', Scheveningen, 27 November.

## EXTERNAL PROFESSIONAL FUNCTIONS

M.A. Baars
- member JGOFS Indian Ocean Planning Group (SCOR)
- member Working Group JGOFS Nederland
- co-editor Journal of Sea Research
- member SLW-discussiegroep PIG (former Zooplankton-FRIENDS)
- board member Stichting ter Bevordering van de Nederlandse Oceanografie

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

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

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

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

J.P. Boon
- member of the committee 'Environmental Contaminants and Reproduction (ecotoxicology)' of the Dutch Health Council (Gezondheidsraad)
- member of the National Organizing Committee of 'Dioxin96', the 16th International Symposium on Organohalogen Compounds, Amsterdam, 12-16 August
- member of the ICES Marine Chemistry Working Group
- member of the ICES Working Group on Biological Effects of Contaminants
- member of the BEON Advisory Group 'Microcontaminants'

G.J.A. Brummer
- member NWO/GOA research program committee 'Tracing a seasonal upwelling'

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

C.J. Camphuysen
- board member Netherlands Ornithologists' Union (NOU)
- chairman Dutch Seabird Group (NZG), section of NOU
- editor *Sula*
- secretary editorial team *Ardea*

- co-ordinator Dutch beached bird survey (NSO)
- member scientific steering group ICES symposium 'Seabirds in the Marine Environment'
- chairman European Seabirds At Sea database (ESAS) Co-ordinating group
- member Intern. Seabird specialist group

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

H.J.W. De Baar
- professor General Oceanography, University of Groningen
- associate editor Marine Chemistry
- chairman committee Joint Global Ocean Flux Study (JGOFS)
- member SCOR Netherlands at KNAW
- member advisory committee on zinc in environnment and human health of the National Health Council
- member NWO/NOP Programmeringsgroep Thema 1
- member MAB/SCOPE/IGBP committee KNAW
- member JGOFS working group Southern Ocean
- coordinator MERLIM research programme EU-MAST

P. De Goeij
- general secretary International Wader Study Group

J.W. De Leeuw
- professor Organic Geochemistry University of Utrecht, fac. Earth Sciences
- member Koninklijke Nederlandse Academie van Wetenschappen' (KNAW)
- board member AWON-NWO
- board member LPP, University of Utrecht, Biology faculty
- board member Inst. für Chem. und Biologie des Meeres, Univ. Oldenburg
- board member EAOG (European Association Org. Geochem.)
- board member working group Mol. Mech. and Anal. Chem. NIOZ-TUD
- professor Geochemistry, Univ. Barcelona

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

G.C.A. Duineveld
- member ICES Benthos Ecology working group

M. Fonds
- member Mariculture Committee ICES

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 of the ICES Working Group on biological effects of contaminants
- member of the ICES Marine Environment Quality Committee
- member of the Editorial Board of the Bulletin of Environmental Contamination and Toxicology
- member of the Editorial Board of Wallaceana
- member of the Editorial Board of the Marine Pollution Bulletin

H.G. Fransz
- member 'Werkverband JGOFS-Nederland' (GOA)
- member GLOBEC international working group for numerical modelling (NMWG)
- member ASMO-working group for International Model Comparison

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

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

J.H.F. Jansen
- member Scientific Committee IGBP-PAGES-IMAGES 2 (The International Marine Past Global Change Study)
- member Dutch Ocean Drilling Project (ODP) working group
- member GEONETH, Geoscience Network of the Netherlands for International Cooperation
- member Scientific Committee: Dynamique à long terme des écosystèmes forestiers intertropicaux, Symposium International, Paris, 20-21 March 1996

W.C.M. Klein Breteler
- member 'SLW-discussiegroep PIG' ( former 'zooplankton-FRIENDS')
- member 'Nederlandse werkgroep deeltjes-karakterisering'
- member users group Quantimet (Image Analysis)

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

H.J. Lindeboom
- member 'Commissie voor Milieueffectrapportage'
- member 'Kernbegeleidingsgroep ecologie Noordzee en Waddenzee'
- external examiner Hogeschool 'Noorderhaaks' environmental science
- member ICES werkgroep 'Effects of Fisheries'
- chairman 'Begeleidingsgroep Effekten Visserij' (BEON)
- coordinator EG-project IMPACT-II
- member Board of the Sir Allistair Hardy Foundation of Ocean Sciences
- member Scientific Steering Committee LOICZ
- board member 'Onderzoekschool Functionele Ecologie'
- member SCOR Working group 105, the IMPACT of World Fisheries
- coordinator EG-project 'Dynamo'
- member Steering Committee and working group Indonesian-Dutch Cooperative Research on Integrated Coastal Zone Management, Teluk Banten
- member Steering Committee Wotro project 'Rivers and coastal zones'
- member UNESCO working group 'Year of the Ocean 1998'
- member 'Gutachtungs Committee', GKSS, Geesthacht, Germany

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

M. Mulder
- member workinggroup 'Monitoring rond Mijnbouwinstallaties'

R.F. Nolting
- member EC commission certification of sea- and estuarine water for trace metals

S. Ober
- member 'overleg grroep 'waarnemen en interpreteren' van de Raad van overleg voor het fysisch-oceanografisch onderzoek van de Noordzee'

C.J.M. Philippart
- editor Journal of Sea Research
- board member Netherlands Society of Aquatic Ecology

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

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

- advisory member School voor Atmosferisch en Marien Onderzoek
- member Committee `Milieueffectrapportage'

R. Riegman
- co-editor Journal of Sea Research

M.J. Rietveld
- member 'Directeuren Overleg Beleidsgericht Ecologisch Onderzoek Noordzee/Waddenzee' (BEON)

R.C. Sidle
- associate editor Journal of Environmental Quality
- associate editor Journal of Forest Research
- vice-chair, International Affairs Committee, American Water Resources Association
- member, Erosion and Sedimentation Committee, American Geophysical Union
- Adjunct Professor, Departments of Civil and Environmental Engineering and Forest Resources, Utah State University, USA

J.S. Sinninghe Damsté
- associate scientist University of Utrecht, faculty of Earth Sciences
- associate editor of Organic Geochemistry
- convenor of ACS Symposium 'The role of Bacteria in processing and sourcing sedimentary organic matter', New Orleans, USA, March 25-26

D.H. Spaargaren
- secretary 'Commissie voor buitenlandse marien-biologische instituten' KNAW, Amsterdam
- member Board of advisory editors 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/Yvette
- secretary, treasurer organising committee 4th International Crustacea Congress, Amsterdam, July 1998
- chairman science committee subtheme Physiology & Biochemistry ICC4

M.H.. Stoll
- member Joint Global Ocean Flux Study Data Management Task Team (JGOFS-DMTT)

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

H.M. Van Aken
- chairman Nederlandse Oceanografen Club
- member of the ICES Hydrography Comittee
- member of the ICES Working Group on Ocean Hydrography

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

C.N. Van Bergen Henegouw
- executive secretary of the International Research Ship Operators Meeting (ISOM)
- member for Ministry O, C & W of the 'Interdepartementaal Overlaeg Zeegaande Vartuigen'(IOZV)

A.J. Van Bennekom
- deputy member Dutch Antarctica committee
- member editorial boardCircumpolar Journal
- member Council for Geosciences of the KNAW
- member ICES working group on oceanographic hydrography

S.J. Van der Gaast
- member of the editorial board of Applied Clay Science
- president of the Dutch Clay Group

J. Van der Meer
- member Working Group on the statistical aspects of environmental monitoring (ICES)
- editor Ardea 'Tijdschrift der Nederlandse Ornithologische Unie'

H.W. Van der Veer
- member Organizing Committee Third Intern. Symposium on Flatfish Ecology, Texel
- member ICES Working Group on Recruitment Processes
- adjunct associate-professor of Zoology, North Carolina State Univ., Raleigh, USA
- adjunct associate-professor of Marine Science, Univ. of South Carolina, Columbia, USA

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

J.M. Van Iperen
- member 'nederlands-Vlaamse kring der Diatomisten'

W. Van Raaphorst
- member 'Begeleidingsgroep Eutrofiëring BEON'

A. Van Schanke
- Member of the organizing committee of the 'Third symposium for PhD students in toxicology', Oosterbeek, 14-15 November

T.C.E. Van Weering
- member Steering Committee OMEX (Mast II and II)
- member Steering Committee ENAM (Mast II and III)
- member Editorial Board Geologie en Mijnbouw
- member Editorial Board Marine Geology
- member scientific committee (IMAGES)
- special Editor Indian Ocean Volume of Deep Sea Research
- special Editor Proceedings Third Conference Gas in Marine Sediments
- special Editor Ice Rafting and Paleoceanography of the NE Atlantic Region volume of Marine Geology

M.J.W. Veldhuis
- member working group JGOFS-NL
- member advisory board Sarsia (USA)
- associate professor University of Maine, USA (till 30 September 1996)

G.J.M. Versteegh:
- Member of the GEM Working Group

C. Veth
- member Southern Ocean Planning Group for JGOFS
- member Committee Antarctic Research
- 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

P.A. Walker
- member ICES Study Group Elasmobranch fishes
- member IUCN Shark Specialist Group
- member European Elasmobranch Association

M.R. Wernand
- member SeaWiFS Scientific Team

J.T.F. Zimmerman
- Professor Fysische Oceanografie, Rijksuniversiteit Utrecht
- member editorial board Continental Shelf Research
- member editorial board Journal of Sea research
- IAPSO representative national UGGI comite (ARA-KNAW)
- member Committee `Milieueffectrapportage'
- member `themacommissie kustonderzoek' (BOA-NWO)
- member New York Academy of Sciences

## DISSERTATIONS

Eggens, M.L. (RIKZ-RWS). Cytochrome P450 1A induction in North Sea flatfish as biomarker of exposure to dioxin-type compounds. University of Utrecht: 159 pp.

Epping, E.H.G. Benthic phototrophic communities and the sediment-water exchange of oxygen, Mn(II), and silicid acid. University of Groningen: 222 pp.

Gelin, F. Isolation and chemical characterization of resistant macromolecular constituents in microalgae and marine sediments. University of Utrecht: 147 pp.

Lohse, L. Sediment-water exchange of nitrogen compounds and oxygen in the North Sea. University of Groningen: 86 pp.

Osinga, R. Sedimentation and degradation of organic matter produced by marine phytoplankton. University of Groningen: 111 pp.

Sleiderink, H.M. Assessment of cytochrome P450 1A in dab as biomarker of exposure to polychlorinated biphenyls and related compounds. Agricultural University of Wageningen: 128 pp.

Stolte, W. Size-dependent restrictions on competition for nutrients by marine phytoplankton. University of Groningen: 122 pp.

Van Bleijswijk Tierens Verhagen, J.D.L. Ecophysiology of the calcifying marine alga *Emiliania huxleyi*. University of Groningen: 72 pp.

Van Duin, A.C.T. Biogeochemical applications of a newly developed carboncation force field. Technical University Delft.

The course **Marine Ecosystems**, which is part of the Marine Biology programme of the University of Groningen, was held from 3 to 28 June. There were 24 participants.
The course started on 3 June at the Biological Centre, Haren, with introductory lectures by Prof. Dr. P.A.W.J. De Wilde. The practical part, coordinated by Dr. B.R. Kuipers, was held at NIOZ from 10 to 21 June and comprised two overnight sampling trips with RV 'Pelagia' to the North Sea (Frisian Front and Oyster Grounds), fishing and sampling benthos in the Wadden Sea with RV 'Navicula', and experimental work. The latter involved the study of factors that limit phytoplankton growth, light inhibition, and micro-zooplankton grazing experiments. As usual, the students together produced a book of 'course results'. The last week of the course was spent studying literature and writing individual reports, ending with the final examination on 28 June.

