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ANNUAL REPORT 1990

Post Office
HOLLAND
Institute for Sea Research
P.O. Box 100
1700 AA IJmuiden



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Correspondence should be addressed to the editor-in-chief, J.J. Beukema, Netherlands Institute for Sea Research, P.O. Box 59, 1790 AB Den Burg, Texel, The Netherlands, telephone 02220 - 69362, telefax: 02220 - 19674.

This Annual Report was produced under the responsibility of the directors:

W.G. MOOK, M.J. RIETVELD AND E. VAN ABS

It was edited by the staff members: H.A. VAN AKEN, G.C. CADÉE AND P. DE WOLF

Read for English by:

B. BAK

Layout:

N. KRIJGSMAN

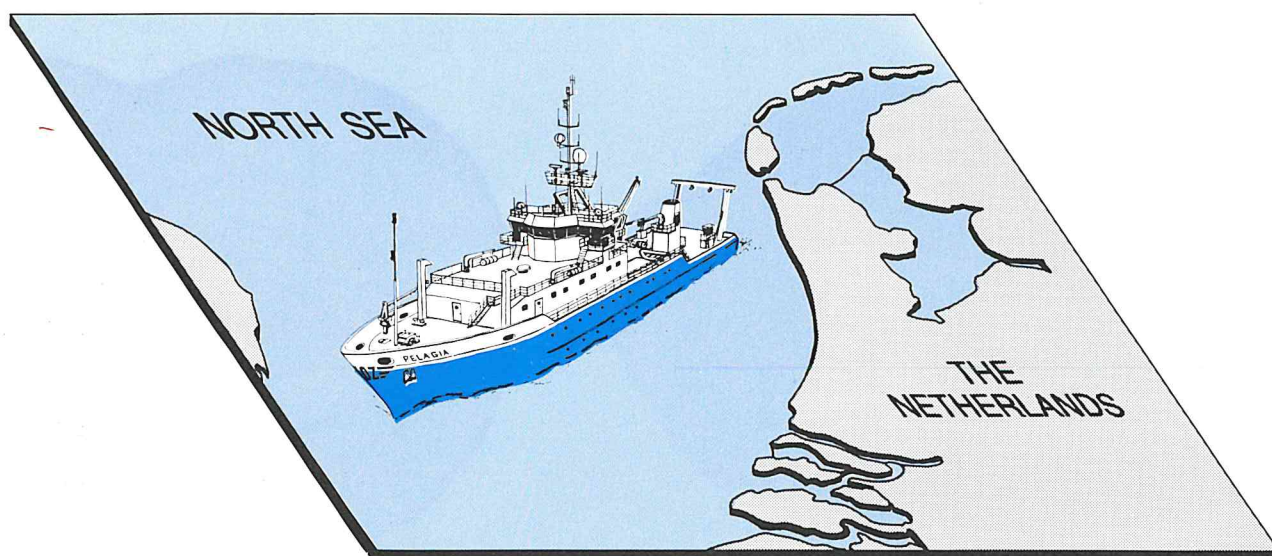
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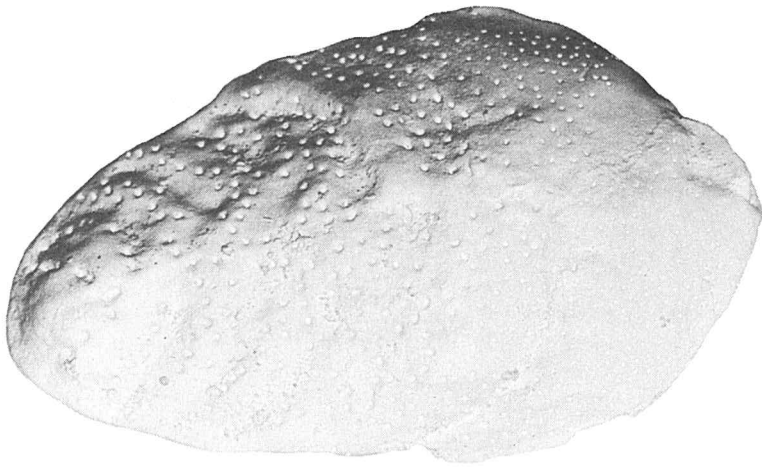
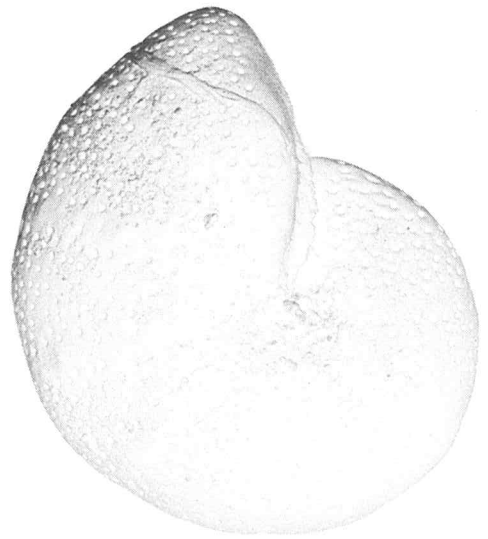
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1. Scientific activity

1.1. INTRODUCTION

While in the previous annual report 1989 was indicated as a tumultuous year, 1990 was one of stabilization and adjustment to new regimes and conditions: a new mother institution and financial source, viz. the Netherlands Organization for Scientific Research (NWO) with NIOZ as a foundation with its separate board, budget and personnel. This foundation belongs to the Science Board for the Biological, Oceanographic and Earth Sciences (BOA). The team of directors was completed by the appointment of Prof. Dr. W.G. Mook, formerly physics professor at, and still part-time attached to, the University of Groningen. The distribution of responsibilities of the directors team was changed to a structure with Drs. M.J. Rietveld as director of general matters, ing. E. van Abs as technical/administrative director and Prof. W.G. Mook as scientific and chief director. The new organization brought NIOZ several memorable visits, e.g. of the minister of Education and Science, Dr. J. Ritzen, on August 15, of the board members of NWO and BOA, and of the ambassador of New Zealand.

The internal structure of NIOZ with a mainly disciplinary subdivision into 6 departments has remained unchanged: chemical oceanography, physical oceanography, marine geology and three marine biological groups: benthic, pelagic and coastal systems. The members of the department responsible for policy-directed (applied) research, BEWON, which receives additional outside funding from various ministries, are, more or less, incorporated within the various disciplinary departments.

Gradually, recommendations of the international Evaluation Committee of 1989 are being materialized, guided by the newly appointed Science Committee consisting of 8 national and international experts in various fields from various institutes. In 1990 the committee held two meetings at Texel in which the research work of departments was discussed and proposals for NIOZ graduate student positions were reviewed.

One of the strong recommendations of the Evaluation Committee, the implementation of a post-doc programme, which receives a high priority of NIOZ, has come into effect with considerable support from NWO. The appointment of young scientists with specific experience to key projects and to departments which require structural support will be a great stimulation.

The relations and cooperation with various university faculties were further strengthened by the appointment of Dr. D. Eisma as part-time professor of Marine Sedimentology at the Utrecht University and Dr. P.A.W.J. de Wilde as part-time professor of Marine Zoology at the University of Groningen. Through these appointments and as a consequence of an increasing interest in marine research and the extension of marine graduate courses at universities, the involvement of NIOZ scientists in education is growing. Many of these activities, however, have an *ad hoc* and voluntary basis. It would be more practical and appropriate if they were formally incorporated in the framework of a graduate (research) school joined with university centres of physical oceanography and meteorology, and of marine biology and geology. Actions for obtaining a formal recognition of such a graduate school are under way.

One of the highlights of 1990 certainly was the laying down of the new NIOZ research vessel 'Pelagia', meant for North Sea and nearby ocean research. The capacity of this ship will be considerably larger than that of the present RV 'Aurelia', which is to be replaced in April 1991.

Marine research is receiving heavy impulses these days by the growing concern of humanity about anthropogenically induced global change, contaminating effects on coastal seas and non-sustainable developments such as overfishing. The year 1990 has become 'the year of the programmes'. Since 1989 NIOZ is actively involved in JGOFS and WOCE, programmes of IGBP and WCRP, respectively. NIOZ has furthermore shown interest in taking part in the IGBP established programme PAGES and in the proposed programme LOICZ. On a national scale NIOZ obtained approval and financial support for various projects belonging to the NOP and has applied for support as well as coordinating tasks in NWO programmes belonging to VvA. Also the number of projects granted by the European Community has increased substantially. Finally some contracts were entered dealing with specific questions concerning anthropogenic changes in the Wadden Sea and the North Sea.

Involvement in these programmes greatly stimulates international cooperation and helps maintain the scientific level of the institute. On the other hand, we feel a growing concern for the fundamental, non-applied and 'useless' aspects of marine research.

Again in 1990 several meetings profited from the facilities of NIOZ for hosting conferences of up to 200 participants. The largest was the Flatfish Symposium which was attended by 110 scientists from 20 nations.

On October 14 NIOZ had open house. Over 2000 visitors from Texel and the mainland wandered through the institute and were introduced to selected topics of marine research. Many of them made improvised short boat trips as well.

The Netherlands Journal of Sea Research has continued to publish two volumes annually (25 and 26). The publication of the Proceedings of the Snellius-II Symposium was completed.

In connection with JGOFS legs 3 and 4 (legs 1 and 2 in 1989) and WOCE the RV 'Tyro' spent 100 days on the north and mid-latitude Atlantic Ocean. The RV 'Aurelia' continued to be almost fully employed in short-term and medium-term North Sea expeditions, while the other RVs 'Navicula' and 'Griend' were concerned with research on the Wadden Sea.

Apart from these Dutch (contributions to international) programmes, NIOZ scientists and analytical staff joined foreign expeditions. A group of 7 NIOZ employees joined an Antarctic programme in early December on the Polish Antarctic station Arctowski, organized by the SOZ and its Antarctic Committee, directed both at terrestrial and marine research. NIOZ scientists incidentally were on board the French RV 'Marion Dufresne' in the western Mediterranean (EROS-2000).

During 1990 a number of new contacts were made with colleagues from abroad, especially the Soviet Union, more specifically from Moscow University, the Sewastopol Marine Research Station, the Marine Biological Station at Murmansk and the Shirshov Oceanology Institute of the Academy of Science in Moscow. NIOZ scientists have shown interest in these new cooperations, for which most projects still are to be specified partly together with other Dutch institutes such as, for instance, DIHO.

Based on the preparative work in 1990, we expect NIOZ to flourish under favourable conditions in 1991. We hope and trust that NIOZ scientists have now entered a year in which they can reap the fruits of all their planning and paper work and of the skilful preparations and guidance of the technical staff for our new ship.

W.G. Mook

1.1.1. Multidisciplinary programmes

H.M. van Aken

World Ocean Circulation Experiment (WOCE)

The World Climate Research Programme has been initiated to determine whether climate changes can be predicted and to assess the influence of human activities on climate. The most serious scientific problem in predicting climatic changes from a few decades to centuries ahead is the inability to describe and model the ocean circulation with sufficient accuracy. In order to improve this situation, SCOR/ICSU and IOC/UNESCO initiated WOCE.

The goals of WOCE are 1) to develop ocean circulation models for the prediction of climate change and to obtain observations to test and validate such models and 2) to determine the representativity of specific WOCE data for the long-term behaviour of the ocean circulation. Important observational parts of WOCE are the large-scale hydrographic and tracer survey of the global ocean, the use of moored current meters in 'choke-points' of the circulation and seasonally repeated CTD and XBT surveys.

At several institutes and universities in the Netherlands WOCE-related research is carried out in the fields of modelling, satellite altimetry and hydrography. These efforts are coordinated by an ad-hoc group instituted by the Commission for Physical Oceanography of the Foundation for Marine Research (SOZ).

The Dutch contribution to the observational part of WOCE will be carried out within the 'DUTCH-WARP' programme, described in section 1.3. This is a two-year programme, planned for 1990-91 with a possible extension till 1995.



European Polarstern Study (EPOS) and follow-up

C. Veth

The European Polarstern study is an international project organized and partially sponsored by the European Science Foundation (ESF) and the Alfred-Wegener-Institute (Bremerhaven, FRG). The project is in its working-out phase and many results have been presented at the different symposia on polar research held this year (among others: the 22nd International Liège Colloquium on Ocean Hydrodynamics (marginal ice zones), the Southern Ocean Symposium (Brest) and the PRO-MARE Symposium (Trondheim)). This project will reach its official end during the EPOS-Symposium in Bremerhaven, May 1991, but during the Brest symposium on the Southern Ocean plans were discussed for international cooperation in Antarctic research with a number of research vessels from different countries. During this meeting a new JGOFS/Southern Ocean working group under SCAR/SCOR was proposed. NIOZ has been invited by the Alfred-Wegener-Institute to help organize a cruise in the framework of JGOFS/Southern Ocean in the austral spring of 1992 with RV 'Polarstern'. This cruise can be seen as a natural follow-up of the EPOS-project and the Dutch JGOFS expeditions in the North Atlantic Ocean.

North Atlantic Pilot Study of the Joint Global Ocean Flux Study

H.J.W. de Baar

The Joint Global Ocean Flux Study is focussing on the role of the oceanic carbon cycle in regulating the atmospheric CO₂ content and has a strong emphasis on biological and chemical processes. JGOFS is a core project of the International Geosphere Biosphere Programme (IGBP) and operates under the aegis of the Scientific Committee for Oceanic Research (SCOR), all part of the International Council of Scientific Unions (ICSU). Scientists of NIOZ and several universities actively participate in the first JGOFS project, the 1989-1991 North Atlantic Pilot Study executed aboard RV 'Tyro' (NWO/SOZ) and ships from five other countries.



Rendez-vous with R.V. 'Charles Darwin' for intercalibration.

Results of the 1989 expeditions were presented and compared at a data workshop hosted by the Institut für Meeresforschung, Kiel, March 1990. By combining data from several countries the time evolution of the spring bloom was reconstructed in terms of a mass balance for carbon in the surface waters at three major sites along the 20°W meridian (33°N, 20°W; 47°N, 20°W and 60°N, 20°W).

RV 'Tyro' left Den Helder on 17 April for the third JGOFS leg via Funchal (Madeira) to Reykjavik (Iceland) and the fourth leg from Reykjavik to Galway (Ireland). During JGOFS Leg 3 the main emphasis was on pelagic processes while during leg 4 mainly benthic processes were studied. Reports on these studies are given in the sections of the different scientific departments.

The first JGOFS Symposium at the National Academy of Sciences, Washington D.C., 26-28 November 1990, was co-organized by The Netherlands. Results of the 1989 campaign were integrated in a suite of presentations co-authored by several NIOZ scientists, with additional contributions during panel discussions. In addition the Dutch JGOFS team presented eight separate papers on their observations in both 1989 and 1990.

The Netherlands' JGOFS group is planning participation in the coming JGOFS Process Studies in the Southern Ocean (1992/1993) and the Indian Ocean (1994), with major contributions by NIOZ envisioned in collaboration also with leading institutes in Germany. Several NIOZ scientists have been invited to serve in SCOR/JGOFS Working Groups dedicated to such themes as Process Studies, Benthic Processes, Modelling and Data Management.

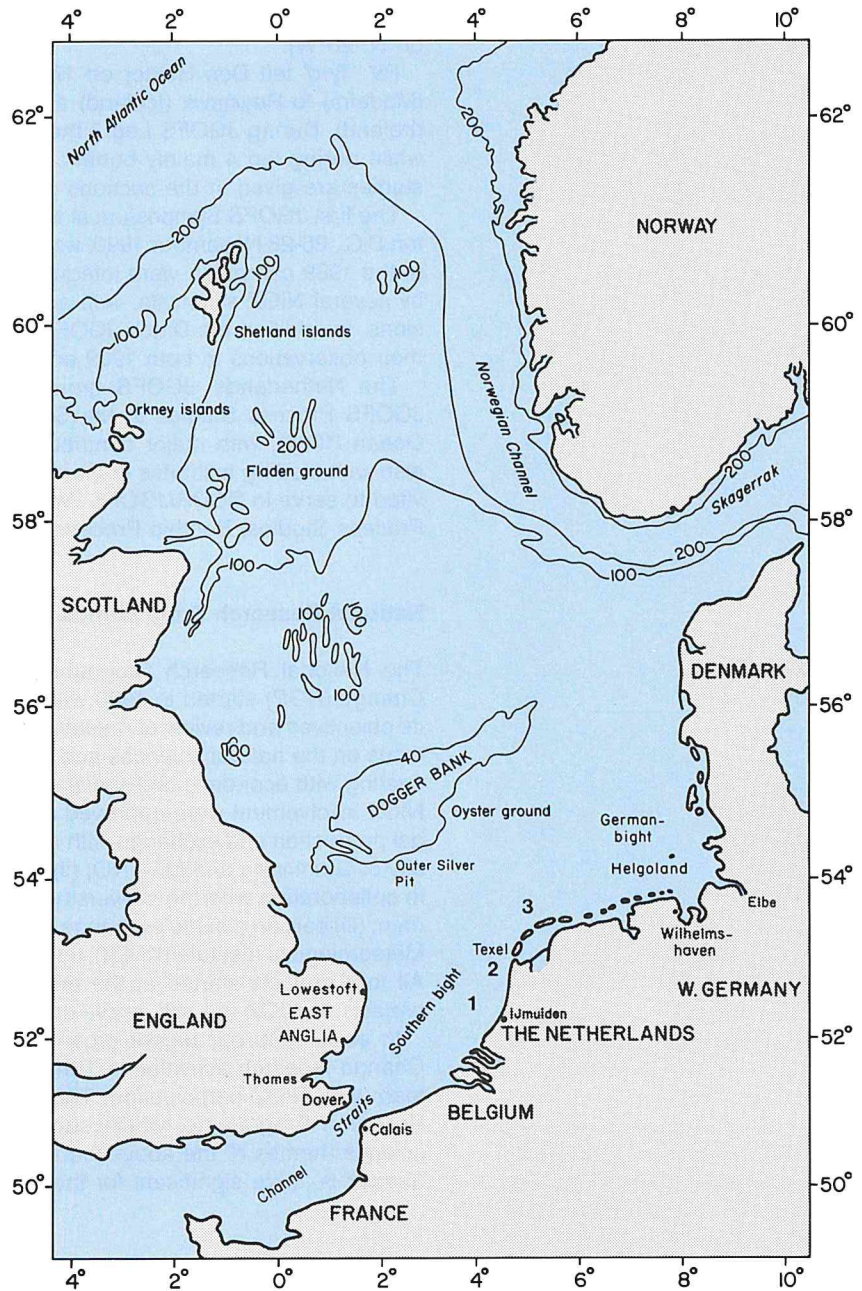
National Research Programmes on Global Change

H.J.W. de Baar

The National Research Programme on Atmospheric Pollution and Climate Change (NOP) started in 1990 with contributions from NIOZ towards defining its objectives and review of research proposals. Three of the five major themes focus on the natural sciences and are directly relevant for NIOZ, other themes dealing with economic and social impact. In this first year several projects with NIOZ involvement were approved and granted: (i) DiMethylSulphide (DMS) algal production and exchange with atmosphere, in collaboration with the University of Groningen and MT-TNO; (ii) The role of *Emiliana huxleyi* in the C cycle, in collaboration with the University of Leiden and the Free University, Amsterdam; (iii) carbon dioxide exchange ocean/atmosphere, with linkage to the Royal Meteorological Institute (KNMI); (iv) nitrous oxide exchange ocean/atmosphere. All four projects started at the end of the year; additional proposed climate projects of NIOZ are still in evaluation.

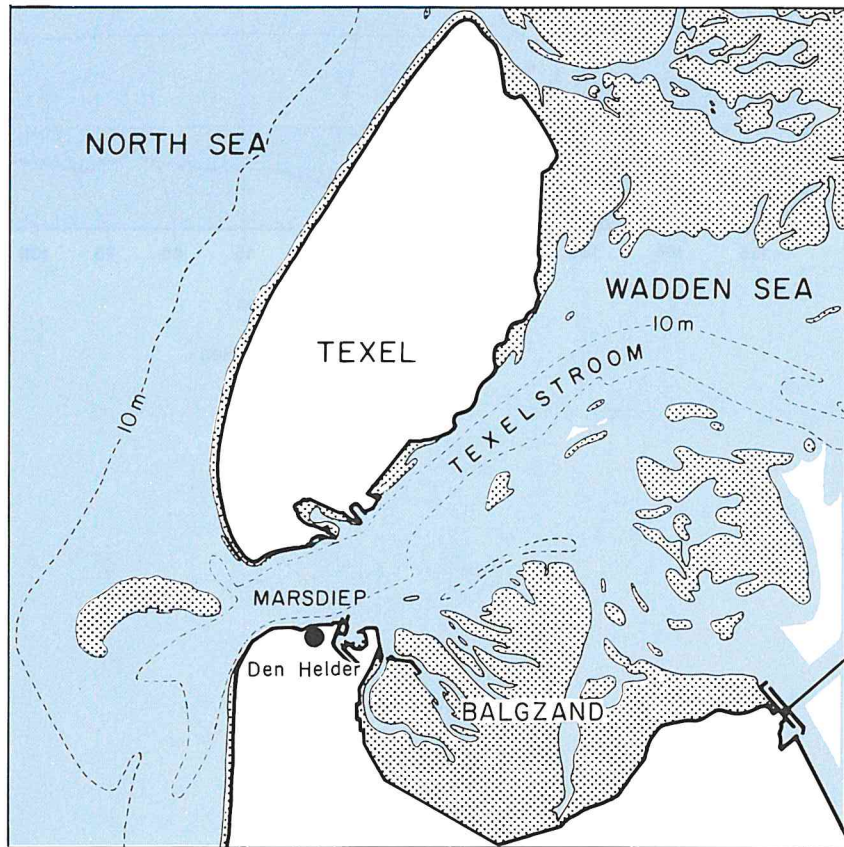
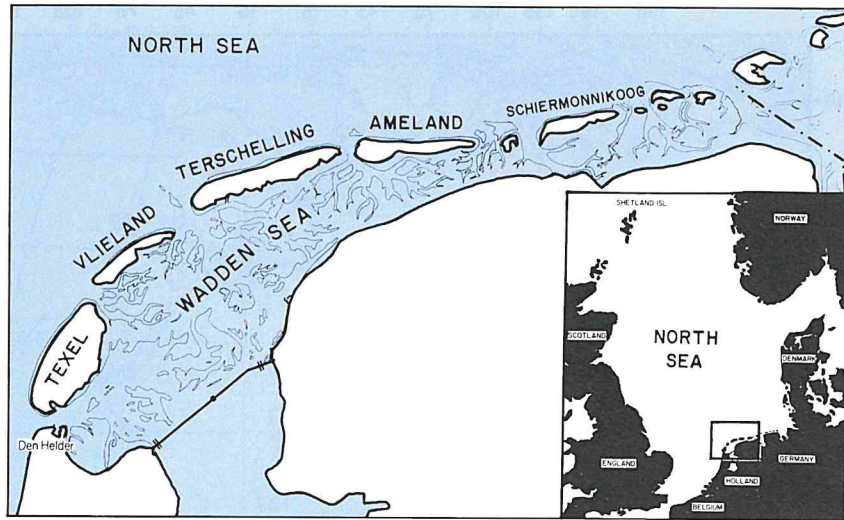
In early 1990 our parent organization NWO published a review of Global Change research activities in The Netherlands as prepared by an NWO task team with NIOZ participation. This led NWO to establish the Global Change Research Programme, which subsequently was integrated with the natural science themes of the above-mentioned NOP. This joint platform will be, and already is, quite significant for the stimulation of climate research at NIOZ.

1.1.2. Maps

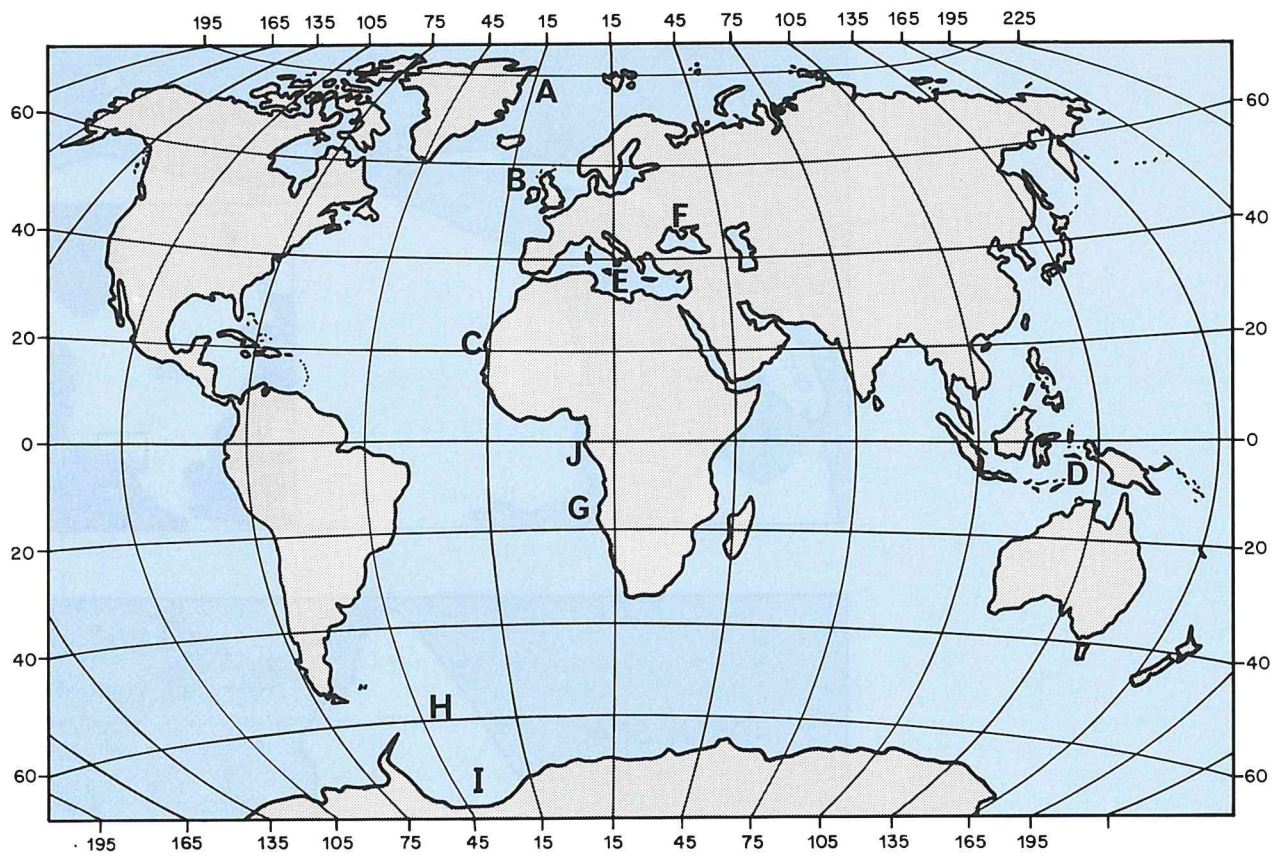


- 1 = Brown Ridge
- 2 = Breeveertien
- 3 = Frisian Front

North Sea with geographical names mentioned in this report.



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



- | | |
|-----------------------|-----------------------|
| A = Greenland Sea | B = NE Atlantic Ocean |
| C = Mauritania | D = Indonesia |
| E = Mediterranean Sea | F = Black Sea |
| G = Angola Basin | H = Scotia Sea |
| I = Weddell Sea | J = Zaire Estuary |

1.2. CHEMICAL OCEANOGRAPHY AND MARINE POLLUTION (H1)

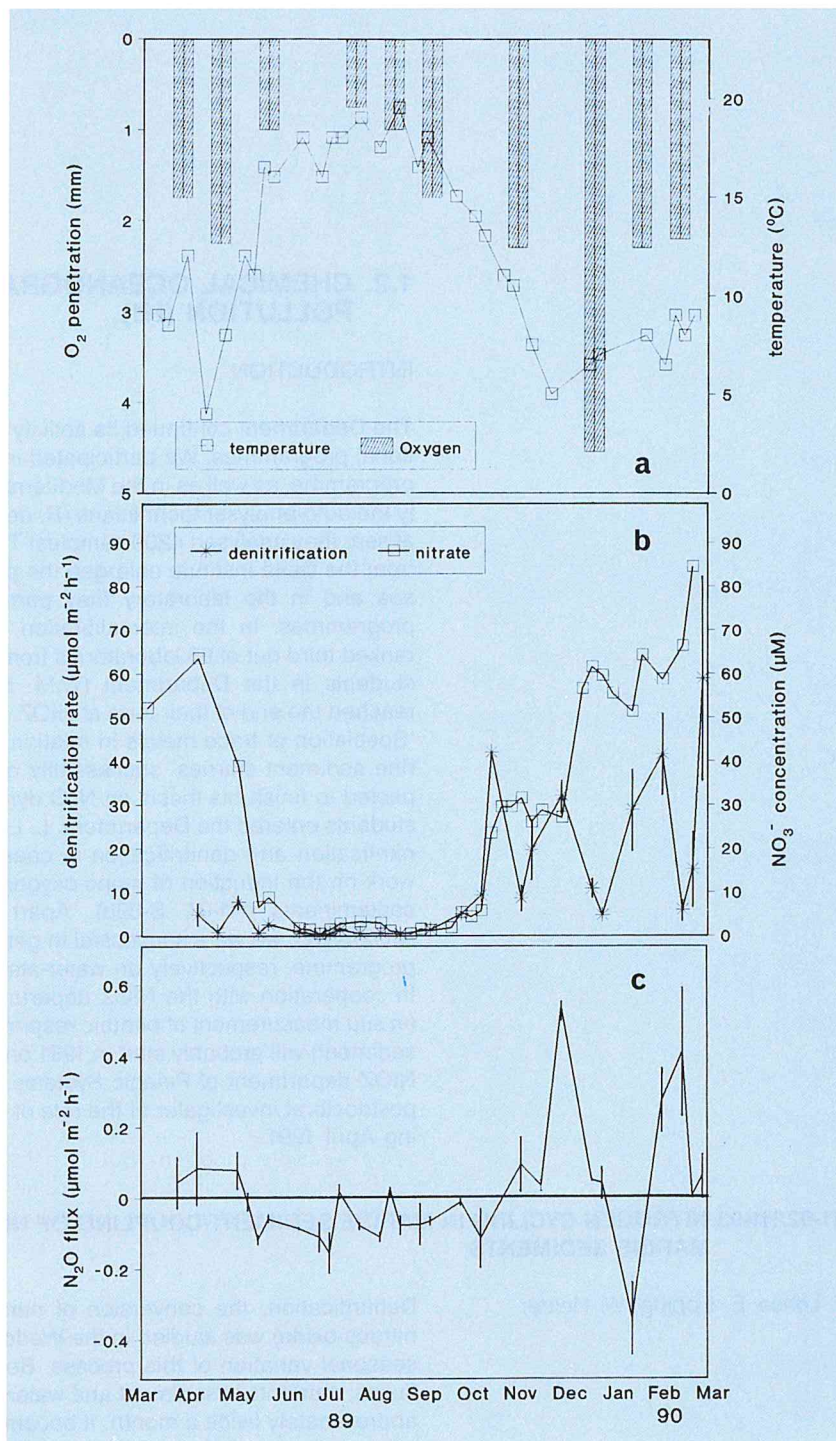
INTRODUCTION

The Department continued its activity in the ongoing multidisciplinary, international programmes. We participated in JGOFS legs 3 and 4 and in the WOCE programme, as well as in the Mediterranean EROS-2000 programme. Especially the auto-analyser technicians (R. de Vries and K. Bakker) spent many weeks at sea; they analysed 4200 samples! The training of technicians from NIOZ and from the Delta Institute enlarged the pool of personnel for this type of work. At sea and in the laboratory they participated in international intercalibration programmes. In the intercalibration for nutrients, organized by ICES, they ranked third out of 65 laboratories from Europe and the U.S. Three of the Ph.D. students in the Department (W.M. Kieskamp, C. Westra and L. Gerringa) reached the end of their term at NIOZ. L. Gerringa (H1-05) defended her thesis: 'Speciation of trace metals in relation to degradation of organic matter in marine sediment slurries' successfully on September 14. W.M. Kieskamp is expected to finish his thesis on N_2O dynamics in the course of 1991. New Ph.D. students entered the Department. L. Lohse (H1-02/03) started his work on N_2O , nitrification and denitrification in coastal systems and H.J. Sleiderink started work on the induction of mono-oxygenase enzyme systems by organic micro-contaminants (H1-07, S-02b). Apart from funding of Ph.D. positions by NIOZ/NWO, we were successful in getting funds for such positions in the NOP programme, respectively on water-atmosphere exchange of CO_2 and of N_2O . In cooperation with the NIOZ department of Benthic Systems a Ph.D. project (*in situ* measurement of benthic respiration and oxygen distribution in deep-sea sediment) will probably start in 1991 on EC-STEP funds. In cooperation with the NIOZ department of Pelagic Systems, we appointed Dr. K.L. Timmermans as postdoctoral investigator of the role of iron (Fe) in phytoplankton ecology, starting April 1991.

H1-02/H1-03 NITROGEN CYCLING IN MARINE SEDIMENT/COUPLING OF NITROGEN AND SULPHUR CYCLING IN MARINE SEDIMENTS

L. Lohse, E. Epping, W. Helder

Denitrification, the conversion of nitrate to gaseous products (nitrogen and nitrous-oxide) was studied in the Wadden Sea. Most attention was given to the seasonal variation of this process. Besides denitrification rates, nitrous oxide fluxes, nutrients in sediment and water and oxygen penetration were measured approximately twice a month. It became obvious that nitrate from the overlying water was one of the most influential factors on benthic denitrification rates.



a. Seasonal oxygen penetration depths in the sediment and temperature in overlying water (NIOZ-harbour); b. Seasonal benthic denitrification rates and nitrate concentrations in overlying water (NIOZ-harbour). Drawn bars indicate standard deviation of denitrification rates ($n=3$); c. Seasonal fluxes of nitrous oxide from sediment to water and nitrate in overlying water (NIOZ-harbour). Drawn bars indicate standard deviation of nitrous oxide fluxes ($n=3$).

During winter, at high nitrate concentrations, rates were between 30 and 60 $\mu\text{mol N m}^{-2}\cdot\text{h}^{-1}$. After depletion of nitrate by the phytoplankton bloom in April denitrification decreased simultaneously to rates between 1 and 2 $\mu\text{mol N m}^{-2}\cdot\text{h}^{-1}$. Addition of organic matter and nitrate verified the nitrate dependence of denitrification. However, the rates were also influenced by nitrification, oxygen distribution within the sediment, bioturbation etc. A similar seasonal pattern has been measured for the greenhouse gas nitrous oxide. Also the fluxes of N_2O seemed to be mainly controlled by nitrate from the overlying water. For the first time long-consistent nitrous-oxide influxes (50 to 300 $\text{nmol N m}^{-2}\cdot\text{h}^{-1}$) were measured during the nitrate-depleted period in summer. This shows that the Wadden Sea can act as a sink of nitrous oxide during summer, while during higher nitrate concentrations (winter and spring) the influx turns into an efflux (100-500 $\text{nmol N m}^{-2}\cdot\text{h}^{-1}$). The threshold for this turning point from in- to effluxes was 6-10 $\mu\text{mol}\cdot\text{dm}^3$ nitrate. The influxes were explained by the fact that denitrifying bacteria can use nitrous oxide instead of nitrate as terminal electron acceptor.

In August a comparative investigation on nitrogen cycling in the Dutch and German Wadden Sea was started. At different tidal flats between the Jadebusen (Germany) and the island of Texel, denitrification rates, nitrous-oxide fluxes, potential denitrification, bacterial counts (MPN) and other factors are being investigated. Preliminary results show distinct differences of benthic nitrogen cycling in certain parts of the Wadden Sea during summer. This has especially been found in the Ems-Dollard estuary, which shows very high nitrous-oxide fluxes (on average 10 times higher than near Texel).

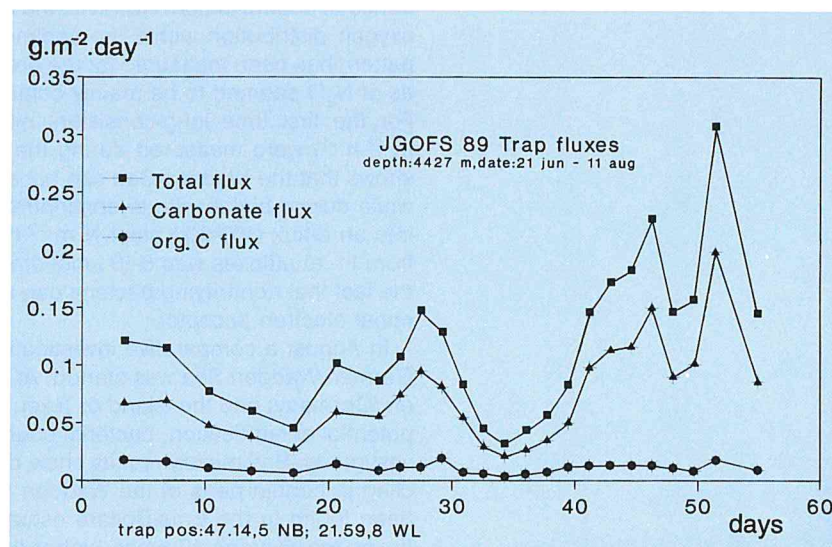
Furthermore we have compared different techniques to measure nitrification (low-acetylene-application, Allylthiourea and N-Serve) on intertidal flats and North Sea mesocosms.

H1-04 EARLY DIAGENETIC PROCESSES AND ORGANIC CARBON MINERALIZATION IN MARINE SEDIMENTS

W. Helder, E. Epping

Samples from the JGOFS 89 and JGOFS 90 surveys were analysed for solid and dissolved phase metals, for organic C, N and carbonate. In cooperation with the Department of Marine Geology of the Free University Amsterdam we analysed the samples from the moored sediment traps, in order to quantify the total mass flux, the organic C flux and the carbonate flux from the productive surface layer of the ocean to the sediment.

From interpretation of the data the following picture of sediment organic C mineralization along the transect from 60°N-30°N, along 20°W in the North Atlantic develops: North of 52°N (position of the sub-polar frontal system) surface waters are not completely depleted in nutrients, making 'new production' on nitrate relatively important. South of the frontal system, surface waters have very low nutrient contents and productivity will be mainly of a 'regenerative' nature. These differences of productivity in the surface water are well reflected in organic C mineralization in the sediment. North of 52°N organic C mineralization in the sediment is relatively high, as can be judged from the oxygen penetration into the sediment to about 10 cm, while south of 52°N organic C mineralization is relatively low (oxygen penetration into the sediment $> > 20$ cm). One of the implications of these observations is that sinking of organic C particles from the surface layers must be relatively rapid, without much lateral dispersion. Calculated organic C mineralization rates are, especially when *in situ* measured oxygen profiles are used, 50 to 100% higher than previously thought.



H1-06a ANALYTICAL ORGANIC CHEMISTRY

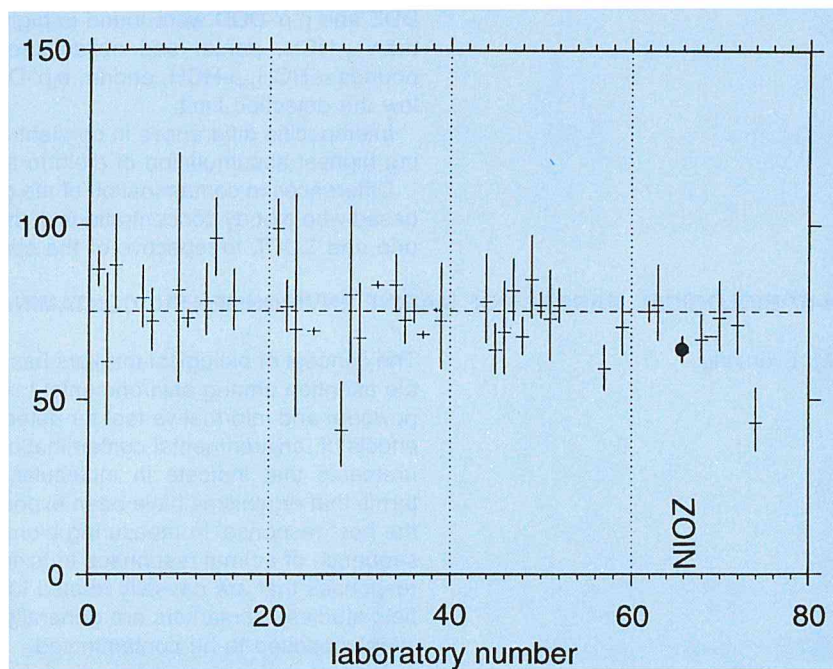
M.Th.J. Hillebrand, K. Booij

This year, much effort has been put into maintaining a high level of accuracy. Thus, in collaboration with the Delta Institute for Hydrobiological Research, a new reference solution of polychlorinated biphenyls (PCBs) was prepared from pure congeners. A start has been made with a system of quality control for PCB and pesticide analysis. Implementation and extension of this system will require substantial effort in the future.

As a part of the quality control effort, we took part in the ICES intercalibration exercise for analysis of PCBs. During this exercise a variety of experimental conditions were used for PCB analysis on gas-chromatograph (GC) with electron capture detection (ECD). Conditions were optimized when appropriate. An unknown solution of various PCB congeners was analysed. The reproducibility of the test results was good; absolute amounts were too low by 15%. This was due to the use of single point calibration. FIG.

Column chromatography is still in use for sample clean-up and pre-separation of PCBs and pesticides. Previously, a High Performance Liquid Chromatography (HPLC) method was set up as an alternative to the classic column chromatography. This year efforts have been directed towards automated operation of the HPLC method.

Results of CB 28. Mean concentrations with 95% prediction-interval (twice the standard deviation of the observations) versus the laboratory number. The broken horizontal line shows the true value.



H1-06b IDENTIFICATION AND QUANTIFICATION OF ORGANIC MICROCONTAMINANTS AND THEIR FATE IN THE MARINE ENVIRONMENT

J.M. Everaarts

The concentration of cyclic organochlorine pesticides, their persistent metabolites, and polychlorinated biphenyls (PCBs) were determined in benthic invertebrate species, representing the phyla Annelida (polychaete worms), Arthropoda (crab and shrimp) and Mollusca (Bivalvia), from three estuarine mud-flat areas along the Malay Peninsula (Thailand and Malaysia).

Polychlorinated biphenyls: In organisms from the contaminated Pattani Bay (Campus, Laem Nok and Ban Da To), PCB concentrations were elevated compared to organisms from two other areas (Bay of Surat Thani and the coastal area of Jeram, Malaysia), particularly in bivalves (*Glauconome virens* and *Potamocorbula fasciata*) and shrimp (*Metapeneaus lysianassa*).