The course **Introduction to Oceanography** is part of the Marine Biology curriculum at the University of Groningen and was attended by 62 students, 24 majoring marine biology and 38 majoring environmental biology. The introductory lectures were given at Groningen from 5 to 16 February by Prof. Dr. Ir. H.J.W. De Baar. The 38 environmental biologists took part in a one-day excursion with demonstrations at NIOZ on 14 February. The 24 marine biologists followed a set of several practical projects in the weeks of 18 to 29 March, including field work at the tidal flats and aboard the vessels 'Navicula' and 'Pelagia' in waters of the Wadden Sea and the North Sea. Each marine biologist completed a written report on one of the research projects. The enthusiastic commitment of a great number of NIOZ scientific and support staff ensured an overall very stimulating practical course. The students evaluated the course as overall very interesting and useful. Final examination was taken by 53 students of which 47 passed.

**Verwey Symposium.** From 27 to 29 January the eigth annual Verwey Symposium was held at NIOZ. These symposia are part of the national Ph.D. programme in Marine Life Sciences organized by the University of Groningen and the Netherlands Institute for Sea Research, and are integrated in the educational programme of the Graduate School of Functional Ecology.

International course on 'Protection and utilization of the Ocean' (organized by Dr. G. Schriever, Zentrum für Klimaforschung, Universitat Hamburg) visited NIOZ on 27-28 August. Lectures at NIOZ on 27 August, cruise with Navicula on 28 August.

'Winter School' of the Research School M&T (Environmental Chemistry & Toxicology). The role of differences in species sensitivity in ecotoxicology, 28 February, 02 to 01 March-03-'96.

IRM-GCMS workshop Department of Marine Biogeochemistry and toxicology. 11 July.

SAMO-days, organized by the 'School voor Atmosferisch en Marien Onderzoek'. On 3 and 4 October presentations were given by Ph.D. students Meteorology and Physical Oceanography of NIOZ and several Dutch universities.

Kuipers , B.R. (with Dr. I. Jenness ) for 11 undergraduate students West Virginia University (US) 'Summer Course in Marine Biology' (13-29 May).

**Flatfish Symposium.** As a sequel to the successful First (1990) and Second (1993), the Third International Symposium on Flatfish Ecology was held at NIOZ from 2 - 8 November. The central theme was: System Dynamics of Flatfish. In total 110 participants visited the symposium. Hundred oral and poster presentations were presented.

IGBP Core Project Officers Meeting. 13-15 February.

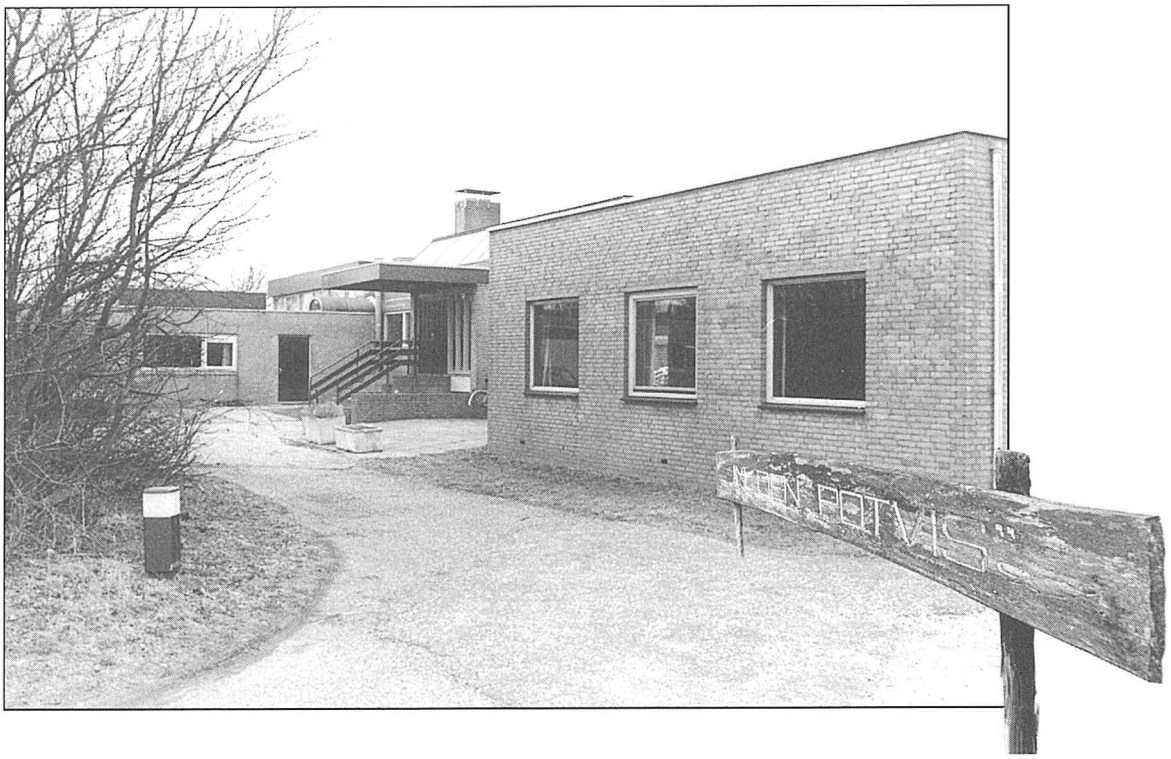
LOICZ Scientific Steering Committee Meeting No. 5. 14-15 April.

Continental Margins Task Team Meeting, 16 April.

LOICZ Workshop on Statistical Analysis of the Coastal Lowlands Database. 27-28 August.

LOICZ Executive Committee Meeting, 12-14 November.

# 3. Guest scientists, visitors and students



## GUEST SCIENTISTS

- Balboni, V., Instituto per la Geologia Marina, Bologna, Italy, 19 September - 14 November.
- Bijma, Dr. J., Alfred-Wegener-Institut für Polar- und Meeresforschung, Bremerhaven, Germany.
- Biscaye, Dr. P.E., Lamont Doherty Earth Observatory, Columbia University, Palisades NY, USA
- Buddemeier, Dr. R.W., Visiting Senior Scientist, Kansas Geological Survey, Lawrence, Kansas, USA, June to December.
- Cappellen, Dr. P. Van, School of Earth and Atmospheric Sciences, Georgia Tech, Atlanta, USA, June 24-27.
- Carlotti, Dr. F., (CNRS Station Zoologique, Villefranche-sur-Mer, France) worked from 29 April to 7 May on Texel with H.G. Fransz to further develop population models of Antarctic copepod species.
- Davidson, Dr. N.C. Joint Nature Conservation Committee, Peterborough, UK: Department Marine Ecology. 25 January - 3 February.
- Donckt, Van der, Prof. Dr. E., Laboratoire de Chimie Organique Physique, Univ. Libre Brussels, Belgium.
- Gordon, Dr. C., Volta Basin Research Project, University of Ghana, Accra, Ghana: Department Marine Ecology. 28 June - 26 July.
- Groenewold, S., University Hamburg: Department Marine Ecology. continued his Ph.D. research in 1996.
- Guy Morrison Dr. R.I., National Wildlife Research Centre, Canadian Wildlife Service, Ottawa, Canada: Department Marine Ecology. 22 January - 4 February.
- Gwinner, Prof. Dr. E., Max-Planck Institut für Verhaltensphysiologie, Erling/Andechs, Germany.
- Hines, Dr. A.N., Smithsonian Environmental Research Centre, Edgewater, Maryland, USA.
- Jaros, Dr P., Universität Oldenburg: Department of marine Ecology, 26-27 November.
- Koski, M., (University of Helsinki, Helsinki, Finland) worked whole year with W.C.M Klein Breteler on the role of food quality on copepod development.
- Mwangi, S., Kenya Marine Fishery Research Institute, Mombasa, Kenya: Department Marine Ecology.
- Melckzedeck K.W. Osore (Kenya Marine and Fisheries Research Institute, Mombasa, Kenya) worked from 18 September to 1 December with M.A. Baars on zooplankton samples from the NW Indian Ocean collected by RRS Discovery in 1963/64.
- Mitchell, Dr. P. I., Department of Biological Sciences, University of Durham, UK.
- Mussie, O., Eritrea as off 15 November.
- Ntiamoa-Baidu Prof. Dr. Yaa, Department of Zoology, University of Ghana, Accra, Ghana: Department Marine Ecology. 28 June - 26 July.
- Rad, Dr. U. Von, Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover, Germany.
- Ramenofsky, Dr M., Department of Zoology, University of Washington, Seattle, WA, USA: Department Marine Ecology. 15-22 May.
- Sakar, Dr. A., National Institute of Oceanography, Dona Paula, Goa 403004, India
- Santos, S. V. Free University of Brussels.
- Schulz, Dr. H., Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover, Germany.
- Singbal, Dr. S.Y.S., National Institute of Oceanography, Dona Paula, Goa 403004, India
- Theodorakis, Dr. C., Oak Ridge National Laboratory, Oak Ridge, USA
- Tintelnot, Dr. M., Forschungsinstitut Senckenberg, Wilhelmhaven, Germany.
- Tomkovich, Dr. P. S., Zoological Museum of Moscow State University, Moscow, Russia.
- Turner, Jefferson T. Biology Dep. Univ. Massachusetts, Dartmouth, USA.
- Valk, S. de, Aquasense, Amsterdam
- Volkman, Dr. J.K., CSIRO Australia, Hobart, Australia, Division of Oceanography Marine Laboratories, Hobart, Australia
- Wefer, Prof. Dr. G., Fachbereich Geowissenschaften, Universität Bremen, Germany.

## VISITORS

- Azam, Prof. Dr F., Scripps Institution of Oceanography, University of California, La Jolla, USA
- Bokhoven, Dr. O., Woods Hole Oceanographic Institution, Woods Hole, USA
- Grosset, A., IFREMER, Centre de Brest, Plouzane, France
- Hagstrom, Prof. Dr. A.K., NERI, Roskilde, Denmark
- Herndl, Dr G., Department of Marine Biology, University of Vienna, Austria
- Hosokawa Yasushi, Port & Harbour Institute, Yokosuka, Japan
- Jongh, Dr. J. de, & drs. H. Kramer; RITOX, University of Utrecht
- Kormas, K.A., University of Athens, Greece
- Leysner, B. Head technical services CARMABI Ecological Institute, Curaçao, Netherlands Antilles
- McLaren, I.A. Dalhousie University, Halifax, Canada
- Shugart, Dr. L.R., Biotechnology Section, Environmental Science Division, Oak Ridge National Laboratory, USA.
- Symens, P., Ecosystems Analysis & University of Warwick, UK
- Tanaka Masahiro, Kajima Technical Research Institute, Tokyo, Japan
- Willett, K.L., Department of Veterinary Physiology and Pharmacology, Texas A&M University, USA.
- Yasuda, Dr. H., Chigoku Industr. Res. Inst., Kure, Japan

## UNDERGRADUATE UNIVERSITY STUDENTS

- Berkhout, IMAU, RUU
- Boer, M.K. de, Dept. Marine Biology, RUG
- Bosch, H.-J., Institute of Earth Sciences, Dept. Geochemistry, RUU
- Bouma, H., Mar. Biol., RUG
- Epstein, N., ISP, UvA
- Goverde, R.C., KUN
- Greve, M. J., Dept. Marine Biology, RUG
- Helle, M.S., Dept. Marine Biology, RUG
- Heijde, Anne van der, LUW.
- Helle, M.S., Dept. Marine Biology, RUG
- Hilterman, M., ISP, UvA
- Jonkman, N., TUD.
- Kardinaal, E., Mar. Biol., RUG
- Keetman, M., ISP, UvA
- Leeuwen W.G. van, Dept. Marine Biology, RUG
- Meulen, J.D. van, v Hall Inst. Groningen.
- Nugteren, P. Van, ISP, UvA
- Stuut, J.-B., Department of Geology, Institute of Earth Sciences, RUU.
- Veefkind, R. Institute of Earth Sciences, Dept. Of Geology, RUU
- Valkering, N., ISP, UvA
- Vink, A., Laboratory of Palaeobotany and Palynology (Faculty of Biology), RUU
- Vries, M. De, ISP, UvA
- Saskia Wiegman, ISP, UvA
- Elze Wieringa, Marine Biology, RUG
- Wilko Steinhoff, ISP, UvA
- Sandra Kloff, ISP, UvA
- Peter John Jonkers, Marine Biology, RUG

# 4. Support Services

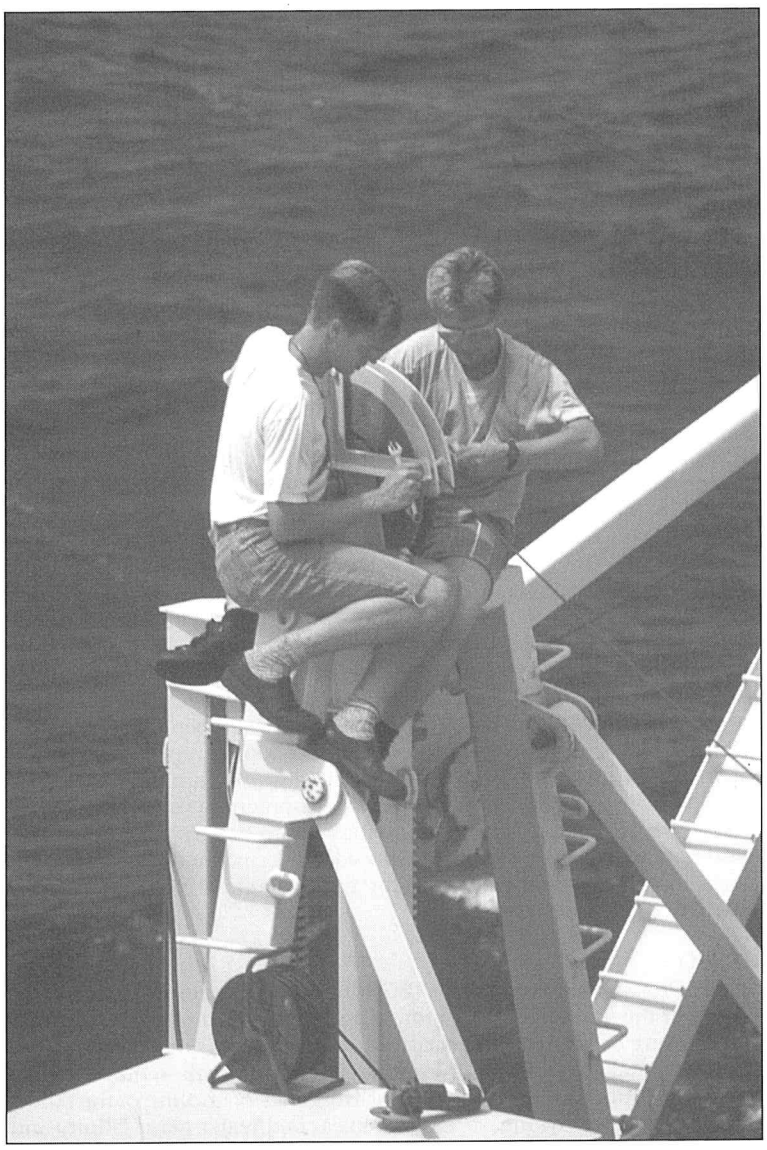


Photo: Taco de Bruin

**In this annual report NIOZ made a start with highlighting specific subjects and achievements. The same approach is chosen for the Support Services as well. In this section of the report this year's focus is on the lander development, the upgrading of the computer network system and the reorganization and computerisation of the Library.**

## TECHNICAL SUPPORT SERVICES

### NIOZ Lander development

The sea floor is an important location for organic matter degradation and burial. Its inaccessibility, the restricted availability of submersibles, the chemical and physiological artifacts due to changes in temperature and pressure when handling samples on deck, have restricted our knowledge of these processes which concentrate in the surface sediment or very near the sediment-water interface in the benthic and diffusive boundary layer.

To understand the role of the sediments deep sea (and its margins) in the global carbon cycle better, the fluxes of particles from the surface of the ocean to the sea bed as benthic nepheloid layers the continental slope to the deep central basins need to be quantified and the relevant processes to be determined. This requires technological developments that enable simultaneous measurements of sediment-water fluxes, biogeochemical process rates, and physico-chemical characteristics *in-situ* near the sediment-water interface, or in the surface sediment.

For this purpose NIOZ started the development of three types of multi-purpose free-falling benthic landers for deep-sea research equipped with micro-sensors and data storage capacities, for chemical, biological and geological marine research.

The concerted activities of scientists and NIOZ technicians (mechanics and electronics) made this unique development a success.

#### TROL

The Temperature, Resistivity, Oxygen Lander (TROL) is an oxygen profiling instrument that can make detailed profiles of oxygen in bottom water and across the diffusive boundary layer into the sediment with high vertical resolution. Apart from micro-electrodes for oxygen measurement, the instrument contains a resistivity probe for determination of the resistivity formation factor, and a temperature sensor. The prototype was developed and successfully deployed in 1989 and improvements have been made ever since then. Foreign marine institutes showed much interest and copies of TROL are present in AWI, Bremerhaven and in GEOMAR, Kiel.

Profiling landers, such as TROL, have provided important information on the depth of oxygen penetration in the sea-floor and on the pH zonation. New chemical sensors are requested for the analyses of $CO_2$ and other gases, for inorganic ions, and for defined organic molecules. Thus, for the second generation of TROL the use of microsensors is under study. Further improvement is foreseen by addition of a calibrated benthic chamber and the application of a rugged solid state sensor for pH measurements. New types of oxygen sensors and adaptation of the electronic circuitry with some modification in the positioning of the ballast weights and the holding frame will complete the upgrading.

#### BOLAS

The Benthic Oxygen Lander System (BOLAS) is a benthic chamber lander equipped with two incubation chambers. The combination of continuous automatic *in-situ* registration and intermittently sampling for later analysis in the laboratory allows calculation of the sediment oxygen demand and the sediment-water nutrient fluxes. The prototype of BOLAS was successfully deployed in 1990. The instrument has been improved since and sediment traps, an underwater camera, a transmissometer and a current meter have been installed. Unfortunately BOLAS was lost during operation in the Atlantic Ocean in 1996. A replacement of the instrument is under construction at present, to be operational in various international programmes next year.

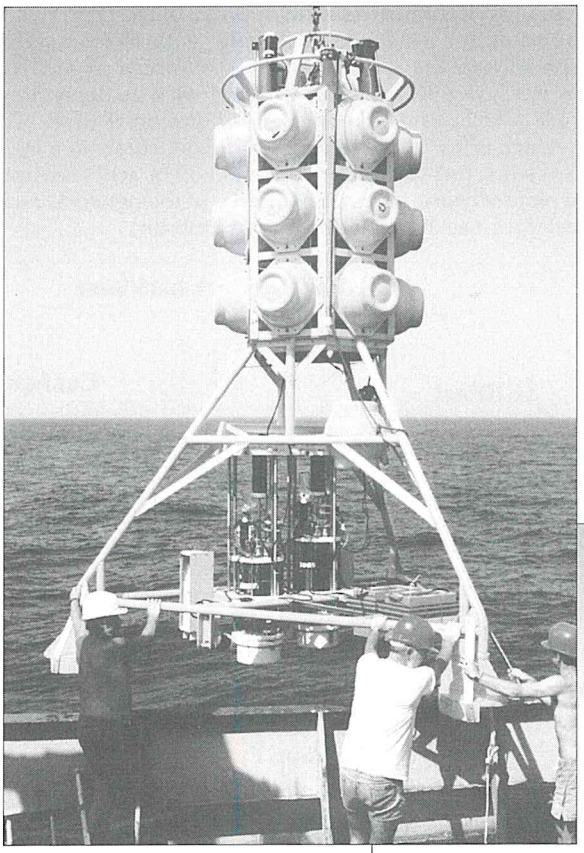
At present a new system is under development to cover the temporal variability in benthic activity in addition to *in situ* experimental manipulation: the Autonomous Lander for Biological Experimentation (ALBEX). This will be a long-term (6 months) deployment benthic chamber lander with up to 12 chambers, some for continuous or intermittent measurements, and others for event-activated measurements.

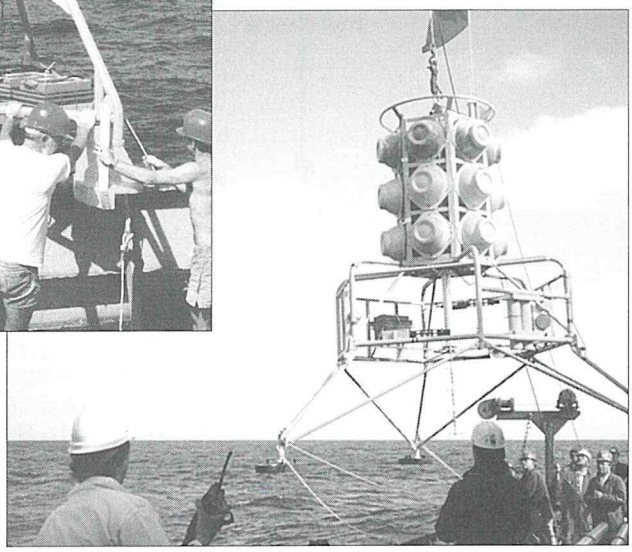
#### BOBO

The BOtom BOundary lander (BOBO) is a long-term (6-12 months) deployment lander for the study of the variability in benthic boundary layer dynamics, equipped with instrumentation for monitoring of near bed physical and sedimentological parameters. *In-situ* observation of the bottom boundary conditions over longer time intervals require advanced technology combining high resolution, and - possibly event-triggered - sampling of the parameters concerned. CTD-sensors are used for the measurement of near bed water mass salinity and temperature, acoustic cur-

rent meters for current velocity and direction at different levels above the seabed, and turbidity, a still camera for seabed morphology and sediment surface observation.

Data storage capacity is no longer a limiting factor using high capacity micro computers. New developments in the field of microcomputer controlled video recording may result in *in-situ* particle settling velocity determination. For a second generation of BOBO this will open the possibility of time series and event triggered recording. Together with more advanced transmisso meter technics, and event-controlled water and sediment sampling this advanced technology could significantly contribute to monitoring short term to seasonal and interannual variability of the physical, chemical, and biological parameters in the near bed benthic boundary layer.





## SCIENTIFIC SUPPORT SERVICES

### Upgrading the NIOZ Computer network

By means of a financial grant from NWO in the framework of a qualitative impuls for infrastructure renewal, NIOZ started the project IMPULS for the upgrading of its computer network in 1995; it was successfully completed in 1996.