Bivalve molluscs showed significant interspecific differences in the Σ PCB concentration, independent of the number of individual CB-congeners taken into account for Σ PCB: *G. virens* and *P. fasciata* with high concentrations (290 and 170 ng·g⁻¹ PEL (pentane extractable lipids), resp.) and in the green mussel (*Perna viridis*) and in the bloody cockle (*Anadara granosa*) with lowest concentrations measured (46 and 31 ng·g⁻¹ PEL, resp.).

Pesticides: In all species studied, dieldrin, p,p'-DDT and its metabolites p,p'-DDE and p,p'-DDD were found in higher concentrations (10-250 ng·g⁻¹, PEL) than γ -HCH, penta- and hexachlorobenzene (1-15ng·g⁻¹ PEL). The compounds α -HCH, β -HCH, endrin, o,p'-DDD and metoxychlor were generally below the detection limit.

Interspecific differences in concentration levels were found, with crab showing highest accumulation of dieldrin and p,p'-DDE.

Differences in contamination of the coastal areas monitored in terms of lipid-based whole-body concentrations of the organisms could be described for dieldrin and Σ DDT, irrespective of the species sampled.

H1-07 BIOLOGICAL MARKERS OF MARINE ENVIRONMENTAL CONTAMINATION

J.M. Everaarts

The concept of biological markers has, the past few years, received considerable attention among environmental toxicologists as a new and potentially very powerful and informative tool for detecting and documenting exposure to, and effects of, environmental contamination. Biomarkers can be defined as measurements that indicate in molecular, biochemical, physiological or cellular terms that organisms have been exposed to a chemical, and the magnitude of the host response. In measuring biomarkers we regress down the conceptual sequence of animal responses to toxicant exposure in order to examine early responses that are causally related to, or predictive of, longer-term effects. In field studies, biomarkers are generally measured in organisms collected from sites supposed to be contaminated.

A guest assignment, within the framework of the Exchange Visitor Program of the Oak Ridge National Laboratory (ORNL, Oak Ridge, Tennessee, U.S.A.), was obtained at the Environmental Sciences Division (ESD), to participate in both experimental and field research on biological marker responses. Research was carried out in cooperation with Dr. L.R. Shugart at the Environmental Toxicology Section of the ESD. The studies involved the determination of DNA damage (DNA strand-breaks and adducts) in fish exposed to genotoxic agents and participation in the biological monitoring programme, applying biomarker responses in environmental assessment.

Two experimental studies were performed with the polyaromatic hydrocarbon benzo[a]pyrene (BaP), a well-known model substance for a carcinogenic toxicant. The experiment on the uptake of ¹⁴C-labelled BaP in the teleost fish *Oryzias latipes* (Japanese medaka) was carried out to describe the uptake of waterborne BaP in fish and preceded an extensive study to establish the effect of BaP on a set of biological markers, such as DNA damage, induction of the mono-oxygenase enzymes and reproductive responses.

¹⁴C-BaP was found to be taken up in Japanese medaka by a bioconcentration factor of about 1.3 to 3.7 x 10², after 8 days' exposure (whole-body analysis). Analysis of BaP in organs (liver, gonad (ovary), gall-bladder and the carcass) showed that the concentration of BaP in the gall-bladder was surprisingly high compared with the liver and ovary. The concentration in the carcass was always highest.

Preliminary results of the 16-day- exposure experiment indicate minor effects of BaP on the integrity (DNA strand breaks or the percentage of double strandedness of the DNA) of DNA isolated from the liver. Females tend to have higher DNA integrity, *i.e.* fewer strand-breaks, than males. Analyses for the determination of the induction of mono-oxygenase enzymes (E. Tan and R. Eppler) and reproductive responses (M. Greeley and C. Gettys) are still in progress.

Sampling of redbreast sunfish in Hind's Creek (Tennessee), by means of electro-shocking.



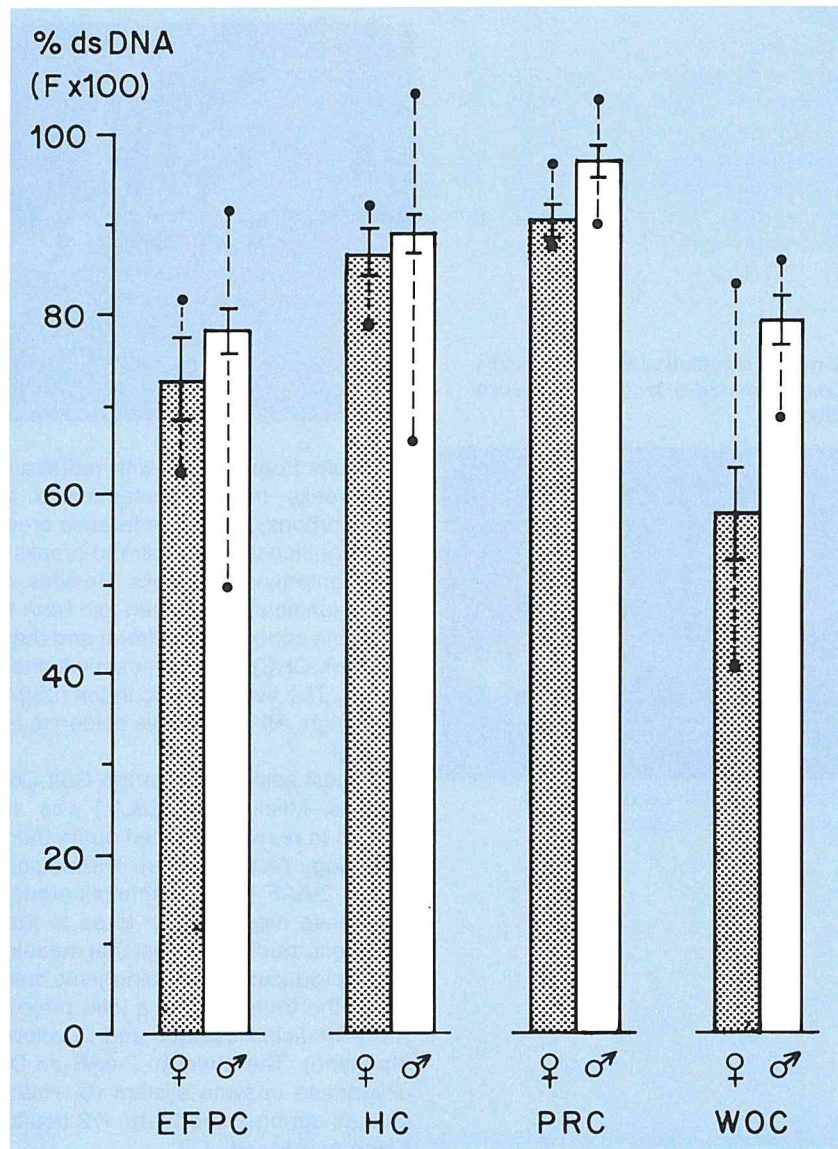
Redbreast sunfish *Lepomis auritus*.
(photos: J.M. Everaarts)

Results from a study with redbreast sunfish *Lepomis auritus* sampled from two creeks mainly contaminated with polychlorinated and polyaromatic hydrocarbons, and two reference creeks, to be considered pristine areas, indicate significantly more strand-breaks in DNA isolated from liver tissue of fish from contaminated creeks. Besides, a number of haematological parameters differ significantly between fish from the different sampling sites: e.g. the haemoglobin concentration (mM) and the mean corpuscular haemoglobin concentration (MCHC) are significantly higher in both males and females from pristine creeks. The liver somatic index (LSI) of fish from contaminated creeks is relatively high. All results give evidence for deleterious effects of the contaminants present.

A guest assignment at the Gulf Coast Research Laboratory (GCRL, Ocean Springs, Mississippi, U.S.A.) was achieved to implement biomarker-based studies in research carried out in the sections Microscopy (W.E. Hawkins) and Toxicology (W.W. Walker). Histological studies have shown that the aromatic amine 2-AAF (2-acetylaminofluorene) is not carcinogenic to *Oryzias latipes* (Japanese medaka), but is so to the *Poecilia reticulata* (King cobra guppy). Metabolic studies suggest that medaka is more efficient in detoxifying AAF than it is in producing the carcinogenic metabolites. An experiment has been carried out in the framework of a joint project of the GCRL, ORNL-ESD and the U.S. Army medical Research and Development Command (Fort Detrick, Frederick, Maryland). The effect of 2-AAF on DNA damage and induction of the mono-oxygenase enzyme system (C. Heard) in the medaka and guppy has been studied during a short-term (72 hours) exposure to 2.5 ppm AAF. The data are being processed.

A field study was carried out in the estuarine and coastal area of Southern Mississippi. From a number of contaminated sites and pristine reference areas, hardhead catfish (*Arius felis*), a common and representative species, were sampled. Responses of the above-mentioned biological markers were measured in adult male, female and juvenile fish. In general, the data agree with the results of the study carried with the redbreast sunfish: high LSI and lower haemoglobin concentration and MCHC in specimens from contaminated areas and higher percentage of double-stranded DNA (fewer strand-breaks) in fish from the reference sites. However, the individual differences in the responses of the biomarkers are large, reflected in high standard deviations.

Percentage double-stranded DNA (\pm SD and min/max values) in female and male specimens from field population of East-Tennessee creeks of redbreast sunfish *Lepomis auritus*. EFPC: East Fork Poplar Creek (contaminated); HC: Hind's Creek (pristine); PRC: Painted Rock Creek (pristine); WOC: White Oak Creek (contaminated).



H1-09 EXCHANGE OF ORGANIC CONTAMINANTS BETWEEN SEDIMENT AND WATER

K. Boojj

Transport of organic contaminants between sediment and water takes place whenever the equilibrium distribution is disturbed.

To determine whether sediment and overlying water are in equilibrium, knowledge of the sediment-water partition coefficient is necessary. This is the ratio of the concentration in the sediment and the concentration in the water phase. The partition coefficient can be determined in the laboratory, by

equilibrating volumes of sediment, water, and an amount of contaminant. After a certain equilibration time the phases are separated by filtration or centrifugation and the concentrations determined.

A problem in the determination of partition coefficients is the incomplete phase separation between sediment and water. Thus, very small sediment particles and colloids end up in the water phase, but actually belong to the sediment phase. As a result, the concentration of hydrophobic contaminants in the water phase is overestimated.

This year a procedure has been developed to determine separately the concentrations of truly dissolved contaminants and particle-bound contaminants in the water phase. This method is based on the principle that dissolved contaminants are readily adsorbed from the water phase by teflon beads, and that the contact time between the teflon beads and the water phase is sufficiently short to prevent desorption of particle-bound contaminants. The effect of insufficient phase separation has been shown to be important for contaminants that are more hydrophobic than hexachlorobiphenyls.

H1-12 EXTRACTION OF DISSOLVED PCBs FROM THE WATER PHASE

M.Th.J. Hillebrand, K. Booij

The water phase is an important medium that links the various environmental compartments: sediment, biota, suspended matter and atmosphere. Accurate knowledge of the concentration of organic contaminants is thus of crucial importance for modelling contaminant transport. The low concentrations of chlorinated hydrocarbons in the open sea and oceans require large water volumes of up to 500 dm³. Blank problems and low extraction efficiencies are commonly encountered in the procedures currently used.

In laboratory experiments, two different methods for the extraction of dissolved chlorinated hydrocarbons have been compared. In one method dissolved contaminants are removed from the water phase by liquid-liquid extraction (LLE). In the second method dissolved contaminants are adsorbed by a solid adsorbent (XAD2). The laboratory experiments have been extended to field measurements during a cruise in the Southern North Sea.

Three water samples (100 to 200 dm³) were filtered over a 1 µm glass fibre filter. A spike of PCB 88 was added to the water. The water volume was split into two sub-samples. One sub-sample was extracted by LLE, the other with XAD2. Drain water of the XAD2 columns was subsequently extracted by the LLE procedure. Extraction efficiencies were tested by repeated application of the procedure, *i.e.* second extractions, and by calculation of the amount of PCB 88 removed. Procedure blanks were run before field samples were treated.

Field measurements have confirmed the observations of the laboratory experiments: (1) The XAD2 procedure removes less PCBs than liquid-liquid extraction. Amounts of hexachlorocyclohexanes are equal for both procedures; (2) The spike of PCB 88 is not quantitatively recovered, not by LLE nor by XAD2; (3) Analysis of the amounts remaining in the XAD2 effluent suggests that the XAD2 procedure removes the dissolved contaminants, and that the LLE procedure removes dissolved and colloiddally bound contaminants; (4) Both techniques suffer from blank problems; XAD2 resin is difficult to clean before use, but sample contamination can easily be avoided.

Although the XAD2 sorption technique is a less complicated procedure and yields information on truly dissolved PCBs, LLE provides better data on total dissolved PCBs.

H1-15 TRACE METALS IN THE OCEANS

River inputs to the Mediterranean (EROS 2000)

R.F. Nolting, J.T.M. de Jong

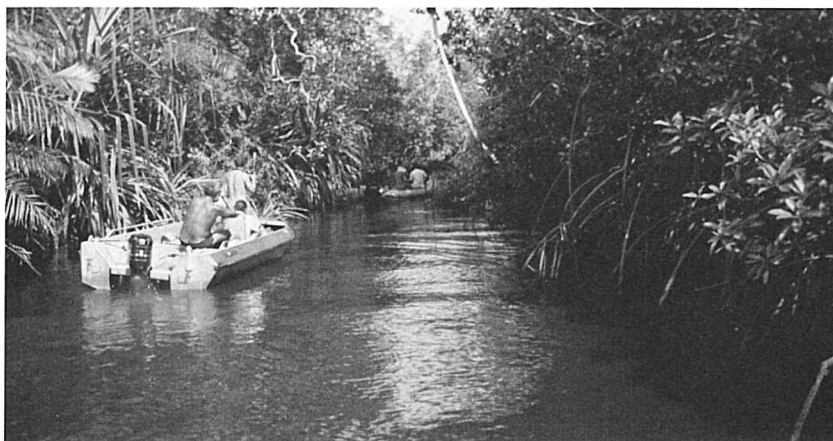
Subsequent to earlier work within the EROS 2000 framework, this year we participated in a cruise with the French RV 'Marion Dufresne'. The purpose of this cruise was to collect extra sediment cores in the Rhône delta, new cores in the Ebro estuary and additional cores in the deeper part of the Mediterranean. In total 15 boxcores were sampled, directly sliced and processed, to obtain the interstitial water, all inside a cool container van. The sediment slices were analysed for the leachable metal fraction and a total residual metal fraction, but definite results are not available yet.

Zaire estuary

R.F. Nolting, H.J.W. de Baar

During the Zaire cruise with the RV 'Tyro' in 1989, samples for trace metal studies were collected in the water column as well as in the sediment, along a transect reaching from fresh to saline water, covering the whole canyon (water depth 200-1500 m). River water was filtered and sediments were sliced and processed immediately after collection.

Dissolved iron concentrations ranged from 1.25 to 12 μM in the freshwater part of the river. At the canyon this concentration increased to 15 μM , while further downstream, at the river mouth, it decreases to 1 μM . Over the continental shelf a further decrease to 5 nM has been observed. Compared with other rivers, iron concentrations in the Zaire river are rather high. The strong pycnocline between river and ocean water in the canyon (within one metre salinity increases from zero to 35) also influences the metal concentrations. The river water in the surface layer contained iron at high concentrations, while below this boundary dissolved Fe levels dropped rapidly with depth. These phenomena were also observed for Cu, Zn, Pb and Ni. Iron concentrations in the interstitial water were extremely high (400 μM) in the anaerobic sediments in the canyon, compared with 40-60 μM in the sandy sediments in the upstream part of the river and 5-20 μM at the end of the canyon and at the most outward station at 4500 meter depth.



Rubber boat sampling for trace metals in river water from the Zaire Estuary.
(photo: R.F. Nolting)

In freshwater, concentrations of zinc and copper were observed to be 100 nM and 20 nM. In the more saline part of the river these concentrations were 10 and 2 nM, respectively. The deep station at 4500 m showed the normal trace metal pattern: low at the surface and increasing with depth. Surface zinc concentration was 2 nM, copper 0.2 nM.

Nickel showed the same distribution as copper and zinc, with concentrations at 2-8 nM, while lead showed sharp decreases in concentration in the canyon part of the river, from 15000 to 500 pM.

Cadmium correlated with phosphate in the watersamples collected at the off-shore Atlantic stations. Their relation is given by the equation $Cd(pM) = 235 PO_4(\mu M) - 167$ with $r=0.92$, similar to earlier published correlations for the East Atlantic. More analyses on the sediment, interstitial water and suspended material have to be carried out before conclusions on processes and distribution patterns can be given. This research is carried out in cooperation with F. Ferreira, Universidade de Sao Paulo, Brazil.

Trace metal distributions in the Southern Ocean (EPOS)

R.F. Nolting, H.J.W. de Baar

During the EPOS 2 cruise in the Scotia Sea, the Weddell Sea and in their confluence, water samples were collected for trace metal determinations along the 49°W meridian. In the upper 300 m samples were collected with high vertical resolution. All samples were filtered over 0.4 μm pore size filters, except for the very surface samples. For several of the determined metals only modest surface depletion was observed.

Cadmium concentrations were low, 0.2 nM in the first 50 m, increasing to 0.8 nM at 300 m in Scotia Sea waters. In the Confluence surface concentrations were 0.4-0.6 nM, reaching 0.8 nM at 300 m. In the Weddell Sea, for most of the time ice covered, surface and 300 m values were almost identical at about 0.6 nM. For phosphate the vertical gradients were similarly stronger in the Scotia Sea than in the Weddell Sea. This suggests that biogeochemical processes were more effective in the Scotia Sea than in the ice-covered Weddell Sea.

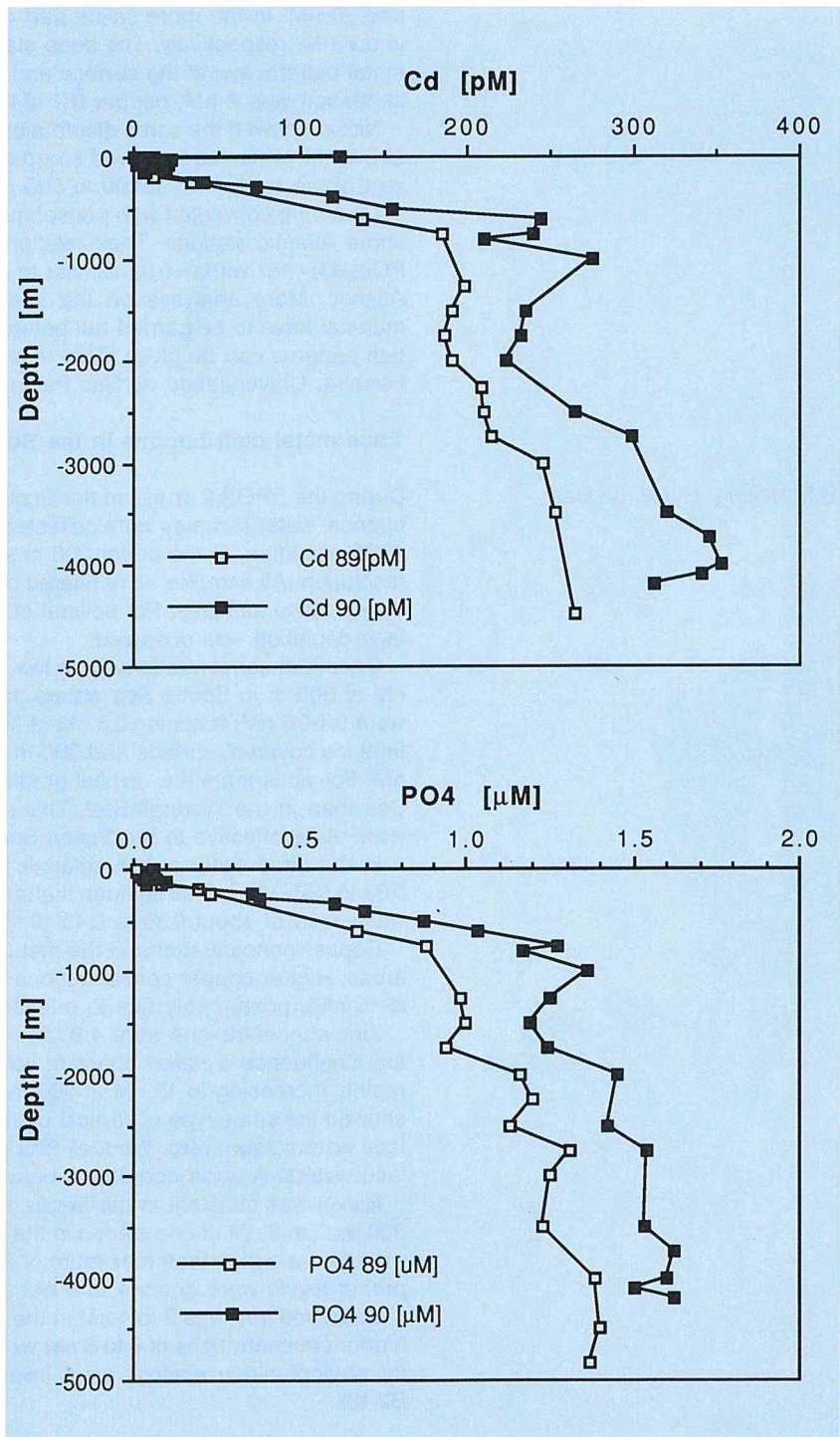
In the deep water of the Antarctic Ocean the Cd/PO_4 ratio appeared to be 0.63 to $0.65 \cdot 10^{-3}$. This is much higher than the generally assumed global deep water ratio of about 0.35 to $0.40 \cdot 10^{-3}$.

Copper concentrations in the first 300 m varied from 2 to 4 nM, in all three areas. Higher copper concentrations were found in the vicinity of Signy Island (5-15 nM), presumably due to releases from the sediments.

Zinc concentrations were 4-6 nM in the Scotia Sea. At station EPOS 186 in the Confluence a rather constant value of 2 nM was found in the first 50 m, rapidly increasing to 12 nM at 300 m depth. Other stations in the Confluence showed the same type of vertical profiles, but with increasing values in the surface waters southward. Weddell Sea concentrations were 4 to 6 nM in the surface waters. A weak correlation between zinc and silicate was found.

Nickel was constant in the Scotia Sea at about 5 nM throughout the upper 300 m, 7 to 8 nM at one station in the Confluence, increasing southward where we found a subsurface maximum of 20 nM at 50 m depth. In the Weddell Sea proper levels were again 4 to 6 nM and virtually constant with depth.

Dissolved iron was 2 to 4 nM in the Scotia Sea. In the Confluence somewhat higher concentrations of 6 to 8 nM were found. Implications of these iron levels for phytoplankton ecology were investigated in a complementary study (see B2-12).



Concentration profiles of cadmium and phosphate at JGOFS station 33°N, 20°W in the Atlantic Ocean in summer 1989 and spring 1990.

H.J.W. de Baar, R.F. Nolting,
J.T.M. de Jong

Trace metals in the North Atlantic Ocean (JGOFS)

During JGOFS cruises in 1989 and 1990, water samples for trace metal determinations were collected. The area studied roughly covered the 20°W meridian from 62°N to 32°N. At three stations, 60°, 44° and 33°N, the total water column was sampled, while at other stations the upper part of the water column only was sampled. Samples from the sea surface were collected from a rubber boat at a distance from RV 'Tyro' on the north-south 20°W transect in 1989, and from east to west (North Sea, Channel and Atlantic Ocean to 25°W) in 1990.

Metal concentrations in the unfiltered surface water samples decreased from north to south with a sharp transition at 55°N. North of 55°N, cadmium concentrations were 200 pM while lowest values were found at 33°N: 10 pM. Copper concentrations decreased from 3 nM in the north to about 1 nM in the south, while zinc decreased from 10 to 5 nM. Nickel concentrations decreased from 4 to 2 nM. The east-west transect showed a trend similar to the north-south one: higher concentrations in the North Sea, English Channel and then values decreasing westward. Cadmium concentrations in the North Sea and Channel were about 150 pM, decreasing to 10 pM at 33°N in the Atlantic, the same value as in 1989. For copper and nickel the North Sea and Channel values were 5 to 7 nM and 4 to 5 nM, respectively. Concentrations in the open Atlantic were the same as in 1989. Iron was high in the North Sea (250 nM) and decreased distinctly in the open Atlantic to 2-4 nM. These data have to be elaborated in connection with nutrients, salinity and other parameters.

At 33°N, 20°W, 36 water samples were collected over the whole water column, with a high vertical resolution in the upper 300 m. The two profiles of dissolved cadmium (1989, 1990) showed equal concentrations in the upper 300 m (10 to 20 pM). Between 300 and 500 m they showed a sudden increase to 200 pM and below 500 m they differ. The cadmium concentration in 1989 increased gradually to 250 pM in the deep water, while in 1990 this maximum value in the bottom water was 300-350 pM. However, if we plot the cadmium data against phosphate, we find the same correlation for both years.

In 1989 copper showed a relatively constant value above 2000 m (0.8 nM). Below this level an increase to 1.5 nM near the bottom was observed in 1989. In 1990 the upper layer value was somewhat higher (1 nM). Below 2000 m it had values comparable to 1989, but below 3500 m it increased strongly up to 3 nM near the bottom. Note that the 1989 cruise was in August while the 1990 cruise was in April, which has consequences for the biological activity in the surface waters.

Nickel showed a very smooth profile in 1990, gradually increasing from 1.5 nM at the surface to 4 nM at the bottom. A similar profile was found in 1989 with the exception that in 1990 between 1500 and 3000 m, higher nickel concentrations were observed. All these deep-water trace metal data and profiles are rather similar to those published earlier, but we sampled at a much higher vertical resolution, especially in the upper layers.

Trace elements in the Indian Ocean

The very high Cd/phosphate ratios in the Indian Ocean as well as in the Southern Ocean (see above) led us to re-assess the now available data set of Cd and phosphate in the world ocean. The hitherto presumed constant ratio of Cd *versus* phosphate throughout the water column was found to be subject to major shifts between ocean basins. In the light of these findings the now com-

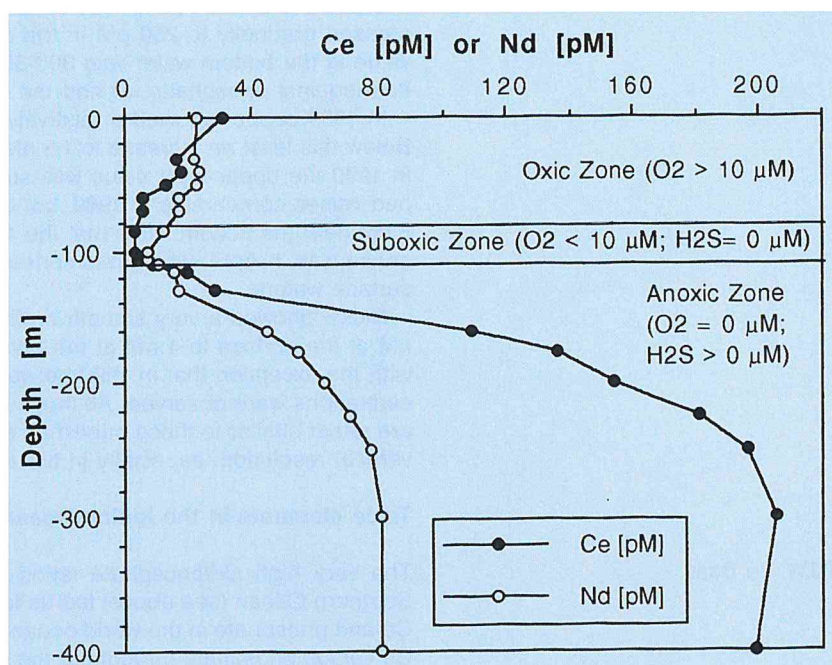
H.J.W. de Baar

mon application in palaeoceanography of Cd/Ca elemental ratios in Foraminifera as an approximation for distributions of nutrients such as phosphate needs re-assessment. (This research is carried out in cooperation with Drs. P.M. Saager, Free University, Amsterdam).

H1-16 RARE EARTHS AND OTHER METALS IN ANOXIC BASINS

H.J.W. de Baar

In the Black Sea concentrations of dissolved Rare Earth appear to be about an order of magnitude higher in the anoxic waters than in surface waters. This is most pronounced for Ce due to its oxidation-reduction chemistry. In 1988 (RV 'Knorr') we found the anoxic (sulphide-rich) waters of the Black Sea at much shallower depths than before. Also the anoxic waters were overlain by a unique suboxic zone stretching from about 50 m to 100 m depth. In this zone traces of oxygen are still found, whereas no sulphide is yet present. In 1990 the samples from shipboard mixing experiments between anoxic and oxic waters were analysed. Over the 24-h interval the dissolved Ce and Nd were first removed within 2-3 hours, then their concentrations slowly increased again. This can be explained by kinetics of adsorption and desorption on fine particles, with the stronger effects on Ce due to its redox chemistry. Suspended particles collected *in situ* during the 1988 expedition are currently being analysed, with emphasis on contents of Rare Earths, Fe-Mn-oxides as well as pigment characteristics of obligate phototrophic, sulphide-oxidizing bacteria. These bacteria live just above the anoxic/oxic boundary at a depth coinciding with the maximum of finely dispersed Fe-Mn-oxides. The combined microbial/mineral assembly is a likely adsorbing agent for removal of other (non-redox) metals from seawater, *i.e.* all Rare Earths.



The concentrations [picoMolar] of dissolved Ce and Nd in the upper 400 m of the water column of the Black Sea.

In September 1990 we participated in the First International Conference on f-Elements (lanthanides and actinides) where an invited keynote presentation was given on solution chemistry of the Rare Earth elements in seawater. Anomalies of La and Gd within the Rare Earths series as we reported in 1985 are now vindicated by a trace metal removal (scavenging) model incorporating organic functional groups on particle surfaces. (This research is executed largely by Drs. Schijf, University of Utrecht/Free University, Amsterdam, as part of his Ph.D. thesis project.)

H1-17 MASS BALANCE OF CARBON IN PELAGIC SURFACE WATERS

M.H.C. Stoll, H.J.W. de Baar,
G.C. Cadée, J. Rommets,
J. Hegeman, C. Brussaard,
M. Hoppema

Results of measurements of the CO₂ system in seawater from the the RV 'Tyro' cruise 1989 were presented at the JGOFS data workshop in Kiel, March 1990. Good agreement within about 0.5% was found with results of colleagues in the UK and USA.

In April-May 1990 CO₂-system determinations were made during JGOFS leg 3 from Madeira to Iceland. Subsequently M. Stoll also participated in the DUTCH-WARP cruise in waters south of Iceland.

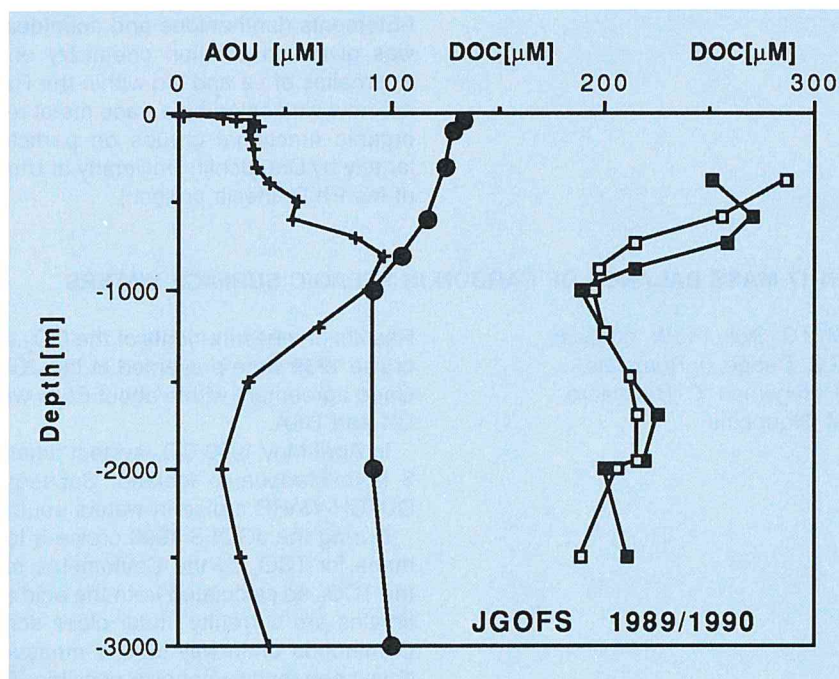
During the JGOFS 1990 cruise a total number of 1212 measurements were made for TCO₂ by the Coulometric method. A comparison will be made with the TCO₂ as calculated from the acid titration data. The algorithms of these estimates are currently under close scrutiny and results are being worked out. Continuous underway on-line measurements for TCO₂ of the surface waters have been made whenever possible. There appears to be a distinct diurnal variation in this parameter (normalized to a salinity of 35 permille). Unfortunately the on-line data from the fluorimeter have too much scatter to be used for comparison.

The DUTCH-WARP cruise yielded a total number of 1416 measurements of TCO₂ from discrete samples taken from the Niskin bottles.

In November 1990 we participated in an experimental study initiated by the Royal Meteorological Institute (KNMI, Dr. W. Oost). At the near-shore platform 'Meetpost Noordwijk' an intercomparison of different methods for determination of CO₂ gas exchange fluxes between ocean and atmosphere was carried out. The quasi-direct eddy correlation approach with two experimental set-ups was compared with the gradient method relying on quasi-diffusion algorithms. The rate of exchange of CO₂ between ocean and atmosphere is a crucial problem in the overall global CO₂ mass balance, hence critical for modelling climate change. Results of the experiment are being analysed.

The concentration and (microbial) turnover rate of Dissolved Organic Carbon in seawater is the subject of considerable debate. Two different methods used during the 1989 JGOFS cruise gave typical concentrations of 100 μM which were in the same range as those observed by other JGOFS scientists. During the April-May 1990 JGOFS cruise C. Brussaard further developed the novel high temperature catalytic combustion method, relying on pure Pt catalyst for the conversion of DOC to CO₂. At 47°N, 20°W the vertical profile of DOC exhibits the expected inverse relation with Apparent Oxygen Utilization (AOU). There is good agreement with the DOC trend observed by US and Japanese colleagues at the same position during JGOFS 1989.

(●) Dissolved Organic Carbon [μM] and (+) Apparent Oxygen Utilization [μM] in 1990. Also shown are DOC data of US (■) and Japanese (□) colleagues at the same site measured during JGOFS 1989.



Upon request of the Department of the Environment (VROM) M. Hoppema and H. de Baar started a review study of the emissions by the North Sea of gases (CO_2 , CH_4 , N_2O , DMS) which are known to affect the global radiation balance and therefore the climate. The emphasis is on assessment of changes of such emissions during the past century as a result of human activities. Generally the eutrophication of mostly nearshore waters of the North Sea appears to be the major change with respect to changes in such gas emissions. For emissions of CO_2 and CH_4 the assessment suffers from great uncertainties in the overall C cycle of the North Sea: notably the role of Dissolved Organic Carbon (DOC) is poorly understood.

1.3. PHYSICAL OCEANOGRAPHY (H2)

INTRODUCTION

A start has been made with the theoretical study of meso-scale eddies generated by the ocean circulation. Cooperation takes place with experimental research on eddies and symmetry properties of eddies in the laboratory of the Institute for Meteorology and Oceanography (RU Utrecht). The study on solitary waves was continued and a number of new properties have been found by investigating the dispersion caused by the Coriolis force.

In the framework of DUTCH-WARP, the first cruise was held in the Iceland Basin. In addition to the regular CTD measurements and nutrient determinations for tracer work, current meter moorings have been deployed and ARGOS buoys launched. Also infrared and optical images of the area have been collected. The NIOZ instruments from moorings in the Greenland Sea were recovered. A contribution was given to the JGOFS cruises this year with CTD measurements and oxygen determinations.

The CTD data collected during the EPOS leg-2 cruise have been the basis for a modelling exercise on the structure of the water column in the marginal ice zone. The results have been used in a model of the Antarctic ecosystem during the ice retreat. The EPOS project is in its final stage and new plans are in preparation for a follow-up within the framework of JGOFS/Southern Ocean.

With the completion of a Ph.D. thesis, the physical oceanographic work in the Frisian Front Project has come to an end.

The optical/remote sensing research was focussed on the analysis of the 1989 data. The applicability and accuracy of the NOAA/AVHRR and CZCS satellite for coastal water monitoring was investigated, and the feasibility of airborne laser bathymetry for the coastal North Sea waters was studied. The low resolution remote sensing receiver was made operational; a permanent exposition with the latest RS images was set up at the Institute.

H2-01 NON-LINEAR DYNAMICS OF OCEAN CIRCULATION

J.T.F. Zimmerman, L.R.M. Maas,
R. v.d. Toorn, W.T.M. Verkley

It is well-known that meso-scale (50-200 km) transport of momentum, salt, heat and trapped (dissolved) substances in the ocean is provided by strong coherent structures: eddies. These coherent vortices originate either from overflow events or from meandering current loops, which can be thought of as laterally breaking waves. It turns out that the dynamics governing these eddies is largely determined by the same forces as determine large-scale dynamics. Therefore a start has been made in investigating the properties of the propagation and evolution of meso-scale eddies and in comparing these with existing physical models. It is anticipated that, as in the ocean's general circulation, here too the homogenization of the eddy's (potential) vorticity is related to the renormalization of the local planetary vorticity gradient by the relative vorticity gradient.

In cooperation with the Universities of Utrecht and Eindhoven, a start has been made to compare these investigations with similar observations obtained in laboratory experiments on a) the spin-up of a tank of water which impulsively starts rotating from rest, and b) the evolution of eddies. The spin-up process, in its initial state, is dominated by an inertial flow and resembles some of the features of the inertial mode of the strongly non-linear circulation of the ocean. Observations of the latter process, that of the propagation and evolution of eddies, is sometimes at variance with our theoretical predictions (concerning the direction in which the eddy should be, or is, moving).

In another project of cooperation with the University of Utrecht, a study has been made of the symmetry properties of the rectified flow on the beta-plane, resulting from an oscillating forcing by the curl of the wind-stress. The problem is surprisingly similar to earlier studied problems of tidal rectification, particularly in the so-called 'weak beta' limit. It has been found analytically that the rectified flow pattern consists basically of a dipole, the symmetry of which is distorted by a quadrupole. The strength of the latter is maximal for intermediate Reynolds numbers, whereas the strength of the dipole is largest for intermediate forcing frequencies. The results are in accordance with those found earlier in numerical modelling. This project is carried out in cooperation with G.J.F. van Heijst (RU Utrecht - TU Eindhoven), R. Kloosterziel (Inst. of Non-linear Science (INSL), USCD, USA) and H.E. de Swart (RU Utrecht).

H2-02 NON-LINEAR TIDAL DYNAMICS: Non-linear internal tides and solitons

L.R.M. Maas, J.T.F. Zimmerman,
Th. Gerkema

Internal tides are often observed to be strongly non-linear and develop into an internal bore, which is subsequently seen to disintegrate into a series of solitary waves. The mechanisms which produce the steepening and splitting of the solitary wave, as well as the dispersive mechanism which balances the non-linearity, are investigated. As an alternative to the usually assumed non-hydrostatic dispersive effects, we investigate the dispersion due to the rotation of the earth (Coriolis force). The resulting non-linear evolution equation has been studied for several aspects (in cooperation with O. Bokhove, a student of TU Delft) and the following results have been obtained: 1) the Stokes expansion for a weakly non-linear wavetrain provides the amplitude dependence of the frequency, 2) a steady-form travelling wave solution containing the linear sinusoidal, as well as the strongly non-linear (consisting of a series of coupled parabolas) limit, has been obtained, 3) a particular (singular) rational solution has been obtained, 4) its relation to a self-similar ordinary differential equation has been established, 5) numerically the recurrence of an initial (cosine) state has been established, 6) numerically the occurrence of 'spikes' in the mildly non-linear wave profile is observed. These spikes seem to lag behind the propagation of the main wave profile.

It is difficult to describe the solitary wave with this model (due to multi-valuedness); an artefact that can only be remedied for by introducing a discontinuity in the derivative of the slope.

H2-05 DUTCH-WARP (Deep and Upper Transport, Circulation and Hydrography - WOCE Atlantic Research Programme)

H.M. van Aken, C. de Boer,
T. de Bruin, L. Otto

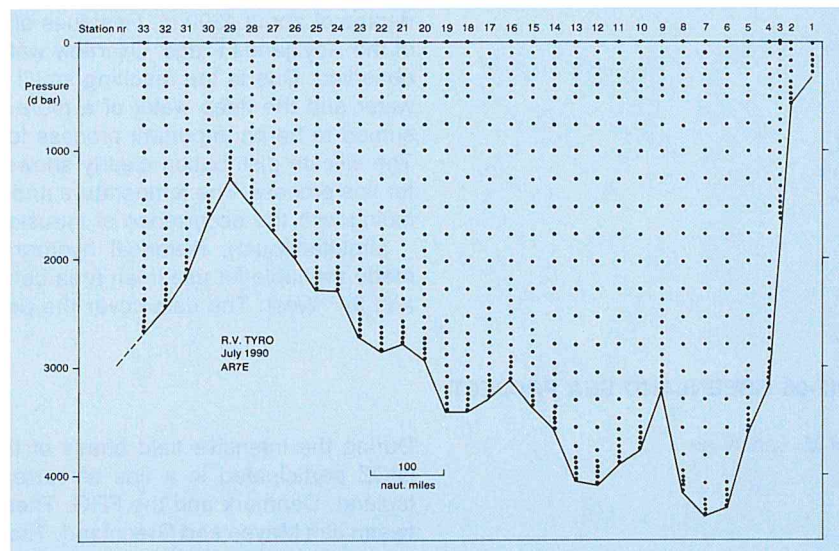
During RV 'Tyro' cruise TY90/3 in July-August 1990, WOCE repeat section AR7 was surveyed from the Porcupine Bank towards Cape Farewell. Due to adverse weather conditions the survey of this section ended prematurely in the Irminger Sea. After the AR7 section a number of CTD sections in the Iceland Basin, with a station distance of 15 nautical miles, were surveyed. These sections form three control boxes which will be used for inverse modelling of the circulation. A total of about 200 Mbyte raw CTD data were recorded.

At all CTD stations water samples were taken for the determination of salinity, nutrients, oxygen, total CO₂, ¹⁴C and Tritium. The nutrient analysis was carried out in cooperation with the NIOZ Chemical Oceanography Department (K. Bakker). Preliminary analysis of duplicate samples indicate that for salinity, nutrients and oxygen the precision of the determinations will be well within the standards for WOCE. SIS electronic reversing thermometers were used for calibration purposes. The mutual difference between thermometers mounted on the same Niskin bottle is generally equal to or less than 1 mK.