### The network before impuls

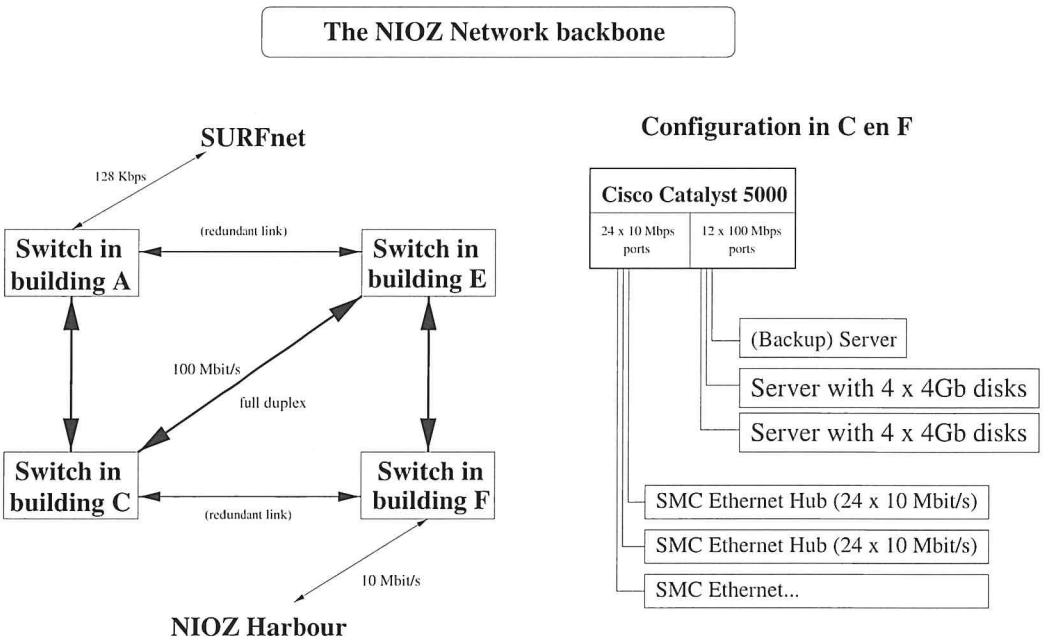
Before upgrading took place the NIOZ network infrastructure was single level, which means that it existed of one big 10Mbps segment without the possibility of division in network sections. The network consisted of 20 Sun workstations, interconnected with approximately 150 IBM compatible personal computers and 40 Macintosh computers. With this number of computers the relative simple structure of the network could not avoid serious delays and interruptions. Besides these

capacity problems the computer network had no point of presence (POP) at/in the NIOZ harbour facility and at the quay, thereby excluding the possibility to connect the ABC shipboard scientific computer system on board the research vessel Pelagia to the NIOZ network. This caused a drawback in data transmission and hampered the maintenance of the ABC system.

## The new network

It was time for renewal. Fresh ideas and concepts were developed taking into account the simultanious installation of a data management group which would generate a considerable growth in network use in the nearby future. The proposal made by the working group IMPULS was accepted by NWO for financial support, provided that the technical advisory board: Technisch Wetenschappelijke Raad (TWR) of SURF would approve of the proposal. In consultation with the TWR the choice was made for a network backbone with four intelligent network switches. These switches are spread over the 300 m long NIOZ building in such a way that every corner of the building can be reached with a 10Mbps or 100Mbps wire depending on what capacity is needed. The four network switches are linked via glass fibre connections. The switches are linked via five so-called interswitch links. These interswitch links operate at a speed of 100Mbps in full duplex mode. Two interswitch links are redundant and will be activated automatically if one of the active links fails. The picture below gives an overview of the network backbone:

The NIOZ network-backbone figuur (Erwin Embsen)




By the accurate positioning of the network file servers the network traffic can usually be handled by one or two switches. This prevents users to be in each others way by accessing or filing data. In comparison with the old network a tremendous improvement in speed and data transmission has been achieved. Even more while the network file servers have a 100Mbps direct link with the backbone.

To be of better service to the users regarding disk space and printers four Sun UltraSPARC machines are used as file servers, each of them equipped with four 4Gb disks. Two Sun UltraSPARC machines are used for general services like controlling printers and the handling of Internet activities such as email, WWW, ftp and telnet. These two servers also take care of the daily backup of all file systems. Another Sun UltraSPARC is in use as a database server (Sybase) for the data management group. All machines work under Sun's Unix version Solaris.

The file servers are distributed over the building, two in the front and two in the back, as are the two UltraSPARC's for general network services. In case of fire or other calamities, only part of the network will collapse. If one of the file servers fails, disks can be connected to another server without any problem. In this way continuity of network services is guarenteed as much as possible.

With the construction of the new network the NIOZ harbour and RV PELAGIA have been taken into account. The harbour buildings are now connected to the NIOZ network and a 10Mbps POP is available on the quay to connect the Pelagia network to the NIOZ network when at berth. Data gathered during scientific cruises can simply be copied to the file servers and workstations. There is no need any more for transport by tape. Furthermore, maintenance of the ABC data logging system aboard the Pelagia can be taken care of from the NIOZ buildings.

### The future

At present all workstations have a 10Mbps link with the backbone. If there is need for more speed the 10Mbps link can easily be upgraded to a 100Mbps link in no time. At present the NIOZ backbone runs at 100Mbps in full duplex mode. If this turns out to be too slow, the backbone can be upgraded with without substantial cost. Also, the direct 100Mbps links between file servers and switches can be upgraded if necessary.

## THE LIBRARY

The year 1996 was still dominated by the computerisation of the NIOZ library. In co-operation with the Groningen University Library nearly all books of the collection were entered in the Shared Cataloguing system.

The collection of periodicals has been sorted out by the Library Committee, because of lack of space in the library. Periodicals were removed from the NIOZ library and tranferred to the Library of the University of Groningen. Based on the following criteria:
no articles on marine science;
many issues are missing;
written in a rather inaccessible language, like Japanese, Russian, Korean, Finnish etc.;
reprints of no interest to the NIOZ, or reprints already available in other periodicals of the library only of temporary value
These periodicals are still available through the Dutch Union Catalogue.
Cataloguing the collection of periodicals was started in connection with a replacement on the shelves, where the periodicals will be placed in alphabetical order.
The reorganisation of NIOZ also affected the library. Since computerisation and reorganisation of the library was not yet finished, an employee of the Groningen University Library was attached to the library for three months to assist with this work.

A subscription was not entered to all periodicals that were hitherto obtained through an exchange with the Netherlands Journal of Sea Research. The book collection increased with 150 books.

There were 1120 loans and 1430 requests for loans from other libraries.




Boxes filled with books ready to be moved to the University of Groningen. Photo: Marlies Bruining

# 5. Sociaal Jaarverslag



Photo: H. Hobbelink

## ALGEMEEN

**Het jaar 1996 was voor het NIOZ een turbulent jaar, wetenschappelijk, financieel en sociaal. Dankzij een financiële injectie van NWO kon de tweede fase van de reorganisatie, bedoeld om de exploitatiekosten structureel te verminderen en vanaf 1999 een gezonde financiële basis te hervinden, met succes worden geïmplementeerd. Deze reorganisatie leidde tot de uitbesteding van de kantine en het logeergebouw, de overname van het Journal of Sea Research door Elsevier Science, echter met behoud van de redactie bij het NIOZ, de herstructurering van diverse ondersteunende diensten en de kwaliteitsverbetering van de administratieve procedures en bewaking van de financiële uitgaven. Daarnaast werd de mogelijkheid benut om verjonging en vernieuwing van de wetenschappelijke staf in gang te zetten.**

**Onder de inspirerende leiding van Prof. dr. J.W. de Leeuw, die als nieuwe directeur in 1996 aantrad, heeft het NIOZ zijn nieuwe wetenschappelijke koers uitgezet en zijn missie opnieuw gedefinieerd in het wetenschappelijke meerjarenplan: Marine Science at NIOZ, Embedding, Organization, Research Topics and Future (1996-2000). De financiële en personele consequenties van dit science plan werden uitgewerkt in een meerjarig Ondernemingsplan, dat tevens aangeeft hoe het NIOZ zijn schulden uit het verleden zal inlossen. Het strikte bezuinigingsregime zal de komende jaren nog voortduren.**

## BESTUUR EN WETENSCHAPCOMMISSIE

### Bestuur Stichting NIOZ

Per 31 december 1996 was het bestuur als volgt samengesteld:

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

Het bestuur kwam in het verslagjaar 1996 vijfmaal met de directie in vergadering bijeen; op 12 februari, 24 april, 24 mei, 17 september en 12 december te Amsterdam. De vergaderingen werden namens de algemeen directeur NWO bijgewoond door Dr. J. Dijkhof. Genotuleerd werd door mevrouw C.S. Blaauboer-de Jong.

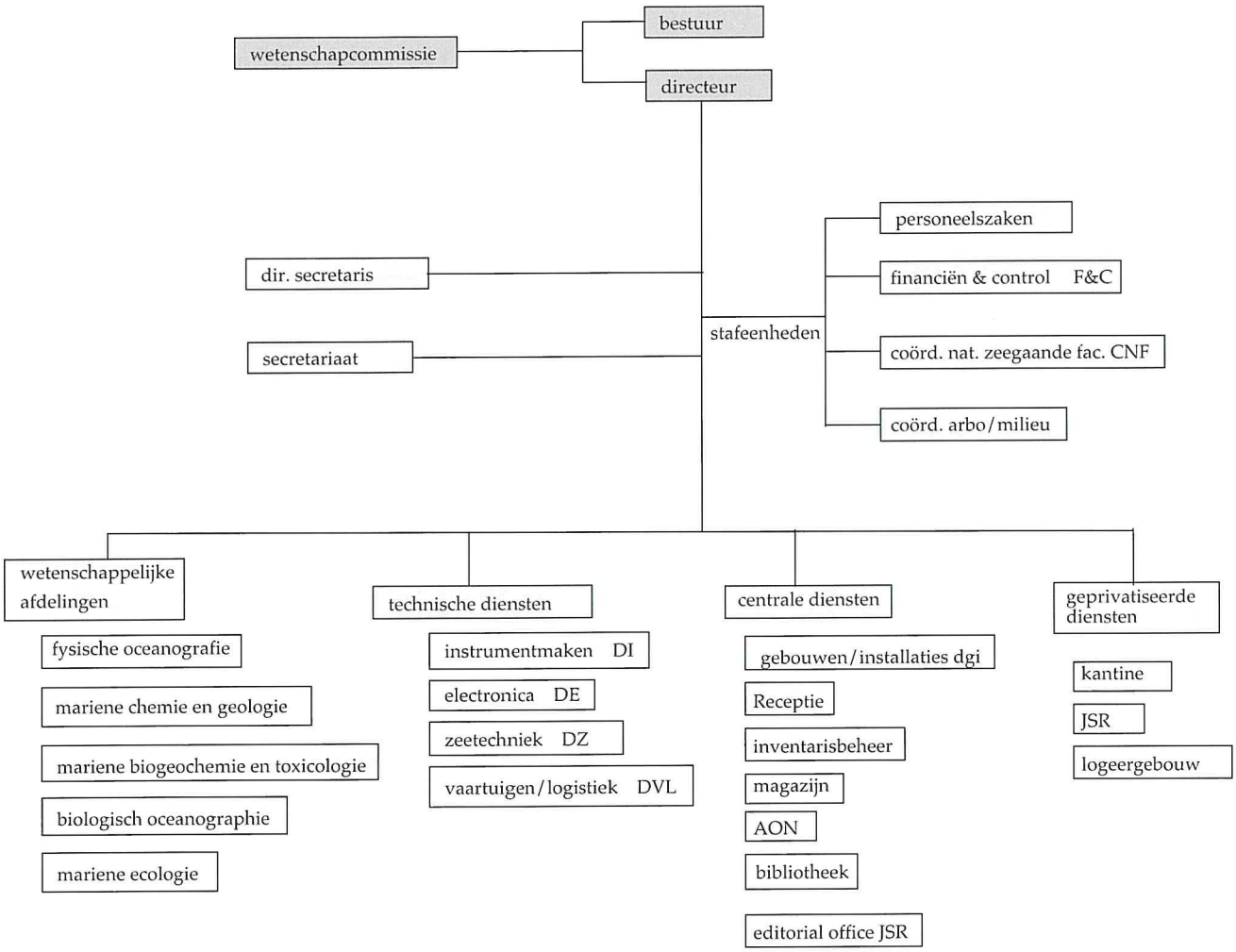
### Wetenschapcommissie NIOZ

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

De Wetenschapcommissie was per 31 december 1996 als volgt samengesteld:

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

## ORGANOGRAM




## PERSONEELSLIJST 31-12-96

### DIRECTIE

| | | | |
|---|---|---|---|
| LeeuwJ.W. de *Prof. dr.* | 34.2 uur | directeur | m.i.v. 1-5 |
| Rietveld M.J. *Drs.* | | directie-secretaris | |
| **Directiesecretariaat** | | | |
| Hart-Stam J.M.G. | | dir. secretaresse | |
| Blaauboer-de Jong C.S. | 30.4 uur | dir. secretaresse | |
| Bol-den Heijer A.C. | 28.2 uur | dir. secretaresse | |

### STAFEENHEDEN

| | | | |
|---|---|---|---|
| **Personeelszaken** | | | |
| Vooys P.C. | | hoofd | |
| Mulder-Starreveld J.P. | 28.5 uur | medewerker | m.i.v. 01-04 |
| **Financiën en control** | | | |
| Bijsterveld-Kessels A.L.M. | | hoofd fin. administratie | m.i.v. 01-02 |
| Arkel M.A. van *Drs.* | | projectcontroller | |
| Wernand-Godee I. | | medew. project-administratie | |
| Bruin D.J. | | medew. financiële administratie | tot 01-04 |
| Keijser A. | | medew. financiële administratie | |
| Spel M.M. | 19.0 uur | medew. financiële administratie | |
| Tuinen H.A. van | 30.4 uur | medew. financiële administratie | m.i.v. 15-04 |
| Porto S.W. de | | medewerker inventarisatieadministratie | |

| | | | |
|---|---|---|---|
| **Nationale zeegaande faciliteiten (MRF)** | | | |
| Bergen Henegouw C.N. van *Drs. Ing.* | | coördinator | |
| **Arbo- en milieuzaken** | | | |
| Rommets J.W. | | coördinator | |

## CORE PROJECT OFFICE (LOICZ/IGBP)

| | | | |
|---|---|---|---|
| Pernetta J.C. *Dr.* | | director | tot 01-06 |
| Sidle R. *Dr.* | | executive officer | m.i.v. 01-12 |
| Boudreau P.R. *Drs.* | | project scientist | |
| Zyp M. van der *Drs.* | | junior data-analist | tot 01-02 |
| | | | m.i.v. 01-06 |
| Bleijswijk Tierens Verhagen J.D.L van *Dr.* | | onderzoeker | m.i.v. 15-08 tot 15-10 |
| Lunter S.M. *Drs.* | | office-administrator | tot 01-02 |
| Pattiruhu C. *Drs.* | | office-administrator | m.i.v. 01-03 |
| Jourdan M.T. | 16.0 uur | administratief medewerkster | |
| Renault A.G.R.A. | | administratief medewerkster | m.i.v. 12-11 tot 12-12 |

## WETENSCHAPPELIJKE AFDELINGEN

### AFDELING FYSISCHE OCEANOGRAFIE

| | | | |
|---|---|---|---|
| Ridderinkhof H.J. *Dr.* | | hoofd | |
| Veth C. *Drs.* | | senior onderzoeker | |
| Zimmerman J.T.F. *Prof. dr.* | 26.6 uur | senior onderzoeker | |
| Aken H.M. van *Dr.* | | senior onderzoeker | |
| Maas L.R.M. *Dr.* | | senior onderzoeker | |
| Haren J.J.M. van *Dr.* | | onderzoeker | |
| Schramkowski G.P. *Dr.* | | project-onderzoeker NWO/GOA | |
| Bruin T.F. de *Drs.* | | datamanager MRF | |
| Lam F.P.A. *Drs.* | 32.0 uur | OIO NIOZ | |
| Wilpshaar J.M.R. *Ir.* | | OIO NWO/BOA | |
| Schrier G. van der *Drs.* | | OIO NWO/GOA | |
| Eijgenraam F. | | automatiseringsdeskundige | |
| Wernand M.R. | | senior onderzoekmedewerker | |
| Ober S. *Ing.* | | senior onderzoekmedewerker | |
| Manuels M.W. | | onderzoekmedewerker | |
| Hiehle M.A. | | senior laboratoriummedewerker | |
| Koster R.X. de | | senior laboratoriummedewerker | |
| Thieme J. *Ing.* | | fysisch assistent (project-) | tot 01-06 |

### AFDELING MARIENE CHEMIE EN GEOLOGIE

| | | | |
|---|---|---|---|
| Helder W. *Dr.* | | hoofd | |
| Raaphorst W. van *Dr. ir.* | | senior onderzoeker | |
| Baar H.J.W. de *Prof. dr. ir.* | 30.4 uur | senior onderzoeker | |
| Eisma D. *Prof. dr.* | | senior onderzoeker | |
| Weering T.C.E. van *Dr.* | | senior onderzoeker | |
| Jansen J.H.F. *Dr.* | | senior onderzoeker | |
| Bennekom A.J. van *Drs.* | | senior onderzoeker | |
| Brummer G.J.A. *Dr.* | | onderzoeker | tot 15-04 m.i.v. 01-06 |
| Timmermans K.R. *Dr.* | | project-onderzoeker | |
| Hey H. de *Drs.* | 30.4 uur | project-onderzoeker | |
| | | NWO/VvA | tot 16-09 |
| Stigter H.C. de *Drs.* | 24.0 uur | project-onderzoeker OMEX | |
| Stoll M.H.C. *Dr.* | | project-onderzoeker NWO/VvA | |
| Lohse L. *Dr.* | | project-onderzoeker | tot 01-07 m.i.v. 01-08 |
| Wilde H.P.J. de *Ir.* | | project onderzoeker | m.i.v. 01-07 |
| Gipp H.J.W. *Drs.* | | OIO NIOZ | |
| Beks J.P. *Drs.* | | OIO NIOZ | tot 01-04 |
| Haas H. de *Drs.* | | OIO NWO/VvA | |
| Wiebinga C.J. *Drs.* | 30.4 uur | OIO NWO/VvA | |
| Löscher B.M. *Drs.* | | OIO NWO/GOA | tot 01-08 |
| Gaast S.J. v.d. | | wetenschappelijk assistent | |
| Vaars A.J. | | applicatietechnicus | |
| Nolting R.F. | | senior onderzoekmedewerker | |
| Kloosterhuis H.T. | | senior onderzoekmedewerker | |
| Ooijen J.C. van | | senior onderzoekmedewerker | |
| Bakker K.M.J. | | onderzoekmedewerker | |
| Malschaert H. *Ing.* | | onderzoekmedewerker | |

| | | | |
|---|---|---|---|
| Boer W. *Ing.* | | onderzoekmedewerker | |
| Iperen J. van | 8.0 uur | senior laboratoriummedewerker | |
| Kalf J. | | senior laboratoriummedewerker | |
| Koutrik A. van | | laboratoriummedewerker | |
| Witte A. | 19.0 uur | project-analist | |
| Koning E. *Drs.* | | toegev. project-onderzoeker | |
| Jong J.T.M. de | | project-assistent NWO/GOA | |
| Jong E. de | | laboratoriumassistent (project) | |
| Das J.H. den | | laboratoriumassistent (project-) | tot 20-03 |
| | | | m.i.v. 01-08 |
| Swagerman H.J.M. | | assistent | tot 15-03 |

## AFDELING MARIENE BIOGEOCHEMIE EN TOXICOLOGIE

| | | | |
|---|---|---|---|
| Leeuw J.W. de *Prof. Dr.* | | hoofd | tot 01-05 |
| Boon J.P. *Dr.* | | senior onderzoeker | |
| | | waarnemend hoofd | m.i.v 15-06 |
| Everaarts J.M. *Dr.* | | senior onderzoeker | |
| | | waarnemend hoofd | m.i.v. 01-05 tot 15-06 |
| Sinninghe Damsté J.S. *Dr. ir.* | 34.2 uur | senior onderzoeker | |
| Booy K. *Dr.* | | onderzoeker | |
| Versteegh G.J.M. *Dr.* | | post-doc NWO/GOA | |
| Koopmans M.P. *Dr.* | | post-doc | m.i.v. 01-03 |
| Schouten S. *Ir.* | | project-onderzoeker NWO | |
| | | /pionier | tot 01-11 |
| Kok M.D. *Drs.* | | OIO NIOZ/pionier | |
| Mensink B.P. *Ir.* | 32.0 uur | OIO NIOZ | |
| Schanke A. van *Ir.* | | OIO NIOZ | m.i.v. 01-09 |
| Hold I.M. *Drs.* | | OIO NWO/pionier | |
| Heemst J.D.H. van *Ir.* | | OIO NWO/VvA | |
| Kaam H. van *Drs.* | | OIO/NWO/GOA | |
| Blokker P. *Drs.* | | OIO-NWO | m.i.v. 01-07 |
| Pool W.G. | | wetenschappelijk assistent | |
| Hillebrand M.T.J. | | senior onderzoekmedewerker | |
| Baas M. | | onderzoekmedewerker | |
| Rijpstra W.I.C. | 19.0 uur | onderzoekmedewerker | |
| Dekker M.H.A. *Ing.* | 36.0 uur | onderzoekmedewerker | |
| Lewis W.E. | 28.0 uur | senior laboratoriummedewerker | |
| Weerlee E.M. van | | laboratoriummedewerker | |
| Fischer C.V. *Drs.* | 28.0 uur | laboratoriummedewerker | |

## AFDELING BIOLOGISCHE OCEANOGRAFIE

| | | | |
|---|---|---|---|
| Ruardij P. *Drs.* | | waarnemend hoofd | m.i.v. 01-09 |
| Fransz H.G. *Dr. ir.* | | senior onderzoeker | |
| Baars M.A. *Dr.* | | senior onderzoeker | |
| | | waarnemend hoofd | m.i.v. 01-03 tot 01-09 |
| Klein Breteler W.C.M. *Dr.* | | senior onderzoeker | |
| Vosjan J.H. *Dr.* | | senior onderzoeker | |
| Veldhuis M.J.W. *Dr.* | | senior onderzoeker | |
| Duyl F.C. van *Dr.* | | senior onderzoeker | |
| Riegman R. *Dr.* | | senior onderzoeker | |
| Kuipers B.R. *Dr.* | | onderzoeker | |
| Hansen F.C. *Dr.* | | post-doc NIOZ | tot 01-04 |
| Boelen P. *Drs.* | | OIO NIOZ. | m.i.v. 01-01 |
| Buitenhuis E.T. *Ir.* | | OIO NWO/VvA | |
| Leenders A. *Drs.* | | OIO NIOZ/UvU | m.i.v. 01-10 |
| Embsen E.G.M. *Ing.* | | automatiseringsdeskundige | |
| Kraay G.W. | | senior onderzoekmedewerker | |
| Pauptit E. | | senior onderzoekmedewerker | tot 01-12 |
| Kop A.J. *Ing.* | | onderzoekmedewerker | |
| Oosterhuis S.S. | | onderzoekmedewerker | |
| Noordeloos A.A.M. *Ing.* | | senior laboratoriummedewerker | |
| Noort G.J. van | | senior laboratoriummedewerker | |
| Gonzalez S.R. | | senior laboratoriummedewerker | |
| Witte H.J. | | senior laboratoriummedewerker | |
| Schogt N. | | laboratoriummedewerker | |
| Schoemann V.F. | | projectonderzoeker | m.i.v. 01-04 |
| Kempers E.S. | 32.0 uur | senior laboratoriummedewerker | m.i.v. 01-09 |
| Snoek J. *Ing.* | 30.4 uur | projectmedewerker | m.i.v. 01-06 |
| Stolte W. *Drs.* | 32.0 uur | projectmedewerker NWO | m.i.v. 01-06 |
| Kip S.F.G. | 7.6 uur | laboratoriummedewerker | m.i.v. 15-09 |