Comparison of temperatures from SIS thermometers with the CTD shows a standard deviation of the difference of slightly over 1 mK. The difference between the salinity values from the CTD and the water samples has a standard deviation of 0.0012 psu. These results indicate that also the CTD observations will, after calibration, be within the quality requirements for WOCE.

In addition to the CTD surveys, over 200 XBT profiles were recorded. At 3 positions ARGOS buoys were launched. A current meter mooring deployed in 1989 was recovered, while 4 moorings were deployed. Each of these moorings contains 4 current meters. Meteorological parameters were continuously recorded.

During the DUTCH-WARP survey of RV 'Tyro' along WOCE-section AR7E water samples were taken at the dotted positions. Of these samples the content of oxygen, nutrients and carbon dioxide as well as salinity was determined on board. A number of samples were stored for later tritium determinations by the University of Groningen.





Looking out for a 'released' mooring.
(Photo: S. Ober)

Preliminary results from the surveys show that the sub-arctic front has a number of meanders and sheds off meso-scale eddies. One of the ARGOS buoys became trapped in one of these eddies for over a month. South of the Rockall-Hatton Plateau the CTD section AR7 showed a larger baroclinic eddy-like structure with a scale of about 200 km. The other two ARGOS buoys circled this eddy at least once. The impression based on the 1989 data that there exist two different types Intermediate Water in the Iceland Basin was confirmed. Whereas over the deeper parts of the Iceland Basin Labrador Sea water is encountered, a slightly warmer and saltier water type with high silicate values is observed to enter the Iceland Basin along the slope of the Hatton Bank at depths of about 1200 m. Residues of this water are observed along the slope of the Reykjanes Ridge. Overflow water with temperatures below 2°C was not observed. Due to the resulting small density difference between the overflow water and the deep water of a more southern origin, isopycnal mixing is assumed to be an important process for the modification of the overflow water. The silicate distribution clearly shows the existence of intrusions responsible for this process. The temperature and salinity profiles show fine-structure coinciding with the occurrence of intrusions.

Simultaneously, historical hydrographical data have been collected and made available for use in an area between latitude 56° and 64° North and 14° and 34° West. The data cover the period between 1904 and 1987.

H2-06 GREENLAND SEA PROJECT

H.M. van Aken

During the intensive field phase of the Greenland Sea project in 1988-1989, NIOZ participated in a line of current meter moorings, in cooperation with Iceland, Denmark and the FRG. These moorings were deployed in a line between Jan Mayen and Greenland. The data from the NIOZ current meters have been processed and provisionally analysed.

Over the continental slope of Greenland a steady southward flow with an order of magnitude of $10 \text{ cm}\cdot\text{s}^{-1}$ was observed at all levels. Over the centre of the sill between Jan Mayen and Greenland, the flow appeared to be variable with a mean northward component of a few $\text{cm}\cdot\text{s}^{-1}$, increasing towards the bottom. At one mooring the passage of a cold eddy at intermediate depths was observed from the veering of current vectors at 300 and 500 m, coinciding with a sudden decrease in temperature. At the current meters moored at a depth of 80 m, the salinity was observed to decrease strongly, coinciding with the seasonal decrease in temperature towards freezing point.

The tides are mainly semi-diurnal. However, over the slope of Greenland the current spectra show a considerable diurnal peak at the K1 diurnal frequency band, which increases towards the bottom. Ray theory of the internal tides will be used to analyse this observation. Over the centre of the sill a significant M4 peak has been found in the spectra. An explanation for this phenomenon is lacking.

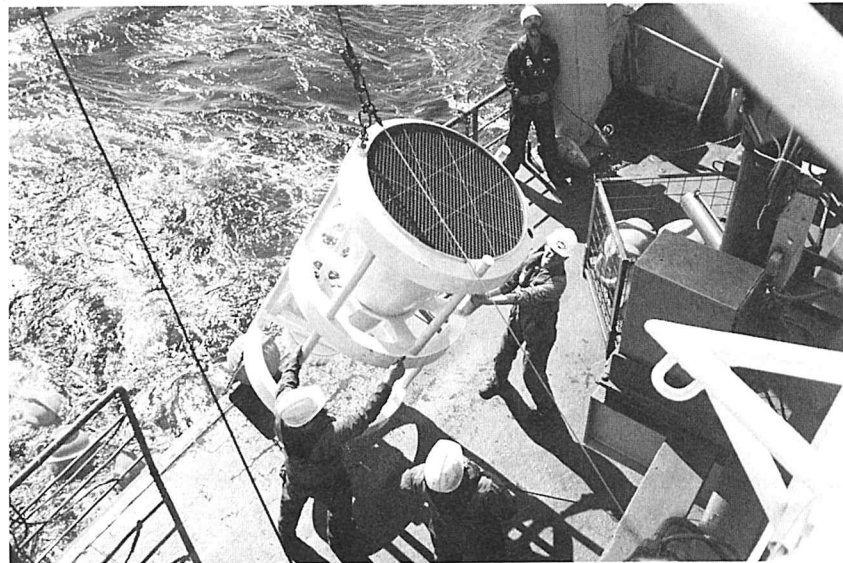
H2-07 JGOFS (Joint Global Ocean Flux Study), physical part

H.M. van Aken

The Physical Oceanography Department takes care of the CTD observations carried out within the multidisciplinary JGOFS-programme. The data will be processed in support of the chemical and biological research within this programme as well as for research carried out within the Physical Oceanography Department.

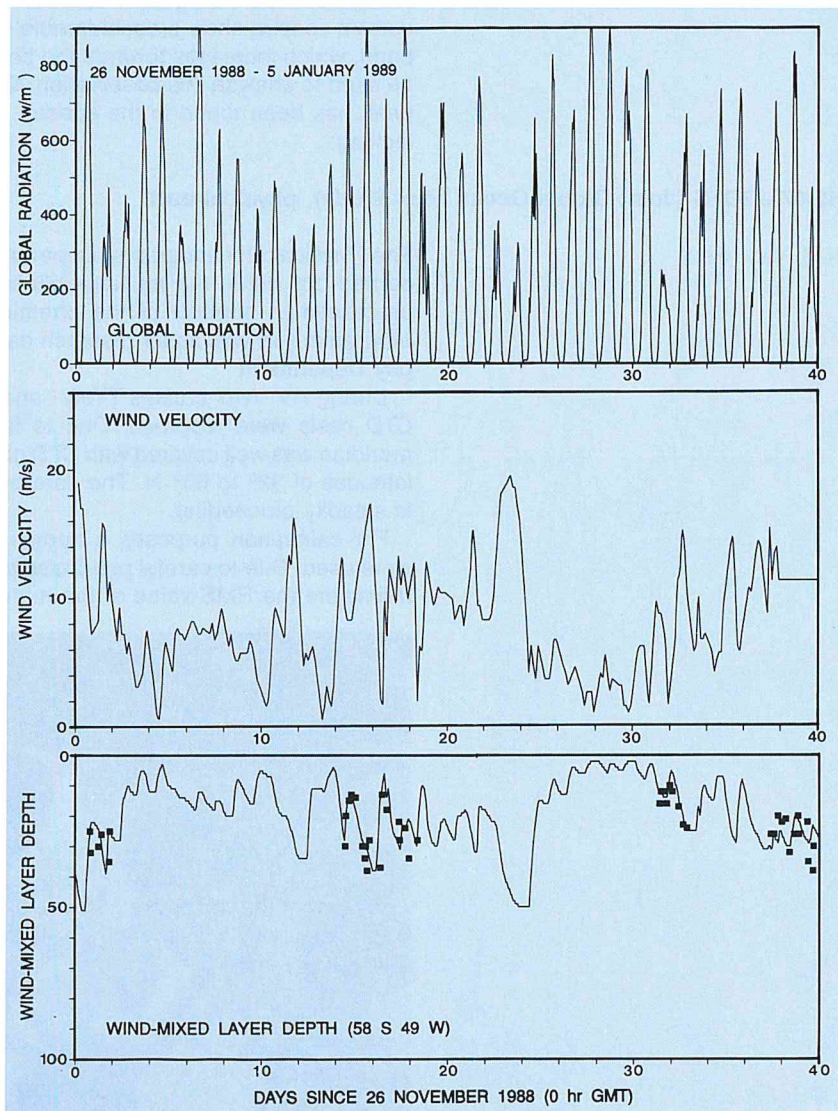
During RV 'Tyro' cruises TY90/1 and TY90/2 from April-June 1990 about 120 CTD casts were recorded. Due to favourable weather conditions the 20°W meridian was well covered with CTD observations to a depth of 1500 m between latitudes of 32° to 60° N. The data processing of the 100 Mbyte of CTD data is steadily proceeding.

For calibration purposes a number of SIS digital reversing thermometers were used. Due to careful pre-cruise and post-cruise calibrations of these thermometers the RMS value of the mutual differences is well below 1 mK.



Recovery of a sediment trap on board RV 'Tyro'.
(Photo: S. Ober)

The CTD data obtained during the 1989 and 1990 JGOFS cruises will be used for the study of the meridional transport of the Labrador Sea water and the Mediterranean water in the north-eastern Atlantic Ocean. The T and S data, together with the available geochemical tracers (nutrients, carbon isotopes) will be used to obtain quantitative estimates of mixing and water-mass transformation.



Wind-mixed layer as a function of global radiation and wind. Model prediction and measurements.

H2-08 EPOS-Leg-2 (European Polarstern Ocean Study), physical part

C. Veth

The CTD data of the upper layers collected during the EPOS leg-2 cruise, complemented with meteorological observations, solar radiation measurements and ice coverage estimates, have resulted in a wind-mixed layer model for the marginal ice zone in the Southern Ocean from the open water in the Scotia Sea into the fully ice-covered water of the Weddell Sea in a period of ice retreat by melting. The results of the wind-mixed layer model correspond very well with data on the wind-mixed layer depth and surface temperature. There is some weak evidence of a north-going advective current. The predictions of the physical structure of the upper layers of the water column have been used in an ecophysiological model constructed by the Groupe de Microbiologie des Milieux Aquatiques (C. Lancelot, Univ. Libre de Bruxelles) for the prediction of phytoplankton blooms in the retreating ice of the marginal ice zone and the estimate of the carbon budget during that period.

The CTD data collected in the deeper parts of the Scotia-Weddell Sea area have been used to study the exchange of water through the Weddell-Scotia Confluence. The frontal zone shows eddies shed off by instabilities. The T-S characteristics of the water in these eddies show that the eddies have risen from much greater depths during their travel southwards along isopycnals. This work is carried out in cooperation with U.E.B. Cederlöf, University of Gothenburg.

H2-09 FRISIAN FRONT PROJECT, physical part

J.J.M. van Haren, L.R.M. Maas,
C. Veth

The subtidal current field in the area 60 km north of the Dutch Wadden Islands has been investigated for its horizontal and vertical variability by confronting the data with a number of modelled generation mechanisms. Generally the current is found to be in (near-) geostrophic balance, the sea surface slope being caused by the local along-isobath-directed wind stress. During passages of depressions the observed along-isobath current component is largest ($25 \text{ cm}\cdot\text{s}^{-1}$) and is driven by the wind stress curl over the southern North Sea. At a specific position, above the steepest bottom slope and near a biological (benthic) front, the (local) wind stress generates only 50-75% of the currents observed. The remaining part is, within large uncertainty bounds, about equally explained by horizontal density gradients and by rectification due to the non-linear tide-topography interaction.

Shallow seas have current and elevation spectra showing increased levels of energy at tidal harmonics. Two alternative processes may explain this phenomenon: either the waves are generated at some specific topographic feature, and propagate away subsequently, or these (highly dissipative) waves are generated at every site, due to the overall presence of advective and frictional nonlinearities. To discriminate between these remotely and locally generated tidal harmonics the response to a step-like topography profile is determined analytically and compared with the response to a flat bottom. Comparison with observations for the Frisian Front region remain inconclusive, so that a combination of the two alternatives is probably responsible for the observed response. Also the geometry of the modelled scattering region is probably oversimplified.

With the completion of the Ph.D. thesis of Van Haren, the physical part of this research project has come to an end.

H2-10 WINDOW PROJECT AND INTEGRATED NORTH SEA PROJECT, physical part

H. Ridderinkhof, C. Veth

Modelling work related to the Window Project: see BEWON project S-01e.

A start has been made to prepare a 'multidisciplinary mooring' within the framework of the Integrated North Sea Project (INP), to be deployed on the Oyster Grounds. Simultaneous measurements of the physical structure of the water column and chlorophyll concentrations are planned to study plankton blooms caused by nutrient entrainment from the bottom layer into the nutrient-depleted surface layer. In this project cooperation has been established by Rijkswaterstaat and several foreign institutes.

H2-12 OPTICAL REMOTE SENSING OF COASTAL WATERS

G. Marees, M.R. Wernand

The NOAA weather satellite is at present the only operational satellite available for oceanographic observations. A further study on the applicability of this satellite was performed: Direct comparison between satellite imagery and sea-truth data is hampered by several factors: 1. the inevitable time difference between satellite pass and sea-truth sampling, 2. atmospheric influences and 3. the patchiness within a NOAA pixel (1.1 x 1.1 km). By simulating the spectral bands of the satellite with an underwater irradiance meter, we have largely eliminated these factors. Correlation of the signals of the simulated bands with sea-truth data in some cases results in reliable relationships. The irradiance-attenuation coefficient (at 520 nm) and the reciprocal Secchi-disk depth were found to be well correlated with the simulated spectral bands of the satellite. This finding is of importance for primary-productivity modelling.

From our underwater spectral data of the 1989 cruises, algorithms for the (historical) Coastal Zone Colour Scanner have been deduced for the North Sea. A notable result is that concentrations calculated from these algorithms in some cases differ as much as 50% from concentrations calculated from the 'standard' algorithms deduced for clear so-called CASE I waters. This finding stresses the importance of the use of locally valid algorithms in the remote sensing of coastal waters.

In 1989 we participated in an airborne remote sensing experiment over the North Sea with the CAESAR scanner of the National Aerospace Laboratory. With respect to the results of the experiments we can be brief: imperfections in the optical system of the airborne scanner resulted in faulty imagery.

In cooperation with Rijkswaterstaat, Fokker, Delft-Instruments and the Hydrography Department of the Royal Navy, investigations on the feasibility of laser bathymetry (optical depth sounding) for the North Sea were performed. Detailed and precise bathymetric information is of vital importance for shipping and fishery. Airborne laser bathymetry should be able to reduce the depth-sounding costs and, due to the faster data acquisition, increase the measuring capacity. All NIOZ optical data of the North Sea of the last few years were processed and analysed with respect to bathymetry applications. It was found that for coastal North Sea waters laser bathymetry would be possible at about 10% of the stations. Shallow waters at the central North Sea (Dogger Bank) were found to be clear enough for application of laser bathymetry in about 50% of all cases. Obviously, the precise percentages depend on the specific season and investigated locations. Our findings were consistent with those of Rijkswaterstaat. Consequently, negative advice was given regarding the feasibility of laser bathymetry.

Further investigations on the use of the NIOZ low-resolution remote sensing receiver were performed. Direct comparisons between the high-resolution NOAA imagery (received at KNMI) and our low-resolution signal were made. The low-resolution thermal imagery was found to have an accuracy of about 1°C; the high-resolution imagery is known (from the literature) to be accurate within 0.5°C. More studies on the applicability of the low-resolution visible imagery have to be performed. A permanent exposition has been set up at the Institute with the most recently received NOAA remote sensing imagery of the North Sea (KNMI and NIOZ received images). Next year the remote sensing receiver will be tested on board a research vessel.

Most of the optical measurements carried out at sea concern the so-called apparent optical properties (Secchi depth, irradiance measurements). These properties depend not only on the water quality but also on solar altitude, cloudiness, wave height etc. For a precise description of the underwater light field, knowledge on the inherent optical properties of the sea is of great importance. A new spectral transmissometer for this kind of measurements was designed. Tests and calibrations will be carried out next year.

This research was carried out within the framework of the National Remote Sensing Programme (NRSP) and was financially supported by the Netherlands Remote Sensing Board (BCRS).



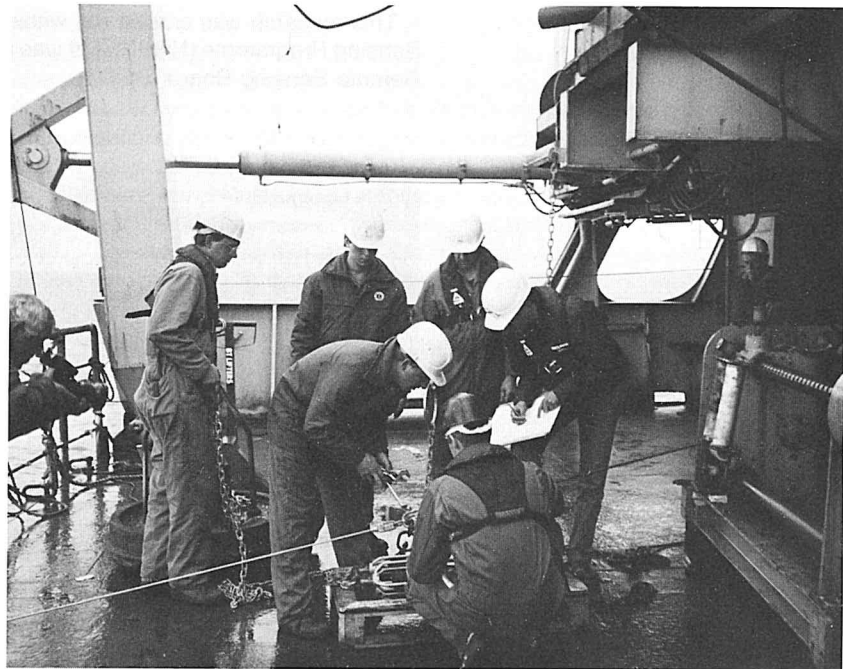
The 22 channel transmission meter under construction at the NIOZ instrumental department.
(Photo: NIOZ)

H2-13 APPLICATION OF INFRARED AND OPTICAL REMOTE SENSING IN PHYSICAL AND BIOCHEMICAL OCEANOGRAPHY

T. de Bruin, L. Otto

International programmes such as WOCE and JGOFS are expected to use different remote sensing techniques in combination with *in situ* measurements. In order to optimize this use in the Dutch contribution to these programmes, this project was started in the end of 1989. The major emphasis is, for the time being, on the study of the factors influencing thermal images of ocean circulation features, and on the collecting of relevant data during WOCE. In this connection the heat exchange at the sea surface plays an important role, and a special meteorological observing programme was developed and implemented on board RV 'Tyro' during DUTCH-WARP in July of this year.

Although cloudiness in the northern part of the North Atlantic is a major setback, a number of adequate pictures have been identified and are now being investigated to discover small-scale structures and their development.



Utmost concentration during the deployment of a current-meter mooring during the DUTCH-WARP expedition in the Iceland Basin.

(Photo: T. de Bruin)

1.4. MARINE GEOLOGY AND GEOCHEMISTRY (H3)

INTRODUCTION

The Marine Geology and Geochemistry Department is studying several topics that are of prime interest in marine sediments: sediment transport and sedimentation (erosion) processes (both for suspended matter and for sand), and the composition of sediments and suspended matter in relation to origin and early-diagenetic changes.

Flocculation of suspended matter is studied under H3-01, viz. in the Zaire river mouth, followed by deposition and erosion in the Dollard (H3-02.1) and along the Chinese coast (H3-02.2), deposition rates in the southern North Sea (H3-02.3), and in the northwest Mediterranean (H3-02.4), Amazon mud dispersal along the north coast of South America (H3-02.5), sand transport off the Dutch coast (H3-05) and at tidal inlets (H3-06), and sediment transport and deposition in the Skagerrak (H3-07). Important aspects of bottom sediments include the silica cycle, which is studied under H3-15, the poorly crystallized (crypto-crystalline) minerals in sediments, which are studied under H3-17, the naturally radioactive isotope used for dating and tracing sediment transport and erosion (resuspension) (H3-19) and the major element composition of particles (H3-20). The largest part of the research is done on recent and subrecent processes and sediments, but this is extrapolated, where possible, to the late and middle Pleistocene. For the latter a programme is under way in the Angola Basin, relating sediment characteristics to palaeoceanographic conditions and climatic changes (see H3-13).

H3-01 FLOCCULATION PROCESSES

D. Eisma

The *in situ* suspension camera system was made fully operable by the completion of the image analysis system so that particle size can now be measured from negatives at a rate of one negative per 1 to 2 hours. Negatives made in the Zaire estuary and the Scheldt estuary in 1989 and older negatives made with the Benthos plankton camera in the Gironde, the Rhine and the Ems estuaries were analysed. The *in situ* particle size did not show any consistent relation with salinity, with organic matter content or particle (floc) composition. *In situ* size appears to be variable, with generally a larger size near the bottom. This can be related to a higher particle concentration (in number as well as in volume or weight) and a higher collision frequency of the particles. The Coulter counter size distributions show (as found before) finer sizes at low salinities, which is related to the mobilization of carbohydrates from the particles, but this does not influence the *in situ* size. The Coulter counter and pipet size analyses were found to indicate the cohesiveness of the flocs rather than their *in situ* size.

Tests were also made with the camera to improve the quality of the negatives and to prevent malfunctioning of the film transport mechanism, which had occurred during a series of measurements in the Ems estuary earlier this year. These measurements will be repeated early in 1991 in collaboration with Dr. A. Spitzky (University of Hamburg), who will take care of the analysis of dissolved and particulate sugars, humic and fulvic acids. Also, first trials were made to use the camera system for *in situ* measurement of the fall-velocity of the particles. Some necessary adaptations are planned in the near future.

Analysis of material collected during the cruise in the Zaire river mouth at the end of 1989 was started in 1990. Temperature and salinity showed the same distribution as during the previous cruises in 1976 and 1978, but suspended matter concentrations were more variable, both in the surface water and in the deep water in the canyon. Low oxygen values and high biological (bacterial) activity occurred in the deeper parts of the canyon. All the suspended matter was flocculated: smaller flocs (500 μm , as measured with the *in situ* suspension camera) in the river, and larger flocs in the estuary, where current velocities are lower. Faecal pellets were rare, except in the bottom sediment on the shallow banks along the estuary, where they are probably produced by benthos. Biological activity in the surface water was low and the euphotic zone only a few metres thick. Therefore in the outflowing surface water turbulence mainly determined the flocculation process, and differential settling dominated in the quiet water in the canyon below the surface water. Both processes result in *in situ* floc sizes of up to 2 mm. The first results show that the particle volume as measured by Coulter counter is only little less than the *in situ* particle (floc) volume. This indicates that the porosity (or water content) of the macroflocs is only little higher than the porosity of the microflocs, and that settling velocities are predominantly determined by particle size.

H3-02.1 SUSPENDED SEDIMENT ACCUMULATION IN THE DOLLARD

D. Eisma

Simultaneous measurements of current velocity and direction and suspended matter concentration were carried out in the Dollard during the first half of 1990 by H. de Haas (Dept. of Sedimentology, University of Utrecht). The measurements covered a series of tidal cycles at different stations in the channels as well as on the tidal flats. Also during a storm, results were obtained so that different situations could be compared. The results show that inward mud transport takes place over the flats, in particular by the incoming flood tide. In the channels mud transport is usually outward. The net effect is accumulation ($1\text{-}2\text{ mm}\cdot\text{y}^{-1}$). Ebb-flood asymmetry apparently is important, as well as erosion during storms.

H3-02.2 DEPOSITION AND EROSION ON TIDAL FLATS ALONG THE CHINESE COAST

D. Eisma, Tj.C.E. van Weering

Because of the political situation no exchange of scientists with China took place, nor any field work in China. A paper, summarizing results of research carried out on the tidal flats along the north coast of Hangzhou Bay was published by B.C. Wang (East China Normal University, Shanghai) and D. Eisma.

H3-02.3 THE ^{210}Pb AND ^{210}Po SYSTEM IN THE SOUTHERN NORTH SEA

D. Eisma, Z. Zuo, G.W. Berger

The measurements of sedimentation rates with ^{210}Pb in the southern North Sea were finished. Additional ^{137}Cs analyses are being made to confirm the results. The data show considerable reworking of bottom sediment in the Oyster Grounds and the Outer Silver Pit and downward migration of ^{137}Cs in the sediment. In order to understand the ^{210}Pb -system in this area, suspended matter and water samples are being analysed for ^{210}Pb and ^{210}Po covering different seasons, and rainwater samples are being collected on Texel and at the Meteorological Institute in De Bilt. Also older rainwater samples collected at Groningen by the Isotope Laboratory are being analysed. This will make it possible to estimate the ^{210}Pb fluxes from the atmosphere to the bottom sediment. The Isotope Laboratory at Groningen provided assistance by making their measuring facilities available for a month.

H3-02.4 SEDIMENTATION RATES IN THE NORTHWEST MEDITERRANEAN (EROS 2000)

D. Eisma

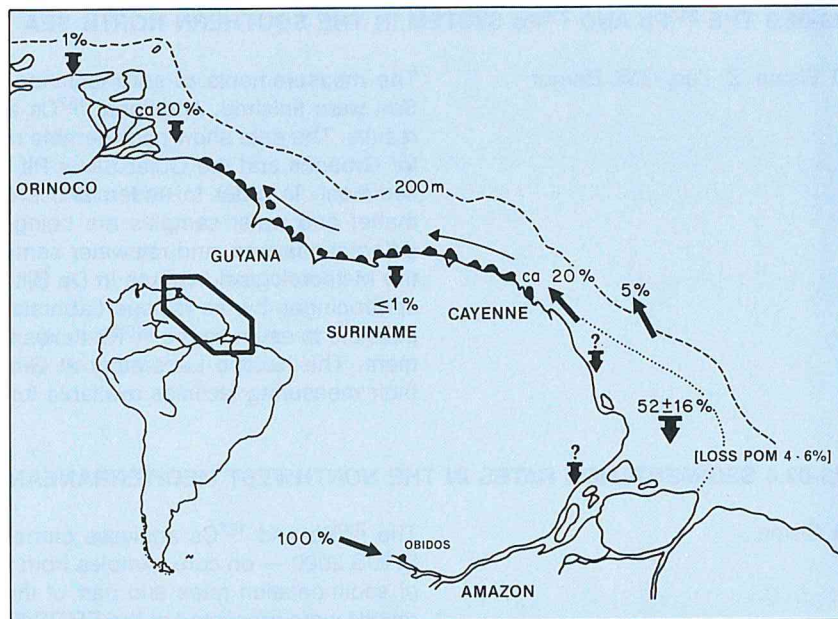
The ^{210}Pb and ^{137}Cs analyses carried out — as part of the EC programme EROS 2000 — on core samples from the NW Mediterranean for determination of sedimentation rates and part of this subprogramme were finished and the results were presented at the EROS-2000 meeting in Blanes (Spain). The data show a zone with relatively high sedimentation rates directly off the Rhône river mouth and decreasing rates away from that area to very low values in the deep water off the shelf. In July the funding for the second phase of this subprogramme was granted for three years as part of the MAST programme. In the framework of this programme, cores were collected in the Golfe du Lion and off the Ebro river mouth for estimation of sedimentation rates with ^{210}Pb and ^{137}Cs , and for determination of composition and origin of the sediment particles. The latter will be carried out in cooperation with the Chemistry Department of Antwerp University (Prof. R. van Grieken). The first series of cores, collected in May by the Institut de Biogéochimie Marine, Montrouge, France, has been opened and X-rayed and the preparations of sediment samples for isotope analysis have been made. The second series, collected in September by the Centro de Investigaciones y Desarrollos, Barcelona, Spain, will be analysed starting January 1991.

H3-02.5 DISPERSAL OF AMAZON MUD

D. Eisma

A literature review by D. Eisma, presented at a meeting in Charleston (USA) in 1988, indicated sub-recent temporal variations in the supply and dispersal of Amazon mud and a possible relation with climatic variations in northern South America during the past 1000 years. Relatively recent changes in sedimentation along the coasts of Suriname and Guyana were considered to be related to a change in force and direction of the (dominant) trade winds. This was confirmed by data from the weather station in Kourou (French Guyana), which were compiled by P.G.E.F. Augustinus (Geography Dept., University of Utrecht). It made a relation of the longer-term variations with wetter and drier periods more likely.

Sketch map of the Amazon mud dispersal system. Percentages indicate the relative amounts of Amazon mud that are transported (long arrows) or deposited (short downward arrows) or, in the case of particulate organic matter (POM), mineralized in the different areas. Mud banks along the coast are indicated by black dots (from Delft Hydraulics Laboratory 1962).



H3-05 FORMATION OF SHORE-FACE CONNECTED SAND RIDGES OFF THE DUTCH COAST

Tj.C.E. van Weering

A field campaign was held in early spring. In between the fieldwork periods a heavy storm affected the area, causing sediment remixing and restructuring. This event has been well recorded in the box-core samples collected across the ridges. At present the sediment cores are being studied and age determinations made. This project is carried out by J. van der Meene, Dept. Physical Geography, University of Utrecht.

H3-06 FORMATION OF EBB-TIDAL DELTAS AND CHANNELS IN AND NEAR COASTAL INLETS OF THE WADDEN SEA

Tj.C.E. van Weering, D. Eisma

The work carried out during the past 5 years was presented in a Ph.D. thesis by L.P. Shah (Dept. Sedimentology, University of Utrecht). He has shown that the increasing tidal volume passing through the inlet causes a cyclic morphological pattern of the ebb tidal delta complex. Sand transport in the Texel inlet proves to be strongly influenced by coast-parallel tidal currents, which interfere with the tidal currents through the inlet and determine the orientation of the main tidal channel. This is also reflected in the asymmetrical shape of the ebb tidal delta. The shape of the ebb-tidal delta furthermore is strongly influenced by the dominant wave direction. To better interpret analog fossil tidal delta deposits a sequential model has been compiled, which is supported by a three-dimensional geometrical study of the Texel inlet. A similar study of the inlet between the islands of Terschelling and Ameland, which is expected to yield more information on the importance of the wave-dominated sedimentary processes,

has been carried out during a cruise in May. A set of samples has been obtained and a few echosounder profiles were recorded; these indicate that a strong change in morphology of the inlet system caused by heavy winter storms has occurred since the previous cruise. The collected samples will form the basis for a student's thesis in 1991.

H3-07 LATE QUATERNARY AND RECENT SEDIMENTS AND SEDIMENTARY PROCESSES IN THE SKAGERRAK, THE NORWEGIAN CHANNEL AND THE ADJACENT CONTINENTAL SLOPE

Tj.C.E. van Weering, L. Moodley

In 1990 box-core samples were collected in the eastern Skagerrak during a cruise with RV 'Aurelia', carried out in cooperation with the Marine Geological Institute of the University of Gothenburg, Sweden. Samples were taken for a study of the distribution of recent, live benthic foraminifera, the relation of their habitats with bottom water and pore-water characteristics, and of the relation between live and dead assemblages. Macrofauna was also sampled to examine the relationship between bioturbation and the infaunal distribution of foraminifera. The structure of the water column was recorded by means of a CTD and a transmissometer. These records show the patchy distribution of the thermocline in the eastern Skagerrak and the presence of thick near-bottom nepheloid layers, which indicate local erosion and near-bottom current transport in the area between Skagen and Sweden. The live foraminifera are concentrated in the upper 5 cm of the sediment, although they are found in low quantities down to 15 cm. Oxygen, however, does not penetrate deeper than a few mm in the sediment. This is also the case in sediments from the southern North Sea, from which foraminifera have been isolated for culture experiments. Species from different depth intervals were examined for their tolerance of and dependence on different oxygen concentrations. An experiment was also designed to examine the positive effects of bioturbation on the infaunal occurrence of foraminifera.

Rare earth element analysis has shown that element fractionation caused by sorting governs the composition of the sediments. The distribution shows a striking relation with the distribution of silts and clay. Cooperation took place with G. Klaver, DIHO, Yerseke.

H3-09 SEDIMENTATION BY SLOPE-PARALLEL BOTTOM CURRENTS

Tj.C.E. van Weering,
A.J. van Bennekom

A detailed study of the penetrating echosounder profiles and piston-cores from the Feni Ridge has shown that sedimentation near the crest and at the foot of the lower slope of Rockall Plateau is governed by Norwegian Sea Overflow Water. At the lower eastern flank of the Feni Ridge sedimentation takes place under the influence of an anticyclonic loop of Northeastern Atlantic Deep Water. The observed variations in sedimentation rate over the last 125 000 years are very large in the late phase of the deglaciation and in the early interglacial periods, possibly as a result of a sudden increase in meltwater supply in combination with increasingly high productivity. The analyses of the penetrating echosounder profiles indicate that building-up of the Feni Ridge has taken place under a predominantly low-energy depositional regime, both in glacial and in interglacial periods. The symmetrical sediment waves are being slowly reshaped into a-symmetrical waves, then into undulatory forms and finally into plane bed sediments because of a reduced near-bottom turbulence in combination with a lower suspension load.

The development of the self-registering tripod system proceeds with some delay caused by the final selection of customized current sensors and associated datalogging systems. It will be operational in 1991. Except for these instruments all components have been delivered and are being assembled.

H3-10 SEISMIC STRUCTURE AND SEDIMENTARY DEVELOPMENT OF THE LOMBOK AND SAVU FORE-ARC BASINS, INDONESIA

Tj.C.E. van Weering,
J.H.F. Jansen, W.J. van der Werff

This year attention was focussed on the understanding of the structural position of the Island of Sumba within the trend of the forearc basins, and its relationship with the development and sedimentary history of the Lombok and Savu forearc basins. This will be the subject of the Ph.D. thesis of W. van der Werff. A literature survey and preliminary re-interpretation of the seismic profiles from the area reveal that the Island of Sumba forms the uplifted segment of a forearc basin which originally extended to and included part of Timor. Fragmentation of the oceanic and continental margin sediments of the downgoing plate may have caused the presence of locally faulted basement ridges and anomalous doming of outerarc ridge fragments. A comparison of gravitational emplaced deposits exposed on Sumba with the slump deposits shown on seismic profiles from the southern Savu Basin confirms this interpretation. Diatoms in surface sediments of the Lombok and Savu Basins have a distribution which is largely governed by the hydrography and surface current patterns.

H3-13 PALAEOCEANOGRAPHY AND TERRESTRIAL CLIMATE

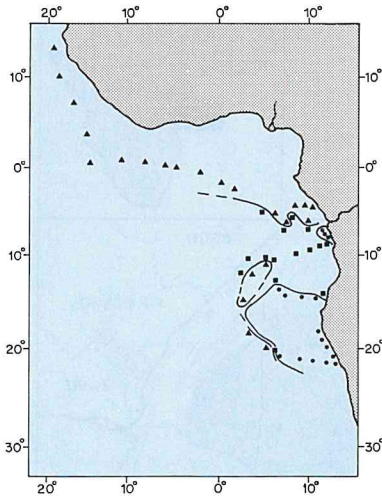
J.H.F. Jansen, E. Ufkes

(Palae)oceanography and geochemistry of the Angola Basin (south Atlantic Ocean)

The opening and description of the box-cores and piston cores are continued and will be finished at the end of the year. We started the distribution of sub-samples to the various specialists.

Planktonic foraminifera

During the 1989 Angola Basin expedition, planktonic foraminifera were sampled from the superficial (0-10 m) and deeper (0-150 m) surface waters. The superficial samples were collected every 8 hours with a 50 and 100 μm net from the water inlet at 5 m depth in the bow of RV 'Tyro', the deeper ones with a 50 μm vertical plankton net (VPN) at a number of selected stations. Specimens larger than 150 μm have been examined. The samples, which were collected 3 times a day, do not show a significant influence of diurnal vertical migration. It is inferred that the daily movements do not considerably affect the frequency distributions of the planktonic foraminifera in interregional studies. From cluster analysis of both the surface water and the VPN samples three assemblages can be recognized: a subtropical, an open-ocean and a transitional-subpolar one. The assemblages seem to be mainly determined by food supply and temperature.



Distribution of planktonic foraminifera in surface water and plankton-net samples from the east equatorial Atlantic Ocean.

▲ = subtropical; ■ = open ocean and ● = transitional-subpolar association.

—The subtropical assemblage represents relatively oligotrophic and warm surface water, and is dominant north of the Zaire river. Patchy occurrences are also found further south.

—The open-ocean assemblage often appears when the environmental conditions become unfavourable for the subtropical assemblage. The assemblage contains cosmopolite species which prefer more nutrient-rich water than the subtropical one. It inhabits the area near and south of the river outflow.

—The third group, the transitional-subpolar assemblage, prefers nutrient-rich and cold water. This group can be subdivided into deep and shallow representatives. The first ones appear in the most nutrient-rich and cold water. The latter are not so much bound by the low temperature of the water. In general, the assemblage is found in the south where the influence of the Benguela Current is still detectable.

By comparing assemblages of the surface water and VPN one can obtain information on the structure of the water column: the similarity and the composition of the assemblage express the thickness of the mixed layer. Four situations can be recognized: a good similarity with deep (a) or shallow (b) species, and a poor similarity pointing to a normal vertical distribution (c) or containing foreign elements (d).

(a) The presence of deep-living species both in the surface water and the VPN usually indicates a thin mixed layer. The deep-dwelling species are brought to the surface by upwelling. When upwelling does not push through entirely, surface-dwelling species (of the same assemblage) are found abundant next to the deep dwellers.

(b) A thick mixed layer can be concluded from the appearance of shallow-living species in both samples.

(c) A normal vertical fauna distribution of shallow- and deep-living species indicates a moderately thick mixed layer. The two ecosystems are kept apart.

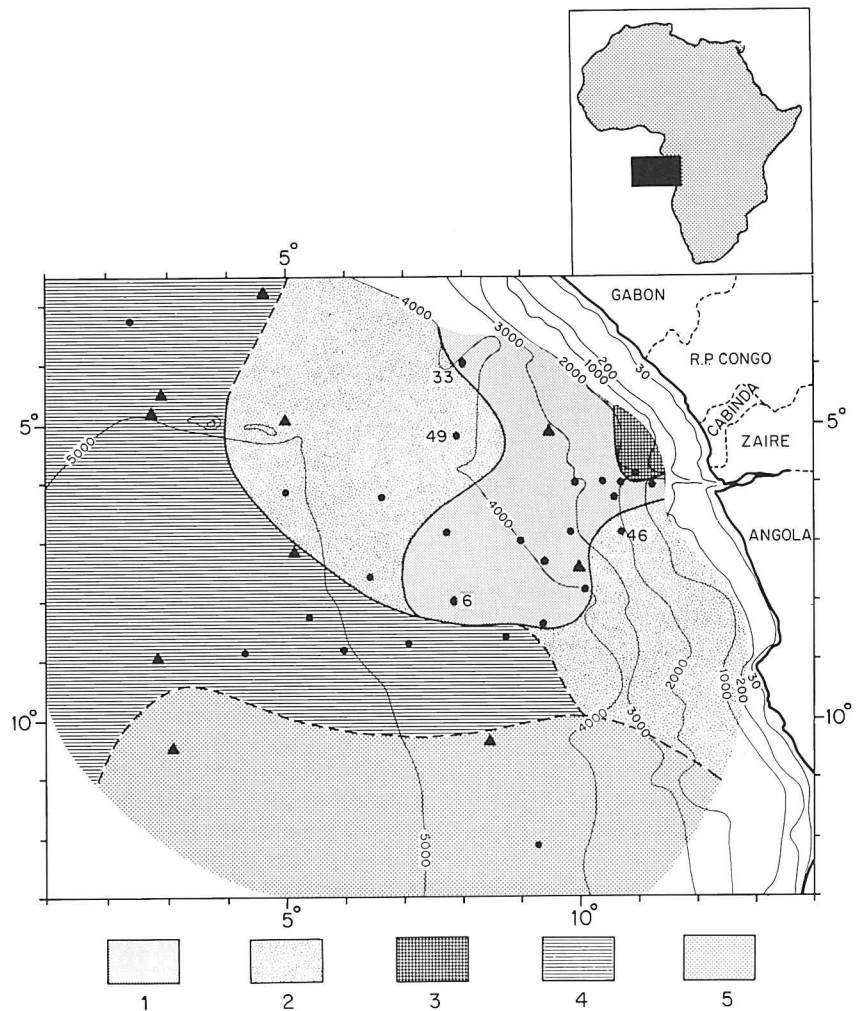
(d) A poor similarity is caused by the occurrence of different assemblages at different water depths. They are kept apart by a moderately thick mixed layer, which prevents the interactions of the two water masses. If upwelling occurs, it does not reach the surface in this situation. As a consequence, no traces of deep-dwelling species are found between the surface dwellers in the upper surface water.

The four types of conditions can be recognized in the Angola Basin.

(a) In the surface water over the Zaire fan, normally deep living species (*Neogloboquadrina dutertrei*) are abundant. This indicates an extremely shallow mixed layer as a result of upwelling nutrient-rich water.

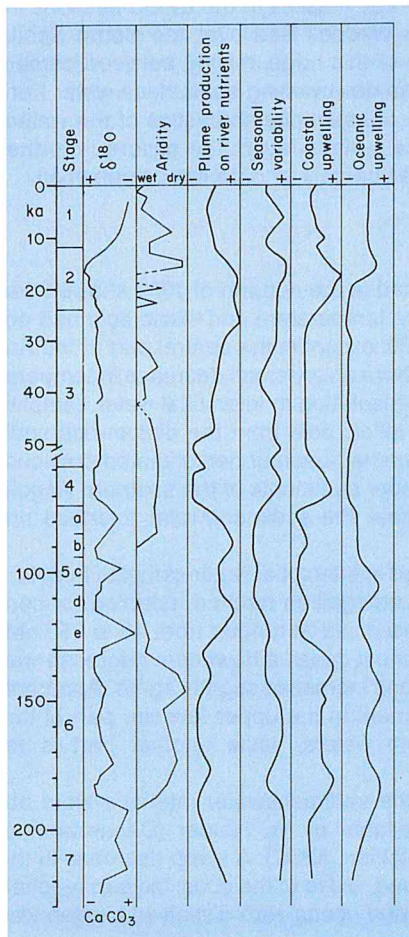
(b) In the southwestern region, shallow-living subtropical species are found both in the surface water and in the VPN samples. This can be explained by a thick mixed layer. At first sight, the patchy occurrence of the assemblage itself near the cooler transitional-subpolar one looks strange. Its main contributor, *Globigerinoides trilobus*, is one of first subtropical species that can profit from the higher surface water temperature (and low nutrient content) compared to the region more to the east.

(c) In the north, differences in surface water and VPN samples are mainly due to variations within the (subtropical) assemblage itself. This is an example of a stable vertical distribution together with a moderately thick mixed layer.



Diatom distribution in sea-floor sediments of the Zaire deep-sea fan region. The 5 groups are related to the low-salinity river plume (1), input of river nutrients and coastal upwelling (2), seasonal variability (3), low nutrient content (4), and oceanic upwelling (5).

(d) At station T89-8 in the middle of this region, the subtropical assemblage in the VPN is pushed away by cosmopolite species, while the subtropical one still flourishes in the surface waters. The sharp contrast between the two can be maintained by a moderate thickness of the mixed layer, but is induced by doming of more nutrient-rich water, in detriment to the oligotrophic species. In the coastal surface waters between 18°S and Walvis Bay, deep-dwelling species of the transitional-subpolar assemblage are dominant. In spite of the lack of VPN samples, some speculations about the water column can be made. The habitat of these species (cool and nutrient-rich water) can be best provided by upwelling, resulting in a very thin mixed layer.



H3-15 THE SILICA CYCLE

A.J. van Bennekom

Diatoms and opal phytoliths

A Late Quaternary climatic record for the east equatorial Atlantic and for equatorial Africa was generated from downcore studies of the diatoms and opal phytoliths in the Zaire deep-sea fan. The studies are based on previous work which related the species distribution of the sea floor sediments with the properties of the overlying surface water masses. The relations were applied to the fossil associations in piston-cores which represent 220 000 years of history of oceanic and continental climatic processes, like continental aridity, primary production in the Zaire river plume, seasonal variability in river supply or coastal upwelling, coastal upwelling and oceanic upwelling.

According to the traditional approach of microfossil studies, the relative contributions of groups of diatoms were investigated. Besides, also the accumulation rates were taken into consideration. It appears that sometimes relatively large percentages of diatom groups are only caused by low accumulation rates of others. In such cases the large percentages do not need an explanation and only the large fluxes of the other groups should be studied.

The downcore variations give no evidence of a strong northward displacement of the Benguela Current over the last 220 000 years. The diatom group which represents the South Equatorial Counter Current is the dominant oceanic group in all samples from the Zaire fan region. In the present circulation, the Benguela Current transports relatively cold and nutrient-rich water northwards in a broad zone along the African coast, and is deflected to the west at 20°S. A narrow subsurface tongue of the Benguela Current can be detected off the continental shelf up to 5°S. During glacial stages, the westward deflection shifted probably only a few degrees to the north in connection with the global glacial increase of the oceanic circulation. This contradicts other reconstructions of the southeast Atlantic circulation which display a northward penetration of the Benguela Current into the Guinea Basin during the last glacial stage. We assume that the glacial floral and faunal microfossil associations of the Guinea Basin indicate increased primary production due to oceanic divergence and upwelling in the first place instead of an entrance of Benguela Current water.

Antarctica

The dissolution kinetics of biogenic silica collected in the Weddell-Scotia Confluence during the EPOS project was investigated in net samples as well as in samples obtained from cultures with and without addition of aluminium. The Al content, about 0.03% in net samples, decreased to 0.009% in cultures without Al and increased to 0.05% in cultures with Al. These small variations in Al content were inversely correlated with the solubility and the dissolution rate of biogenic silica. The results fit well into those obtained previously on samples with higher Al content from other regions and in monospecific culture experiments carried out by Van Beusekom at the University of Hamburg. The armouring of biogenic silica by Al has a physico-chemical basis and does not depend on species. Diatoms from the Antarctic dissolve faster than those from temperate and upwelling regions; the effect of low temperatures is more than compensated for by the low Al-content. This contributes to the high concentrations of silicic acid in the upper and intermediate water layers of the Weddell Sea.

Further studies on the distribution of water masses in the EPOS sections indicate overflow of deep water from the Weddell Sea over the South Scotia Ridge at 49°W. A few hundred km north of this ridge, mixing between parcels of upwelling Circumpolar Deep Water and downwelling subsurface water from the Weddell Sea is able to generate the unusual characteristics of the waters in the Weddell-Scotia Confluence. In the surface layers the picture is further complicated by lateral intrusions of water parcels of different composition.

Angola Basin

Preliminary analysis of the results obtained in the autumn of 1989 showed that the mutual relationships between salinity, temperature and silicic acid had not changed since previous work in 1976-1980, except in the central part of the Angola Basin, between 3 and 5 km depth where a very small decrease in temperature and silicic acid was found. A better resolution in interstitial water samples from box cores showed that the flux of silicic acid from the diatom-rich sediments of the Guinea and NE Angola Basin had been underestimated previously. This was not the case for the diatom-poor sediments of the southern Angola Basin, where gradients of silicic acid near the sediment/water interface are smaller.

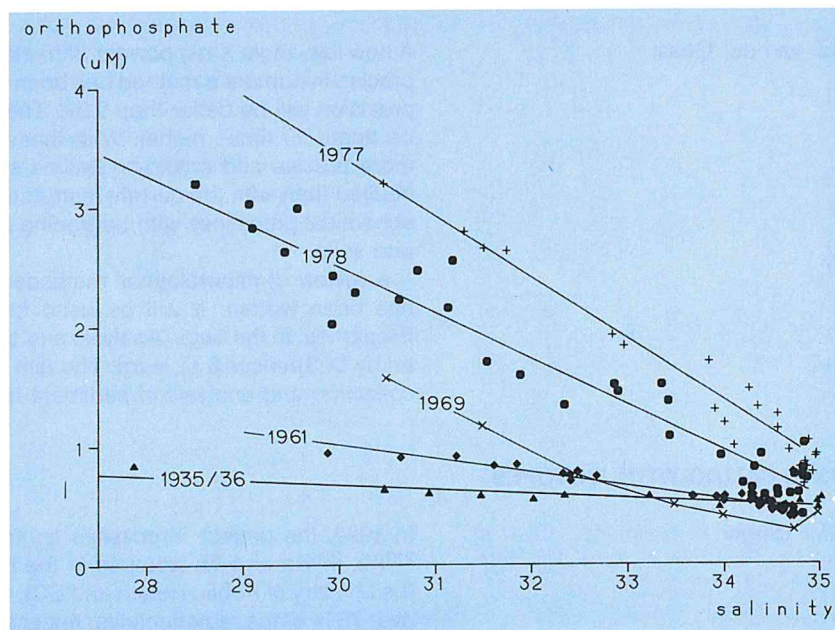
Profiles of dissolved Al were determined in interstitial water samples from box cores with an improved version of the Lumogallion method, adapted for continuous flow analysis. In the upper cm dissolved Al ranged from 40 to 250 nM, always higher than in bottom waters. In most cases a downcore decrease was found; below 5 cm depth the concentrations increased slightly again. Apparently dissolved Al is leached from the sediment in the upper few cm; part of this is lost by upward diffusion into bottom waters, while another part is re-adsorbed.

Gradients of dissolved oxygen near the sediment/water interface were obtained with micro-electrodes made available by W. Helder (Department of Chemical Oceanography and Marine Pollution, NIOZ). A steep decrease in the upper 0.5 cm of sediment was always found, close to the coast oxygen reached zero at about 1 cm depth, while in the open ocean zero dissolved oxygen was not reached in the upper 3 cm.

North Sea

No common opinion exists on the interpretation of nutrient trends in the Southern Bight over the past 60 years. Increased loads from rivers as well as possible changes in circulation and internal cycling play a role. Previous interpretation of trends in the winter concentrations of dissolved nutrients heavily depended on the measurements carried out in 1961 by the MAFF laboratory at Lowestoft (U.K.); some doubts have risen recently about the reliability of these measurements. Dissolved phosphate measurements by Kalle, carried out in the winters of 1935/6, show a clear increase in phosphate from the mid-thirties to the mid-seventies.

Historical winter (Jan. + Feb.) concentrations of dissolved orthophosphate as a function of salinity off the Dutch coast between the mouth of the Rhine and the Marsdiep. Values for 1935/6 have been added from KALLE (1937).—Ann. d. Hydr. **65**: 1-18.



Diatom growth measured with radioactive ^{32}Si .

Radioactive ^{32}Si (β -emitter, $T^{1/2}$ about 170 y) has unique possibilities as a tracer in studies of the silica cycle. It was applied for the first time during EPOS-leg 2 to measure the productivity of diatoms. The specific activity of the available stock of ^{32}Si was sufficiently high for studies in Antarctic waters, but in the North Sea, with much lower concentrations of silicic acid, a new stock is necessary. This will be prepared in cooperation with the Paul Scherrer Institute, Villigen, Switzerland.

Because of its easy accessibility the Marsdiep was selected as a suitable site for a pilot project. In cooperation with G.C. Cadée (Department of Coastal Systems, NIOZ), the seasonal cycles of diatoms and silicic acid were studied in samples taken at high tide. During the spring diatom bloom in early April, silicic acid was consumed down to $0.1 \mu\text{M}$; in the course of the year it ranged from 0.2 to $4 \mu\text{M}$; there is not always a straightforward relationship between silicic acid and diatoms. It is necessary to establish if the diatom community is actively growing or advected in a latent state. Data on growth kinetics of diatoms at low ambient levels of silicic acid are also needed to assess the role of Si in the ecosystem of the North Sea. This project is carried out in cooperation with L. Lindner, University of Utrecht, and R. Riegman, BEWON.

H3-17 THE ROLE OF CRYPTO-CRYSTALLINE MINERALS IN SEDIMENTS

S.J. van der Gaast

A new low-angle X-ray powder diffractometer is being constructed. For this very precise instrument a method has been invented for reproducible alignment. The precision will be better than 0.01°. The detected intensity of the instrument will be about 10 times higher. With these two properties data corrections will be more precise and crypto-crystalline structures in clay minerals can better be studied than with the current instrument. These structures are important in geochemical processes with upgrading and downgrading reactions in sediments and soils.

A review of mineralogical methods and pre-treatment of sediment samples has been written. It will be used for the chapter 'Mineralogy and Surface Properties' in the book 'Analysis and Characterization of Marine Particles', edited by D. Spencer & D. Hurd. The aim of the book is to serve as a guideline for collection and analysis of sediment trap samples.

H3-19 DATING WITH ISOTOPES

G.W. Berger

In 1990, the project 'Processes controlling the regional distribution of ^{210}Po , ^{210}Pb , ^{226}Ra and Th isotopes in the river Rhine and its estuary' (financed by the Ministry of Public Health and EC), was finished. The main conclusion is that over 75% of the radionuclides, released by phosphate processing plants in the New Waterway, are transported to the North Sea absorbed on suspended material. In cooperation with RIVM, a radiological dose effect study will be performed. Financially supported by the EC, a project called 'Behaviour of ^{210}Po and ^{210}Pb in European marine environments' has been started. This project will be carried out in cooperation with the RIVM, the CEA (France) and the LNE-TI (Portugal) and is a continuation of projects carried out in the river Rhine. At the request of, and financially supported by the Ministry of Transport and Public Works, a start has been made to date three cores taken in the Eastern Scheldt. Cores taken off the Italian coast in the Adriatic Sea have been dated by ^{210}Pb and ^{137}Cs . This has provided a time scale for changes in primary productivity due to eutrophication in this area. The results will be worked out in cooperation with the University of Utrecht and the Center for Marine Research in Rovinj, Croatia, Yugoslavia.

H3-20 SEMI-AUTOMATIC MICROPROBE ANALYSIS OF SUSPENDED PARTICLES

D. Eisma, J. Beks

The automatization of the SEM-EDAX-microprobe system, made possible by the development of a precision sample stage by A. Vaars, was developed by J. Beks, who wrote an automatic measuring steering computer programme and calibrated the measurements with standard mineral samples of known composition (elementary composition, XRD). The method makes it possible to indicate any number of particles in a sample under the SEM, that are subsequently automatically measured with the microprobe. The measured spectra are recorded and classified according to the spectra obtained from standard minerals. A series of measurements on suspended matter samples from the Scheldt river and estuary have been made to investigate the application of the measuring system to natural samples.

1.5. BENTHIC SYSTEMS (B1)

INTRODUCTION

The Department of Benthic Ecosystems focusses on the structure and functioning of marine benthic ecosystems and on the assessment of their relations with environmental conditions. As there are numerous interrelationships between the benthic system and the pelagic system - a major part of the energy needed to fuel the benthos is provided by sedimentation of organic matter from the euphotic zone - some studies of the water column are also included.

Thus, the Department was involved in a wide variety of projects, including field studies in Antarctic waters (projects B1-02, B1-06), in the North Atlantic Ocean (B1-04), in the tropical Atlantic and Pacific Oceans (B1-05), in the North Sea (B1-04, B1-06, B1-09, B1-10, B1-11, B1-12 and B1-13) and in the Wadden Sea (B1-02, B1-06); semi-field (mesocosm) work included studies using North Sea bottoms (B1-01, B1-02, B1-03, B1-06, B1-09). Long-term trends of time fluctuations in growth rates of *Arctica islandica* were studied in the laboratory (B1-10). The projects B1-12 and B1-13 are new.

The processing and analysis of benthic samples is often so time-consuming that Department members still have to pay attention to earlier, not yet completed, projects: e.g. the North Sea benthos survey, 1986 (B1-07), Mauritania Expedition 1988 (B1-08), JGOFS 1989 (B1-04) and the SEDEX experiments, 1987-1989 (B1-01).

A major effort was the design and realization of an advanced type of a remote-operating benthic lander system. This system is expected to measure benthic community activity and sediment-water interactions in shelf and deep sea (B1-04).

Dr. J. Gutt (AWI, Bremerhaven), as a post doctoral guest, joined our group in the period July-December. He is elaborating his extensive Antarctic photo and video collection in order to assess benthic community structure in the Weddell Sea area.

B1-01 BENTHIC MESOCOSMS

P.A.W.J. de Wilde, G.C.A. Duineveld,
R.P.M. Bak, R. Dekker

Benthic mesocosm research is often frustrated by the lack of statistical conviction caused by too low a number of replicas. The use of undisturbed bottom sections collected in the field, moreover, suffers from the large variations which are inherent to the patchiness of natural ecosystems. Therefore, when a large-scale eutrophication experiment in the North Sea mesocosms was planned, the use of uniform boxcosms, artificially composed from homogenized sediments and organisms, was reconsidered.

North Sea eutrophication experiment

Increased eutrophication of the southern North Sea, and the enhanced deposition of organic matter on the bottom are topics of major concern. To obtain detailed insight into the effects of organic matter on subtidal benthic communities in terms of sediment chemistry, development of micro-, meio- and macrobenthos, and community activity, research in the North Sea mesocosms was carried out.

Ninety-six PVC vessels, 40 cm high, 30 cm in diameter, were filled with sterilized sandy sediment from the southern North Sea, up to 5 cm below the rim. Sixty-four were subsequently stocked with known numbers of echinoderms (*Echinocardium*) bivalves (*Tellina*) and polychaetes (*Nephtys*). A freshly collected mud sample was added to facilitate the recolonization of small food web organisms. The remaining vessels were without animals and served as controls, or were used for sediment chemistry. All artificial systems were arranged in the two available North Sea mesocosms in such a way that the upper parts of the vessels emerged from the surrounding water.



The North Sea mesocosms
(Photo: NIOZ)

A moderate flow-through ($1 \text{ dm}^3\text{h}^{-1}$) of North Sea water and a gentle bubbling of air provided sufficient renewal and turbulence of the overlying water in the vessels. Temperature in the mesocosms followed the annual bottom temperature excursion in the southern North Sea. Energy supply of the ecosystems was simulated by administering portions of deep-frozen *Phaeocystis* collected during its previous spring bloom in the Marsdiep. The experiments lasted from May to October.

Benthic community respiration, protist numbers, and development and growth of macrofauna and bioturbation activity were studied by our Department. For further details and results see also B1-03, B1-09 and S-06. (This research takes place in collaboration with BEWON, DIHO, TNO.)

B1-01/S-06 SEDEX

R. Dekker, P.A.W.J. de Wilde

In SEDEX, the effects of different types of harbour sludge on tidal flat ecosystems were tested in large outdoor mesocosms. After the practical work of the SEDEX programme, which expired at the end of 1989, the results of the macrozoobenthos part, covered by NIOZ, were reported.

In summary, the use of fresh sludges caused an enhanced nutrient release in the overlying water, generally resulting in micro-algal blooms. Apart from reduced shell growth in adult bivalve molluscs (*Cerastoderma edule*, *Macoma balthica* and *Mytilus edulis*), most parameters of the macrozoobenthos increased as a result of this enhanced food supply, although the development of populations of some species (*Arenicola marina* and *Hydrobia ulvae*) was inhibited. The release of toxic components from the fresh sludges (heavy metals, organic micropollutants) caused aberrations in shells and tissues, especially in *Cerastoderma edule*, followed by increased mortalities in this species.

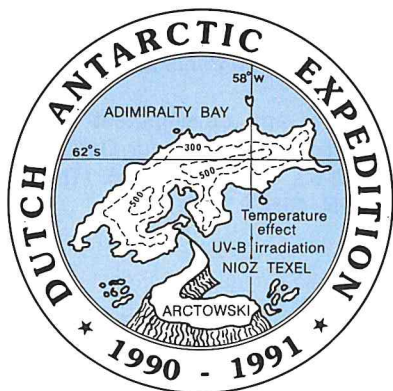
Sludges that were exposed to air prior to testing in the mesocosms in order to reduce the nitrogen content by denitrification caused less dramatic effects, although they too had high primary productivity.

The different types of harbour sludge treatment resulted primarily in increased primary production. Inter- and intra-specific relationships, moreover, played a prominent role: in the ecosystem development a decline in one species is compensated for by the increased settlement of other (opportunistic) species. After a mass mortality in a certain species, a remarkable increase of growth in the few remaining specimens of the same species was observed. The high values of primary production and phytoplankton biomass up to the end of the experiments in late autumn point to unnatural circumstances and to suboptimal adaptations of the macrobenthos to these abnormal situations.

B1-02 MICROBIAL BIOMASS AND ACTIVITY IN MARINE ECOSYSTEMS

J.H. Vosjan, P. Visscher

In the framework of the research on the effect of UV-b radiation on microbial ecosystems, the penetration of PAR (photosynthetic active radiation), UV-a and UV-b in the upper water layer of the Dutch Wadden Sea and in the water column of the Admiralty Bay (Antarctica) was studied. For experimental work on the effects of UV-b an experimental set-up was designed. A cuvet system on an optical bank with filters, light source and light sensors was built.



In North Sea mesocosm experiments, the effect of input of organic matter on the distribution of microbial (ATP) biomass and microbial respiration (ETS) activity was studied. Vertical distribution of these parameters in the model system was comparable to the natural ecosystem of the North sea. A few weeks after addition of organic matter, the activity and biomass in the deeper sediment layers increased. Reworking of the sediment by bioturbating fauna will have influenced the distribution of organic matter to deeper layers.

Data on the work in the tropical regions off West Africa, Angola Basin and Zaire river were processed.

Much time was spent in preparing the expedition to Arctowski station on King George Island (Antarctica). Here the effect of temperature on the microbial respiration and the effect of UV-b on the microbial system of Admiralty bay will be studied.

As part of the BION-project 427.022 BO (Van Gernerden of the University Groningen, Vosjan, Visscher), Visscher continued his research on laminated microbial ecosystems. The study of the sulphur cycling in the microbial mats focussed on activities of several functional groups of sulphur bacteria. As a representative of the anoxygenic phototrophic community, *Thiocapsa roseopersicina* was studied in continuous cultures in order to reveal the sulphur metabolism of this functional group of organisms. A variety of inorganic and organic sulphur compounds can be used as electron donor for photosynthesis. The most striking result was that polysulphides are found in the field at growth-inhibiting (supra-optimal) rather than growth-limiting concentrations. A chemolithoautotroph, *Thiobacillus thioparus*, was isolated and its organic sulphur utilization studied. This marine strain is the first in which autotrophic growth on dimethylsulphide was demonstrated. As part of the sulphate-reducing side of the sulphur cycle, radioactive-labelled sulphate was employed to measure sulphate reduction rates. Most probable number counts already showed that the largest viable sulphate-reducing bacteria population can be found at the sediment surface (top 5 mm). Actual rate measurements also demonstrated the highest activity during the anoxic period at the same location. Whole-core incubations revealed that during oxic periods (daylight), due to cyanobacterial photosynthesis, sulphate reduction occurs in the top layer despite the presence of high concentrations of oxygen. During active photosynthesis, the highest rate of sulphate reduction is shifted to the 5-10 mm depth horizon. Integrated over a diurnal cycle, the most important layers of sulphate reduction (hence mineralization) can be found in the upper 10 mm of the microbial mat.

B1-03 BIOTURBATION

P.A.W.J. de Wilde

Observations on bioturbative activities of the heart urchin *Echinocardium cordatum* in sandy sediments were made in the experimental North Sea ecosystem containers stocked with known numbers of heart urchins. They were covered with a thin layer of coloured and fluorescent sand grains and the effect of ploughing and sediment reworking was studied. The depth of the reworked sediment layer amounted to about 7 cm.

B1-04 COMMUNITY METABOLISM OF SHELF SEAS AND THE DEEP-SEA

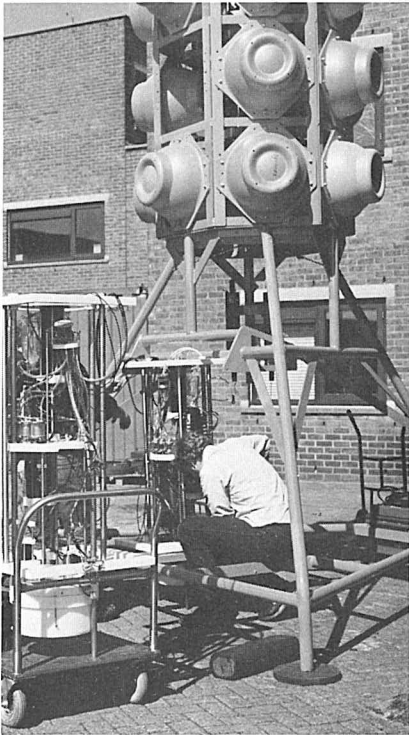
P.A.W.J. de Wilde

JGOFS is focussing on the role of the organic carbon cycle in the regulation of the world's climate. As a small part of the organic matter produced in the euphotic zone of the oceans ultimately sediments at the ocean bed, knowledge of the amount, quality and ultimate fate of these deposits is needed. Results from sediment trap studies showing the downward particle transfer at several depths in the water column have shed insufficient light on the amounts which actually enter the sea bed. Methods for direct measurements of deposition of organic matter are lacking, but an estimate of the metabolizable part is to be obtained from determination of benthic community respiration.

Therefore the opportunity to take part for a second time in JGOFS on board RV 'Tyro' was eagerly accepted. In June during leg 4, which focusses on benthic studies in the North Atlantic, 6 incubation experiments with undisturbed bottom cores were carried out. The stations occupied covered a range of geographical latitudes, water depths and ecological conditions. The estimated community respiration (not yet corrected for the respiration in the water and for the demand of the electrodes) ranged from $32 \mu\text{mol O}_2 \cdot \text{m}^{-2} \cdot \text{h}^{-1}$ at the southernmost station west of Spain to $85 \mu\text{mol}$ west of Ireland. Additional samples for the characteristics of sediment and biota have been stored for further processing.

Benthic Lander

After many years of hand-operated respiration chambers in the intertidal areas and boxcorer-related bell-jar systems in shelf seas to estimate community respiration and other bottom-water interactions, the need arose for an instrument with which also the continental slope and deep sea could be tackled. It was recognized that deep-sea research largely depends on the deployment of sophisticated and generally expensive equipment. Thus, in 1989 when the Ministry of Education and Science allocated financial support, the NIOZ Departments Benthic Systems, Chemistry and Geology started to cooperate in the development of three largely complementary benthic lander systems. The Benthic Systems Department aimed at the development of an instrument with the following specifications:—easy to handle during launch and recovery from a research vessel;—free falling;—remotely operating two bell-jar systems at depths down to 6000 m;—operating two Niskin bottles to provide a sufficient volume of bottom water for initial O_2 and nutrient concentration;—taking photographs of sediment surface prior to the setting of the bell jars;—proper setting of a bell-jar system with oxygen and temperature sensors and an adequate stirring mechanism;—sufficient penetration of the bell jars into the sediment;—proper sediment surface/overlying water volume ratio;—proper closure of the bell jars;—continuous recording of the temperature and the oxygen concentration of the enclosed body of water and subsequent data storage in a computer;—subsequent water sampling in a programmable time series in and outside the bell jars to estimate nutrient fluxes;—collection of a final water sample from the bell jars to provide the end value of the oxygen concentration;—proper opening of the bell jars;—acoustic release at will from the research vessel;—easy to detect from the research vessel when emerged (radio emitter, flash light, radar reflector). Moreover, the lander frame should provide the support for a sediment sampler, suspended matter trap and a current meter.



The benthic lander
(Photo: J. Nieuwenhuis)

In June, during leg 4 of JGOFS in the North Atlantic, a prototype of the lander system envisaged was available. Though the instrument suffered from some growing pains that prevented the collection of useful scientific data, the 4 lander deployments at depths ranging from 2700 to 4650 m are to be considered a most valuable test programme of a unique machine at real deep-sea conditions.



The benthic lander at sea
(Photo: J. Nieuwenhuis)

B1-05 CORAL REEFS

R.P.M. Bak

The dominant reef builder of Caribbean reefs, *Montastrea annularis*, a massive, potentially very large stony coral, is of crucial importance in the maintenance of the reef habitat. The large variation in colony size and shape of this species was believed to be related to environmental parameters, but the causal relationships were not known. Research on reefs in Curaçao shows a particular pattern of distribution of colony size and shape along the coast with small-sized colonies in the area of anthropogenic influence.

Along Bonaire and Curaçao it appears to be possible to distinguish three morpho-types ('columnar', 'bumpy', 'massive'), of which the last one can be subdivided in 5 separate morphological groups. An electrophoretic study is initiated with the Smithsonian Tropical Research Institute to investigate if these morpho-types are identical with similar forms in Panama (San Blas Islands). There is evidence that the three morpho-types differ in ecological characteristics. Histocompatibility experiments show consistent patterns of intraspecific aggression with the bumpy forms dominating the columnar, dominating the massive forms. Other aspects of the life history characteristics of the morpho-types such as reproduction are being investigated.

Surveys on the importance of damage and regeneration in corals along the coasts show significant differences in occurrence of damage on living surfaces of coral colonies. Experimental series of lesions in different species (*Acropora*, *Montastrea*, *Porites*, *Agaricia*, *Diploria*) and at different sites have been initiated. The first results show an extraordinarily rapid regeneration of 1 cm² lesions in *Acropora palmata*. Within a month all lesions had recovered at a control site (pristine reef) but regeneration at polluted sites was significantly slower. This research is carried out with M. van Veghel and E. Meesters, stationed at Carmabi, Curaçao, Netherlands Antilles.



A large colony of the dominant Caribbean reef-building coral *Montastrea annularis* at a depth of 12 m at Playa Bengé, Bonaire. (Photo: R. Bak)

Research in French Polynesia provided the following results and conclusions: After thin sections of echinoid faecal pellets became available to estimate primary framework consumption by the different urchin species, total impact of the populations in terms of coral reef bio-erosion could be calculated. On Moorea, *Diadema savignyi* is the main bio-eroder, accounting for 9 g of the total urchin erosion of $12.5 \text{ g m}^{-2} \cdot \text{d}^{-1}$. When a calcium carbonate budget is calculated it appears that constructional forces (coral growth) accumulate $2100 \text{ g solid reef frame m}^{-2} \text{ yr}^{-1}$. Total rate of framework erosion by echinoids amounts to $4550 \text{ g m}^{-2} \text{ yr}^{-1}$ and the conclusion is that the reef structure in Tiahura lagoon is rapidly turned into a sandy sediment. In Takapoto urchin densities were low, except at inlets to the lagoon, and echinoid bio-erosion was negligible.

B1-06 PROTOZOANS

R.P.M. Bak, B.J.M. Hondeveld

Benthic heterotrophic flagellate densities were obtained in spring, summer and autumn in fresh North Sea sediments and in North Sea bottom mesocosms. We compared sandy (Broad Fourteens) and muddy sediments (Frisian Front). Densities in sandy sediments ($\text{max. } 300 \times 10^3 \text{ cm}^{-3}$) are in the range of Wadden Sea values and the data suggest a similar seasonal density variation. In the muddy sediments flagellate densities are low ($< 50 \times 10^3 \text{ cm}^{-3}$) and do not show a clear density pattern.

To assess if bacterivory at such densities of heterotrophic flagellates in the benthos could have a regulatory effect on the bacterial community, rates of flagellate predation and bacterial production should be known. We used fluorescently labelled bacteria mixed in sediment samples to study flagellate predation and measured preliminary predation rates varying from 8 to 96 bacteria flagellate⁻¹ hour⁻¹. Calculations show that the heterotrophic flagellates could consume between 11 and 100% of the hourly bacterial production in the sandy and 1 to 5% in the muddy North Sea bottoms. There are apparently large differences between the microbial communities in sandy and muddy sediments.

Analysis of the EPOS 3 47° W transect showed differences in the distribution of living and non-living particles in Scotia Sea water and Weddell Sea water. Scotia Sea water showed a higher particle density, higher chlorophyll *a*, high POC and PON but in Weddell Sea water densities of bacteria and flagellates were much higher. These characteristics can be related to processes in the phytoplankton. A preliminary analysis of the variables studied in the benthos of the Weddell Sea showed significant correlations between the abiotic factors such as porosity, densities of small flagellates ($< 5 \mu\text{m}$) and meiofauna. There were also significant correlations between the components of the small food web such as bacteria, larger flagellates (5-10 μm) and meiofauna.

Fluctuations in communities of bacteria, nanoflagellates and ciliates through the years in Marsdiep water are being analysed and for time intervals related to similar data on phytoplankton and copepods.

B1-07 SYNOPTIC MAPPING OF THE NORTH SEA BENTHOS

G.C.A. Duineveld, P.A.W.J. de Wilde

In cooperation with other participants, an analysis has been made of the distribution of macrobenthic assemblages in the entire North Sea on the basis of the complete data set produced by this project. The result confirms the position and similarities of the structural entities in the Dutch Sector that were previously recognized only by samples from this area. The overall division furthermore shows that the major transition in the macrofauna composition is located at the 80 m depth contour in the central North Sea. The southern assemblages are delimited by the 30 and 50 m isobaths in combination with the grain-size distribution. In contrast with the macrofauna, the composition of the epifauna in the Dutch Sector shows a gradual change from south (coast) to north (central North Sea) and thereby seems to be less influenced by grain size and depth. No significant correlation was found between the biomass of the macrofauna and epifauna in the Dutch Sector. In some areas, notably the Frisian Front, however, both epifauna and macrofauna biomass show increased levels compared with adjacent regions. One of the striking differences within the epifauna in the Dutch Sector is the scarcity of sessile organisms in the southern North Sea in comparison with the central North Sea. This could be a result of the historically higher intensity of bottom fishery in the southern North Sea.

B1-08 MAURITANIA EXPEDITION

G.C.A. Duineveld, P.A.W.J. de Wilde

During the Dutch Mauritania I expedition, a diverse and rich benthic fauna was found on the offshore shelf. Such relatively high biomass and density of macrofauna in comparison with more southern and northern shelf areas point to an enhanced food input which is possibly related with the upwelling off the Mauritanian coast. Adjacent to this area is the shallow Banc d'Arguin, which sustains large numbers of overwintering palaeartic waders that require a substantial primary and secondary production. One of the questions is whether there is any transfer of organic material between the offshore shelf and the shallow Banc d'Arguin. Pigment analyses (HPLC) of sediment-trap contents and sediment along two transects on the shelf show that the southern transect and the deepest station of the northern transect receive, respectively contain, low amounts of fresh material. These are the same localities as, during the expedition, were covered by oxygen-poor South-Atlantic central water (SACW). Also benthic biomass was lowest at these stations, suggesting a more long-lasting depressed food input. The remaining stations at the northern transect had a higher input and quantity of plant pigments, but here the pigment composition indicated more reworked material. Macrofauna biomass at these sites was at least twice as high as at the other stations. The water mass that covered these northern stations was characterized by high salinity and temperature, and probably originated from the Banc. These findings suggest that part of the organic material from the Banc is exported on to the shelf. No evidence was found that the plant material was derived from seagrass, which covers extensive areas of the Banc. Data from the hydrographical survey were elaborated in close collaboration with Y. Loktionov of the Fisheries Institute, Kaliningrad, USSR.

The final results of the Mauritania expedition will be presented at the International Mauritania Symposium, to be held at Leiden in March 1991.

B1-09 GROWTH AND PRODUCTION

G.C.A. Duineveld

During the running eutrophication experiment in the North Sea mesocosms (B1-01), we studied how various amounts of algal matter deposited on the North Sea sediment affected the growth of *Echinocardium cordatum* and *Tellina fabula*. Over a 5-month period a distinct relation between length, growth and g organic $C \cdot m^{-2}$ could be observed. Starved animals in the controls showed weight losses.

B1-10 LONG-TERM TRENDS IN BENTHIC FAUNA OF THE NORTH SEA

R. Witbaard, P.A.W.J. de Wilde,
G.C.A. Duineveld

In order to detect gross changes in the conditions for benthic macrofauna in the North Sea, a retrospective study on the growth of the long-lived mollusc *Arctica islandica* was started in 1989. By counting growth bands in acetate peels of the cross sections of the shells, differences in growth rates between different parts of the North Sea were determined. Also congruent fluctuations were found in the growth of specimens from one locality. On the basis of reports on the annual formation of growth bands in *Arctica* from the east Atlantic, the same periodicity was assumed for North Sea specimens. This assumption has been verified in two specimens from the North Sea. For this purpose ^{14}C contents were measured (by Dr. K. van der Borg, Physical Laboratory, University of Utrecht) in consecutive shell sections that each comprised five bands or a supposed period of five years. The ^{14}C levels in these sections showed a sharp increase in the section which covered the period 1960-65 on the basis of yearly band formation, and elevated levels in successive sections. This result complies with the general increase of ^{14}C levels in marine organisms in the 1960's due to atmospheric bomb tests. It seems likely, therefore, that growth bands in North Sea specimens are also formed annually. This provides a basis for the absolute dating of growth fluctuations in *Arctica* and relating these to measured environmental variables.

B1-11 COMPARATIVE INVESTIGATIONS OF BENTHIC SYSTEMS IN FRONTAL AREAS

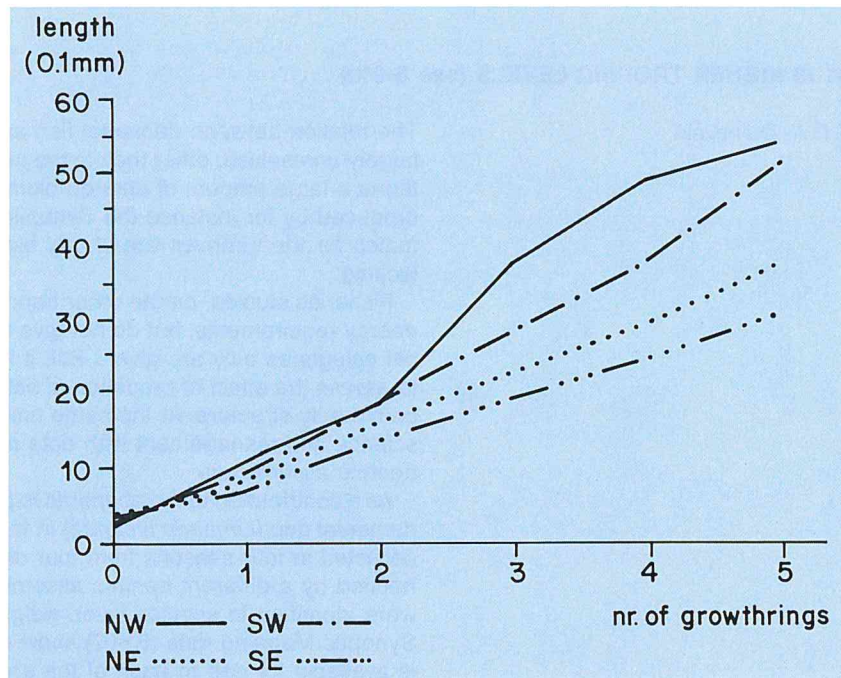
A. Cramer, R. Heyman

From earlier figures collected during the Window Expedition in the Dogger Bank area in July 1988, Cramer calculated an average benthic respiration of about $600 \mu\text{mol O}_2 \cdot \text{m}^{-2} \cdot \text{h}^{-1}$, at an average macrofauna biomass of $15 \text{ g AFDW} \cdot \text{m}^{-2}$. In the assumed frontal areas on the slopes of the Dogger Bank a significantly higher biomass than at the shallow part of the bank occurred.

A direct relation between community respiration and biomass was not found. Also with the organic carbon content, with chlorophyll of the sediment and with temperature no direct relation could be proved. However, respiration appeared to be correlated with macrofaunal biomass according to the function of metabolic activity with body size. Moreover, it was attempted to estimate macrobenthic production from a function of individual body weight and to use this as a measure of metabolic activity. In this way macrofauna production showed an enhancement at the slopes of the Dogger Bank coinciding with the areas of assumed higher primary productivity. Secondary production at the 'front' appeared to be significantly higher than in the adjacent stratified or mixed areas.

Heyman's research aimed to recognize benthic zones in the Dogger Bank area and to describe faunal composition. The analyses of the benthic samples from 6 transects across the Dogger Bank were completed in previous years. The benthic fauna of the Dogger Bank and surroundings could be divided into 4 characteristic macro-benthos clusters. —Southwest of the Dogger Bank (Oyster Ground fauna); —Dogger Bank; —North slope of the Dogger Bank; —North of the Dogger Bank.

The transition zone between the stratified central North Sea and the mixed water on the Dogger Bank is also a remarkable transition zone between the characteristic Dogger Bank and northern North Sea faunas. High C-fixation rates at the surface indicated enhanced productivity in this area, as shown by Riegman and co-workers, Department of Special projects. The zone is characterized by high densities of polychaetes and young echinoderms. The ubiquitous sea urchin *Echinocardium cordatum* and the bivalve *Tellina fabula* were chosen for a comparison of growth rates in the different habitats. This shows differences in the benthic food supply and in production.



Mean length of growth rings in *Tellina fabula*

B1-12 IOC/ICES SEA-GOING WORKSHOP BREMERHAVEN

G.C.A. Duineveld

As an initiative of the ICES Working Group on the Biological Effects of Contaminants, a workshop was organized in March 1990 for the calibration of techniques for monitoring biological effects of contaminants. One of the sites chosen for field work was an abandoned drilling area in the Dutch Sector of the North Sea. Shortly after the drilling operations (discharging oil-based muds) had stopped on this site in 1988, benthic monitoring studies (TECON project

-02c) had established clearcut effects on the macrofauna. For the Workshop three types of studies were envisaged in this drilling area, viz. a bioassay study, a benthic community (macrofauna, meiofauna) study and a study of pathology and enzyme (MFO) activity in the dab. Since earlier data giving an impression of the recovery rate were available, and the area had, moreover, been investigated earlier by NIOZ, participation was granted for the macrobenthic analysis. Samples were taken in the drilling area with the RVs 'Aurelia' (NIOZ) and 'Holland' (Dir. North Sea, RWS) at 8 stations at progressive distances from the drilling site in the residual current direction. Concurrent with sediment sampling, measurements of community respiration and beam-trawling for dab and epifauna were carried out. First results of the macrofauna community analyses show a decreased number of species, especially deep-burrowing ones, in the vicinity of the drilling site. Notably species found to be adversely affected shortly after the drilling operation occurred in depressed numbers or were absent within the first 500 m. The *in situ* sediment photographs showed that a new layer of sediment had been deposited on top of the older polluted layer. This could explain the absence of any signals in the meiofauna studies (core-depth: 10 cm) and in the burying tests.

B1-13 HIGHER TROPHIC LEVELS (see S-01d)

G.C.A. Duineveld

The relation between demersal fish and benthos in the offshore North Sea is largely unresolved, other than in the most general terms. For the macrobenthic fauna a large amount of data on biomass and species distributions has been produced by for instance the Synoptic Mapping programme (B1-07), but estimates for the turnover rate of this biomass into higher trophic levels are still lacking.

Fisheries studies, on the other hand, give estimates of fish stocks, and their energy requirements, but do not give details on prey species; gross taxonomical categories only are given. Still it is detailed information that is necessary to assess the effect of predation of fish on benthic populations and on benthic community structure. At the same time, such information can supply fisheries science and management with data on the supply of fish food by a particular benthic assemblage.

As a contribution to the cooperative project on the population dynamics of the demersal dab (*Limanda limanda*) in the North Sea (see S-01d), stomachs were collected in four seasons from four different areas in the North Sea, each inhabited by a different benthic assemblage. Food items from these stomachs were identified to species level, weighed and their caloric value determined. Synoptic Mapping data (B1-07) show what percentage of the benthic biomass is available for dab in each of the areas and what the quality of this food is. Such information can be used to explain differences in growth rate and condition between dab of the separate areas. From the perspective of benthic populations, the data will show to which degree the prey populations are exploited by dab predation and its potential effect on community structure.

1.6. PELAGIC SYSTEMS (B2)

INTRODUCTION

Recommendations of a peer review of NIOZ in 1989 led to discussions on better incorporation of our phytoplankton research in global change programmes which resulted in two new projects: participation in an (inter)national programme on the role of the coccolithophore *Emiliana huxleyi* in the carbon flux (B2-13) and a mesocosm project (to be started in 1991) on species interactions leading to monospecific algal blooms (B2-14).

Project B2-13 was started in cooperation with the universities of Leiden, Amsterdam and Groningen. A team of one postdoc, one Ph.D. student and one assistant partly funded by the CO₂ Foundation of TNO and the National Research Programme for the study of global change (NOP). For the second project a postdoc will study the role of microheterotrophs in pelagic ecosystems, filling a gap in the structure of the Department. The important role of microheterotrophs (ciliates, flagellates, small metazoan plankton including copepod nauplii) as grazers, as food for larger zooplankton and in recycling nutrients used by phytoplankton has become widely acknowledged in recent years. To provide a more continuous base for research on microheterotrophs the work on zooplankton by B.R. Kuipers and H. Witte of our Department (B2-03) will be redirected towards the study of microzooplankton and pelagic mesocosms, in concert with F. van Duyl and R. Riegman (BEWON) and R.P.M. Bak and J.H. Vosjan (Benthic Systems).