## AFDELING MARIENE ECOLOGIE

| | | | |
|---|---|---|---|
| Lindeboom H.J. *Dr.* | | hoofd | |
| Meer J. van der *Drs.* | | senior onderzoeker | |
| Wilde P.A.W.J. de *Prof. dr.* | | senior onderzoeker | |
| Beukema J.J. *Dr.* | | senior onderzoeker/hoofdredacteur NJSR | |
| Bak R.P.M. *Prof. dr.* | | senior onderzoeker | |
| Spaargaren D.H. *Dr.* | | senior onderzoeker | |
| Fonds M. *Dr.* | | senior onderzoeker | |
| Cadée G.C. *Dr.* | | senior onderzoeker | |
| Veer H.W. van der *Dr. ir.* | | senior onderzoeker | |
| Piersma T. *Dr.* | | senior onderzoeker | |
| Wolf P. de *Dr.* | | gastonderzoeker | |
| Bergman M.J.N. *Ir.* | | onderzoeker | |
| Duineveld G.C. *Drs.* | 30.4 uur | onderzoeker | |
| Daan R. *Dr.* | | onderzoeker | |
| Dekker R. *Drs.* | | onderzoeker | |
| Berg A.J. van den *Drs.* | 24.0 uur | project-onderzoeker | tot 01-02 |
| Brugge J. van den *Drs.* | | project-onderzoeker | tot 01-03 |
| Philippart C.J.M. *Dr.* | | project-onderzoeker | |
| Holtmann S.E. *Drs.* | 28.0 uur | project-onderzoeker | |
| Lavaleye M.S.S. *Drs.* | | project-onderzoeker | m.i.v. 01-07 tot 01-11 |
| Witbaard R. *Drs.* | 30.4 uur | project-onderzoeker | m.i.v. 01-08 |
| Santbrink J.W. van *Drs.* | | toegevoegd projectonderzoeker | |
| Camphuysen C.J. | 19.0 uur | wet. assistent (project-) | m.i.v. 01-02 |
| Gast G.J. *Drs.* | | OIO NIOZ | |
| Goeij P.J. de *Drs.* | | OIO NIOZ | tot 01-07 |
| Honkoop P.J.C. *Drs.* | | OIO NOP | tot 01-04 |
| Walker P.A. *Drs.* | 36.0 uur | OIO NAM | tot 20-09 |
| Boon A.R. *Ir.* | | OIO NWO/VvA | |
| Drent J. | | OIO NWO | m.i.v. 01-11 |
| Epstein N. | 24.0 uur | OIO NIOZ | m.i.v. 01-12 |
| Dapper R. | | automatiseringsdeskundige | |
| Berghuis E.M. | | senior onderzoekmedewerker | |
| Nieuwland G. | | senior onderzoekmedewerker | |
| Spaans B. | 16.0 uur | senior onderzoekmedewerker | m.i.v. 01-08 |
| Hegeman J. | | onderzoekmedewerker | |
| Duiven P. | | onderzoekmedewerker | |
| Kok A. | | onderzoekmedewerker | |
| Mulder M. | | onderzoekmedewerker | |
| Witte J.IJ. | | onderzoekmedewerker | |
| Puyl P. van der | | laboratoriummedewerker | |
| Bruin W. de | | laboratoriummedewerker | |
| Zuidewind J. | | laboratoriummedewerker | |
| Kracht B. *Drs.* | 24.0 uur | project-assistent | tot 01-08 |
| Belgers J.J.M. | 24.0 uur | project-analist | m.i.v. 22-04 tot 22-06 |
| Weele J.A. van der | | project-assistent | tot 01-06 m.i.v. 01-08 tot 01-12 |
| Kwast D. | | project-assistent | tot 16-08 |
| Winter C. | | project-assistent | |
| Dekinga A. *Drs. Ing.* | | project-medewerker NWO | m.i.v. 01-08 |
| Koolhaas, A.N. *Drs. Ing.* | | project-medewerker | m.i.v. 01-10 |
| Visser P.M. *Dr.* | | project-onderzoeker NWO | m.i.v. 01-10 |

## CENTRALE DIENSTEN

| | | |
|---|---|---|
| Abs E. van *Ing.* | | hoofd |
| **Dienst gebouwen en installaties** | | |
| Schilling F.J. | | hoofd |
| Alkema P.R. | 35.15 uur | med. werktuigbouw |
| Groot S.P. | 30.4 uur | med. werktuigbouw |
| Kuip T. | | med. werktuigbouw |
| Lakeman R. | 20.0 uur | med. werktuigbouw |
| Daalder R.M. | | med. houtbewerking |
| Witte R.J.C. | | med. houtbewerking |
| Brondsema A. | | med. energietechniek |
| **PR-logistiek** | | |
| Nieuwenhuizen J.M. | | medewerker |
| **Kantine** | | |
| Spigt H. | | hoofd |
| **Logeergebouw 'In Den Potvis'** | | |
| Steenhuizen G.H. | | beheerder |

| | | | |
|---|---|---|---|
| Borkulo T.C. van | 19.0 uur | medewerkster | |
| **Receptie** | | | |
| Kikkert A. | 20.0 uur | telefoniste/receptioniste | |
| Jourdan M.T. | 20.0 uur | telefoniste/receptioniste | |
| Starink J.M. | 19.5 uur | telefoniste/receptioniste | |
| **Inventarisbeheer** | | | |
| Porto S.W. de | | medewerker | |
| **Magazijn** | | | |
| Ran A. | | hoofd | |
| Gieles S.J.M. | | medewerker | |
| **Reprografische afdeling** | | | |
| Aggenbach R.P.D. | | eerste medewerker | |
| Verschuur B. | 35.15 uur | medewerker | |
| Nichols R.C. | | medewerker | tot 01-10 |
| Graaf A.C. de | 30.0 uur | medewerker | |
| **Audiovisuele middelen** | | | |
| Hart W. | 24.0 uur | medewerker | |
| **Bibliotheek** | | | |
| Brouwer A. | | hoofd | |
| Bruining-De Porto M. | 31.5 uur | medewerker | |
| Zonnenberg G. | 35.15 uur | administratief medewerker | |
| **Redactie** | | | |
| Beukema J.J. *Dr.* | | hoofdredacteur | |
| Bak-Gade B. | 20.0 uur | assistent redacteur | |
| Mulder-Starreveld J.P. | 28.5 uur | redactie-assistente | tot 01-04 |
| Barten-Krijgsman N. | 15.2 uur | redactie-assistente | |
| Hobbelink H. | | grafisch ontwerper | |

## TECHNISCHE DIENSTEN

| | | | |
|---|---|---|---|
| Bakker C.L. | | hoofd | |
| Nieuwenhuis J. | | middelbaar electronicus | |
| Manshanden G.M. | 30.4 uur | automatiseringsdeskundige | |
| Bonne E. | | medewerker (detachering) | |
| **Instrumentmaken** | | | |
| Boekel H.J. | | hoofd | |
| Keijzer E.J.H. | | medewerker | |
| Heerwaarden J. van | | medewerker | |
| Kuiken N.E. | | medewerker | tot 01-06 |
| **Electronica** | | | |
| Groenewegen R.L. *Ing.* | | hoofd | |
| Koster B. *Ing.* | | plv. hoofd | |
| Franken H. *Ing.* | | hoger electronicus | |
| Laan M. | | hoger electronicus | |
| Derksen J.D.J. | | electronicus Pelagia | |
| **Zeetechniek** | | | |
| Porto H.H. de | | hoofd | |
| Schilling J. | | plv. hoofd | |
| Bos E.B.M. | | eerste medewerker | |
| Willems C. | | medewerker | tot 05-08 |
| Polman W. | | medewerker | |
| Bakker M.C. | | medewerker | |
| Blom J.J. | | medewerker | |
| Wuis L.M. | | medewerker (detachering) | |
| Boom L. | | medewerker | |
| **Vaartuigen en logistiek** | | | |
| Buisman T.C.J. | | hoofd | |
| Zwieten C. van | | med. naut. zaken | |
| Eelman A. | | chauffeur (detachering) | |
| Souwer A.J. | | gezagvoerder Pelagia | |
| Groot J.C. | | 1e stuurman Pelagia | |
| Duyn M.D. van | | 2e stuurman Pelagia | |
| Pieterse J.M. | | hoofdwerktuigkundige Pelagia | |
| Seepma J. | | 1e werktuigkundige Pelagia | |
| Kalf J.J. | | 2e werktuigkundige Pelagia | |
| Grisnich P.W. | | scheepstechnicus Pelagia | |
| Saalmink P.W. | | scheepstechnicus Pelagia | |
| Stevens C.T. | | scheepstechnicus Pelagia | |
| Koomen W.J.M. | | scheepskok Pelagia | tot 01-04 |
| Adriaans E.J. | | schipper Griend | |
| Star C. van der | | schipper Navicula | |
| Tuntelder J.C. | | scheepstechnicus/kok Navicula | |
| Schagen P.J. | | machinist/motordrijver Navicula | tot 18-04 |
| Jongejan W.P. | | komvisser | |

## ARBEIDSVOORWAARDEN.

### Algemeen

De secundaire en tertiaire arbeidsvoorwaarden voor de werknemers van NWO, FOM, SMC en NIOZ zijn opgenomen in de Collectieve Arbeidsvoorwaardenregeling (CAR). Na overleg met de vakbonden is besloten de looptijd van de CAR per 1 september 1996 met één jaar te verlengen zulks in verband met een aantal in breed verband te onderzoeken en te bespreken onderwerpen met als doel de eventuele invoering van een systeem van flexibele arbeidsvoorwaarden. Slechts enkele technische wijzigingen zijn per 1 september 1996 in de CAR aangebracht.

### Primaire arbeidsvoorwaarden

In1996 is tussen de centrales van overheidspersoneel en de Minister van Onderwijs, Cultuur en Wetenschappen overeenstemming bereikt over de ontwikkeling van de collectieve arbeidsvoorwaarden in de sector Onderzoek en Onderwijs. Het akkoord is ingegaan op 1 juni 1996 en heeft een looptijd tot 1 januari 1999.
De inhoud van het onderhandelingsakkoord bestaat uit:
een eindejaarsuitkering in december 1996 van 0,5% van de in 1996 genoten bezoldiging;
een salarisverhoging van 1% per 1 augustus 1997;
een eindejaarsuitkering in december 1997 van 0,5% van de in 1997 genoten bezoldiging;
een salarisverhoging van 1,5% per 1 augustus 1998;
een salarisverhoging van 0,5% per 1 december 1998;
een eindejaarsuitkering in december 1998 van 0,5% van de in 1998 genoten bezoldiging.