B2-01 EUTROPHICATION AND PHYTOPLANKTON IN DUTCH COASTAL WATERS

W.H.M. van Boekel

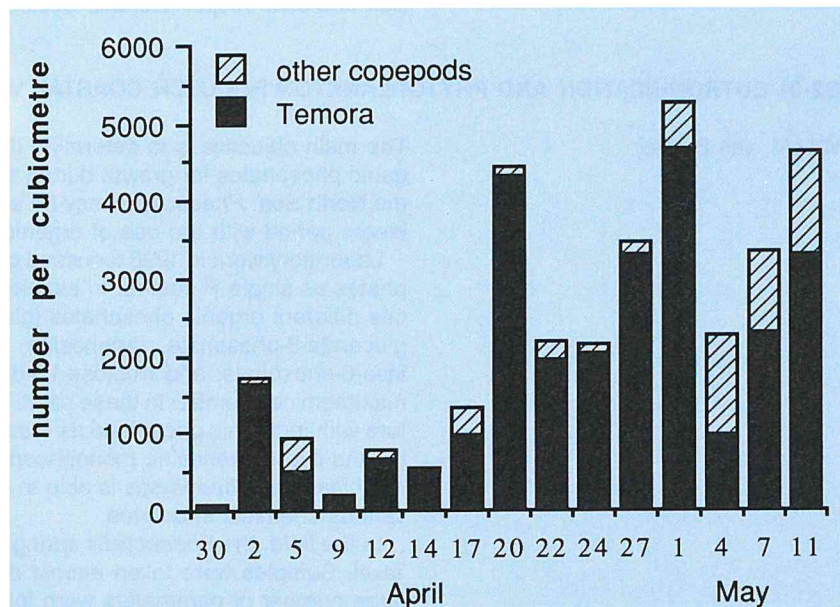
The main objective is to determine if *Phaeocystis* is able to use dissolved organic phosphates for growth during the spring bloom in the Southern Bight of the North Sea. *Phaeocystis* may be able to increase its biomass or prolong the bloom period with the use of organic phosphates.

Laboratory work in 1990 focussed on growth of *Phaeocystis* on organic phosphates as single P source. In axenic batch cultures, *Phaeocystis* was able to use different organic phosphates (glucose-1-phosphate, glucose-6-phosphate, glucerate-3-phosphate, adenosine mono-, di-, and tri-phosphate, fructose-6-phosphate, and fructose-1,6-diphosphate) for growth. Growth rate and maximum cell number in these batch cultures were comparable to a control culture with inorganic phosphate as P source. Two other organic phosphates (phytin and cyclic-adenosine monophosphate) were not used by *Phaeocystis*. Still it is clear that *Phaeocystis* is able to grow efficiently on organic phosphates of various chemical structures.

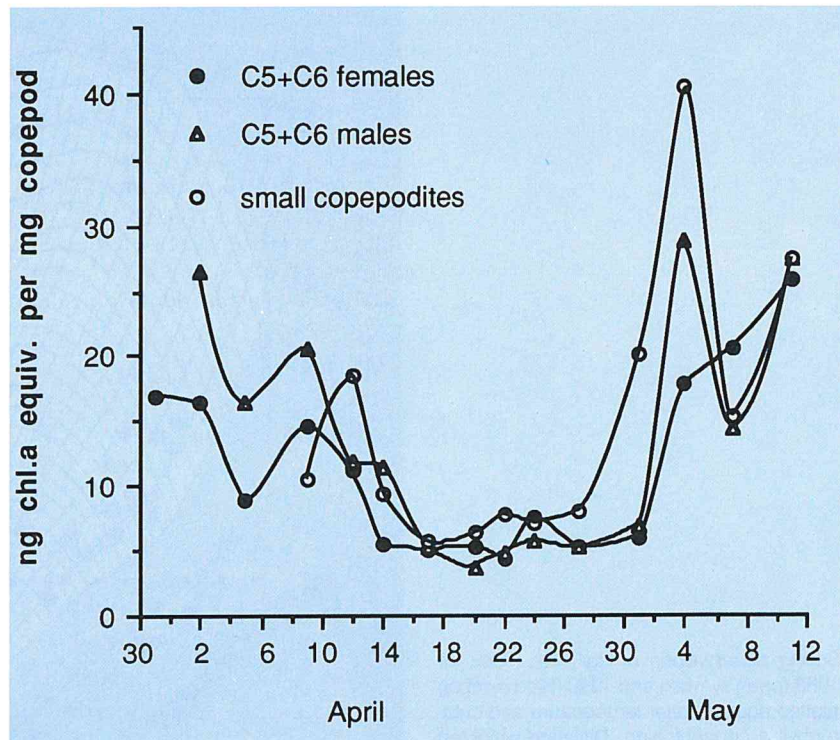
In the field, the *Phaeocystis* spring bloom was followed in the Marsdiep near Texel. Samples were taken almost daily at high water from the NIOZ jetty. A large number of parameters were followed, in particular those involved in the P cycle. The results indicate that nitrogen rather than phosphorus was growth-limiting for *Phaeocystis* in the Marsdiep area in the 1990 spring bloom.

In the scope of the EC project 'Dynamics on *Phaeocystis* blooms in nutrient-enriched coastal zones', an intensive field programme was carried out to evaluate the role of copepod grazing on a *Phaeocystis*-dominated spring bloom in the Marsdiep. From 30 March to 11 May copepod abundance and gut fluorescence were determined from 300 μm fractionated samples. Sampling occasions were synchronized with studies on microzooplankton and bacteria by R.P.M. Bak and G. Nieuwland and for phytoplankton by W.H.M. van Boekel (University of Groningen) as well as G.C. Cadée and J. Hegeman. Copepod studies focussed on the calanoid copepod *Temora longicornis*, which previous grazing experiments have shown to be the dominant potential mesozooplanktonic grazer on *Phaeocystis*.

Generally, *Temora longicornis* was the dominant copepod in all samples, comprising on average 81% by number. Until the peak of the *Phaeocystis* bloom in mid-April, *Temora* occurred in low abundance, usually less than one specimen per dm^3 . Gut fluorescence declined in the course of the bloom, reaching a minimum when *Phaeocystis* cell numbers peaked. Highest values of gut fluorescence were observed during May, when small diatoms dominated the phytoplankton community. During the *Phaeocystis* bloom, estimated consumption rates amounted to less than 1% of the *Phaeocystis* standing stock. Thus, *Temora* grazing upon *Phaeocystis* seems to play a minor role in controlling the *Phaeocystis* bloom. Despite the low phytoplankton grazing, *Temora* abundance increased in the second half of April, exceeding concentrations of $4 \cdot \text{dm}^{-3}$. This suggests that they covered their energy demand by switching over to a heterotrophic food source while the phytoplankton was dominated by *Phaeocystis*.



Copepod (> 300 μm) abundance in spring in the Marsdiep.

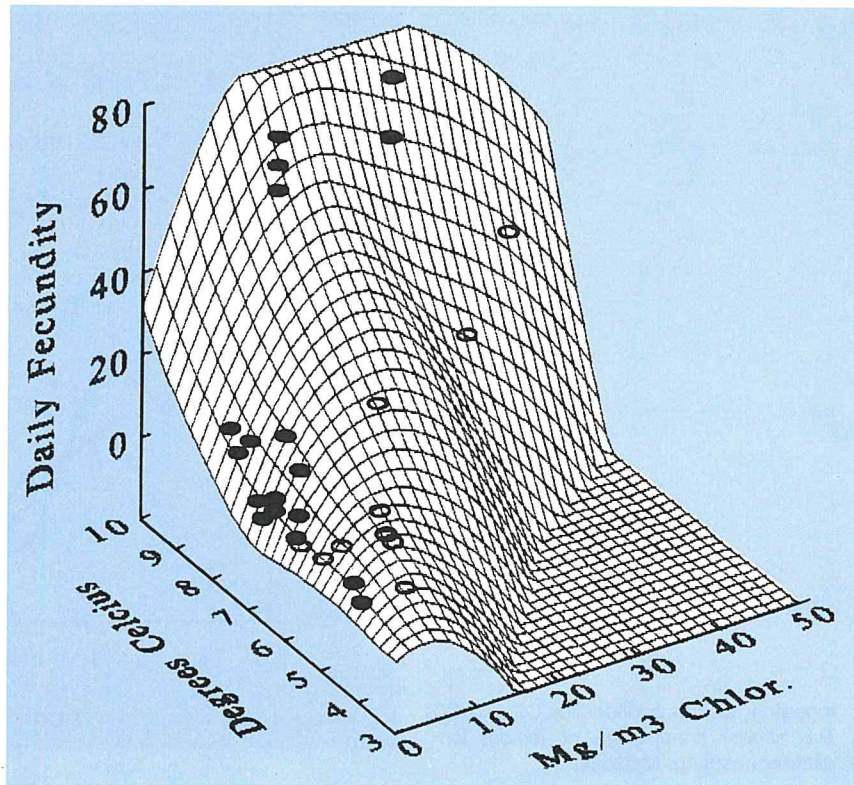


Ingestion rates of copepodites C5 and C6 and smaller copepodites of *Temora longicornis* in spring, Marsdiep.

B2-02 MODELLING OF PLANKTON DYNAMICS IN THE SOUTHERN NORTH SEA

H.G. Fransz

In the copepod *Temora longicornis* daily fecundity is a major factor controlling the seasonal population cycle. A population model published in 1989 indicates that a low daily fecundity (in the order of 5 eggs produced per female per day) is sufficient for persistence of the population at low food levels during summer and winter. To complete our information on daily fecundity, adult females were collected from the Marsdiep between 4 October 1989 and 5 April 1990 at intervals of 1 to 2 weeks and incubated at transient conditions of food and temperature. Daily egg production decreased from 5-25 in November to 2-10 throughout winter. Between 14 February and 14 March it increased to a mean of 15, and between 30 March and 5 May it reached maximum values of around 65 during the diatom spring bloom. The winter and pre-bloom spawning will enhance the utilization of the early diatom bloom and makes the population virtually independent of resting eggs in the bottom.



Spring observations of daily fecundity for 1988 (open symbol) and 1990 (filled symbol) plotted against water temperature and chlorophyll a concentration. Distance weighted least squares 3-D smoothing produced the curved surface.

B2-03 PRODUCTION AND CARBON BUDGETS IN THE NORTH SEA IN RELATION TO HYDROGRAPHICAL STRUCTURE

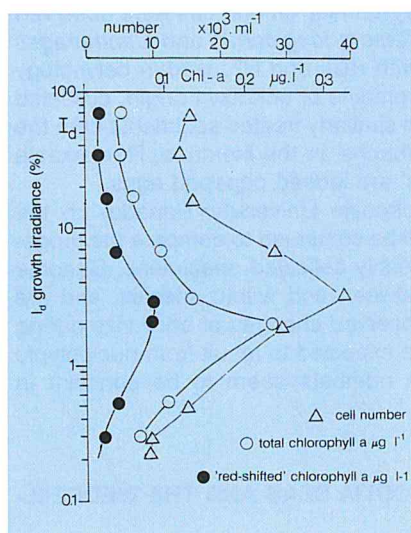
M.A. Baars, H.G. Fransz,
B.R. Kuipers, M.J.W. Veldhuis

The zooplankton research aimed at quantifying the relative importance of predation by invertebrate carnivores on mesozooplankton was concluded with the contribution to the JGOFS northern Atlantic Programme 1989-1990 (B2-04). Results from the stratified ocean confirmed those from the vertically mixed as well as from the stratified shelf area and from an oceanic upwelling area (Mauritania), and led to the conclusion that the concept of 'top-down' (predator) control of mesozooplankton production should in general be replaced by that of resource limitation. Two papers on the subject appeared in 1990, and a final report will follow. The macroplankton being left, Kuipers turned to preparing a new project with the emphasis on the impact of microzooplankton grazing and the function of microzooplankton as an intermediate trophic level between nanoplankton (bacteria) and mesozooplankton (copepods). As a first step, after a literature study and discussions with colleagues, a post-doc research proposal was formulated and a cooperative experimental pelagic mesocosm research project was given shape, together with BEWON and the Benthic Systems Department. The change of subject from higher to lower trophic levels in the pelagic food-chain must lead to methods for quantification of microzooplankton standing stocks and grazing rates in the course of 1991, when the role of microzooplankton will be an important object of study during RV 'Pelagia' cruises in the northern North Sea.

B2-04 JOINT GLOBAL OCEAN FLUX STUDY NORTH ATLANTIC PILOT PROGRAMME

H.G. Fransz, B.R. Kuipers,
M.J.W. Veldhuis

The pelagic part of the Dutch JGOFS cruise took place from April 17 to May 31. Three different water types were observed, based on chlorophyll *a* content, transparency and species composition, along the transect from Madeira to Iceland (see Table). The euphotic zone, taken as the surface layer down to a depth corresponding with 0.5% of surface irradiance, was 100 m in the southern waters but increased to 30 m at the most northern part of the transect. Nevertheless, daily phytoplankton primary production in the north was twice as high as in the south (ca. 1500 vs 700 mg C·m⁻²·d⁻¹). On average, primary production values for the same area were two to three times higher than found during summer 1989. An intercomparison made between ¹⁴C fixation, community oxygen production, and total CO₂ consumption revealed a rather close agreement between these three methods for estimating primary production.



Characterization of different types of water masses encountered along the 20°W meridian.

	33°N - 45°N	45°N - 54°N	54°N - 60°N
irrad. atten. coeff. K (m ⁻¹)	0.059-0.0682	0.128-0.143	0.119-0.207
chlor. <i>a</i> (surface mg·m ⁻³)	0.13 - 0.30	0.89 - 1.38	1.67 - 3.51
chlor. <i>a</i> (at chlor. <i>a</i> max. mg·m ⁻³)	0.32 - 0.98	0.89 - 1.42	2.33 - 3.51
depth of chlor. <i>a</i> maximum	30 - 75	0 - 30	0 - 30
dominant phytoplankton	coccolithophorids	dinoflagellates	diatoms

Most of the significant zooplankton biomass was restricted to the upper 100 m of the water column and values were much higher in spring than in summer 1989. A striking regional difference was observed, with the area north of 47° N much richer in biomass. Species composition also changed according to the north-south gradient in nutrients and primary productivity. The presence of diatoms seems to be the key factor for copepod growth and production of copepod eggs. For dry weight data of different size classes of mesozooplankton sampled in August 1990, see the JGOFS data report.

Vertical distribution of total chlorophyll *a*, a 'red-shifted' chlorophyll *a* (typical of prochlorophytes), and abundance of prochlorophytes as function of surface irradiance. This only recently described picoplankton (ca. 0.6 µ in size) was found to be abundant in (sub)tropical waters of North Atlantic and West Africa, often comprising up to 50% of total chlorophyll content.

B2-10 POPULATION DYNAMICS AND BIO-ENERGETICS IN EXPERIMENTAL PELAGIC ECOSYSTEMS

W.C.M. Klein Breteler

The experimental research on zooplankton centres on the influence of important environmental variables on the ecophysiology of marine zooplankton under controlled conditions in the laboratory. The experimental approach is based on the need to support the population-dynamical investigations carried out at sea; it contributes to a better interpretation of data collected in the field. Since copepods have a major share in the total biomass of zooplankton, the experimental work is concentrated on this group. The copepod *Centropages*

hamatus was isolated from the sea and cultivated in (newly built) climate rooms, according to standard techniques established in the past years. When stable development through successive generations has been reached, experiments will be performed to study the influence of temperature and quantity of food on the rate of development.

Experiments with *Pseudocalanus elongatus* and *Temora longicornis* were carried out to determine the exact rate of development through successive stages. This was necessary to check for the assumption of isochronal development underlying our current calculation method. At the same time the data collected can be used to test an alternative method, for which a model will be developed to improve its fundamentals. Comparison of the two methods will show whether our own method suffices to describe the development of copepods, or if it should be abandoned and the new, much more intensive, method adopted in the experiments planned with *Centropages hamatus*.

A newly developed automatic food control system has entered the phase of testing in the cultivation of copepods. Calibrations have been carried out, using an electronic particle counter as control. Systematic differences were observed which demand an explanation. Eggs of *Temora longicornis* and *Centropages hamatus* were submitted to a treatment with HCL and HF used in palynology to compare them with spherical organic remains of unknown origin, collected by I. van Waveren (University of Utrecht) in similarly treated sediments from the Banda Sea, which are described as 'acritarchs' in the literature. Remarkable similarities suggest that these 'acritarchs' are indeed copepod eggs.

A joint project with I.A. McLaren (Dalhousie University, Canada) on the nucleus and DNA content of copepods will be continued to compare the progeny of 'domestic' copepods with that of freshly collected specimens. Genome size of copepods are widely different between and within species, and are known to be correlated with body size. Observed changes of body size during prolonged cultivation of single species are expected to result from nucleotypic effects on cell size, since total nucleus numbers seem to be constant in copepods.

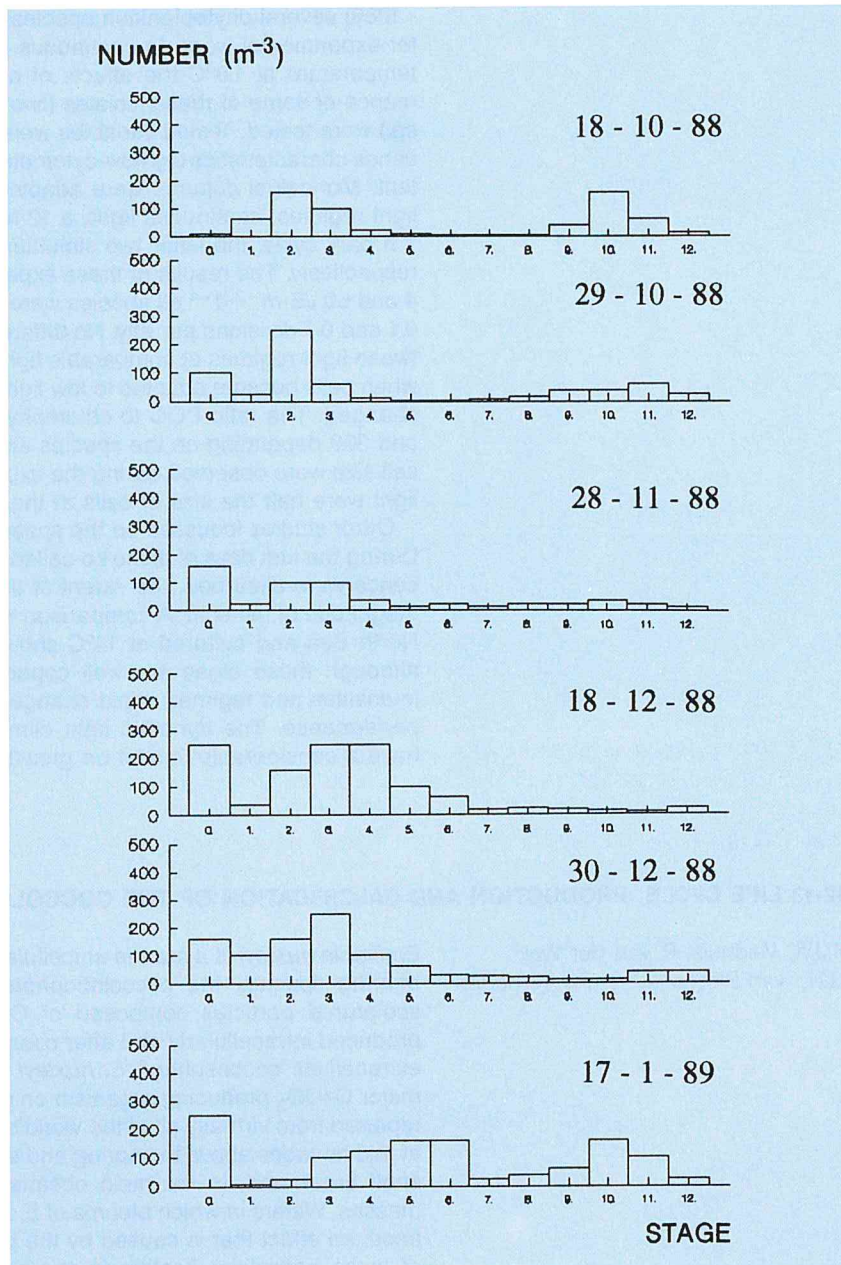
B2-11 KEY FACTORS OF PLANKTON SUCCESSION IN THE WEDDELL AND SCOTIA SEAS AND THE WEDDELL-SCOTIA CONFLUENCE

H.G. Fransz, A.G.J. Buma

Cluster analysis was applied on the combined list of species densities obtained for the stations sampled during the 3 legs on the 47°S transect (in cooperation with S. Schiel and P. Schalk, AWI, and I. Hempel and U. Piatkowski, the Kiel Institute for Polar Ecology). The species and stages composition are divisible into 4 clusters. The main dichotomy is in the difference between the Scotia Sea and the Weddell Sea. The first is much more diverse and rich in species than the latter. In the Scotia Sea the stations were poorer in species and abundance during the second leg than during the first and the third. In the Weddell Sea area the stations of the first leg deviate from those of the later legs. These subdivisions may be due to differences in distribution of water masses among the 3 legs or in the state of development of the populations.

A population model was applied to simulate the population development of *Oithona* and to find the best fit for the parameters stage duration, mortality rate and recruitment rate. Best results were obtained when a very low mortality and a long stage duration of 30 d were used. This corresponds with a 2-year cycle with the copepods overwintering twice, once as copepodite stage 4 and once

as adult. Such a life cycle can be sustained at low growth rates, but persistence would also require low mortality rates. The secondary production is correspondingly low, with a daily P/B ratio of about 0.75%. This would allow an average daily production of the species of 5.5, 2.4 and 0.9 mg AFD m^{-2} in the areas sampled of, respectively, the Scotia Sea, the Confluence zone and the Weddell Sea between October and February.



Density of stages 0 - 12 of the copepod *Oithona similis* in the Weddell Sea.

B2-12 ECOPHYSIOLOGY OF ANTARCTIC PHYTOPLANKTON

A.G.J. Buma

The question which factor(s) limit(s) phytoplankton production in Antarctic waters is a central issue in Antarctic plankton research. Besides factors such as intense macro- and microzooplankton grazing, overall low light intensities in deep mixed waters are considered to play a key role. During EPOS Leg 2 (1988 - 1989) several phytoplankton species were isolated and kept in the laboratory for experimental work. In continuous and semi-continuous cultures at a fixed temperature of 1.0°C the effects of different light regimes on growth performance of some of these isolates (two *Rhodomonas* spp. and a *Pyramimonas* sp.) were tested. Tested variables were: specific growth rate, cell size, fluorescence characteristics (by flow-cytometry), pigments (by HPLC) and carbon content. Monoalgal cultures were adapted to light-limiting conditions at different light regimes; continuous light, a 12 h light / 12 h dark cycle and a 2 h light / 2 h dark cycle, the latter two simulating stable waters and well-mixed waters, respectively. The results of these experiments show that in the range between 4 and 60 $\mu\text{E}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$ all species were able to grow, with growth rates between 0.1 and 0.7 divisions per day. No differences in growth rates were observed between light regimes at comparable light intensities. Pigment content increased when cells became adapted to low light but pigment composition remained unchanged. The ratio POC to chlorophyll a (w/w) was always high: between 80 and 300 depending on the species and the light climate. Large differences in cell size were observed during the experiments; cells that were adapted to low light were half the size of cells at the highest light intensity tested.

Other studies focussed on the speed of adaptation to a certain light climate. During the first days of these so-called transient states, cell growth and fluorescence were disturbed, the extent of this disturbance being dependent on the magnitude of the shift. A comparison with a *Rhodomonas* sp. isolated from the North Sea and cultured at 14°C showed less dramatic effects. It seems that although these algae are well capable of adapting to a spectrum of light-intensities and regimes, rapid changes in the photic climate suppress growth performance. The dynamic light climate in Antarctic waters could therefore have a considerable impact on growth performance in the field.

B2-13 LIFE CYCLE, PRODUCTION AND CALCIFICATION OF THE COCCOLITHOPHORE *EMILIANIA HUXLEYI*

M.J.W. Veldhuis, P. van der Wal,
J.D.L. van Bleijswijk Tierens Verhagen

Emiliana huxleyi is a marine unicellular alga belonging to a group of coccolith-bearing species, the coccolithophores. Coccoliths are rounded, delicately sculptured particles composed of CaCO_3 and organic material. They are produced intracellularly and after completion extruded and incorporated in the extracellular 'coccosphere'. *E. huxleyi* has a world-wide distribution and is the major CaCO_3 producing organism on earth. Blooms of this species have been reported from virtually all of the world's oceans. They are particularly abundant at mid-latitudes above the spring and early summer thermocline both along the shelf break and, in the main oceans, at the interface between major water masses. Waters in which blooms of *E. huxleyi* occur have a pale green appearance, an effect that is caused by the backscattering of light by large numbers of loose coccoliths floating in the surface layer. The light reflectance may

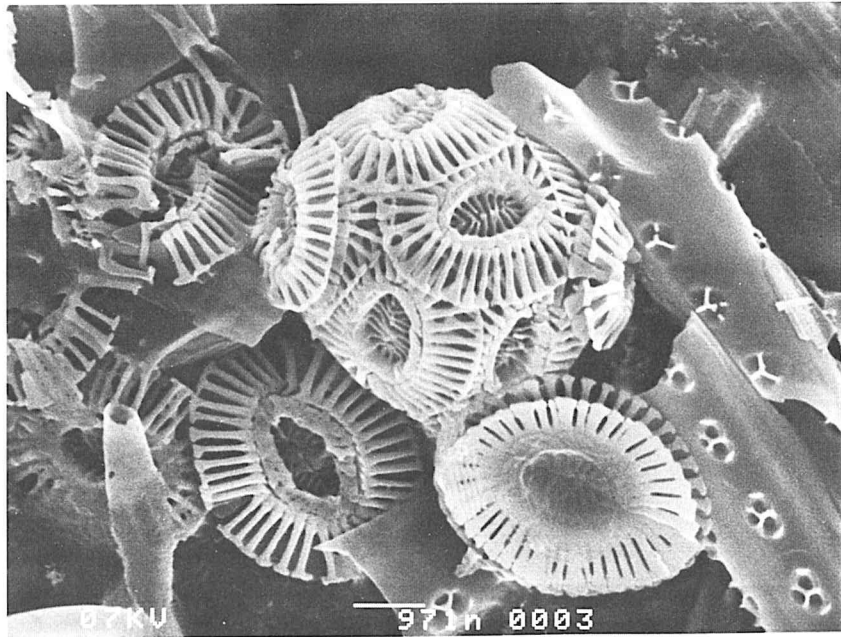
amount to 20% of the incident light, by virtue of which blooms are easily detectable by satellite imagery. Remote sensing is therefore an important tool in determining the areal extent of blooms of *E. huxleyi* and in estimating the amount of CaCO_3 produced.

In the first half of this year a research project was started at NIOZ to study the population dynamics of *E. huxleyi* and its role in the global carbon cycle. Field work and laboratory experiments will be devoted to the study of the factors controlling the waxing and waning of blooms, and to the production and mechanisms of sedimentation of CaCO_3 . The geological aspects of the occurrence of *E. huxleyi* are studied at the Free University, Amsterdam, in a newly started project concurrent with the *E. huxleyi* research project at NIOZ.

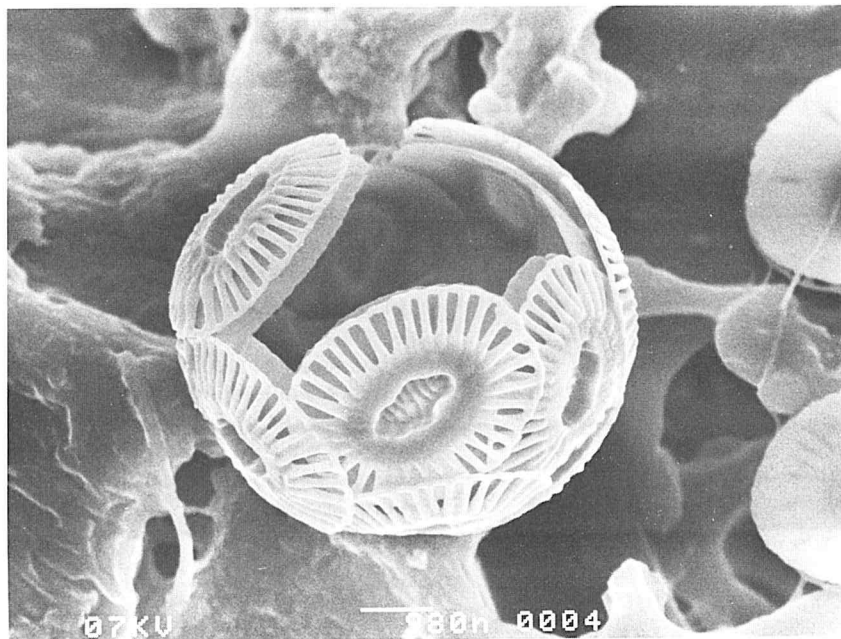
In May of this year we participated in the Dutch JGOFS leg 3 cruise of RV 'Tyro' from Madeira to Iceland and from June 21 to June 29 we participated in RRS 'Challenger' cruise 67/1990, leg 1, from Great Yarmouth, Norfolk, along Shetland, Rockall and the Outer Hebrides to Oban, Scotland. During these cruises the occurrence of *E. huxleyi* was monitored, sea water was sampled and fixed, and living coccolithophorids were collected for cultivation. Sediment traps were deployed in the upper 100 m of the water column at the main stations during the 'Tyro' cruise.

Immuno-labelling experiments were performed on fresh phytoplankton material on board RV 'Tyro', and, in the laboratory, also on fixed material from both cruises. We used two antisera that were raised against an organic component, viz., a water-soluble polysaccharide, present in the coccoliths of *E. huxleyi*. The antisera were derived from two strains: strain 92D and strain L. Each antiserum was so specific as to not react with the antigen of the other strain.

E. huxleyi was present in all sea water samples collected from the ocean surface to the thermocline, as was revealed by light-microscopy. The highest cell counts were obtained during the 'Challenger' cruise. In the surface waters above the shelf edge to the west of Shetland the concentration of *E. huxleyi* amounted to $1250 \text{ cells-cm}^{-3}$; the only other phytoplankton component encountered here was a small diatom, presumably *Thalassiosira pseudonana*. Due to lack of time we were not able to extensively study this interesting occurrence of *E. huxleyi*. The antisera 92D and L reacted only with specimens of *E. huxleyi*. In all samples examined positive labelling occurred with antiserum L. With antiserum 92D only cells of a sample from the North Sea showed a positive labelling. From these experiments the following conclusions were drawn: 1) The polysaccharide associated with the coccoliths of *E. huxleyi* is a very conservative organic compound: even after decades of cultivation in the laboratory its chemical composition is still indistinct from the coccolith polysaccharide met with in the natural environment. 2) Different strains of *E. huxleyi* may occur in the same area. 3) The areal extension of strains of *E. huxleyi* can be delineated by using antisera raised against the coccolith polysaccharide of these strains. The resulting map may show the patterns along which this ubiquitous, relatively young species was distributed in the world oceans.



JGOFS-Tyro-Leg 3; station 68-1, 2 meter. Coccosphere and loose coccolith of *Emiliana huxleyi* (Bar=971 nm).



JGOFS-Tyro-Leg 3; station 68-1, 2 meter. Empty coccosphere of *Emiliana huxleyi* showing the mode of stacking of the individual coccoliths (Bar=980 nm)(Photos: P. van er Wal)

1.7. COASTAL SYSTEMS (B3)

INTRODUCTION

The Coastal Systems Department studies structure and functioning of coastal soft-sediment ecosystems, in particular in the Dutch Wadden Sea. The emphasis is on quantification of the food chain and production processes. All trophic levels are included: primary production (B3-01), secondary production (B3-02), energy transfer from algae to molluscs (B3-03), interactions between primary consumers (B3-04), dynamics and distribution patterns of secondary consumers (flatfish: B3-05; birds: B3-08 and B3-09), energy transfer from primary to secondary consumers (B3-06), and energy budgets in secondary consumers (B3-07). A project not fitting into this scheme is on physiology of marine organisms (B3-10). Nevertheless, it is clear that a real insight into processes at the ecosystem level can be gained only by the inclusion of research at integration levels of populations and individuals. Therefore, studies in the fields of population biology (e.g. B3-02, B3-04, B3-08a), autecology (e.g. B3-07, B3-08b) and ecophysiology (e.g. B3-10) are indispensable parts of the programme of the Department. A new project is included to study actuopalaeontological problems (B3-11).

B3-01 PRODUCTION AND TRANSPORT OF ORGANIC MATTER

G.C. Cadée

Apart from the regular measuring of phytoplankton biomass and taxonomic composition at the NIOZ pier, Marsdiep, this year also primary production measurements were carried out. The seasonal cycle of phytoplankton showed only a small spring diatom peak in which large diatoms like *Coscinodiscus concinnus* and *Biddulphia sinensis* played a dominant role; small diatoms, notably *Leptocylindrus minimus*, formed a late summer peak. The spring diatom peak was followed by a *Phaeocystis* peak which was less high than in 1989. Nevertheless the total duration of the *Phaeocystis* bloom (the period with >1000 cells per cm³) was almost 150 days, indicating a dominating role of this alga in the Marsdiep phytoplankton for 5 months.

The discovery of historical data on net phytoplankton for the Marsdiep made it possible to compare this bloom duration with those of 1897 and 1899. P.P.C. Hoek, then director of the Institute, regularly sent net phytoplankton samples to P.T. Cleve in Uppsala to include these data in his annual North Sea plankton surveys. From Cleve's indications of 'common' and 'very common' for *Phaeocystis* we tentatively conclude its presence in cell numbers exceeding 1000 per cm³. Unfortunately sampling for 1898 was incomplete but for both 1897 and 1899 the duration of *Phaeocystis* blooms was ca. 50 days. This would indicate that compared with these pre-eutrophication data the duration of *Phaeocystis* blooms has now tripled.

Primary production amounted to ca. 250 gC·m⁻²·a⁻¹, which is lower than measured in the mid 1980s. Also chlorophyll data suggest that the trend of increase in phytoplankton has stopped and that values tend to stabilize, albeit at higher values than observed in the early 1970s.

B3-02 SECONDARY PRODUCTION AND DYNAMICS OF TIDAL-FLAT MACROZOOBENTHOS

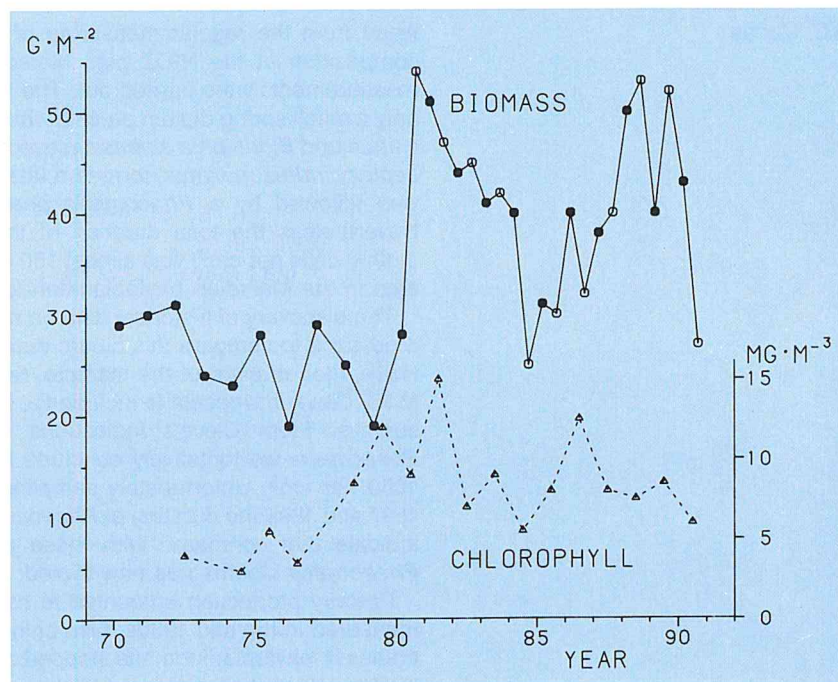
J.J. Beukema

Long-term investigations (started in 1969) of the intertidal benthic macrofauna in the western part of the Wadden Sea have been continued. The usual sampling schedule yielded the twice-annual data on numbers, biomass, recruitment, survival, growth rates and production of several tens of species of molluscs, polychaetes and crustaceans.

The winter of 1989-1990 was extraordinarily mild. As the two foregoing winters were also too mild, the composition of the bottom fauna on the tidal flats has changed dramatically. Species sensitive to low winter temperatures now occur in high densities (e.g. the worms *Lanice conchilega* and *Nephtys hombergii*), whereas several important bivalve species experienced their third summer with a failure of reproduction. Moreover, the resulting low numbers of mussels and cockles were heavily fished. Intertidal mussel banks virtually disappeared from the tidal flats this year. Macrobenthic biomass values were exceptionally low by the end of 1990.

This year special attention was paid to a comparison of two series of long-term data, viz. the one on chlorophyll and phytoplankton concentrations in the Marsdiep tidal inlet (see B3-01) and the one on abundance and growth of macrozoobenthos on the nearby Balgzand. Annual values of total biomass of macrozoobenthos closely followed mean annual chlorophyll concentrations: from a relatively low level during the 1970s via a rapid increase around 1980 to a higher level during the 1980s. The annual growth rates of the bivalve *Macoma balthica* were strongly correlated with diatom concentrations in spring (the growing season of this species), but not with flagellate concentrations. In particular the concentrations of *Phaeocystis* (the phytoplankton species with the

Long-term trends in chlorophyll concentrations and biomass of the bottom fauna in the westernmost part of the Wadden Sea. A significant correlation ($r=+0.71$, $p<0.01$) is observed between chlorophyll in year (n) and benthic biomass in year (n+2). The fluctuating chlorophyll concentrations can be used as a measure of the variable food supply of most bottom animals. The cause of the time lag between a change in food supply and the response shown by the major consumers will be that any food-induced increase of reproductive success in bottom animals needs at least 1 or 2 years to become fully expressed in biomass values, because this time is needed for most species of larger bottom animals to reach (near) adult size. Chlorophyll expressed in $\text{mg}\cdot\text{m}^{-3}$, annual means found by G.C. Cadée in the Marsdiep tidal inlet. Biomass expressed in $\text{g}\cdot\text{m}^{-2}$ ash-free dry weight, annual or biannual means (corrected for the season) found by J.J. Beukema on Balgzand (15 sampling stations on tidal flats).



strongest response to eutrophication) did not show any relationship with *Macoma* growth. The single cells of *Phaeocystis* were shown to be suitable food for *Macoma* (see B3-03). However, during its blooming periods most *Phaeocystis* cells are present in big and gelatinous colonies that cannot be swallowed by bivalves.

B3-03 COMPETITION FOR FOOD BETWEEN BIVALVE MOLLUSCS IN THE WADDEN SEA

P. Kamermans

Beukema & Cadée (B3-02) have shown a positive correlation between the growth rate of the bivalve *Macoma balthica* and the presence of high concentrations of diatoms during the growing season of *Macoma* in the field. No correlation was found for the flagellate *Phaeocystis pouchetii*. A laboratory experiment was carried out in May 1990 to study whether *Macoma* can grow faster on a diatom diet than on a *Phaeocystis* diet. Comparable growth was found whether the animals were fed with diatoms or with *Phaeocystis*. This is remarkable, for both the added amounts of chlorophyll a and particulate organic carbon were lowest for the groups fed with *Phaeocystis*, suggesting a high food value of this species. However, in the laboratory the single-cell form of the flagellate was used, while in the field *Phaeocystis* was mostly present as large colonies, which may be difficult for the bivalve to ingest.

Long-term investigations show retarded growth of *M. balthica* in years with a high *Cerastoderma edule* abundance (Beukema, pers. comm.). Morphologically these two species belong to different groups, *Cerastoderma* being a suspension feeder and *Macoma* a deposit feeder. One would expect them to use different food sources (water column and surface of the sediment, respectively). Fieldwork has shown a considerable overlap in diet of these two species. Stomach contents show more similarity with water samples than with sediment samples. This indicates that deposit feeders can behave as suspension feeders and compete for food in the field. Experiments carried out in mesocosms indicate that *Macoma* behaves as a deposit feeder in a situation similar to the field, except that there are no siphon-nipping predators present. It is, therefore, proposed that siphon-nipping — which makes the siphon shorter — is the key factor in determining the feeding behaviour of *Macoma*.

Results of a survey of 8 different stations in the western Dutch Wadden Sea indicate that *Macoma* can regenerate its inhalant siphon quickly when the food supply is high and predation pressure low. At present stomach samples of *Macoma* collected at these 8 stations are being analysed to see if the feeding behaviour of the bivalve follows the expected trend.

B3-04 INTERACTIONS BETWEEN MACROZOOBENTHIC SPECIES ON TIDAL FLATS

E.C. Flach

To study the consistency of the zonation pattern generally found in the Wadden Sea (with a *Corophium* zone in the upper parts and an *Arenicola* zone in the lower parts of the tidal flats) a transect from the upper, muddy zone to the lower, sandy part was sampled year round on the Balgzand in the westernmost part of the Wadden Sea. In the upper part high densities of *C. volutator*, *Nereis diversicolor* and *Heteromastus filiformis* were found. Their densities declined very fast in the middle part where the numbers of *Arenicola marina* and *Cerastoderma edule* increased. In the lower part a quite stable population of *Corophium arenarium* was found. The population of *C. volutator* varied much in abundance and distribution. During the summer it reached very high densities (up to 100 000 ind·m⁻²) in the upper part and extended onto the lowest parts where it was found together with *C. arenarium*, but in much smaller numbers.

Previous studies with azoic plots in the middle part showed that *C. volutator* can reach very high densities in empty places also in this part, but when *A. marina* and/or *C. edule* had been added to such otherwise empty places, the numbers of *Corophium* remained low. When high densities of *A. marina* and/or *C. edule* were added to otherwise undisturbed plots in the *Corophium* zone, the numbers of *C. volutator* decreased. When in such plots in the *Arenicola* zone, *A. marina* and/or *C. edule* were taken away, the numbers of *C. volutator* increased. In both cases the influence of *A. marina* was stronger than that of *C. edule*.

To see if *A. marina* and *C. edule* affect *C. arenarium* in the same way, azoic plots were made in the lower zone, one close to the boundary with the *C. volutator* zone and another one far away from it. In small parts of these plots *A. marina* and *C. edule* were added in different densities. The plot close to the *C. volutator* zone became occupied by this species, with high densities in the empty parts and declining numbers with increasing densities of *A. marina* and/or *C. edule*. The other plot was invaded by *C. arenarium*, but due to the low numbers no significant differences were found between the parts with and without *A. marina* and/or *C. edule*.



Skipper Ewout gives a (helping) hand to the people he takes to the tidal flats
(Photo: E. Flach)

B3-05a RECRUITMENT MECHANISMS IN FLATFISH POPULATIONS

H.W. van der Veer

This project continues the former project: Population dynamics of 0-group flatfish (investigations on 0-group plaice at NIOZ between 1970 and 1990) and focusses on the following questions:

—Is the year-class strength of flatfish species determined already during the pelagic egg and larval stages?;

—Are regulating mechanisms only acting after settlement in the demersal stage?;

—Is the concentration hypothesis of Beverton, relating variability in recruitment of North-Atlantic fish species to degree of 'concentration' of juveniles in nursery areas, also valid for other areas and (sub-)tropical regions?;

—Are food conditions always optimal for juvenile flatfish, also in (sub-)tropical waters?