Op 1 april 1996 zijn de salarissen als gevolg van het vorige onderhandelingsresultaat met 1,1% verhoogd.

De eindejaarsuitkeringen en salarisverhogingen werken door in de pensioenen en uitkeringen

Het akkoord hield verder in een vermindering van de arbeidsduur van 3% met ingang van 1 augustus 1998. De wijze waarop invulling aan deze arbeidsduurverkorting wordt gegeven, zal worden bepaald in het overleg met de organisaties op het niveau van de Werkgeversvereniging Onderzoekinstellingen (WVOI).

De WVOI bestaat uit de Koninklijke Bibliotheek (KB), het Rijksinstituut voor Oorlogsdocumentatie (RIOD), de Koninklijke Nederlandse Academie voor Wetenschappen (KNAW) en de Nederlandse organisatie voor Wetenschappelijk Onderzoek (NWO) waarin vertegenwoordigd o.a. het NIOZ.

## DECENTRALE ARBEIDSVOORWAARDENMAATREGELEN

### Wijziging en verlenging SOP-regeling (Seniorenregeling Onderwijs Personeel)

De SOP-regeling houdt in dat medewerkers vanaf 57 jaar in aanmerking kunnen komen voor een kortere werkweek tegen een beperkte vermindering van het salaris.
Per 1 mei 1996 is de SOP-regeling gewijzigd: de medewerker die vanaf genoemde datum gebruik gaat maken van deze regeling, verplicht zich om op uiterlijk 61-jarige leeftijd gebruik te maken van de overgangsregeling FPU (Flexibel Pensioen en Uittreden), die met ingang van 1 april 1997 in werking treedt, en uit te treden voor ten minste het aantal dagen dat men gebruikt voor de SOP-regeling. Voor degenen die voor 1 mei 1996 gebruik zijn gaan maken van de SOP-regeling, geldt deze verplichting niet. De met deze deelnemers gemaakte afspraken blijven onverminderd van kracht.
De regeling is verlengd tot uiterlijk 1 september 1997.
In 1996 hebben 6 medewerkers gebruik gemaakt van deze regeling.

### Regeling ouderschapsverlof

Deze regeling biedt aan ouders van kinderen die jonger zijn dan 4 jaar de gelegenheid om voor maximaal 50% van de werktijd ouderschapsverlof te genieten. Over de verlofuren wordt 75% van het salaris doorbetaald. Er zijn flexibele verlofvormen mogelijk. Voorwaarde is dat het verlof binnen een tijdvak van 12 maanden opgenomen moet worden.

### Kinderopvang

De regeling Kinderopvang is in 1996 ongewijzigd ten opzichte van 1995 toegepast. Het NIOZ heeft bij de Stichting Kinderdagverblijf Texel de beschikking over 10 dagdelen kinderopvang op grond van de kindplaats die het NIOZ jaarlijks betaalt.

## OVERIGE MAATREGELEN / WIJZIGINGEN

### Wachtgeldhiaat

Ter voorkoming van een financieel risico dat op den duur kan ontstaan bij partiële arbeidsongeschiktheid, het zogenaamde "wachtgeldhiaat", is per 1 januari 1996 door de NWO-koepel een collectieve verzekering gesloten met verzekeraar OHRA.
De gezamenlijke werkgevers hebben hun medewerkers op het belang gewezen om zich tegen dit risico te verzekeren en deel te nemen aan het collectieve contract. Het deelnemerspercentage voor de gehele koepel kwam neer op circa 80%. Ook bij het NIOZ werd dit percentage ruimschoots gehaald.

### Ziektekostenverzekering

In de loop van het jaar 1996 zijn door tussenkomst van de Kooijman Groep een aantal offertes bestudeerd van zorgverzekeraars. Naast de verschillende premietarieven en de jaarlijkse maximale premieverhoging werd vooral ook het pakket van voorzieningen in overweging genomen. Het meest gunstige totaalpakket werd geleverd door Zorgverzekeraar Oostnederland met o.a. een tandartsvergoeding voor volwassenen.
Besloten is dan ook om per 1 januari 1997 een nieuw collectief contract te sluiten met genoemde verzekeraar en het oude contract met het Zilveren Kruis per dezelfde datum op te zeggen. Bijna driekwart van de NIOZ particulier verzekerden hebben zich aangemeld bij de nieuwe verzekeraar.

## TWEEDE FASE REORGANISATIE NIOZ 1996 (zie tevens "Introduction")

Zoals in de inleiding is verwoord, richtte het Reorganisatieplan 1996 zich voornamelijk op het structureel terugdringen van de exploitatiekosten. Gekozen werd voor een aanpak waarbij de kernaktiviteiten van het NIOZ, zijnde het optimaal verrichten van nieuwsgierigheidsgedreven en maatschappijgedreven multidisciplinair marien onderzoek en de organisatie en uitvoering van zeegaand wetenschappelijk onderzoek, zo min mogelijk zouden worden geschaad.
Een deel van het pakket van maatregelen leidde tot het reduceren en privatiseren van een aantal ondersteunende, niet tot de kerntaken van het instituut behorende aktiviteiten.
Het gevolg hiervan was dat voor zes medewerkers een ontslagprocedure werd ingesteld.
In drie gevallen verliep deze procedure via het kantongerecht. Met het verzoek tot ontbinding van de desbetreffende arbeidscontracten stemde de kantonrechter in. De datum van beëindiging van het dienstverband varieerde echter per werknemer om reden dat de kantonrechter dit afhankelijk stelde van de duur van de wachtgeldaanspraak.
Op de 6 medewerkers voor wie het reorganisatieontslag gold, was van toepassing het bij het Reorganisatieplan II behorende Sociaal Plan.
Een aantal medewerkers werd herplaatst in een nieuw opgerichte afdeling respectievelijk overgeplaatst naar reeds bestaande afdelingen.
Ter begeleiding van het reorganisatieproces werd er een Begeleidingscommissie Reorganisatie ingesteld. Deze commissie had tot taak de voortgang van het reorganisatieproces te bewaken en er op toe te zien dat de afspraken en de gedragsregels zoals die in het Sociaal Plan waren vastgelegd in acht werden genomen. De commissie behoefde geen enkele keer bijeen te komen.

## REGELING FUNCTIONERINGSGESPREKKEN / PERSONEELSBEOORDELING

In het verslagjaar is er een begin gemaakt met het periodiek houden van beoordelings- en functioneringsgesprekken nadat door de afdeling Personeelszaken aan medewerkers en afdelingshoofden voorlichting is gegeven over het systeem van personeelsbeoordeling en het houden van functioneringsgesprekken.

## ARBEIDSOMSTANDIGHEDEN

### Arbo- en milieujaarverslag NIOZ 1996
### Arbo- en milieujaarplan NIOZ 1997

### Inleiding

In dit verslag wordt gerapporteerd over de belangrijkste activiteiten op het terrein van arbo en milieu die in 1996 hebben plaatsgevonden. Omwille van de leesbaarheid is de rapportage zo beknopt mogelijk gehouden.

In het volgende hoofdstuk is aangegeven welke zaken in 1997 extra aandacht verdienen: het kan worden beschouwd als een arbo- en milieujaarplan.

### Jaarverslag 1996

1. Beleid
De stafmedewerker arbo- en milieuzaken heeft een arbo- en milieuboek samengesteld met daarin de volgende onderwerpen:

- veiligheidsbeginselen
- veiligheidsbevordering
- een samenvatting van de Arbeidsomstandighedenwet
- de intentieverklaring van de directie betreffende arbo- en milieuzaken
- uitgangspunten van het arbo- en milieubeleid
- bevoegdheden en verantwoordelijkheden
- realisering en toetsing van het arbo- en milieubeleid
- welzijn
- bedrijfsgezondheidszorg
- bedrijfshulpverlening
- VGWM voorschriften (Veiligheid, Gezondheid, Welzijn, Milieu)
- register van gevaarlijke stoffen

Na overleg met de diverse geledingen heeft de directie, na overleg met de Ondernemingsraad, de inhoud op 13 juni 1996 vastgesteld, waarna implementatie plaatsvindt.

2. Personeel
Arbo- en milieuzaken werden besproken in de overlegvergaderingen van directie en afdelingshoofden.

3. Ongevallen
Door het wegglijden van een ondeugdelijke ladder viel een stagiaire bij DGI van een hoogte van 3,5 meter op een betonnen vloer en bezeerde elleboog en heup. Na vier dagen kon hij zijn werk weer hervatten; de ladder is vervangen.

4. Veiligheids- en milieuzaken
De risicoinventarisatie en -evaluatie volgens deel C van het Inspectie Plus Pakket (IPP) van het Nederlands Instituut voor Arbeidsomstandigheden (NIA) wordt gedaan door de afdelings- en diensthoofden tijdens functioneringsgesprekken met hun medewerkers.

Via de gehuurde container is in 1996 door de firma Ecotechniek 2295 kg klein gevaarlijk afval afgevoerd; dit was in 1993 805 kg, in 1994 2155 kg en in 1995 1395 kg. De belangrijkste componenten waren oplosmiddelen, giftige chemicaliën, verfafval, ontwikkelaar, batterijen en TL buizen.

De firma Tatenhove, een gespecialiseerd bedrijf, voerde 2520 kg asbesthoudende bakken af naar het Centraal Afvalverwijderingsbedrijf West Friesland.

Een gedeelte van het radioactieve afval van het isotopen laboratorium is afgevoerd door de COVRA.

Er is een contract afgesloten met Océ Nederlandse Verkoopmaatschappij b.v. om dubbelzijdig kopiëren op meer machines makkelijker mogelijk te maken. Het effect hiervan blijkt duidelijk uit het onderstaande overzicht.

Overzicht papierverbruik in vellen A4.

| Jaar | totaal | kopieermachines | overige printers |
|---|---|---|---|
| 1990 | 746.567 | 736.567 | 10.000 |
| 1991 | 1.034.654 | 886.654 | 148.000 |
| 1992 | 1.279.539 | 993.539 | 286.000 |
| 1993 | 1.391.614 | 967.614 | 424.000 |
| 1994 | 1.686.015 | 1.124.015 | 562.000 |
| 1995 | 1.696.993 | 996.993 | 700.000 |
| 1996 | 1.172.000 | 774.175 | 397.825 |

Overzicht energieverbruik en energiekosten

| Jaar | kWh | m3 gas | m3 water | energiekosten |
|---|---|---|---|---|
| 1991 | 1.406.820 | 300.707 | 15.500 | f 404.437 |
| 1992 | 1.729.800 | 278.716 | | f 454.748 |
| 1993 | 1.991.180 | 307.489 | | f 481.909 |
| 1994 | 2.082.247 | 479.480 | 16.716 | f 443.122 |
| 1995 | 1.285.740 | 422.477 | 15.923 | f 417.168 |
| 1996 | 1.147.907 | 562.329 | 13.599 | f. 462.221 |

5. Bedrijfsgezondheidszorg
Door de afdeling Bedrijfsgezondheidszorg van de Gewestelijke Gezondheids Dienst Kop van Noord Holland zou een Periodiek Bedrijfs Geneeskundig Onderzoek verricht worden bij een groep technici. Dit is uitgesteld naar februari-maart 1997.

De bemanningen van de schepen zijn medisch gekeurd door de GG&GD te Den Helder volgens eisen van Scheepvaartinspectie.