A first step has been the investigation of the flatfish populations near Sapelo Island (Georgia, USA) by M.J.M. Reichert. In a salt marsh system, immigration, settlement, distribution and growth of the flatfish species have been followed. Densities of flatfishes are found to be a factor of 5 to 10 lower in the gullies than in the Wadden Sea. It is unclear whether this is caused by a lower immigration of larvae or by a higher mortality rate after settlement. A comparison of growth in the laboratory with length increase observed in the field suggests that at least in the subtropical estuary of Sapelo Island growth of 0-group flatfish species is not food limited. This project is carried out in close cooperation with Marine Institute, Sapelo Island (R. Kneib and D. Goshorn).



Sampling of juvenile flatfish in the salt marsh system near Sapelo Island, Georgia, USA. (Photo: Marine Institute, Sapelo Island)

The questions listed above will be investigated within an international research programme in cooperation with the Belle W. Baruch Institute, Columbia, USA (J.M. Dean, R.J. Feller), North Carolina State University, Raleigh, USA (J.M. Miller), Kyoto University, Kyoto, Japan (M. Tanaka), Kristineberg Marine Station, Fiskebäckskil, Sweden (L. Pihl) and the University of Hamburg, Hamburg, FRG (R. Berghahn).

All participants met at NIOZ for 2 days in November, when the final research programme for the first year, 1991, was established. Within the group, each participant will bear responsibility for one aspect of the programme, such as sampling gear, sampling strategy, sampling and data analysis. In 1991 the NIOZ contribution will be the design of sampling gear and sampling strategy in the various areas. The actual flatfish research is planned for 1992.

M. Fonds

The data of experiments with Japanese flounder *Paralichthys olivaceus* (in cooperation with Dr. M. Tanaka, Kyoto University) have been analysed. The weight (W,mg) to length (L,mm) relationship of 0-group fish is $W = 0.009 L^3$. Hence, feeding condition of the fish can be described by the commonly used 'condition factor' $K = 100 \cdot W \cdot L^{-3}$. Body composition of the Japanese flounder shows a variation with condition factor similar to other flatfish species. For example: with K values from 0.6 to 0.9 the % ash-free dry weight increases from 13 to 18. The growth rate (in length) of 0-group fish (3-6 cm) increased with water temperature, from a lower limit of 0.1 mm per day at 10°C to a maximum of 1.0 mm per day at the optimum temperature of 24°C.

The net food conversion efficiency has been estimated with fish fed different rations of mussel meat (*Mytilus edulis*) or mysids (*Neomysis integer*) at 20°C. In ash-free dry weight (AFDW) units the relation between food consumed (F) and growth of the fish (G) is: $G = -1.833 + 0.493 F$ ($r=0.991$, $n=7$). For food consumption (F) and growth (G) expressed in proteins: $G = -1.608 + 0.679 F$ ($r=0.993$, $n=7$). The net food conversion efficiency from food to fish amounts to ~49% (AFDW) and ~68% (proteins).

B3-05b LONG-TERM CHANGES IN FISH STOCKS IN THE COASTAL ZONE

H.W. van der Veer, J.I.J. Witte,
J. van der Meer

This new project concentrates on long-term changes in fish stocks in the Dutch coastal area (Wadden Sea and North Sea). Such a study requires long-term data series. A number of sources are at present available: 1. daily fish trap catches from 1960 onwards at a location near the entrance of the western Wadden Sea; 2. a spring and autumn beam trawl survey in the coastal zone of the North Sea from 1950 onwards, carried out by the Netherlands Institute for Fishery Investigations (RIVO), IJmuiden, with the aim to estimate the year-class strength of some commercial fish species; by-catches have never been analysed so far, but will now be analysed in cooperation with A.D. Rijnsdorp (RIVO); 3. records of catches of rare fish species by the commercial fish fleet from 1930 onwards. This exceptionally long time series offers the opportunity to trace changes in especially rare fish species.

Analyses of such series are extremely time consuming, since they can only be handled after automation of the data storage. All fish trap data have been stored in a data base and the first analyses concern the relative efficiency of fish traps. Three types have been compared as well as the locations of the traps and fishing time. Especially the so-called 'kom-fyke' appears to be relatively efficient in catching flatfish. Location is very important and seems to be related to the total area of surrounding tidal flats. Fishing efficiency decreases rapidly with time. Catches after 48 h of fishing are only 20% higher than after 24 h.

B3-06 FISH - BENTHOS INTERACTIONS

H.W. van der Veer

This project is a continuation of project B3-06 'Fish - benthos interactions in the Wadden Sea'. Research concentrates on the role of 0-group plaice in the Wadden Sea. In cooperation with project B3-03 the impact of siphon nipping by flatfish on the food intake of bivalves has been studied. The food intake of the bivalve *Macoma balthica* has been studied in relation to food availability and predation pressure. With increasing predation pressure and decreasing food availability *M. balthica* seems to change from deposit feeding (which requires relatively long siphons) to suspension feeding (which requires only relatively short siphons). Next year this phenomenon will be studied in Pamlico Sound, North Carolina, USA.

Extensive research on the growth of 0-group plaice in the whole Dutch Wadden Sea by means of daily growth increments of otoliths has shown that in the whole area growth is optimal and not food limited. The whole area is supplied with larvae from the same patch and hence the same spawning location. Only in the Ems-Dollard estuary can a different patch of larvae be traced. It is suggested that this stock originates from the German Bight.

B3-07 ENERGY BUDGETS OF BENTHIC CARNIVORES

M. Fonds

Growth rates of seastars (*Asterias* and *Astropecten*) were measured in the laboratory at constant temperatures of 5, 10, 15 and 20°C. Sampling of populations of *Asterias* in the Wadden Sea and the coastal area of the North Sea was continued.

B3-08a DYNAMICS AND FEEDING OF SEA-BIRDS IN THE WADDEN SEA AND TROPICAL TIDAL-FLAT AREAS

C. Swennen

The high mortality among Eiderducks in 1989, which was attributed to heavy infestation with *Polymorphus botulus*, continued on a slightly smaller scale in 1990. A survey indicated that the intermediate host, the shore crab *Carcinus maenas*, was more infected than in the late 1960s. Also the area with heavily infected crabs was larger than formerly. Tameness and retarded moult in large flocks of Eiders pointed to heavy infection. Mortality among them was again high in the central and eastern parts of the Dutch Wadden Sea, but less in the westernmost area.

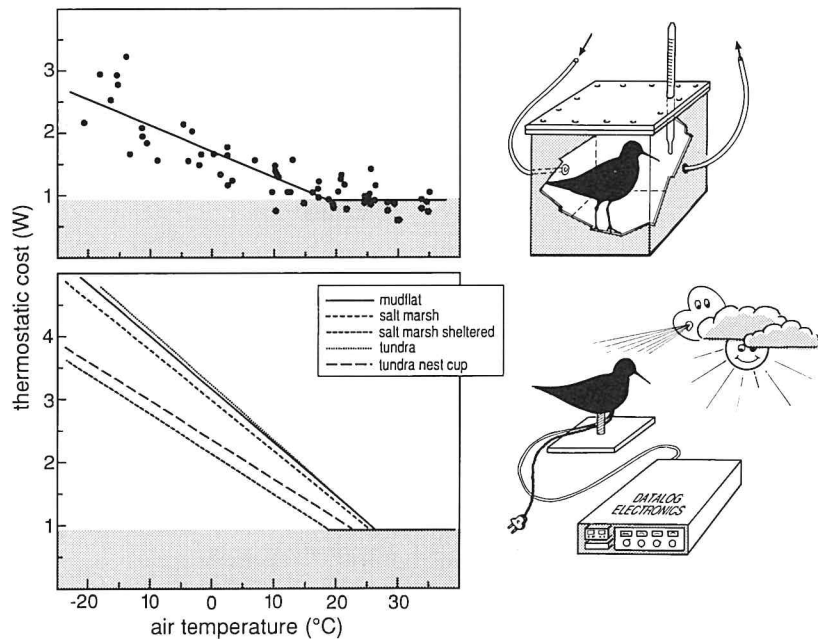
From 24 June to 15 July, C. Swennen participated in a cooperative research project of the Institute of Ornithology, Seoul and the Asian Wetland Bureau, Kuala Lumpur, on the importance of Korean intertidal flats for coastal birds. A colour-banding programme for the endangered Chinese Egret *Egretta eulophotes* has been started in the colony on Shin Islet in the Yellow Sea. Some data on egg size and growth of the chicks have been collected suggesting a similar growth rate to that of *E. garzetta*. Food samples from regurgitations of fledglings contain three species of Gobiid fish and one species of shrimp. The species composition indicates that the Egrets collect their food on the intertidal mudflats along the coast and not along the rocky shores of the small offshore islands.

B3-08b ANNUAL ENERGETICS OF KNOTS

Expenditure and intake studies

T. Piersma

The different subspecies of Knots, *Calidris canutus*, show a fascinating range in their wintering sites, and therefore wintering climates. Of the two subspecies frequenting Europe, the *canutus* subspecies winters in tropical W. Africa, whereas the *islandica* subspecies winters in temperate W. Europe. A step in understanding the evolution and maintenance of these two migration strategies will be to make a comparison of the energetics of the two. Our studies aim to empirically describe the changing energy expenditure and intake rates of Knots in the course of their annual cycle, and to relate these to concurrent body mass changes. Growing and declining, and sometimes adaptive, fat and protein reserves accommodate the daily energy gains and deficits. The building of empirical models hierarchically incorporating the various factors affecting energy expenditure and intake will eventually allow the exploration of the energetic limits to Knots' distributions.



Thermostatic costs of Knots (subspecies *islandica*) under laboratory conditions (top) and in different microhabitats in the field (bottom). For the latter, environmental conditions were standardized as for a cloudy midday with a gentle breeze (3 Beaufort): wind speed is set a 3 m/s and global solar radiation at 400 w/m². The data in the upper panel refer to night-long continuous O₂-measurements of sleeping Knots in black plexiglass boxes in a climatic chamber, the air temperature reflecting the temperature in the box. The field data are extrapolations of measurements under a range of environmental conditions in a variety of habitats with heated taxidermic Knot-mounts, calibrated in the laboratory under different temperature and wind conditions to live Knots. Field data were collected on and near Griend in the Dutch Wadden Sea, on Rowley Island, Foxe Basin and at Alert, Ellesmere Island, both in the Canadian Arctic. In the two panels the shaded levels indicate the minimum or basal metabolic rate (BMR).

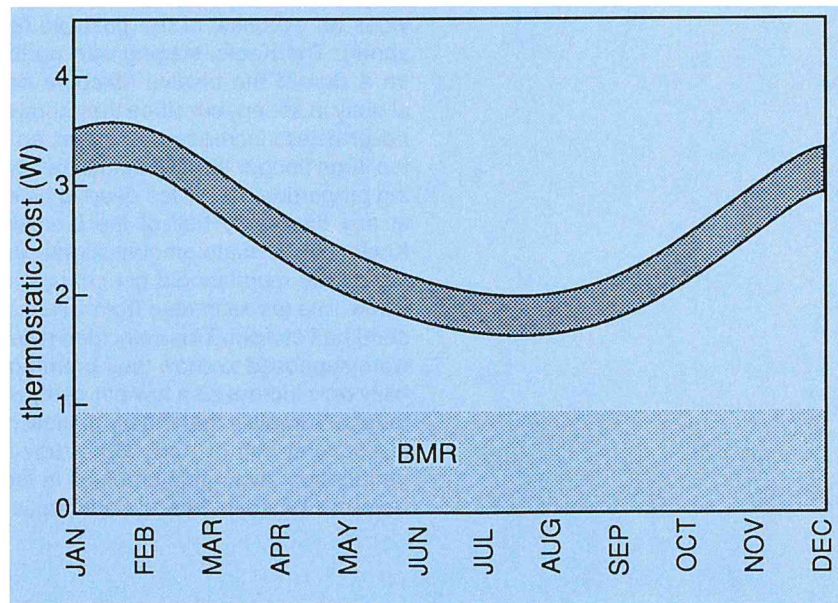
T. Piersma, P. Wiersma

Thermostatic costs of Knots

Wintering on the open mudflats, Knots have little opportunity to hide away from the elements. Knots are fairly small birds, and with a lower critical temperature of 20°C, the birds wintering in W. Europe usually incur energy costs for thermoregulation. For these northerly wintering Knots, thermostatic costs are likely to contribute significantly to the daily energy budget. How large are these costs, and how do they vary in the course of the northern winter?

Thermostatic costs associated with a decreasing temperature can easily be measured under laboratory conditions in live Knots. The metabolic rate increases below the lower critical temperature. In the thermo-neutral zone the metabolic expenditure equals the basal metabolic rate, BMR, of about 1 W. However, such laboratory measurements do not take the important effects of wind and radiation on a bird's expenditure into account. Since it is all but impossible to experimentally measure the combined effects of temperature, wind and radiation on metabolic rate simultaneously, and since it is also impossible to measure thermostatic costs of live birds in the field, we have attempted to approximate the situation by building Knot-models which mimic the bird in its environment as well as its thermoregulatory response (*i.e.* an increasing metabolism). To do so, a hollow copper model covered by a preserved skin of a Knot is mounted in a natural standing position. A thermistor inside the copper Knot is connected to a thermostat which can be set as to keep the internal temperature of the model at the natural constant of 41°C, the required heat being generated by a heating wire embedded in the copper model's wall. In this way the additive effects of air temperature, radiation and wind, as they effect Knots in different micro-habitats (open mudflats, sheltered roost in saltmarsh, nestcup on tundra, open tundra), can be measured in an integrated way. Under standardized laboratory conditions the power consumption of copper-Knots can be correlated to that of live birds.

Seasonal changes in the thermostatic cost incurred by Knots when living on the open mudflats of the Dutch Wadden Sea. The costs are calculated from a predictive equation relating air temperature, wind speed and global solar radiation as measured by meteorological stations in the Wadden Sea to the thermostatic cost of laboratory-calibrated heated taxidermic Knot-mounts. The proportion of the thermostatic cost, which is accounted for by the lowest metabolic rate of Knots Basal Metabolic Rate (BMR), defined as the energy consumption of post-absorptive resting birds under thermoneutral conditions, measured in the laboratory), is given by the shaded area.



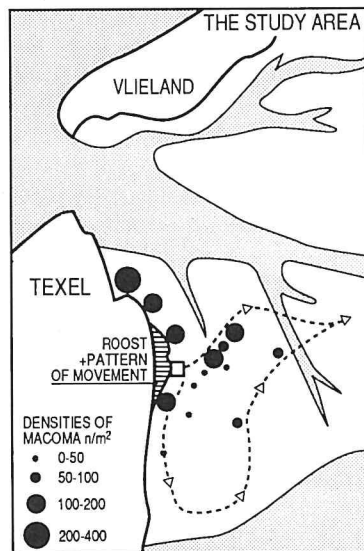
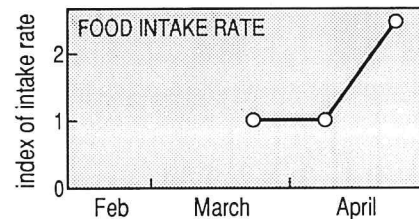
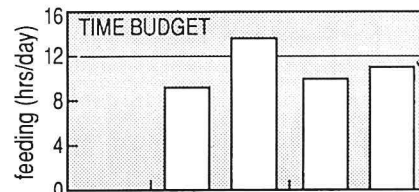
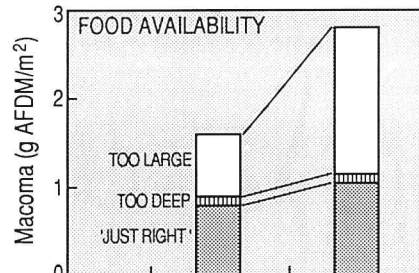
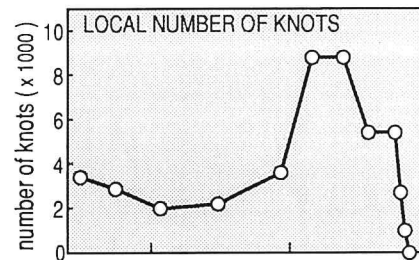
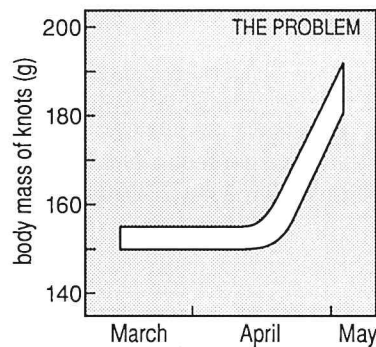
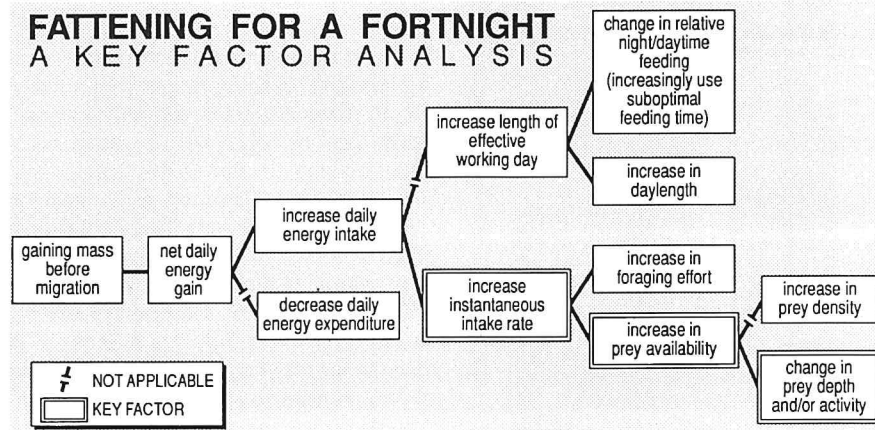
Such an exercise was carried out for a fine cloudy day with a light breeze and in different microhabitats. It comes as no surprise that the more sheltered the microhabitat is from wind effects (salt marsh, nestcup on tundra), the lower the thermostatic costs are. By regressing the three major environmental factors (air temperature, wind speed and solar radiation) on the energy requirement of live Knots as estimated by the heated copper Knot models, equations can be derived to estimate the thermostatic energy requirements in different microhabitats from meteorological measurements. In this way it is possible to calculate the seasonally changing thermostatic cost of Knots on the open mudflats of the Wadden Sea. Thermostatic costs appear to vary between 1.5 and 5.3 times the basal metabolic rate, the average mid-winter value actually coming quite close to the inferred maximum sustainable metabolic rate of about 4-5 times BMR. This is noteworthy since the cost of activity (presumably in the order of 1-2 times BMR) has yet to be added to this thermostatic cost curve. We must conclude that wintering at our latitudes is a costly strategy for Knots.

Changing feeding conditions for Knots in spring

T. Piersma, I. Tulp, Y. Verkuil

The long flights between the spring staging sites force Knots to store large energy reserves before take off. This must entail a substantial increase in the daily intake rates. Spring in temperate tidal flats shows many changes in the behaviour, condition and depth distribution of the benthic mollusc prey of Knots. In February-April we have studied the feeding of Knots of the *islandica* subspecies on Texel, The Netherlands, as they prepared their flight in the last days of April to Iceland. We wondered whether: 1) intake rates do indeed increase in spring; 2) the benthic species making up the Knots' diet show corresponding and favourable changes in availability; 3) any increases in daily food intake were due to increases in the birds' effort or to improving food availability. Our problem can be summarized in an explanatory framework, which provides an overview of the possible factors contributing to a mass increase in spring. The Knots, staging with up to 10 000 birds on Texel, mainly subsisted on a diet of the bivalve *Macoma balthica*. Densities of *Macoma* decreased slightly in spring, but since they showed a considerable growth, biomass values nevertheless increased. However, an increasing proportion of bivalves became too large (longer than 16 mm) to be swallowed by a Knot, and a slightly decreasing proportion buried too deep to be reached by the 3.5 cm long bill. Therefore, at any time, only half of the biomass of *Macoma* present was available for Knots, the absolute amount slightly increasing in spring. The time spent foraging on the mudflats did not change in the course of the study period, but the intake rate (as estimated from visual observations) increased 2.5-fold in the second half of April. This coincided nicely with the fortnightly period that the birds were supposed to show their premigratory mass gain. The fact that food availability only increased a few per cent, whereas the intake rate increased by a factor of 2.5, implies that the birds must have increased their foraging effort during the second half of April. Our study shows that Knots are not completely dependent on favourable changes in food availability to be able to depart in time from the Wadden Sea to their Arctic breeding grounds in spring.

FATTENING FOR A FORTNIGHT A KEY FACTOR ANALYSIS



How do Knots in spring manage to gain 30% of their body mass in half a month's time? This pictorial explains the problem (the mass gain graph at left), shows the study area (the Vlake van Kerken, just northeast of Texel in the westernmost Dutch Wadden Sea), the distribution of the Knots' main prey *Macoma balthica* and the typical daily pattern of the Knots' movements over the mudflats (at lower left). It also gives the explanatory framework (top) indicating which factors could in theory contribute to the rapid mass gain. The key factors identified in this study (the results of our field studies being summarized in the right-hand column) are indicated by heavy boxes.

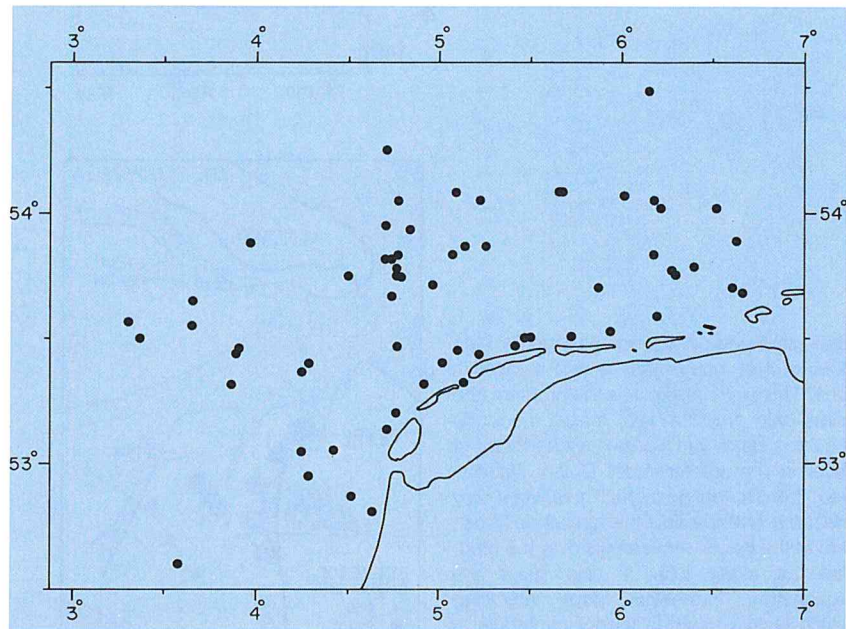
B3-09 SEA-BIRDS AND CETACEANS

M.F. Leopold

Sea-bird and cetacean distributions in the North Sea have been recorded, using research vessels ranging from the small 'Aade' (11 m) to the large 'Tridens' (72 m). Over the year, waters between the English Channel and the northern North Sea, between NE Scotland and the Skagerrak area, were visited. Most attention was devoted to the Dutch sector of the North Sea. An atlas of the sea-bird densities in this area is planned for 1991. The data collected by NIOZ and by DGW and the Dutch Seabird Group will be used collectively to produce this atlas. Sea-trips into areas within the Dutch sector that had not yet been visited in a particular time of year were therefore favoured in 1990.

Special attention has been given to seaducks, wintering in coastal waters. These birds are difficult to approach, because they live in waters that are too shallow for most ships, and because they are usually very shy. A combination of counts from the air by DGW and work from a ship suitable for the shallow coastal waters is used for this work. Bottom samples are taken to assess benthic biomass and to follow the impact of seaduck predation on the benthos during the winter. We have joined forces with the Flemish Institute for Nature Conservation, which is working on a similar project.

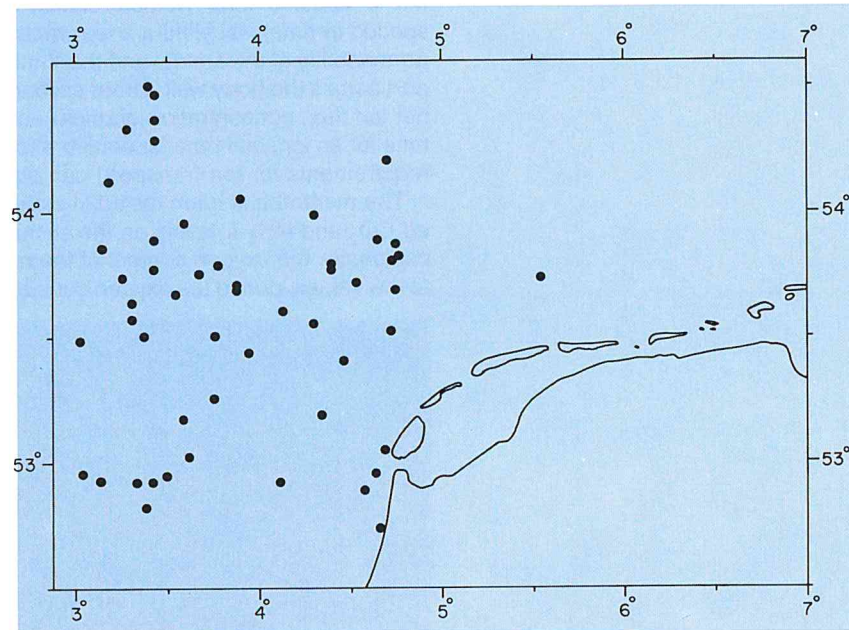
Outside the Dutch sector, most work was done in the British and Danish sectors. Results of the work in Danish waters were sent to our Danish colleagues, to be used in their atlas of the Danish sector. In return, we will receive their figures for the Dutch sector. In the British sector, the herring-spawning grounds off eastern Scotland and England were visited in September. With the results



Sightings of harbour porpoise *Phocoena phocoena* in the Frisian Front area, off the Dutch coast, 1984-1990, from ship-based and aerial surveys (unpl. data H.J.M. Baptist, C.J. Camp-huysen & M.F. Leopold).

obtained in these waters over the previous 3 years, it is now possible to map sea-bird densities in a large area off these coasts. Very large numbers of sea-birds use these waters in late summer. Cetaceans are also attracted to these waters. Compared to the past 3 years, large numbers of harbour porpoises (>150) and minke whales (>25) were seen. Cetaceans were also seen throughout the Dutch sector, but the majority of sightings come from the area north of the Wadden Isles.

In the German sector, the work centred around Heligoland. On this rocky island, the only colony of Guillemots in the eastern North Sea is found. Work was done in the colony to assess prey choice and prey size of the breeding birds. Sprat of about 12 cm were found to be the main prey of the birds. The at-sea distribution was mapped with two ships of the Biologische Anstalt Helgoland, and with the ferry to the mainland. The Guillemots appeared to use the waters west of the island, and to avoid waters on the mainland side of the island.



Sightings of white-beaked dolphins *Lagenorhynchus albirostris*, white-sided dolphins *L. acutus* and unidentified dolphins in the Frisian Front area, off the Dutch coast, 1984-1990, from ship-based and aerial surveys (unpublished data H.J.M. Baptist, C.J. Camphuysen & M.F. Leopold).

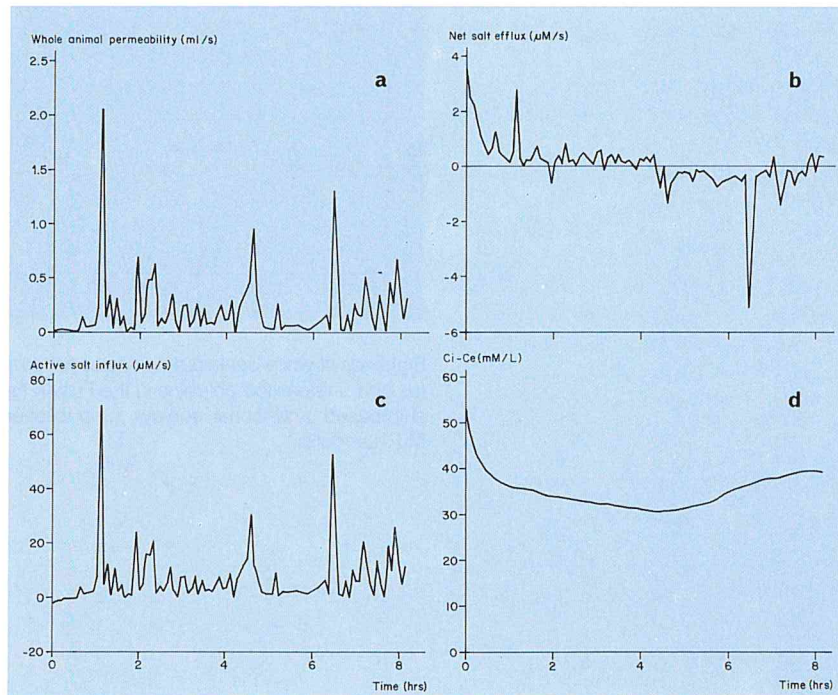
B3-10 CHEMICAL INTERACTIONS BETWEEN MARINE ANIMALS AND THEIR ENVIRONMENT

D.H. Spaargaren

In the framework of this project, a procedure for on-line signal analysis has been developed, which makes it possible to monitor continuously a number of ion-ion-exchange characteristics in aquatic animals. The method proved to be useful for the characterization of salt-permeability and salt-fluxes (active and passive fluxes separately) in shore crabs in their normal environment. Also, the effects of exposure to elevated CO_2 and NH_4^+ concentrations were studied.

When an animal is kept in a closed volume of seawater, the measurable change in the medium ion concentration can be described as the result of passive and active transport processes. The passive transport depends on ion-permeability and concentration difference between the extracellular fluids and the medium. Permeability and fluxes can be derived by measuring time-series of medium ion concentrations, measured either by means of a conductivity electrode (for total ion concentrations) or by means of an ion-selective electrode (for a specific ion). Autocorrelation of subsequent measurements (evenly spaced in time) will yield a linear relation. The slope can be related to the ion permeability of the animal and the Y-intercept can be related to the active transport across the body wall. Other exchange characteristics (e.g. passive ion flux, net ion flux, concentration gradient across the body wall, biological residence time for an ion, half time for equilibration to a change in external salinity, energy requirements for ion transport) can subsequently be derived.

The method has been tested in experiments considering the effect of elevated CO_2 and NH_4^+ levels on the exchange characteristics of shore crabs. Occasionally, the oxygen content of the natural environment of shore crabs drops to low values, due to the oxygen consumption of live organisms and of decaying



Whole animal permeability (a); net salt efflux (b); active salt influx (c); and concentration difference between the body fluids and the medium (d), in *Carcinus maenas* adapted to 28.5 salinity and at time zero exposed to a medium salinity of 22.2. Temperature 19.5°C; animal weight 39.3 g.

dead material. Concurrent with the fall in oxygen content, the concentration of metabolic end-products, e.g. ammonia and TCO_2 (TCO_2 = carbon dioxide, carbonic acid, bicarbonate and carbonate), will increase.

With respect to the effects of elevated CO_2 levels, it appears that permeability and net efflux at elevated TCO_2 levels are increased. However, as soon as the medium TCO_2 level exceeds the internal TCO_2 level then permeability and net efflux decrease. Concurrent changes in active flux in response to changed external TCO_2 concentrations are not sufficient to compensate for the increased passive losses. Already in short-term experiments a reduction of the concentration gradient across the body wall becomes visible.

Moderately elevated ammonia concentrations also induce increased permeability and higher salt fluxes across the body wall. In this case, however, active salt transport compensates for the increased passive losses. Prolonged exposure to elevated NH_4^+ levels in the environment will nevertheless be unfavourable, not because of NH_4^+ toxicity, but because of the higher energy requirements associated with the higher salt fluxes.

B3-11 PALAEOBIOLOGY

G.C. Cadée

A palaeobiology project group has been founded in 1990 to accommodate various projects already in progress with an actual palaeontological signature. Actual palaeontology is the (actualistic) study of the recent environment and its biota for a better understanding of the past. These projects are mainly related to horizontal (currents, biological) and vertical (bioturbation) transport of organic remains in the Dutch Wadden Sea.

A study of size-frequency distribution of living and dead *Cerastoderma edule* shells of the 1987 cohort on a tidal flat in the Mok was completed. Even in this sheltered tidal-flat area, empty shells were transported from the place where they lived. The study of empty shells produced by one cohort during several years was possible because spatfall in 1988 and 1989 was negligible, as is normal after a mild winter.

Much time was devoted to writing an invited 'History of Taphonomy', i.e. the study of all the processes between the death of an organism and its final embedding, including diagenetic processes in the sediment. Although the term 'taphonomy' was invented by Efremov in 1940, much work in this field was accomplished, particularly by German palaeontologists, as early as the beginning of this century, and even such early scientists as Da Vinci, Steno and Buckland made taphonomic observations. The goals of taphonomic research show a cyclic pattern: from 'information gain' on the sedimentary environment (Walther, Weigelt, Abel), to the study of 'information loss' during the fossilization process (Efremov), back to 'information gain' again in recent times. Taphonomic research is scattered over different palaeontological fields and published in different languages, and as a consequence unknown duplication of research has occurred. Synthesis of the ever increasing stream of publications, particularly after 1970, has been made possible by the invention of genetic classification systems of taphofacies, Fossil-Lagerstätten and fossil-assemblages.

Corina Brussaard - as an unpaid research assistant - made a start with the comparison of phytoplankton diatoms living in the water column and the diatoms found in sediment samples of the ocean bottom. Samples (net phytoplankton, bottom samples and a few floating sediment-trap samples) were collected during the Angola Basin expedition in 1989.

1.8. SPECIAL PROJECTS (S)

APPLIED SCIENTIFIC RESEARCH NIOZ (BEWON)

The BEWON project is part of the larger BEON project (= Policy Linked Ecological Research North Sea and Wadden Sea), a cooperative effort between 9 Dutch institutes including NIOZ. Its 17-member staff execute a scientific research programme to improve the scientific basis for the management of the North Sea and Wadden Sea. This scientific research concerns politically sensitive problem areas: eutrophication, micropollutants and the effects of fishery activities on the benthic ecosystem.

In close cooperation with other Dutch institutes this year's programme focussed on early diagenesis of nutrients in sediments, size partitioning of phytoplankton, biology of the small foodweb, physical and ecological modelling, pollution and higher trophic levels, and the study of changes in the North Sea ecosystem caused by fisheries. Together with the NIOZ Benthic Systems Department, TNO and the Delta Institute, a large-scale mesocosm experiment was carried out. Several cruises were made to investigate the biology of different fish populations and to study the effect of beam-trawl fishing. A new climate room became available in which competition experiments between different algal species will be conducted. New projects within the framework of the EC-MAST programme were initiated. A new computer network was installed to facilitate easy exchange with other European marine research institutes.

Various advising reports written or supported by the group concerned the effects of oil platforms on the ecosystem (an environmental impact study), the effects of fisheries, the establishment of protected areas in the North Sea, the Frisian Front, and what to do with PCBs.

During a workshop, initiative was taken to set up an Integrated North Sea Programme in 1991/92.

S-01 EUTROPHICATION

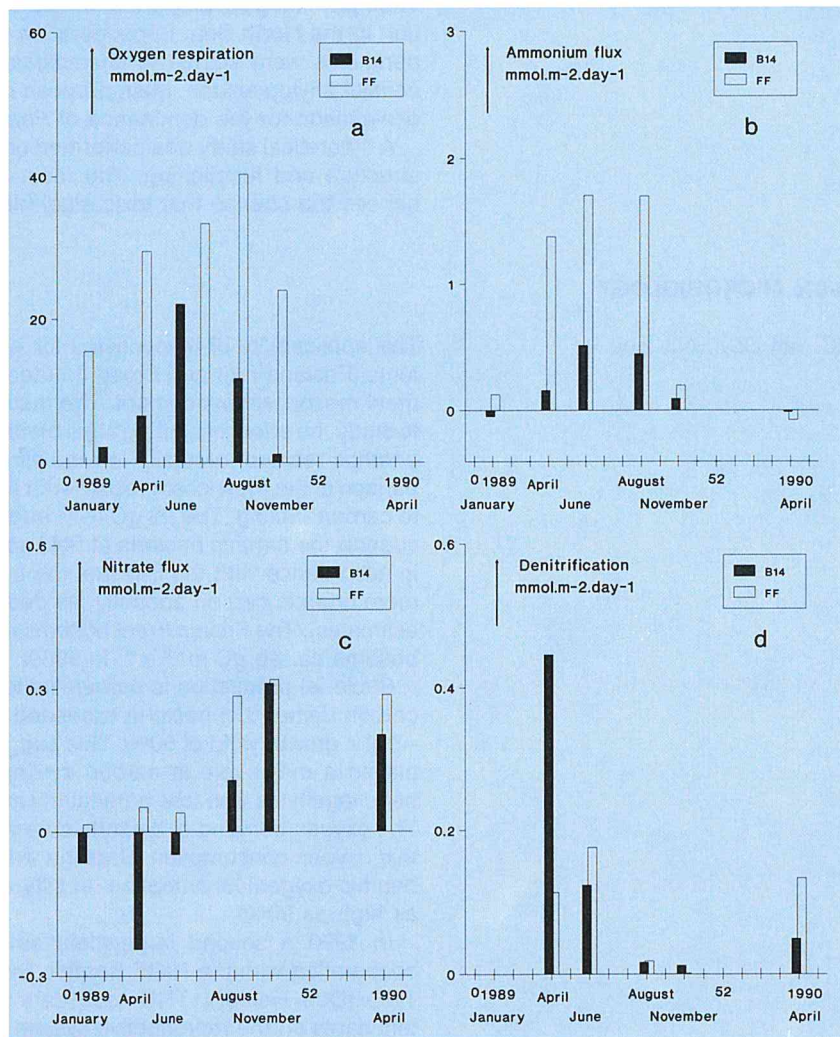
S-01a NUTRIENT CHEMISTRY

W. van Raaphorst, J.F.P. Malschaert,
H.T. Kloosterhuis, R.T.P. de Vries,
K.J.M. Bakker

During 1990 all activities were concentrated on early diagenesis of nutrients in North Sea sediments. Sandy sediments of the Dogger Bank area were analysed for their phosphate and silicate sorption and dissolution characteristics. A sequential extraction technique was applied to assess the amount of 'easily' exchangeable, adsorbed, and total inorganic P in these sediments. Results are in good agreement with adsorption/desorption experiments, indicating that the easily exchangeable fraction ($\sim 0.2-1.0 \mu\text{molP}\cdot\text{g}^{-1}$) is most important in short-term sedimentary P cycling. The characteristic time for P-sorption in the Dogger Bank sediments is *ca.* 1 h. A sodium-carbonate extraction technique for analysing biogenic Si was tested and applied to sandy sediments poor in organic matter. First results suggest that this method is also suited for biogenic Si contents less than *ca.* $100 \mu\text{molSi}\cdot\text{g}^{-1}$, and consequently may be used for North Sea sediments.

Much effort has been put in work related to North Sea mesocosm experiments. In April the '1989 sediment mesocosm experiment' was finished by collecting the last data (Frisian Front, Breeveertien) on nutrient sediment-water exchanges and denitrification. In May a new series of experiments in North Sea mesocosms started. In total 26 cores were analysed on benthic nutrient fluxes, denitrification rates, pore-water concentrations and organic N, C contents of the sediment.

A programme concerning benthic nutrient cycling in the eastern North Sea, which will be part of the Integrated North Sea Programme 1991/1992 (INP), was developed. Supervised by W. Helder (Chemical Oceanography and Marine Pollution), and W. van Raaphorst, a Ph.D. student will study the phosphorus binding to sediments and suspended matter of shallow marine systems.



Benthic oxygen respiration (a), ammonium (b) and nitrate (c) fluxes across the sediment-water interface, and benthic denitrification (d) measured at two stations off the Dutch coast: Frisian Front (silty) and Breeveertien (sandy). The data indicate much higher respiration and ammonium fluxes at the Frisian Front, but higher denitrification at the Breeveertien.

S-01b PHYTOPLANKTON

R. Riegman, J.F.P. Malschaert,
A. Noordeloos, W. Stolte

Central theme of the present research is the size partitioning of phytoplankton. Possible mechanisms that will lead to a 'microbial loop' type of food web or the more 'traditional' type of food web are under investigation. One of the major driving forces of the microbial loop in natural systems might be natural phytoplankton mortality. This process is studied in the laboratory and in the Marsdiep, using a method which was designed to quantify phytoplankton losses due to mortality. Preliminary results indicate that natural mortality is significant in the Marsdiep area. Another mechanism behind size partitioning of phytoplankton is expected to be related to the dynamics of nutrient availability in natural systems. During the coming 4 years W. Stolte will investigate the kinetics of growth and nutrient uptake of various common North Sea species. Their physiological properties will be studied and used to explain their distribution in the North Sea. In cooperation with DGW (The Hague) competition experiments were started in chemostats to investigate population dynamics of coastal phytoplankton. Main purpose of the present investigations is to find an explanation for the dominance of *Phaeocystis* in Dutch coastal waters.

A theoretical study was performed on the effects of eutrophication in foodweb structure and functioning. The main conclusion was that eutrophication enhances the chance that toxic algal blooms will occur.