Ziekteverzuim
In 1996 is er sprake van een significante stijging van het ziekteverzuim ten opzichte van 1995. (7,3% tegen 4,1%). De stijging van het ziekteverzuim is waarneembaar bij alle categorieën maar is opvallend bij de categorie niet wetenschappelijk personeel (zie onderstaande tabel). Bij deze categorie kan een mogelijk oorzakelijk verband worden gelegd tussen het hoge percentage ziekteverzuim en de implementatie van de reorganisaties 1995 en 1996.

| | WP | M | V | NWP | M | V |
|---|---|---|---|---|---|---|
| 1995 | 1,47 | 1,31 | 2,16 | 5,16 | 4,98 | 5,82 |
| 1996 | 2,1 | 1,8 | 4,3 | 9,5 | 8,1 | 14,1 |

6. Bedrijfshulpverlening
Ten behoeve van de EHBO voorziening zijn acht personen op herhalingscursus geweest voor het eenheidsdiploma EHBO van het Oranje Kruis. De cursus werd gegeven door de Regionale Arbodienst uit Den Helder.

Er is een hoofd van de EHBO aangesteld.

Om de bedrijfsbrandweer op de vereiste sterkte en de leden op het gewenste opleidingsniveau te brengen, hebben vier aspiranten de opleiding tot brandwacht bij de regionale brandweer met succes gevolgd.

De leden van de bedrijfsbrandweer oefenden maandelijks 2 uur.

De jaarlijkse controle van de brandmeldinstallatie en alle brandmelders is verricht evenals de controle van de kleine blusmiddelen en de zes adembeschermingsapparaten van de brandweerploeg.

7. Investeringen
Door de afdelingen en diensten is in totaal f 43.000 geïnvesteerd voor de verbetering van de werkplek.

8. Vergunningen
Door de gemeente Texel is een nieuwe, de gehele inrichting omvattende vergunning verleend ingevolge de Wet milieubeheer.

Er is een vergunning verleend door het Ministerie van Verkeer en Waterstaat voor de lozing van afvalwater van laboratoria en aquaria op de Waddenzee voor drie jaar en een vergunning voor het storten/verspreiden van baggerspecie afkomstig uit de NIOZ-haven.

**Jaarplan 1997**

ad 4. Veiligheids- en milieuzaken

Er zal een overzicht worden gemaakt van alle gasreduceerventielen die binnen het NIOZ gebruikt worden. Daarna zal een contract worden afgesloten om deze apparatuur periodiek te onderhouden.
Er zal een controle op aarding worden uitgevoerd van de wandcontactdozen van alle gebouwen van het NIOZ conform NEN 3140.
Met ingang van 1 januari zullen ten behoeve van de door Rijkswaterstaat verleende lozingsvergunning elk kwartaal analyses worden gedaan van het afvalwater van het aquariumgebouw en de laboratoria.

ad 5. Bedrijfsgezondheidszorg

Door de afdeling Bedrijfsgezondheidszorg van de Gewestelijke Gezondheids Dienst Kop van Noord Holland zal een Periodiek Bedrijfs Geneeskundig Onderzoek verricht worden:
bij een groep technici in februari- maart
bij de onderzoekers in mei-juni en
bij het personeel van de ondersteunende groepen in september-oktober.

ad 6. Bedrijfshulpverlening

Omdat een van de leden van de Bedrijfsbrandweer niet meer in dienst van het NIOZ is, gaat een NIOZ werknemer in september de cursus brandwacht volgen.
Om de EHBO ploeg weer op sterkte te brengen gaat één persoon in april de basiscursus EHBO volgen te Den Helder.

ad 7. Investeringen

Aan de afdelingen en diensten is voorlopig f 77.000 toegewezen voor verbeteringen van de werkplek. Vooralsnog is f 58.000 toegewezen aan de afdeling Mariene Ecologie voor de afvoer van radioactief materiaal naar de COVRA.

ad 8. Vergunningen

In verband met de vergunning voor het lozen van afvalwater op de Waddenzee zal het laboratorium van Tauw Milieu te Deventer ieder kwartaal het geloosde afvalwater analyseren op de onderstaande parameters volgens de vermelde methode:

| Omschrijving | Methode | Rapportage grens |
|---|---|---|
| Zware metalen ontsluiting | NEN 6465 | |
| Cadmium | NEN 6458 | 0,2 mg/l |
| Kwik | NEN 6449 | 0,1 mg/l |
| Arseen | NEN 6457 | 1,0 mg/l |
| Zink | NEN 6426 | 4 mg/l |
| Chroom | NEN 6426 | 2 mg/l |
| Nikkel | NEN 6426 | 2 mg/l |
| Koper | NEN 6426 | 4 mg/l |
| Lood | NEN 6426 | 10 mg/l |
| Molybdeen | NEN 6426 | 6 mg.l |
| Zilver | NEN 6426 | 4 mg/l |
| PAK EPA (16) | o-NEN 5771 | 0,01 mg/l |
| EOX | NEN 6676 | 1 mg/l |
| Som van MAK | o-NEN 6407 | 0,1 mg/l |
| Totaal cyanide | o-NEN 6655 | 3 mg/l |
| pH` | NEN 6411 | 0,1 eenheden |
| Chloride | NEN 6476 | mg/l |
| OCB-PCB | NEN 5718 | 0,01 mg/l |

Het NIOZ zal opgave doen van de geloosde hoeveelheid zeewater en laboratoriumafvalwater in $m^3$/kwartaal. Voor een beter inzicht in de aard van het water zal een chloride bepaling worden gedaan als aanvulling op de vereiste metingen.

Deze gegevens zullen uiterlijk één maand na het beeindigen van ieder kwartaal worden toegezonden aan Rijkswaterstaat Directie Noord Holland met afschrift aan het RIZA.

## PERSONEELSVERENIGING

De personeelsvereniging organiseerde op 8 maart het jaarlijkse kinderfeest. Het bestuur bakte hun inmiddels beroemde pannenkoeken die weer gretig aftrek vonden bij de kinderen (en hun ouders). Als afsluiting trad de toneelgroep 'Julia' uit Den Helder op met het stuk 'Berend Botje'

Ook de 'Comedia de la NIOZ' liet dit jaar van zich horen. Men had de monsterproduktie 'De wind in de takken van de laurierbomen' in studie genomen, een kamerwestern geschreven door R. d'Obaldia. De colloquium zaal was voor dit stuk omgetoverd in western decor met heuse blokhut. Dit alles resulteerde in twee zeer succesbolle opvoeringen op 18 en 19 april. De avond van 19 april werd afgesloten met een personeelsfeest ondersteund met muziek van de Amsterdamse funkgroep 'Moving 2 Cool'.

Omdat er in 1996 geen personeelsreisje was georganiseerd, werd besloten om de PV-leden éénmalig te verrassen met een kerstpakket. Het bestuur heeft vernomen dat dit gebaar zeer op op prijs werd gesteld.

## ACRONYMS USED IN THIS ANNUAL REPORT

| | |
|---|---|
| AABW | Antarctic Bottom Water |
| ACC | Antarctic Circumpolar Current |
| ADCP | Acoustic Doppler Current Profiler |
| ALBEX | Autonomous Lander for Biological Experimentation |
| ARGOS | a satellite location and data collection system |
| AWI | Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany |
| BELS | Benthic Links and Sinks in North Sea Nutrient Cycling |
| BEON | Beleidsgericht Ecologisch Onderzoek Noordzee/Waddenzee<br>Applied Ecological Research North Sea and Wadden Sea |
| BOA | Gebiedsbestuur voor de Biologische, Oceanografische en Aardwetenschappen<br>Foundation for Biological, Oceanographic and Earth Sciences |
| BOBO | Bottom benthic boundary lander |
| BOLAS | Bottom Lander System |
| CNRS | Centre National de la Recherche Scientifique |
| CTD | Conductivity-Temperature-Depth |
| DCM | Deep Chlorophyll Maximum |
| DCMU | Dichloromethylurea |
| DCS | Dutch Continental Shelf |
| DMS | Dimethylsulphide |
| DMSP | Dimethyl sulphoniopropionate |
| DNZ-RWS | Dienst Noordzee-Rijkswaterstaat<br>Directorate North Sea, Ministry of Transport and Public Works |
| DUTCH-WARP | Deep and Upper Transport, Circulation and Hydrography, WOCE Atlantic Research Programme |
| EC | European Community |
| EDMED | European Directory on Marine Environmental Data |
| ERSEM | European Regional Seas Ecosystem Model |
| GLOBEC | Global Ocean Ecosystem Dynamics |
| GOA | Geologie, Oceanografie, Aardwetenschappen<br>Geosciences Foundation |
| ICES | International Council for the Exploration of the Sea |
| IfM | Institut für Meeresforschung, Hamburg, Germany |
| IFREMER | Institut Français de Recherche pour l'Exploration de la Mer |
| IMAU | Instituut voor Marien en Atmosferisch Onderzoek, Universiteit Utrecht<br>Institute for Marine and Atmospheric Research |
| INP | Integrated North Sea Programme |
| ISOW | Iceland-Scotland Overflow Water |
| ISP | Institute for Systematics and Population Biology |
| JGOFS | Joint Global Ocean Flux Study |
| KUN | Katholieke Universiteit Noord Brabant |
| LDW | Lower Deep Water |
| LOICZ | Land Ocean Interaction in the Coastal Zone |
| LSW | Labrador Sea Water |
| LUW | Landbouw Universiteit Wageningen<br>Agricultural University Wageningen |
| MAFF | Ministry of Agriculture, Fishery and Food (UK) |
| MAST | Marine Science and Technology programme |
| MRF | Marine Research Facilities |
| NAC | North Atlantic Current |
| NAM | Nederlandse Aardolie Maatschappij<br>Dutch Oil Company |
| NAO | North Atlantic Oscillation |
| NAOI | North Atlantic Oscillation Index |
| NEADW | North East Atlantic Deep Water |
| NIOO-CEMO | Nederlands Instituut voor Oecologisch Onderzoek-Centrum voor Estuariene en Mariene Oecologie<br>Netherlands Institute of Ecology-Centre for Estuarine and Coastal Ecology |
| NMR | Nuclear Magnetic Resonance |
| NODC | National Oceanographic Data commission |
| NOP | Nationaal Onderzoeksprogramma voor luchtverontreiniging en klimaatverandering<br>National Research Programme on Atmospheric Pollution and Climate Change |
| NOWESP | Northwest European Shelf Programme |
| NSDW | Norwegian Sea Deep Water |
| NWO | Nederlandse Organisatie voor Wetenschappelijk Onderzoek<br>Netherlands Organization for Scientific Research |
| OBM | Oil Based (drilling) Muds |
| PFD | Photon Flux Density |
| RGD | Rijks Geologische Dienst |
| RIKZ | Rijksinstituut voor Kust en Zee<br>National Institute for Coastal and Marine Management |
| RUG | Rijksuniversiteit Groningen<br>University of Groningen |

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| RUU | Rijksuniversiteit Utrecht<br>University of Utrecht |
| RWS | Rijkswaterstaat<br>Department of the Ministry of Transport and Public Works |
| SPMW | Subpolar Mode Water |
| STED | Short-Term Dynamics in benthic microbial activities and nutrient fluxes related to sedimentation and current velocities in the Oystergrounds, North Sea |
| TNO | Toegepast Natuurwetenschappelijk Onderzoek<br>Applied Research Netherlands |
| TRIPLEB | Bay of Biscay Boundary |
| TROL | Temperature Resistivity Oxygen Lander |
| TUD | Technical University Delft |
| SPMW | Sub-polar Mode Water |
| ULB | Université Libre Bruxelles |
| UvA | Universiteit van Amsterdam<br>University of Amsterdam |
| VU | Vrije Universiteit Amsterdam<br>Free University Amsterdam |
| VvA | Verstoring van Aardsystemen (NWO) |
| WHP | WOCE Hydrographic Programme |
| WOCE | World Ocean Circulation Experiment |