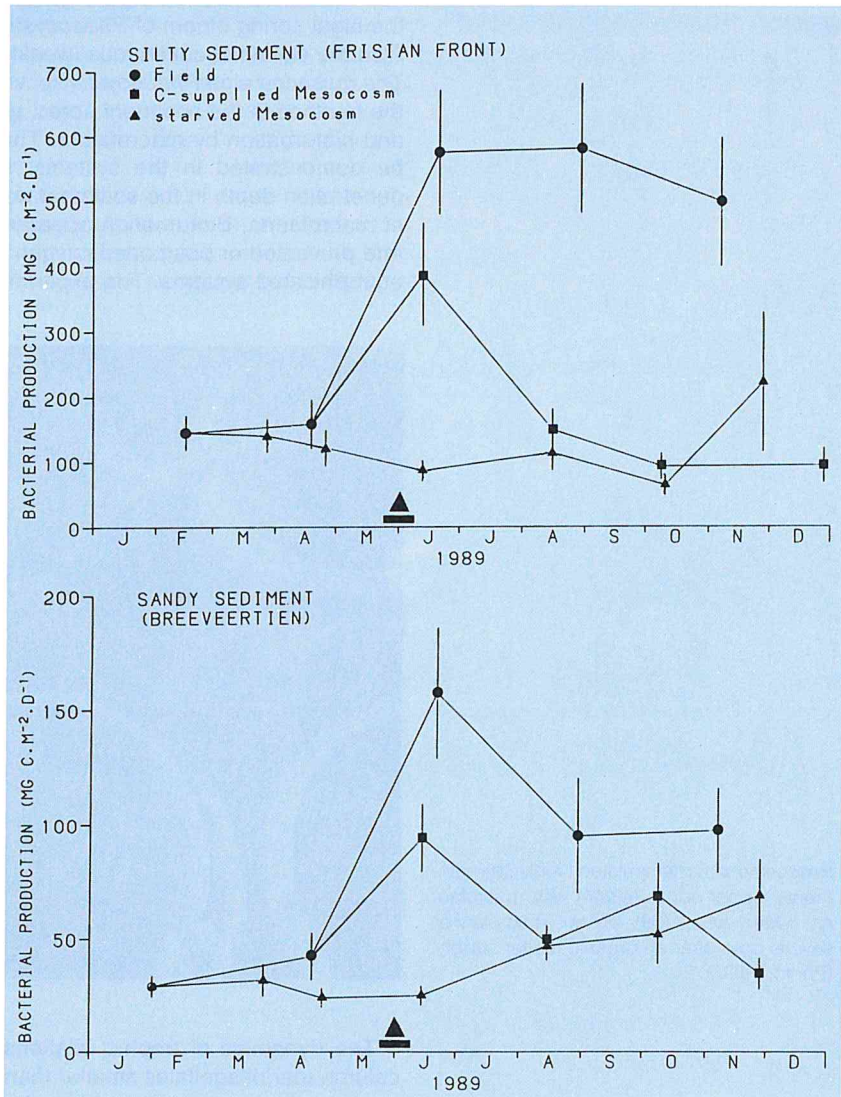
S-01c MICROBIOLOGY

F.C. van Duyl, A.J. Kop

The applicability of mesocosms for eutrophication studies of North Sea bottoms (Frisian Front and Broad Fourteens) was demonstrated in our 1989 sediment mesocosm experiment. The results show that these systems are suitable to study the effect of settling algal blooms on North Sea bottoms. The microzoobenthos reacted 'naturally' on the simulated algal sedimentation event. Comparison of the mesocosm results with field results were satisfactory with respect to carbon cycling. The $23 \text{ gC}\cdot\text{m}^{-2}$ added to the mesocosms was insufficient to support the benthic bacteria at field activity levels during the season. This was in accordance with the fact that the field stations were found to receive much more organic carbon annually (as deduced from benthic oxygen consumption estimates). The Frisian Front bottoms respired ca. 145 and the Broad Fourteens bottoms ca. $45 \text{ gC}\cdot\text{m}^{-2}\cdot\text{a}^{-1}$ in 1989.

Bacterial production is carbon-limited in North Sea sediments. The organic carbon demand of bacteria exceeded the annual respiration by a factor of 1.4 - 3 at a growth yield of 50%. This suggests that recycling of carbon by bacteria played a major role in carbon cycling. Bacterial mortality due to grazing of nanoflagellates was low, particularly in the silty sediments of the Frisian Front. The oxygen demand of bacteria determined the size and variations of the benthic oxygen consumption. Bacteria were responsible for more than 75% of the benthic oxygen consumption. In silty sediments the bacterial contribution was as high as 90%!

In 1990 a second large-scale eutrophication experiment was started in cooperation with the NIOZ Benthic Systems Department, DIHO (Yerseke) and TNO (Den Helder). TNO took care of the ecotoxicological effects of contaminants on the reproductive system of macrobenthos in the experiment. Ca. 100 sediment chambers each with a surface of 0.07 m^2 containing a ca. 25-cm-thick sediment layer and two 1.1 m^2 containers were installed in the 'North



Seasonal variations in bacterial production in the 5 mm sediment surface layer, field and mesocosm data compared; mesocosms starved (▲) or supplied with organic matter (■) in May-June.

Sea' basins in April. The sediments, collected from sandy Broad Fourteens bottoms, were defaunated, oxygenated during winter time, sieved and distributed over the containers. Series were faunated with micro- and meiofauna with and without macrofauna. The development in the sediments was followed over 6 months. The role of microzoobenthos and the influence of macrofauna in/on the degradation of different loads of organic matter in sediments were studied to find out whether eutrophication under physically undisturbed conditions would lead to biomass increase within the different size groups of benthic organisms or to enhanced turnover rates of organic carbon. This was tested for different feeding scenarios. Bacterial production, biomass, oxygen consumption and oxygen penetration depths in the sediments were monitored. The effect on

microzoobenthos of a single organic matter pulse simulating the settlement of the algal spring bloom of *Phaeocystis* sp. was followed at short time intervals. Also the effects of continuous (weekly) supply with algal detritus were studied. The nuisance alga *Phaeocystis* sp. was readily redistributed and consumed by the benthos in the sediment cores, particularly in the presence of macrofauna and bioturbation by macrofauna. The purported toxicity of the alga could not be demonstrated in the systems. In the absence of macrofauna, oxygen penetration depth in the sediment was considerably less than in the presence of macrofauna. Bioturbation apparently greatly enhanced oxygen penetration and prevented or postponed oxygen depletion in surface sediments in heavily eutrophicated systems. The experiment was terminated in October.



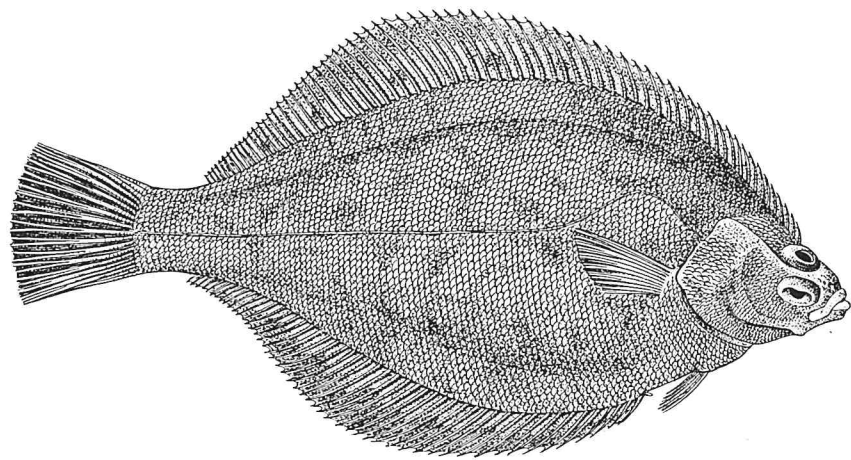
Boxcosms with manipulated North Sea sediments: upper series (43/44) with macrofauna, lower series (39) without macrofauna, several days after an organic matter supply. (Photo: NIOZ)

The dynamics of trophic relationships in the small food web in the water column (nanoflagellates smaller than 20 μm in length and bacteria) were analysed for the frontal system north of the Dogger Bank. A hypothesis was formulated in which the size class distribution of heterotrophic nanoflagellates is indicative of the trophic relations. Mixing events in frontal zones result in a redistribution and decline of autotrophic nanoflagellates, which are concentrated just under the thermocline, decoupling the trophic relation between 5-20 μm long heterotrophic and autotrophic nanoflagellates. The shift in predominant prey for heterotrophic nanoflagellates from autotrophic nanoflagellates to bacteria enhances the nutrient regeneration in the water column and the specific bacterial growth rate of bacteria. This pattern is characteristic for fronts in summer. This hypothesis still needs further verification. Actual measurements of grazing of heterotrophic nanoflagellates on bacteria are now being realized in cooperation with project B1-06.

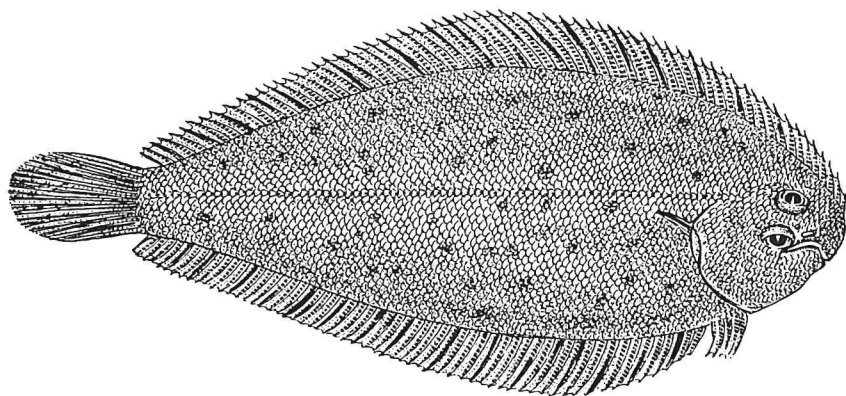
S-01d HIGHER TROPHIC LEVELS

H.W. van der Veer, M. Fonds,
J.I.J. Witte

The analysis of the 'Aurelia cruise reports' collected in the 1970s by Creutzberg and coworkers has been concentrated on the dragonet *Callionymus lyra*, a common non-commercial species in the coastal zone of the North Sea. A great deal of basic information on the ecology of the dragonet was obtained, and a comparison could be made with the 1950s. A comparison of the 1950s and the 1970s showed that growth was not significantly different. Eutrophication of especially the coastal zone apparently did not affect the growth rate of this species. This suggests that in both periods growth may have been optimal, only depending on prevailing water temperature. The population structure showed a remarkable difference: in the 1950s more age groups were found than in the 1970s. In the 1950s even 6-year-old individuals could be found. In the 1970s the oldest individuals belonged to age group-3. This difference might be due to the increased fishery intensity in the area. The analysis of a number of other slow-growing species may yield more insight into the changes between the 1950s and 1970s.



Dab *Limanda limanda* (Linnaeus, 1758) (after Day).



Little sole *Bullossidium luteum* (Risso, 1810) (after Poll).

Initial laboratory measurements have been carried out on the growth rates of dab (*Limanda limanda*) and solenette (*Buglossidium luteum*) at different constant temperatures of 5, 10, 15, 18, 20°C.

The study of the impact of micropollutants on the population dynamics in the North Sea resulted in data sets on the growth and population dynamics in flatfishes in a number of areas in the North Sea. The remarkable differences especially in growth will be analysed in laboratory experiments comparing untreated and with pollutant-infected individuals. This project is carried out in cooperation with projects S-02a and b.

Further laboratory research on the effect of PCBs on the reproductive success of *Limanda limanda* is in preparation.

S-01e MODELLING

H. Ridderinkhof, J.W. Baretta,
P. Ruardij

Physical oceanography

The set-up has been completed of a one-dimensional mixed layer model which includes both a turbulent surface and bottom mixed layer and a non-turbulent thermocline. The model can serve as the physical part of a coupled physical-biological column model. It simulates the time-evolution of the thickness of both mixed layers, of the thermocline, and of the vertical temperature profile at an arbitrary location.

Simulations with realistic meteorological forcing for two years (1987 and 1988) have shown that due to differences in wind regime large differences may occur in the physical vertical structure of a water column. In relatively shallow regions, storm events cause a cross-thermocline exchange of surface and (nutrient-rich) bottom water which may trigger the blooming of algae. Time-averaging the meteorological forcing shows that short-period wind mixing events influence not only the variability in vertical structure (e.g. the depth of the surface mixed layer) but also its longer term mean (e.g. the average heat content of a water column). In general, the results suggest that in coupled physical-biological models of stratified regions short-term events have to be taken into account for a realistic simulation of the long-term behaviour of phytoplankton.

Ecological modelling

The ERSEM-proposal, submitted to DG-XII for funding from the Marine Science and Technology (MAST) programme, has been accepted by the EC. The goal of this project is to construct, calibrate and validate an ecosystem model of the North Sea in a concerted effort of the following marine research institutes:

- NIOZ (lead institute)
- Plymouth Marine Laboratory (PML), U.K.
- Institut für Meereskunde Hamburg (IfM), FRG
- Marine Laboratory Aberdeen (MLA), Scotland, U.K.
- Water Quality Institute Copenhagen (WQI), Denmark
- University Oldenburg (UO), FRG
- Centre d'Estudis Avancats Blanes (CEAB), Spain
- University Gothenburg (UG), Sweden
- Askö Laboratory (AL), Sweden
- Strathclyde University Glasgow, Scotland, U.K.
- Aberdeen University, Scotland, U.K.

The project is structured in such a way that all participating institutes use the same computer hard- and software to preclude incompatibility problems.

The simulation software package BAHBOE, developed by P. Ruardij, has been converted from a proprietary operating system to UNIX and made available to the project partners.

Bundled with BAHBOE will be the first version of a water-column model developed at NIOZ. This model will be used in the ERSEM project as the test bed for newly developed formulations of ecological processes and at the same time it will define the overall logical structure of the ecosystem model. The model comprises three submodels, each describing the dynamics of a subsystem:

—The pelagic submodel, containing descriptions of the major biological and chemical processes in the water column.

—The benthic submodel, describing the biological and chemical processes in the sediment underlying the water column.

—The physical submodel simulating the physical processes in the water column, either stratified or mixed. By incorporating vertical transport processes it couples the benthic and the pelagic systems. This submodel ensures the integration of the physical environment with the biological and chemical dynamics of the pelagic and benthic systems.

S-01f MODELLING PHYSICAL OCEANOGRAPHY OF THE WESTERN WADDEN SEA

H. Ridderinkhof, J.T.F. Zimmerman

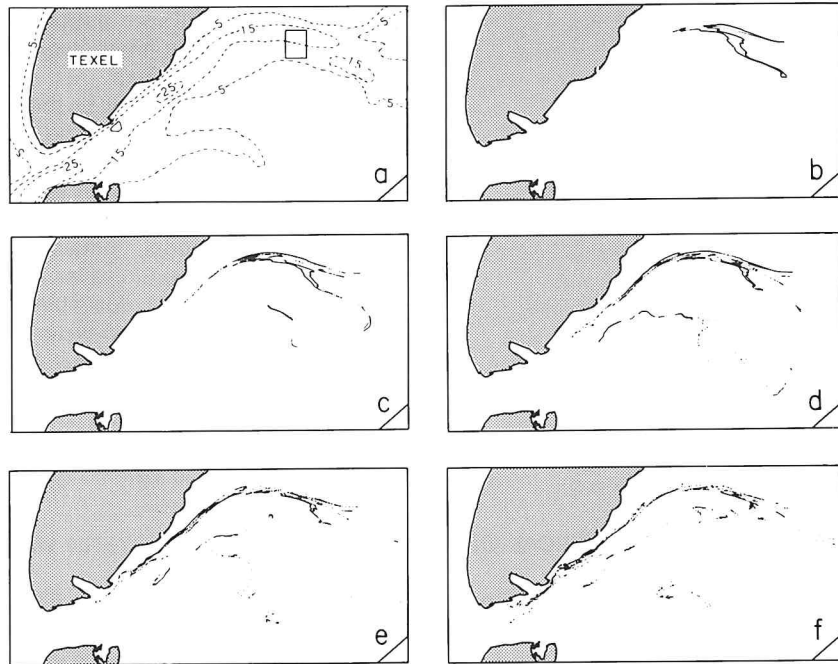
This project concerns the study of tidal currents, tidally driven residual currents and mixing processes in the western Dutch Wadden Sea by means of experiments with a detailed hydrodynamical numerical model. Horizontal dispersion (or mixing) has been studied by analysing Lagrangean trajectories of labelled particles in the model. With respect to tidal dispersion, the results are in conflict with the classic shear dispersion concept in that dispersion occurs without the presence of random motions (small-scale turbulence). Similarities with results from (theoretical) studies on the chaotic aspects of fluid mixing in simple deterministic flows can be recognized, *e.g.* the extremely fast growth of the perimeter of a water mass and the strong sensitivity of particle trajectories to their initial position. Regarding the tidal dispersion as a non-linear dynamical system which can have chaotic behaviour suggests the application of methods from non-linear dynamical systems theory to improve our understanding of mixing due to tidal and residual currents. This approach will be examined in a following project.

S-01g WADDEN SEA ECOSYSTEM MODEL (EMOWAD)

W. van Raaphorst, P. Ruardij,
J.W. Baretta

The ecosystem model EMOWAD, developed at NIOZ, was made available to RIN for further application concerning Wadden Sea management questions.

Together with German and Danish institutes an EC-MAST proposal on Wadden Sea modelling (WASP = Wadden Sea Project) has been submitted. From September 1990 onwards, different institutes (including WL, RIN, DGW, NIOZ) will model surface waves and currents, erosion and sedimentation, and ecological processes in the Wadden Sea. In close cooperation with RIN, NIOZ will be performing the ecological parts of WASP by extending and improving EMOWAD (inclusion of nitrogen dynamics, improving of the filter-feeder module). For this reason a start has been made with a detailed analysis of structure and performance of the present EMOWAD benthic submodel.



Tidal deformation of a water column initially released in the middle of the Marsdiep basin. Fig. a gives particle positions at the time of release and some isobaths. Figs b to f give the particle positions after 1, 2, 3, 4 and 5 tidal periods.

S-02 MICROPOLLUTANTS

S-02a IDENTIFICATION AND QUALIFICATION OF POLYAROMATIC HYDROCARBONS (PAHs) AND POLYCHLORINATED BIPHENYLS (PCBs), AND THEIR FATE IN THE MARINE ENVIRONMENT

J.P. Boon, E. van Arnhem, S. Jansen
M.Th.J. Hillebrand

In last year's annual report, results were described of a method involving the use of activated carbon columns to separate polychlorinated biphenyl (PCB) congeners with the highest toxicity of the 'dioxin-(TCDD-) type' from other CBs. This year, the performance of carbon separation and multidimensional gaschromatography (MDGC) were compared during a one month visit of J.P. Boon to the Department of Environmental Chemistry at the Institute of Marine Science at the University of Kiel, FRG. In this collaborative research project with N. Kannan, D. Schulz, G. Petrick and J.C. Duinker, it was found that both techniques had their own strengths and weaknesses: commercial charcoals behaved differently in their separation behaviour of planar CBs and moreover, MDGC still showed the presence of substances co-eluting with the planar CBs even after separation on carbon columns, although the amount of these substances was often drastically reduced. On the other hand, the use of MDGC without pre-separation on carbon columns yielded concentrations of planar CBs below their detection limits in blubber samples of harbour seals (a gift from P.J.H. Reijnders, RIN, Texel), because they had to be diluted to prevent overloading of ortho-Cl substituted CBs on the column. In conclusion, the use of the two techniques together produced a synergistic effect for the determination of the three most toxic members of the group of PCBs.

The method described was used to separate the most toxic PCBs from their co-eluting congeners in blubber samples of harbour seals only after the use of the newly developed HPLC clean-up to get rid of interfering substances such as animal lipids.

A comparison of the environmental danger of several toxic congeners was made by multiplying their relative concentrations and their relative toxicities as determined in rats. The relative concentrations of classes of CBs with regard to their degree of ortho-Cl substitution were inversely proportional to their relative 'TCDD-type' toxicity, *i.e.* di-ortho > mono-ortho > non-ortho. The hazard of CB congeners as the product of their relative concentrations and toxicity in seal blubber samples is given in the table below. Values of di-ortho-Cl-substituted congeners are not given, since no Toxic Equivalency Factors (TEFs) have been established. Surprisingly, CB-118 is the only congener mentioned in this table that is regularly involved in international monitoring programmes in the marine environment such as the Joint Monitoring Programme.

Relative concentrations (expressed as their ratios to CB-153 \pm SEM; n=5 for all congeners) and relative number of toxic equivalents (TE) of some non-ortho-Cl substituted PCBs and their mono-ortho substituted derivatives in blubber of harbour seals (*Phoca vitulina*). The Toxic Equivalency Factors (TEFs) used, are those established by the Dutch group of experts on TEFs. The mean concentration of CB-153 was $3.4 \pm 1.6 \mu\text{g}\cdot\text{g}^{-1}$ wet weight \pm SEM.

CB-nr.	Cl-substitution pattern	Concentration Ratio		
		CB-x/CB-153 \pm SEM	TEF	TE range
77	3,3',4,4'	1.4 $0.4 \cdot 10^{-5}$	$1 \cdot 10^{-2}$	$1\text{-}2 \cdot 10^{-7}$
126	3,3',4,4',5	2.1 $0.6 \cdot 10^{-4}$	$1 \cdot 10^{-1}$	$1\text{-}3 \cdot 10^{-5}$
169	3,3',4,4',5,5'	7.3 $2.3 \cdot 10^{-5}$	$5 \cdot 10^{-3}$	$2\text{-}5 \cdot 10^{-7}$
105	2,3,3',4,4'	4.6 $0.5 \cdot 10^{-2}$	$1 \cdot 10^{-4}$	$4\text{-}5 \cdot 10^{-6}$
118	2,3',4,4',5	7.4 $2.0 \cdot 10^{-2}$	$5 \cdot 10^{-5}$	$3\text{-}5 \cdot 10^{-6}$
123	2',3,4,4',5	1.3 $0.6 \cdot 10^{-2}$	$5 \cdot 10^{-5}$	$0.4\text{-}1 \cdot 10^{-6}$
156	2,3,3',4,4',5	8.3 $2.2 \cdot 10^{-2}$	$5 \cdot 10^{-4}$	$3\text{-}5 \cdot 10^{-5}$

S-02b BIOMARKERS OF MARINE ENVIRONMENTAL CONTAMINATION

J.P. Boon, J.M. Everaarts,
H.M. Sleiderink, M.J.C. Rozemeijer,
C. Swennen, P. Duiven,
J.S.J. van de Sant

This project primarily focusses on the interaction between polyaromatic contaminants and the Mono-Oxygenase (MO) enzyme system in the liver. Because of the experience of the laboratory of the Department of Chemical Oceanography and Marine Pollution, PCB mixtures act as model compounds for this study, but dioxins, dibenzofurans and polyaromatic hydrocarbons (PAHs) show very similar effects in that some representatives are able to induce MO enzyme system and can be metabolized themselves by it. In 1990, the project has centred on fish and birds.

In continuation of last year's laboratory experiments with plaice, a field study was undertaken to establish the concentrations of total cytochrome P450 (Σ P450) and the activity of ethoxyresorufin-o-deethylase (EROD). This time dab (*Limanda limanda*) was chosen, because this species is present in high densities throughout a major part of the North Sea. It will be investigated whether there is a relation with the general contamination of coastal waters, for which

PCB contamination will act as a chemical marker. The first results will be available next year. This part of the project is carried out in close cooperation with M.L. Eggens of the department of Chemistry of the RWS Tidal Waters Division.

During the last decade, the population of the eiderduck (*Somateria mollissima*) was affected by diseases, such as high rates of infections with the parasite *Polymorphus botulus*, and abnormal death rates. Also, abnormal plumage in possibly senile female eiders was observed, which was attributed to hormonal imbalances. Environmental pollution is regarded as one of the possible causes. A hydroxylated metabolite of 3,3',4,4'-tetrachlorobiphenyl (CB-77) is able to interfere with the mode of transport of retinol (vitamin A) and thyroxine in blood, resulting in lowered plasma levels of both compounds because of increased excretion. Both compounds play an important role in the integrity of the immune system of an organism.

Harbour seals (*Phoca vitulina*) in captivity that were fed with fish from the Wadden Sea showed significantly lower levels of vitamin A and thyroxine than seals fed with fish from the Atlantic Ocean. This correlated with the higher levels of PCBs and DDE in their blood. Whether this toxicity mechanism also applies to birds is uncertain, since the spectrum of PCB molecules that can be metabolized by seabirds, differs from seals and cetaceans.

To investigate the possible consequences of these differences, an experiment was performed with eider ducklings. This experiment was performed at NIOZ in cooperation with the department of toxicology of the Agricultural University of Wageningen. Chicks of the eider were exposed to two doses of either CB-77 alone or the technical CB mixture Clophen A50, containing about 60 individual congeners. A reference group was injected with only corn oil, which acted as the solvent of the PCBs. To investigate the effect of PCB contamination on the resistance against parasites, a number of animals exposed to the highest levels of CB-77 and Clophen A50 were infected with the parasite *Polymorphus botulus*.

The results of this study will be available in the course of 1991.

S-02c BIOLOGICAL EFFECTS OF DRILLING ACTIVITIES IN THE NORTH SEA (TECON)

R. Daan, W.E. Lewis, M. Mulder,
J. v.d. Hoek

Biological effect studies on the discharges of drill cuttings (with adhering drilling fluids) at offshore installations on the Dutch continental shelf were continued. The attention focussed on effects of material contaminated with oil-based muds. The analysis of the results of the research programmes carried out in 1987 and 1988 was completed. These data have given important information on *in situ* dose-effect relationships. Seven effects have been defined at community level, which are all expected to occur at oil concentrations above 100 mg·kg⁻¹ dry sediment. At concentrations between 10 and 100 mg·kg⁻¹ a limited number of effects may be expected, whereas at contamination levels of 1 to 10 mg·kg⁻¹ some very sensitive species may occur in reduced numbers. A synthesis of all data collected since 1985 has yielded much evidence for the existence of some species very sensitive to contamination of the sediment with oil-based muds. The small bivalve *Montacuta ferruginosa* is one of the most sensitive species.

In 1990 the research programme included field-surveys and boxcosm experiments. In the Frisian Front area a drilling location (L5-5) was visited, where new methods had been applied to clean the drill cuttings before disposal. It was of

particular interest to what extent such waste treatment procedures lead to a reduction of sediment contamination and, thus, to a decrease in effects on the benthic community. Preliminary results show that, indeed, adverse effects in the close vicinity of the discharge point seem to be less severe than at other drilling locations. However, at 250 m clear effects are still observed, which suggests that the surface of the affected area is not reduced. Contamination levels at stations 25 m and 250 m from the discharge point were rather similar and so were mortality rates of *Echinocardium cordatum* introduced on sediment cores of both stations. Among 4 species tested in the boxcosms, this one appeared to be the best suited as a test species. In August, boxcosm experiments were started to study the effect of discharged oil-based mud cuttings after 'SCS'-treatment. 'SCS' is an advanced method to clean contaminated material and to regain the oil. By this method oil contents are reduced to below 1%. Intact sediment cores were collected and a range of concentrations added to duplicate cores stocked with *Echinocardium cordatum*. Effects were recorded at species level as well as community level.

The investigations are carried out under contract with RWS (North Sea Directorate) and NOGEPa (oil companies) and performed in close cooperation with MT-TNO Den Helder.

S-03 EFFECTS OF TRAWL FISHERIES ON THE BENTHIC ECOSYSTEM OF THE NORTH SEA

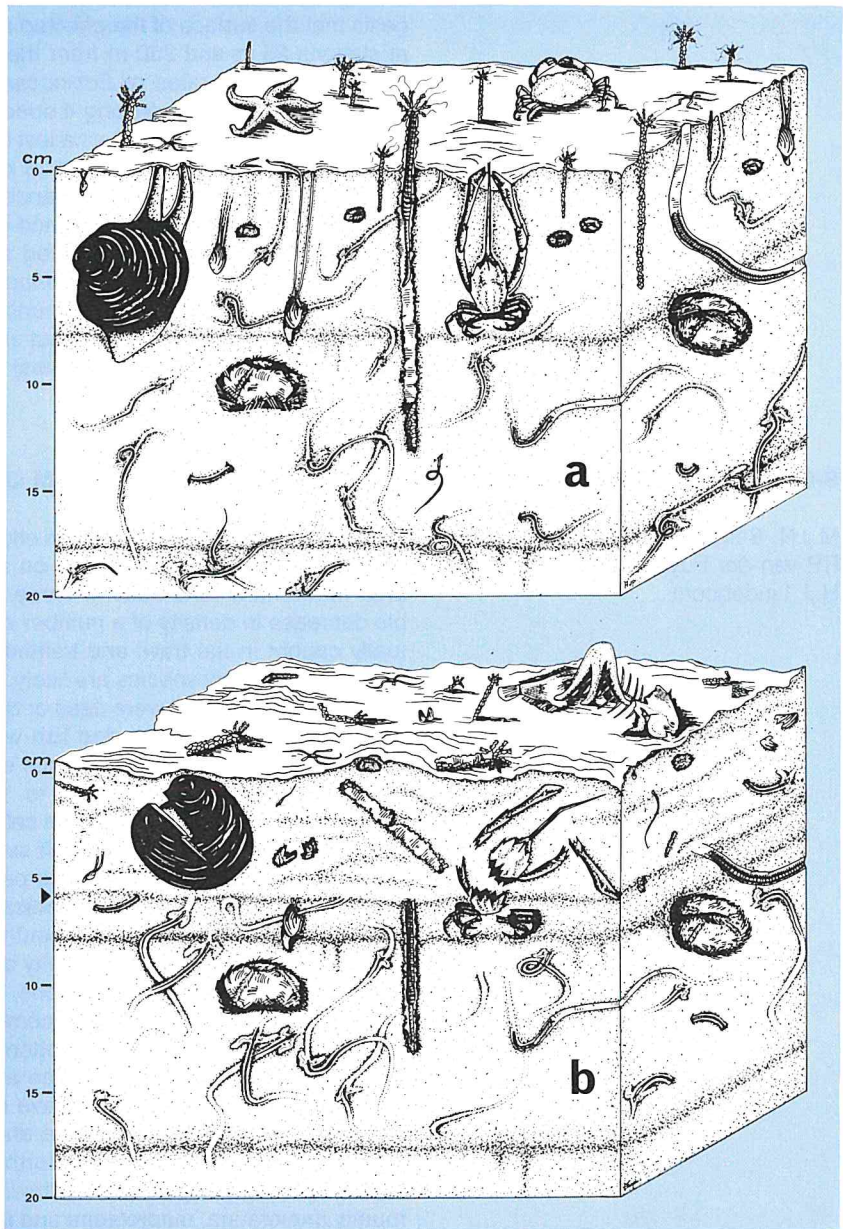
M.J.N. Bergman, M. Fonds, M. Hup,
P.P. van der Puy, A. Stam,
H.J. Lindeboom

Results of the study on short-term effects of beamtrawling on the bottom fauna (1989) clearly show direct effects on some benthic species in the investigated area with a hard sand bottom. Three-fold trawling has resulted in a considerable decrease in density of a number of species. Mortality of (other) species actually caught in the trawl and treated on board the trawler is estimated at 30 to 90%. Only a few species are likely to survive after returning to the sea. Most fish caught in the trawl were dead or died soon after, and during this experiment the amount of dead discarded fish was estimated at 2-4 times the amount of marketable fish. Survival of benthos escaping through the meshes was almost 100%: survival of fish was 56 to 100%, depending on the species. The presence of benthic infauna in the catches indicates that tickler chains and the ground chain probably scraped off successive layers of sediment and reached 6 cm into the sediment at least in part of the area.

This study (1989) only gives indications of the short-term effects of beamtrawling on an already affected benthic infauna. To be able to study the long-term effects, the benthic community of a fished and an adjacent unfished zone should be compared. Such locations, however, are rare in the North Sea, where large-scale beamtrawling is fairly common. Therefore, to study the long-term effects it is recommended that bottom trawling should be banned in a large representative fished area as soon as possible.

Because such closed areas have not been realized so far, in 1990 a pilot-study was carried out both inside and outside the 'Borkumer Stenen', one of the few suitable locations in the North Sea where a scarcely trawled area is enclosed by a relatively frequently trawled zone. Differences in the benthic community (meiofauna, macrofauna and fishes) may be related to the considerable differences in beamtrawl effort during the last 15 years.

In 1990 the survival of benthic species and fish after their treatment on board the trawler, or their escape through the meshes of the trawl, was studied in more detail.



Presentation of possible effects of beam-trawling on benthic infauna. a) before and b) after beamtrawling.

In cooperation with the Netherlands Institute for Fishery Investigations (RIVO), IJmuiden, the survival of benthic organisms in commercial beamtrawl catches was estimated on board a beamtrawler fishing for sole (*Solea solea*) with 12-m beams, 8 cm mesh-size nets and 10 tickler chains. The general catch composition and the survival of benthos were estimated in 6 catches lasting from 0.5 to 1.5 hours. The survival of living benthic organisms collected from the catches was estimated in seawater tanks on board the ship, over a period of 2-3 days.

The general catch composition indicated that fish (mainly flatfish) made up 30% in numbers and 64% in weight of the total catch. Discard fish, mainly dab (*Limanda limanda*) and undersized plaice (*Pleuronectus platessa*), amounted to 86% in numbers and 67% in weight of the total fish catch.

The bycatch of benthos was 70% in numbers and 35% in weight of the total catch. Most of the benthos consisted of seastars (*Asterias rubens*, 7-13 cm diameter).

The overall survival of benthic animals was estimated to be 60-80% for echinoderms (*Asterias*, *Astropecten*, *Ophiura*), about 60-70% for crabs (*Cancer*, *Liocarcinus*, *Corystes*), 100% for hermit crabs (*Eupagurus*) and whelks (*Buccinum*). Large shellfish like *Arctica islandica* were damaged during sorting of the catch, leading to low survival rates of 10% of the animals caught in the net.

Discard flatfish going through the meshes of the nets in very short hauls (2-5 min) and collected in a fine-mesh covering net showed a high survival rate in the following two days: 80-100% for sole (*Solea solea*), 75-90% survival for plaice (*Pleuronectes platessa*) and 90-100% for small species such as solenette (*Buglossidium luteum*) and dragonet (*Callionymus lyra*). The survival of dab (*Limanda limanda*) was much lower: 38-67%.

The total production of dead organic matter in the beamtrawl fishery for sole in coastal areas in summer was estimated at 0.2 - 0.3 g ash-free dry weight per m² per haul. Part of this material is probably consumed by the seastar (*Asterias rubens*).

The penetration depth of the beamtrawl was studied by estimating the disturbance of the sediment by means of parameters as e.g. meiofauna, grain-size, porosity, resistivity and structure of the sediment.

The samples were collected with support of the RWS-North Sea Directorate and in cooperation with the Netherlands Institute for Fishery Investigations, Delta Institute for Hydrobiological Research and National Geological Service.

S-04 ENVIRONMENTAL IMPACT STUDY: DUMPING OF OIL-CONTAINING WASTE FROM OFFSHORE INSTALLATIONS

M.J.N. Bergman

The Environmental Impact Study consists of ten basic documents and a principal report. NIOZ compiled three of these basic reports. The ecosystem of the North Sea and the biological impacts of waste disposal during exploration and exploitation of gas- and oil-producing platforms in the North Sea were described. The environmental effects of the present regulations applying to offshore activities as well as possible alternative regulations were compared. Advice was given for preparing summaries and recommendations in the principal report, which has not been finished yet.

The study was carried out by order of Grontmij N.V.

S-05 BIOLOGICAL RESEARCH IN RELATION TO DEEP-SEA DUMPING OF RADIOACTIVE WASTE (NAZORG)

M.S.S. Lavaleye

The NAZORG project, which compares the abyssal benthos of the dumpsite for low-level radioactive waste in the N.E. Atlantic with other nearby deep-sea areas to reveal possible effects of dumping on the benthos, was continued from May to November. In this period special attention was paid to the megafauna, caught during the second NAZORG expedition in 1989. First, to measure the actual radionuclide concentrations in fauna from the dumpsite and stations downstream. Because of the expected low concentrations, this is only feasible in large animals. So far, these analyses, carried out at the International Laboratory of Marine Radioactivity in Monaco, have not shown exceptionally high levels of the gamma radiating radionuclides. Secondly, to study the composition, density and biomass of this fauna. The biomass data for the dumpsite station are at the same level as those from the DORA project. The nearest station outside the dumpsite has somewhat lower figures, but the composition of the megafauna is rather similar. However, the shallower station 4, which is situated about 300 km to the north of the dumpsite with a bottom depth of 4000 m instead of 4700 m has a much higher biomass (> 300%). It is striking that the group Anthozoa, a major biomass constituent, is almost non-existent at this station.

At the end of the year the final report was written. It is concluded that the bottom fauna of the dumpsite is not significantly different from surrounding deep-sea areas with the same depths and bottom configuration, and so no major disturbance of the ecosystem at the dumpsite is yet discernible.

S-06 SEDIMENT EXPERIMENTS (SEDEX)

R. Dekker, P.A.W.J. de Wilde

(see B1-01)

S-07 POLLUTION RESEARCH IN THE ADRIATIC SEA

C.G.N. de Vooy

From 24 April to 4 June C.G.N. de Vooy carried out research at the Centro Universitario di Studi e Recerche sulle risorse Biologiche marine at Cesenatico (Italy). The stay at the Centro was made possible by a grant from the Royal Netherlands Academy of Arts and Sciences to A. de Zwaan (DIHO) and C.G.N. de Vooy.

The research is related to pollution problems in the northernmost part of the Adriatic Sea, particularly to the very low oxygen content of the water and the high heavy metal contamination. The bivalve *Scapharca inaequivalvis* was used, which has red blood cells with haemoglobin.

The investigations carried out are a continuation and a rounding off of earlier research in 1989. During this stay effects of anaerobiosis were studied on specific activities and kinetics of key enzymes in erythrocytes. Also *in vitro* experiments were performed with erythrocytes in aerobic and anaerobic conditions. The presence of hexokinase in the erythrocytes was demonstrated. It was shown that during anaerobiosis aspartate is the source of succinate and glucose the source of the alanine formed.

S-08 LONG-TERM CHANGES IN THE OCCURRENCE OF RARE FISH SPECIES IN THE SOUTHERN PART OF THE NORTH SEA

C.G.N de Vooy, H.W. van der Veer,
J.I.J Witte, J. van der Meer

An analysis was made of data on rare fish species collected by NIOZ from about 1930 till the present. The data concern fish landed at the fish auction at Den Helder, and bought by NIOZ. The object of this research is to trace alterations in the occurrence of various rare fish species over the past 60 years, and their possible causes.

A pilot study was carried out on changes in the occurrence of shark and ray species. First results demonstrate strong changes over the years, but a statistical analysis will be necessary in combination with life history information and landing data of the commercial fleet before conclusions can be drawn.

The investigation was carried out with the support of the RWS-North Sea Directorate.

S-09 PROTECTED AREAS NORTH SEA

M.J.N. Bergman, H.J. Lindeboom

The most serious threats to the North Sea ecosystem were assessed, based on the most recent scientific information on this ecosystem and on results of studies on ecological impacts of human activities. The possibility of introducing protected areas in order to conserve and restore the natural diversity in the ecosystem of the North Sea was discussed. In such protected areas activities such as fishing, mining, sand and gravel extraction, dredging, shipping and military activities should be restricted. Although the report has not yet been finished, a large area on the Dutch continental shelf north of the Frisian Islands is probably the area most suitable to be protected.

This study was carried out on request of the Ministry of Agriculture, Nature Management and Fisheries in cooperation with Sea Use Management Studies, Education and Advice (S.E.A.).

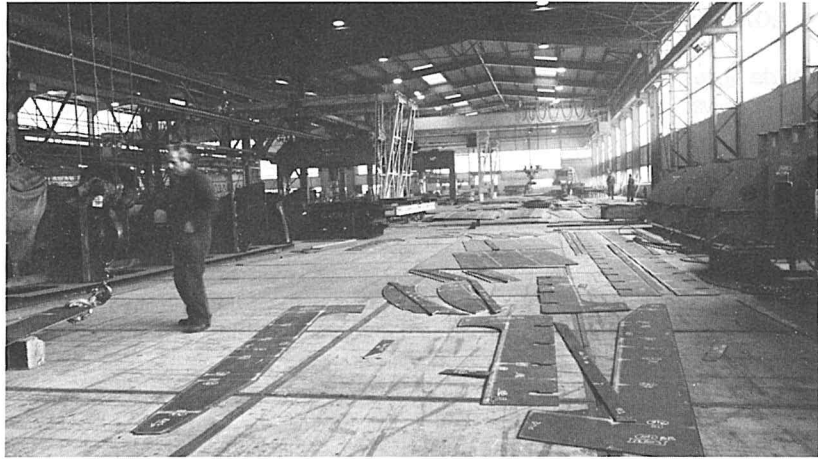
S-10 MONITORING SUBTIDAL MACROBENTHOS WESTERN WADDEN SEA

R. Dekker

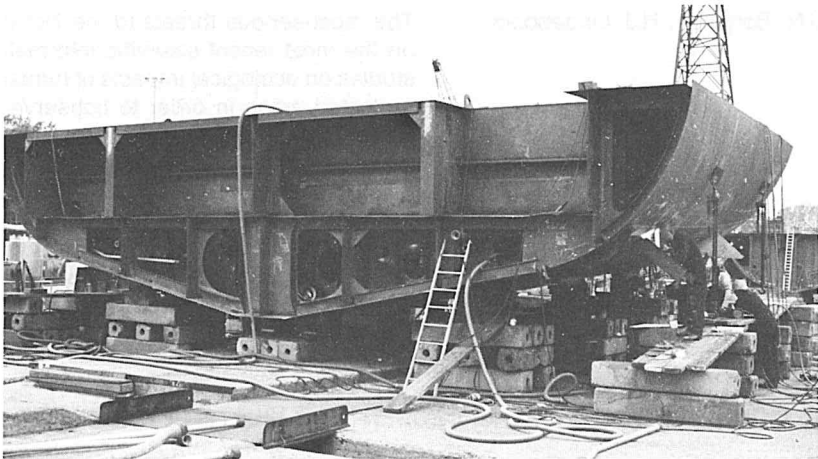
A monitoring programme for macrozoobenthos in the sublittoral western Wadden Sea was started at three stations in September 1989, and continued in 1990, under the direction of the RWS-Tidal Waters Division (DGW). During an earlier survey in 1981, these subtidal stations proved to be rich in macrozoobenthos. This programme runs parallel to similar programmes in the intertidal parts of the Dutch Wadden Sea carried out by DGW and NIOZ (see B3-02).

As previously found in intertidal locations, total biomass values of the macrozoobenthos in winter were considerably lower than in summer (43-85% of the summer values). The high densities of the mud snail *Hydrobia ulvae* are significant and seem to be a common and constant feature of the subtidal.

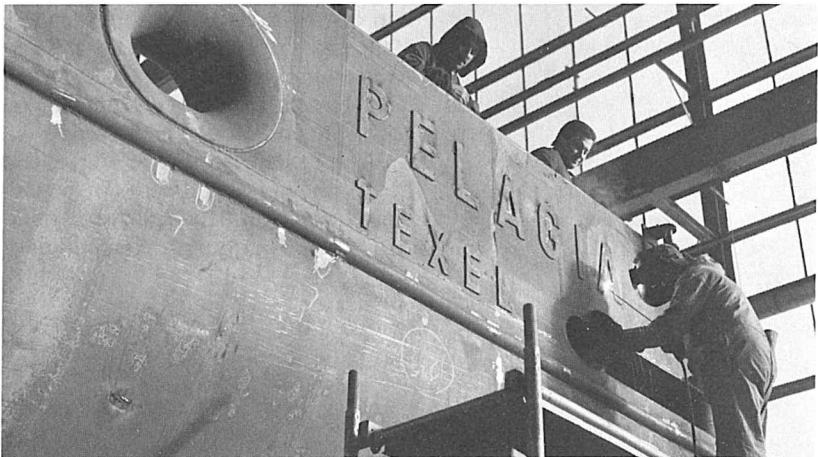
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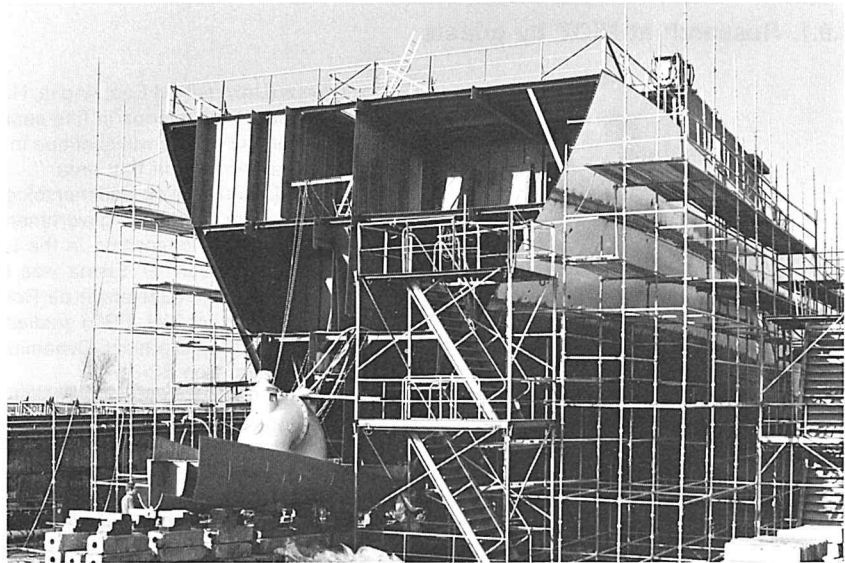
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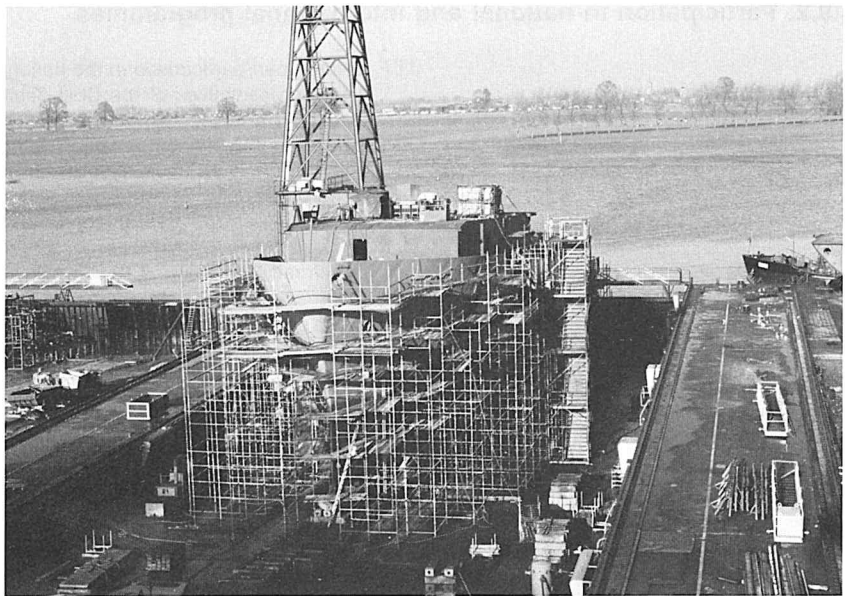
Het oplassen van een naam is eenvoudiger
dan het bedenken ervan.



De zojuist geplaatste boegschroefsectie.



In de steigers.
(foto's: H. Hobbelink)



1.9. ADDITIONAL RESEARCH

1.9.1. Research at NIOZ by guests

- Dr. David Brew (University of East Anglia, Norwich, UK), on a grant from the British Council, worked on microfauna in fine sediments from the German Bight. The purpose of this work, which he will continue in 1991, is to trace recent changes in the near-bottom environment in that area.
- Dr. Th. Courp (Laboratoire de Sédimentologie et Géochimie Marine, Perpignan, France), on a grant from the French government, started a study on suspended matter transport in relation to deposition in the Lacoze-Duhiers canyon in the Golfe du Lion, N.W. Mediterranean. D. Eisma was member of the commission for judging the theses of R. Lafite (Université de Rouen) and Th. Courp (Perpignan).
- F. Hansen (University of Kiel, FRG) studied grazing on *Phaeocystis* by copepods in the framework of the EC project 'Dynamics on *Phaeocystis* blooms in nutrient enriched coastal zones' (see B2-01).
- Dr. Y. Loktionov (Kalingrad Fisheries Institute, USSR) participated in the elaboration of the hydrographical data collected during the Mauritania expedition.
- Dr. Li Daoji (East China First Normal University, Shanghai) till 1 March worked together with B. Kuipers on bioturbation in tidal mudflats. After his 9 month-stay at NIOZ, he left for DIHO.
- Dr. H.E. de Swart (Institute of Meteorology and Oceanography, University of Utrecht) participated in theoretical work on ocean circulation during July.
- D. Zykov (State University of Moscow, USSR), via Unesco, worked together with Tj.C.E. van Weering on principles and application of acoustic and seismic stratigraphy.

1.9.2. Participation in national and international programmes

- J.T.F. Zimmerman participated in the national working group on radar altimetry, together with representatives of the Delft Technological University (Depts. Aerospace and Geodesy) and the University of Utrecht (Inst. Meteorol. Oceanogr.). The group represents the national research contribution to the coming missions of the ERS-1 and TOPEX/POSEIDON satellites.
- G. Marees participated in a national working group studying laser bathymetry applications for the North Sea, in cooperation with among others Rijkswaterstaat.
- G. Marees and M.R. Wernand assimilated data from the 'European Imaging Spectroscopy Aircraft Campaign' (EISAC), which was carried out over the German Bight and the Skagerrak.
- M.A. Baars and J.W. Baretta continued participation in the North Sea Project, coordinated by the Proudman Oceanographic Laboratory, Bidston, UK. A workshop on the seasonal cycle was attended on 26-27 February, and J.W. Baretta subsequently attended a training course on the use of the data base (28 Febr.- 2 March). NIOZ participants have formally obtained access to this huge base, containing all basic oceanographic data from 15 monthly surveys by RRS 'Challenger' in the southern part of the North Sea, August 1988 - October 1989.
- J.D.L. van Bleijswijk, P. van der Wal and R. Kempers participated in an international working group on the calcification by the coccolithophorid alga *Emiliania huxleyi*. M.J.W. Veldhuis, H.G. Fransz and G.W. Kraay also participate in this programme, which is a collaboration of NIOZ with the department of biochemistry and geobiochemistry of the University of Leiden, the GCA-Geomarine Center, the Free University at Amsterdam, ETH at Zürich, the Plymouth Marine Laboratory, the marine biology department of the University of Groningen and the Natural History Museum in London.

- T. Piersma participated with Dr. R.I.G. Morrison in a Canadian Wildlife Service-programme on the arrival biology of high arctic breeding shorebirds. From 30 May to 28 June 1990 the time and energy budgets of Knots *Calidris canutus* were studied at Alert, Ellesmere Island, Canada (82°N).
- T. Piersma, in cooperation with Dr. N.C. Davidson of the Nature Conservancy Council, Peterborough, UK, continued editing the proceedings of an international workshop on 'Recent advances in understanding Knot migrations' to be published in 1991.
- T. Piersma provided European link-up in an international collaborative programme by D.B. Lank (Kingston, Canada), under auspices of the Wader Study Group, to study the population genetics and dynamics of the peculiar behavioural/morphological dimorphism in male Ruffs *Philomachus pugnax*.
- D.H. Spaargaren participated in a project considering ion-exchange processes in the gills of *Carcinus maenas* and *C. mediterraneus*. To this end, in May and September he joined the experimental work on extirpated, perfused gills by Prof. Dr. C. Lucu (University of Rijeka, Yugoslavia) and Dr. D. Siebers (Biologische Anstalt Helgoland, FRG) at the Ruder Boskovic Institute for Marine Research in Rovinj, Yugoslavia.
- D.H. Spaargaren participated in the European intensive course on chemical evolution and exobiology organized by the Council of Europe working group on chemical evolution, early biological evolution and exobiology, held in December 1990 in Aussois, France.
- J.H. Vosjan, G. Nieuwland, E. Pauptit, M. Leopold, H.J. Lindeboom, participated in Netherlands Antarctic Expedition to Arctowski (Antarctica) December 1990/January 1991.
- R. Riegman participated in the EC project *Phaeocystis*, in cooperation with G. Billen and C. Lancelot, Université Libre de Bruxelles.
- H.J. Lindeboom participated in EC-MAST project WASP (=Wadden Sea Project), a cooperation between German, Danish and Dutch institutes.
- H.J. Lindeboom was one of the initiators of the Integrated North Sea Programme (INP 91/92).
- H.J. Lindeboom participated in the initiating phase of the DMS (=Dimethyl Sulphide) project, a cooperation between TNO, RUG and NIOZ.
- J.W. Baretta was made scientific coordinator of the EC-MAST project ERSEM for which NIOZ is the leading institute.
- From 3 to 10 October, R. Dekker and C. Swennen worked with Prof. J. Tardy (Laboratoire de Biologie Biochimie Marines et Phycoécologie) at La Rochelle, France. They studied the habitats of Opisthobranch molluscs, especially of the Zuyder Sea slug, *Doridella batava* (Kerbert, 1886). In France, this slug seems to prefer gelatinous, crusting Bryozoa living under stones and seaweeds in muddy, sometimes brackish, environments. After the enclosure of the Zuyder Sea, in which the slug was common, the species has been found only twice. There is a chance, however, that with the new information the animal can be found at other sites in The Netherlands.
- L. Lohse and R.F. Nolting participated in the EROS-2000 Mediterranean Sea cruise (Golfe du Lion) on RV 'Marion Dufresne' from 1 to 10 May.
- R.F. Nolting participated in the EC Brussels programme (Bureau of Certification of Reference Material) for the certification of trace metals in seawater reference material.
- M.Th.J. Hillebrand participated in an ICES/IOC/OSPARCOM intercomparison exercise on the analysis of chlorobiphenyl congeners in marine media.
- M.Th.J. Hillebrand was as chief technical adviser involved in the establishment of a marine pollution monitoring and training programme in Jakarta, Indonesia. The immediate objectives of the programme are: Achievement of the capability in the Centre for Oceanological Research and Development (P3O/LIPI) to plan and implement marine pollution monitoring programmes and to elaborate pollution control policy for management of the marine environment. The programme was carried out under responsibility of UNESCO/LIPI and funded by UNDP.

1.9.3. Visitors from abroad

Prof. Dr Y. Achituv, Life Science Dept, Bar-Ilan University, Ramat-Gan, Israel.
M. Althaus, University of Southampton, UK.
Dr. D.K. Atwood, NOAA, Ocean Chemistry Division, Miami, Florida, USA.
Dr. W. Bayens, Free University Brussels, Belgium.
Dr. A. Boldrin, Istituto di Biologia del Mare, CNR Venice, Italy.
C. Burdin, University of Moscow, USSR.
Dr. J. Bradford, New Zealand Institute of Oceanography, New Zealand.
Dr. N. Cameron, Conaco Inc., Houston, USA.
Dr. U.E.B. Cederlöf, University of Gothenburg, Sweden.
Prof. Chen-Tung Arthur Chen, Institute of Marine Geology, National Sun Yat-Sen University, Kaohsiung, Taiwan.
Prof. Cheng-Han Tsai, Department of Oceanography, National Taiwan Ocean University, Keelung, Taiwan.
Dr. T. Courp, Laboratoire de Sédimentologie et Géochimie Marine, Perpignan, France.
Dr. A. Cruzado, CEAB, Blanes, Spain.
Dr. Cy-Chain Chen, Industrial Technology Research Institute, Hsinchu, Taiwan.
Dr. B. Dennegard, Department of Marine Geology, University of Gothenborg, Sweden.
Prof. W. Ebenhöf, University of Oldenburg, FRG.
E.M. Evans, Shell, London, UK.
Dr. H. Farke, Nat. Park Adm., Niedersachsen, FRG.
G. Fengler, Institut für Biogeochemie und Meereschemie, Hamburg, BRD.
Dr. S.P. Fondekar, National Institute of Oceanography, Dona Paula, Goa, India.
Dr. J. Franco, University of Bilbao, Spain.
Dr. R. Glud, University of Aarhus, Denmark.
Dr. L. Goeyens, Free University Brussels, Belgium.
Dr. D.C. Gordon, BIO, Halifax, N.S., Canada.
J. Gundersen, Institute for Ecology and Genetics, Aarhus University, Denmark.
I. Hall, University of Southampton, UK.
Dr. M. Heath, MLA, Aberdeen, U.K.
Prof. Hin-Kiu Mok, Institute of Marine Biology, National Sun Yat-Sen University, Kaohsiung, Taiwan.
Dr. P.A.R. Hockey, University of Cape Town, South Africa.
Dr. T. Hupner, University of Oldenburg, FRG.
Dr. M.K. Ivanov, Department of Marine Geology, State University of Moscow, USSR.
Prof. Dr. A. Kalinin, Department of Marine Geology, State University of Moscow, USSR.
Dr. D.C. Krause, Unesco, Paris, France.
Dr. I. Kröncke, AWI, Bremerhaven, FRG.
Dr. A. Künitzer, AWI, Bremerhaven, FRG.
Dr. A. Kuyper, University of Aarhus, Denmark.
Dr. C. Lancelot, Groupe de Microbiologie des Milieux Aquatiques, Université Libre de Bruxelles, Belgium.
Dr. P. Larsen, Institute of Marine Research, Lysekil, Sweden.
Dr. R.J. Law, Chemical Services and Environmental Quality, Ministry of Agriculture, Fisheries and Food, Fisheries Laboratory, Burnham on Crouch, UK.
Mr. P. Loth, FAO, Harare, Zimbabwe.
Dr. S.J. Malcolm, Ministry of Agriculture, Fisheries and Food, Fisheries Laboratory, Lowestoft, UK.
Dr. A. Malmgren-Hansen, WQI, Copenhagen, Denmark.
C. Mandeville, University of Rhode Island, U.S.A.
Dr. D. Mills, University College of North Wales, Menai Bridge, UK.
Prof. Min-Pen Chen, Institute of Oceanography, Taipé, Taiwan.
Dr. G. Mrazek, Sektion Geologische Wissenschaften, Ernst-Moritz-Arndt Universität, Greifswald, DDR.
Dr. S. Rabitti, Istituto di Biologia del Mare, CNR Venice, Italy.
Prof. Dr. E. Orive, University of Bilbao, Spain.

Dr. S. Piontkowski, Institute for Marine Biology of the Southern Seas, Sebastopol, USSR.
Dr. G. Radach, IfM, Hamburg, FRG.
Dr. P. Radford, PML, Plymouth, UK.
Dr. J.C. Relaxans, University of Bordeaux, France.
Dr. R. Rippingale, University of Technology, Perth, Australia.
Dr. D. Schwartz, Office de la Recherche Scientifique et Technique Outre-Mer (ORSTOM),
Pointe Noire, R.P. du Congo.
H. Siemoneit, University of Oldenburg, FRG.
Dr. H.H. Sloterdijk, Ecotoxicology Laboratory, St. Lawrence Center, Longueuil, Quebec,
Canada.
I. Soehardi, BPPT, Jakarta, Indonesia.
Dr. P. Tett, University College of North Wales, Menai Bridge, UK.
Prof. Dr. V.T. Trofimov, Department of Marine Geology, State University of Moscow, USSR.
Dr. U. Vietinghoff, Wilhelm Pieck Universität, Rostock, DDR.
Prof. Wen-Ssn Chuang, Institute of Oceanography, Taipé, Taiwan.
Prof. M.T. Zen, BPPT, Jakarta, Indonesia.
D. Zykov, State University of Moscow, Moscow, USSR.



(Photo: I. Tulp)

2. Publications, lectures, etc.

2.1. PUBLICATIONS

2.1.1. Netherlands Journal of Sea Research and other series issued

In 1990, more than two volumes of the Netherlands Journal of Sea Research appeared (vols 25 and 26 plus the first number of vol. 27), whereas only one issue was published of the NIOZ Publication Series (no 17: the Annual Report 1989).

The publication of the Proceedings of the Snellius-II Symposium was completed by publication of the theme 'Pelagic Systems' in vol. 25, no 4, containing 21 papers on plankton and nekton in the Banda and Arafura Seas. Editors of this issue were the late J.J. Zijlstra, M.A. Baars and G.C. Cadée.

A total of 6 issues of the Netherlands Journal of Sea Research have now been devoted to the 5 themes of the Snellius-II Symposium: 1. 'Ventilation of deep-sea basins' in vol. 22 no 4 (December 1988) 2. 'Coral reefs' in vol. 23 no 2 (April 1989) 3. 'River inputs into ocean systems' in vol. 23 no 4 (August 1989) 4. 'Geology and geophysics of the Banda Arc and adjacent areas' in vol. 24 no 2/3 (November 1989) and no 4 (December 1989) 5. 'Pelagic systems' in vol. 25 no 4 (July 1990).

The assistance of J.G. Baretta-Bekker in editing all issues of the Proceedings of the Snellius-II Symposium has been invaluable. The Netherlands Marine Research Foundation financed the publication of these Proceedings.

The publication of the Proceedings of the International Symposium on the Ecology of the North Sea started with a double issue (Vol. 25, no 1/2, May 1990) containing the 26 contributed papers. In vol. 26, no 2-4 (November 1990) most of the invited (review) papers were published. The publication of the last few review papers of this Symposium is foreseen for 1991. These Proceedings are edited by P. de Wolf, H.J. Lindeboom and R.W.P.M. Laane. They are issued with financial support of the Ministry of Transport and Public Works.

During 1990, three regular issues (edited by the permanent editors) of the Netherlands Journal of Sea Research appeared, viz. vol. 25 no 3 (June 1990) with 9 papers, vol. 26 no 1 (October 1990) with 13 papers and vol. 27 no 1 (December 1990) with 11 papers. Among these 33 papers, 14 were on marine biology, 9 on marine chemistry, 7 on physical oceanography, and 3 on marine geology. Among the 33 first authors, 12 were from outside the Netherlands.

G.C. Cadée (NIOZ) and J. Dronkers (RWS/DGW, The Hague) joined the editorial staff.

2.1.2. Publications NIOZ 1990

- 1 AKEN, H.M. VAN. Natuurkunde. In: P. DE WOLF. De Noordzee. Terra, Zutphen: 42-54.
- 2 AKEN, H.M. VAN, G.C. CADÉE & J.H. VOSJAN. Annual report NIOZ 1989. Neth. Inst. Sea Res. Publ. Ser. 17: 1-151.
- 3 ARINARDI, O.H., M.A. BAARS & S.S. OOSTERHUIS. Grazing in tropical copepods, measured by gut fluorescence, in relation to seasonal upwelling in the Banda Sea (Indonesia).—Proc. Snellius-II Symp. (theme 3) Neth. J. Sea Res. 25: 545-560.
- 4 BAAR, H.J.W. DE. De Oceaan een Silo voor CO₂?—Chemisch Magazine (bijlage bij KNCV Chemisch weekblad vol. 44) 11: 570-574.

- 5 BAAR, H.J.W. DE, A.G.J. BUMA, G. JACQUES, R.F. NOLTING & P.J. TRÉGUER, 1989. Trace metals - iron and manganese effects on phytoplankton growth.—Ber. Polarforsch. **65**: 34-44.
- 6 BAAR, H.J.W. DE, A.G.J. BUMA, R.F. NOLTING, G.C. CADÉE, G. JACQUES & P.J. TRÉGUER. On iron limitation of the Southern Ocean: experimental observations in the Weddell and Scotia Seas.—Mar. Ecol. Prog. Ser. **65**: 105-122.
- 7 BAAR, H.J.W. DE, H.G. FRANZS, G.M. GANSSSEN, W.W.C. GIESKES, W.G. MOOK & J.H. STEL, 1989. Towards a joint global ocean flux study: rationale and objectives. In: A. AYALA-CASTANARES, W.A. WOOSTER & A. YANEZ-ARANCIBIA. Oceanography 1988, Proceedings Joint Oceanographic Assembly, Acapulco, Mexico: 11-33.
- 8 BAARS, M.A. & G.C. CADÉE. Introduction and bibliography.—Proc. Snellius-II Symp. (theme 3). Neth. J. Sea Res. **25**: 423-424.
- 9 BAARS, M.A., G.C. CADÉE & J.J. ZIJLSTRA (eds).—Proc. Snellius- II Symp. (theme 3). Neth. J. Sea Res. **25**: 423-650.
- 10 BAARS, M.A., A.B. SUTOMO, S.S. OOSTERHUIS & O.H. ARINARDI. Zooplankton abundance in the eastern Banda Sea and northern Arafura Sea during and after the upwelling season, August 1984 and February 1985.—Proc. Snellius-II Symp. (theme 3). Neth. J. Sea Res. **25**: 527-543.
- 11 BAK, R.P.M. Patterns of echinoid bioerosion in two Pacific coral reef lagoons.—Mar. Ecol. Prog. Ser. **66**: 267-272.
- 12 ——. Een duik in de tropische mariene biologie. Inaugurele rede, Treub-maatschappij: 1-22.
- 13 BAK, R.P.M., J.H. VOSJAN & G. NIEUWLAND. Microorganisms in a N-S transect across the Weddell-Scotia confluence zone.—Ber. Polarforsch. **68**: 31-35.
- 14 BARETTA, J.W. & P. RUARDIJ. Carbon flows in the western Wadden Sea: Model calculations. In: J.D. ROS. Topics in Marine Biology. Scient. Mar. **53**: 523-528.
- 15 BENNEKOM, A.J. VAN & F.J. WETSTEIJN. The winter distribution of nutrients in the Southern Bight of the North Sea (1961-1978) and in the estuaries of the Scheldt and the Rhine/Meuse.—Neth. J. Sea Res. **25**: 75-87.
- 16 BERGMAN, M.J.N., M. FONDS, M. HUP & A. STAM. Direct effects of beamtrawl fishing on benthic fauna in the North Sea. ICES 1990/Mini **11**: 1-19.
- 17 BEUKEMA, J.J., 1989. Long-term changes in macrozoobenthic abundance on the tidal flats of the western part of the Dutch Wadden Sea.—Helgol. Meeresunters. **43**: 405-415.
- 18 BEUKEMA, J.J. Expected effects of changes in winter temperatures on benthic animals living in soft sediments in coastal North Sea areas. In: J.J. BEUKEMA, W.J. WOLFF & J.J.W.M. BROUNS. Expected effects of climatic change on marine coastal ecosystems. Kluwer Academic Publishers, Dordrecht: 83-92.
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- 20 ——. Introduction. In: J.J. BEUKEMA, W.J. WOLFF & J.J.W.M. BROUNS. Expected effects of climatic change on marine coastal ecosystems. Kluwer Academic Publishers, Dordrecht: 1-3.
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- 22 BUMA, A.G.J., P. TRÉGUER, G.W. KRAAY & J. MORVAN. Algal pigment patterns in different watermasses of the Atlantic sector of the Southern Ocean during fall 1987.—Polar Biology **11**: 55-62.
- 23 CADÉE, G.C. Bioturbation by birds on a tidal flat in the Dutch Wadden Sea.—Ichnos **1**: 23-30.
- 24 ——. Eutrophication in Dutch coastal waters. In: D. HARDWICK & T. HEATH. Nutrients in the North Sea. Symposium Fertiliser Manufacturers Association, Peterborough, U.K.: 1-5.
- 25 ——. Fossielen op de Noordzeebodem. In: P. DE WOLF. De Noordzee. Terra, Zutphen: 41.
- 26 ——. Juvenile *Petricola pholadiformis* vastgehecht aan strandkrabben.—Correspondentieblad Ned. Malac. Ver. **254**: 684-686.

- 27 CADÉE, G.C. Increased bloom.—*Nature* **346**: 418.
- 28 ——. Lokale sterfte van kokkels op het wad tijdens een *Noctiluca* bloei.—*Het Zeepaard* **50**: 119-128.
- 29 ——. Door de wind getransporteerde *Mya* schelpen.—*Correspondentieblad Ned. Malac. Ver.* **256**: 724-727.
- 30 ——. Increase of *Phaeocystis* blooms in the westernmost inlet of the Wadden Sea, the Marsdiep, since 1973. In: C. LANCELOT, G. BILLEN & H. BARTH. Eutrophication and algal blooms in North Sea coastal zones, the Baltic and adjacent areas.—*Water Pollution Res. Rep.* **12**: 105-112.
- 31 ——. Assessment of impact of algal blooms. In: C. LANCELOT, G. BILLEN & H. BARTH. Eutrophication and algal blooms in North Sea coastal zones, the Baltic and adjacent areas.—*Water Pollution Res. Rep.* **12**: 260A-260E.
- 32 ——. De Driehoeksmossel maakt het milieu niet schoner.—*Lev. Natuur* **91**: 220-221.
- 33 ——. Trends in North Sea phytoplankton.—*Lutra* **33**: 187-189.
- 34 CADÉE, G.C. & F. COLIJN. Planten in Zee. In: P. DE WOLF. *De Noordzee*. Terra, Zutphen: 82-91.
- 35 CHENG, L., M.A. BAARS & S.S. OOSTERHUIS. *Halobates* in the Banda Sea composition.—*Bull. mar. Sci.* **47**: 421-430.
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- 38 DIRKS, R.W.J. On the colour of the sea with reference to remote sensing. Thesis Utrecht: 1-206.
- 39 DRENT, R.H. & T. PIERSMA. An exploration of the energetics of leap-frog migration in arctic breeding shorebirds. In: E. GWINNER. *Bird migration: ecology and ecophysiology*. Springer-Verlag, Berlin: 399-412.
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- 41 DUINEVELD, G.C.A., P.A.W.J. DE WILDE & A. KOK. A synopsis of the macrobenthic assemblages and benthic ETS activity in the Dutch sector of the North Sea.—*Neth. J. Sea Res.* **26**: 125-138.
- 42 DUYL, F.C. VAN & A.J. KOP. Seasonal patterns of bacterial production and biomass in intertidal sediments of the western Dutch Wadden Sea.—*Mar. Ecol. Prog. Ser.* **59**: 249-261.
- 43 DUYL, F.C. VAN, R.P.M. BAK, A.J. KOP & G. NIEUWLAND. Bacteria, auto- and heterotrophic nanoflagellates, and their relations in mixed, frontal and stratified waters of the North Sea.—*Neth. J. Sea Res.* **26**: 97-100.
- 44 EISMA, D. Dispersal of Mahakam river suspended sediment in Makasar Strait, Indonesia. In: V. ITTEKKOT, S. KEMPE, W. MICHAELIS & A. SPITZY. *Facets of Modern Biogeochemistry*. Springer-Verlag, Berlin: 127-146.
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- 50 ——. *Homeward bound: problems waders face when migrating from the Banc d'Arguin, Mauritania, to their northern breeding grounds in spring*.—*Ardea* **78**: 1-16.
- 51 ENS, B. J., P. DUIVEN, C.J. SMIT & T. VAN SPANJE. Spring migration of Turnstones from the Banc d'Arguin, Mauritania.—*Ardea* **78**: 301-313.

- 52 ERFTEMEIJER, P. & C. SWENNEN. Densities and biomass of macrobenthic fauna of some intertidal areas in Java, Indonesia.—*Wallaceana* **59 & 60**: 1-6.
- 53 EVERAARTS, J.M. Uptake and release of cadmium in various organs of the common mussel *Mytilus edulis* (L.).—*Bull. env. Contam. Toxicol.* **45**: 560-567.
- 54 EVERAARTS, J.M. & J. BOERE, 1989. Cadmium in seawater, marine sediment and the benthic invertebrate *Arenicola marina* (Annelida, Polychaeta): an experimental approach. Proc. 21st EMBS, Gdansk, Polish Academy of Sciences-Institute of Oceanography: 559-574.
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- 56 FRANSZ, H.G. Life cycle and production in Antarctic epipelagic copepods. ICES CM 1990/L:80.
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- 61 HAREN, J.J.M. VAN. Sub-tidal dynamics of a near-coastal zone in the North Sea.—*Neth. J. Sea Res.* **25**: 31-44.
- 62 ——. Observations on the horizontal and vertical structure of currents at sub-tidal frequencies in the central North Sea.—*Neth. J. Sea Res.* **27**: 1-23.
- 63 ——. Observations on the structure of currents at tidal and sub-tidal frequencies in the central North Sea. Ph.D. thesis, State University Utrecht. XIV + 1-102.
- 64 HAREN, J.J.M. VAN & C.A. JOORDENS. Observations of physical and biological parameters at the transition between the southern and central North Sea.—*Neth. J. Sea Res.* **25**: 351-364.
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- 66 HELDER, W. Early diagenesis and sediment-water exchange in the Golfe du Lion. In: J.M. MARTIN & H. BARTH. *Eros 2000, Water Pollution Research Report* **13**: 87-101.
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- 68 JANSEN, J.H.F. Geologie. In: P. DE WOLF. *De Noordzee*. Terra, Zutphen: 30-40.
- 69 JUKEMA, J. & T. PIERSMA. Bytanke by Peazens-Moddergat: oer de foarjierstrek fan reade skriezen, *Limosa lapponica*.—*Vanellus* **43**: 31-39.
- 70 KANNAN, N., G. PETRICK, D.E. SCHULZ, J.C. DUINKER, J.P. BOON, E. VAN ARNHEN & S. JANSEN. Multidimensional GC and Charcoal Separation Techniques in the Determination of non-ortho Cl chlorobiphenyls - A comparison. In: HUTZINGER & H. FIEDLER. *Proc. 10th international meeting 'Dioxin 90', Bayreuth Short papers, vol. 2: Organohalogen compound*. Eco Informa Press: 165-168.
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- 72 KLEIN BRETELER, W.C.M., N. SCHOGT & S.R. GONZALEZ. On the role of food quality in grazing and development of life stages, and genetic change of body size during cultivation of pelagic copepods.—*J. exp. mar. Biol. Ecol.* **135**: 177-189.
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2.1.4. Cruise Reports 1990

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2.2. LECTURES, ETC.

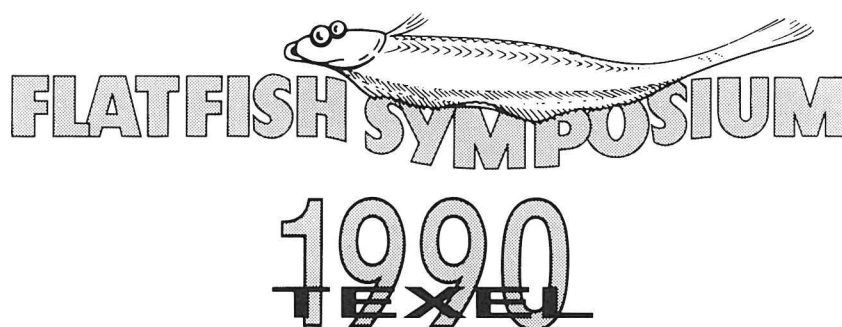
2.2.1. Colloquia and workshops at the institute

(titles translated)

19 January	W. van Raaphorst (NIOZ): Nutrient regeneration and bacterial production in the sandy sediments of the Dogger Bank area
26 January	Wadden Sea ecosystem research H. Farke (National Park Administration, Lower Saxony, FRG): Our ecosystem research concept T. Höpner (University of Oldenburg, FRG): The aims of the project and the role of modelling
23 February	G.J.F. van Heijst (University of Utrecht): (Coherent eddy structures in rotating and stratified liquids) G. Muyzer and J.D.L. van Bleijswijk (University of Leiden): (Application of immunological techniques in ecology and geology)
2 March	W. Helder (NIOZ): (In situ oxygen profiles in the North Atlantic) J.-P.R.A. Sweerts (Limnological Institute, Nieuwersluis): (Oxygen-consuming processes at the sediment-water interface in lakes)
9 March	M.H.C. Stoll (NIOZ): (A comparison between two methods for calculating total CO ₂ and alkalinity data and the coulometric total CO ₂ method) H.J.W. de Baar (NIOZ): (Astronomic variation, greenhouse and climate: cause and effect)
16 March	A. Iedema (NIOZ): (Metabolism and growth of eelpout (<i>Zoarces viviparus</i>) at different temperatures) M. Hup (NIOZ): (Laboratory measurements of metabolism, feeding and growth of starfish (<i>Asterias rubens</i>)) M. Fonds (NIOZ): (Density and growth of starfish in the Wadden Sea and North Sea)
23 March	Tj.C.E. van Weering (NIOZ): (Report of an expedition to the island of Sumba and some geological observations) E.C. Flach (NIOZ): (Influences of <i>Arenicola marina</i> , <i>Nereis diversicolor</i> , <i>Cerastoderma edule</i> and <i>Macoma balthica</i> on the abundance of <i>Corophium volutator</i>)
30 March	H. van Haren (NIOZ): (Structure of the currents round the Frisian Front) M.A. Baars (NIOZ): (The distribution and seasonal development of plankton in the North Sea up to 55° 30' N) (North Sea Surveys RRS Challenger, August 1988 - August 1989)
6 April	C.J. de Boer (NIOZ): (Fractals in heart physics) L.R.M. Maas (NIOZ): (Non-linear dynamics and deterministic chaos: revolution in science?)

12 April	D.K. Mills (School of Ocean Sciences, Menai Bridge, Wales): Use of a recording fluorometer for continuous measurement of phytoplankton concentration
18 May	R. Riegman (NIOZ): (Structure and functioning of communities in pelagic systems)
22 May	R.J. Feller (University of South Carolina, USA): Immunological studies of feeding and digestion using polyclonal antibodies
1 June	H. van der Veer (NIOZ): (NIOZ fish research: past and future) D. Boddeke (RIVO): (The development of the Dutch shrimp fishery and the role of research) J. Baretta and H.J. Lindeboom (NIOZ): BOVA BOEDE EON BEWON
8 June	L. Lohse (NIOZ) and H.P. Epping (NIOZ): (Denitrification on intertidal flats)
15 June	L.J.A. Gerringa (DIHO): (Mobility of trace metals in relation to degradation of organic material) J. Schijf (Free University, Amsterdam): (Chemistry of Rare Earths in anoxic basins)
22 June	C. Veth (NIOZ): (Structure and evolution of the surface layer in the marginal ice zone in spring (Weddell-Scotia confluence)) H.M. van Aken (NIOZ): (Physical and biological gradients at the Arctic front (Greenland Sea))
25 September	D.K. Atwood (National Oceanographic and Atmospheric Administration (NOAA), Miami, USA): The NOAA nutrient enhanced productivity program: The Mississippi experiment
3 October	P.A.R. Hockey (University of Cape Town, South Africa): Shorebird predation and invertebrate life-history characteristics: Do waders act as agents of directional selection on their prey?
5 October	J.P. Boon (NIOZ): (Effect of PCB on the induction of biotransformation enzymes and on the blood parameters in plaice: possible consequences for the North Sea population) M.L. Eggens (RSW-DGW): (Induction of biotransformation enzymes in flounder) H.W. van der Veer (NIOZ): (Influence of pollution on North Sea flatfish populations: experimental set-up of field and laboratory research)
12 October	C. de Boer (NIOZ): (Variability in hydrographical parameters in the Iceland basin) L. Otto (NIOZ): (Argos buoys: satellite determinations of surface circulation)
19 October	E. de Vries (RUG): (Chemical warfare and other defence mechanisms in corals)
26 October	D. Huisingsh (Erasmus University, Rotterdam): Cleaner production: the most effective approach to achieving improved water quality J.M. Everaarts (NIOZ): DNA-damage and blood parameters as biomarkers of marine environmental contamination
16 November	R. Kneib (Marine Institute, Sapelo Island, USA): The nursery function of intertidal marshes for fish species J. Gutt (NIOZ): Antarctic icebergs and their influence on the benthos
20 November	R. Glud (University of Aarhus, Denmark): Photosynthesis and respiration in biofilms measured by the oxygen microelectrode technique

- 23 November L. Pihl (Kristineberg Marine Station, Sweden): Effects of periodic hypoxia on distribution and diet of demersal fish and crustaceans in Chesapeake Bay
J.M. Dean (Belle Baruch Institute, University of South Carolina, Columbia, USA): Growth rings: daily calcification processes in fishes and bivalves. Research for the future
- 30 November Long-term changes in the Wadden Sea
G.C. Cadée (NIOZ): (Marsdiep phytoplankton in 1990. Is the end of increase in sight?)
J.J. Beukema (NIOZ): (Changes in macrozoobenthos caused by eutrophication and climatic change: Western Wadden Sea)
K. Essink (RWS-DGW): (Changes in macrozoobenthos caused by eutrophication and climatic change: Eastern Wadden Sea)
- 14 December W. van der Werff (NIOZ): Sedimentation processes in a fore arc basin (Lombok, Savu, Sumba)
J. Beks (NIOZ): Analysing the mineralogy of individual microparticles using a scanning electron microscope (SEM) equipped with an x-ray fluorescence device
- 19 December S. Seitzinger (Philadelphia Academy of Natural Sciences, USA): Comparative studies on denitrification
- First International Symposium on Flatfish Ecology Long-term experience with research on flatfish ecology in the Netherlands both by NIOZ and RIVO (Netherlands Institute for Fishery Investigations, IJmuiden) has resulted in the organization of the First International Symposium on Flatfish Ecology by the two institutes, held at NIOZ from 19 to 23 November. The Organizing Committee consisted of members of the institutes and experts from U.K. (R.J.H. Beverton) and Germany (R. Berghahn). About 100 scientists from all over the world visited this symposium and contributed in the form of oral presentations or posters. The symposium offered facilities especially for starting workers in the field of flatfish ecology. A number of workshops were organized and during the symposium special 'clinics' were open to all participants to consult experts personally. About 50 papers were submitted to appear in the Netherlands Journal of Sea Research in 1991.



2.2.2. Lectures and posters

2.2.2.1. Lectures by NIOZ scientists

(titles translated)

- BAAR, H.J.W. DE: (Chemical oceanography). Lecture series, Earth Sciences, Free University, Amsterdam, February/March.
- : (Carbon dioxide, the oceans and our climate). Keynote lecture symposium on energy conservation (NOVEM), Arnhem, 7 March.
- : (The role of the oceans in the carbon dioxide greenhouse effect). Clingendael Cultural Committee, The Hague, 10 April.
- : (The scavenging removal of trace metals from seawater from the perspective of their natural ocean cycling). Earth Sciences (AWON) Theme day, Amsterdam, 22 May.
- : The solution chemistry of the Rare Earth Elements in seawater. Plenary lecture First International Conference on f-Elements, Leuven, Belgium, 4 September.
- : Testing the hypothesis of Fe-limitation in the Southern Ocean. Geochemical Society of Belgium, University of Leuven, 6 September.
- : JGOFS and the Ocean Carbon Cycle. European Marine Interdisciplinary Network, NIOZ, Texel, 28 September.
- BAARS, M.A.: Distribution and seasonal cycle of zooplankton in the southern North Sea, August 1988 - August 1989. Workshop North Sea Project, Bidston, England, 26 February.
- BAK, R.P.M.: (Tropical ecology). Lecture series, University of Amsterdam, March.
- : North Sea field and mesocosm bottoms show variation in response of benthic heterotrophic nanoflagellate communities to a pelagic algal spring bloom. First International Symposium on Free-living Heterotrophic Flagellates. Helsingør, Denmark, 6-11 August.
- : Reflections on the intermediate disturbance theory. International Society for Reef Studies 1990 Meeting, Noumea, New Caledonia, 19 November.
- : (A dive into tropical marine biology). Inaugural address, University of Amsterdam, 6 December.
- BARETTA, J.W.: (Complex ecosystem models of the North Sea). Complex models in aquatic ecology, Utrecht, 23 February.
- : A water column model for the North Sea. Proudman Oceanographic Laboratory, Liverpool, U.K., 1 March.
- : (The influence of stratification on the productivity of the water column). Nederlandse Oceanografenclub, Amsterdam, 29 May.
- : (The ERSEM project). SOZ, Amsterdam, 3 October.
- BARETTA, J.W. & P. RUARDIJ: Advanced course in marine ecosystem modelling. EIASO, Marseille, France, 20-29 August.
- BARETTA, J.W., P. RUARDIJ & A. MALMGREN-HANSEN: North Sea Modelling. Energi & Miljö 90, Jönköping, Sweden, 24 April.
- BENNEKOM, A.J.: Estuarine processes. Lectures National Institute for Hydraulic and Environmental Engineering, Delft, 7 May.
- : (River plumes in the North Sea; the use of silicic acid as tracer). Colloquium Institute for Meteorology and Oceanography, University of Utrecht, 11 October.
- BERGER, G.W.: The behaviour of radionuclides released by the non-nuclear industry in the river Rhine. Meeting of EC members participating in project 'Behaviour of ^{210}Po and ^{210}Pb in European marine environments'. RIVM, Bilthoven, 30-31 January.
- : (The use of radionuclides in marine geology). Meeting 'Werkgroep Radon', NIOZ, Texel, 11 May.
- : (Dispersion of emissions from the non-nuclear industry and dosis calculations). Symposium 'Reguleerbare vormen van natuurlijke achtergrondstraling', Amersfoort, 14 December.

- BERGMAN, M.J.N.: Direct effect of beamtrawl fishery on bottom fauna in the North Sea.
 —: idem. RWS/DNZ Rijswijk, March.
 —: idem. RIVO, IJmuiden, March.
 —: idem. ICES, Mini-Symposium Benthos, Copenhagen, Denmark, 9 October.
- BLEISWIJK, J.D.L VAN: Study of distribution and physiology of different *E. huxleyi* strains and cell types. Château de Blagnac, Cabara, France, 2 September.
- BEUKEMA, J.J.: Expected effects of sea-level rise on the tidal-flat ecosystem in the Wadden Sea. German-Dutch meeting on sea-level changes, Hengelo, 18 January.
 —: (Recent changes in the zoobenthos living on tidal flats of the Wadden Sea). University of Groningen, 5 March.
 —: Long-term changes in the macrozoobenthos of tidal flats in the Wadden Sea. Symposium National Parken Watten Meer, Wilhelmshaven, FRG, 8 May.
 —: (Marine benthos and secondary production). Series of 4 lectures, University of Groningen, 5-6 June.
 —: Zoobenthos studies on tidal flats of the Wadden Sea. Husö Biological Station, Åbo Akademi, Finland, 13 July.
 —: Eutrophication in the western Wadden Sea ecosystem: differential role of diatoms and flagellates. 25th European Marine Biology Symposium, Ferrara, Italy, 11 September.
 —: Some possible effects of eutrophication on the benthic fauna living on tidal flats in the westernmost part of the Wadden Sea. 7th International Wadden Sea Symposium, Ameland, 24 October.
- BOON, J.P.: (The kinetics of individual PCB congeners in toothed whales and seals with structure-related evidence of differences in biotransformation capacity). Course in ecotoxicology of the University of Utrecht, held at NIOZ, Texel, 22 March.
 —: Changes of hepatic biotransformation enzymes and haemoglobin levels in female plaice (*Pleuronectes platessa*) after oral administration of a technical PCB mixture (Clophen A40). 12th Symposium of the European Society for Comparative Physiology and Biochemistry, Utrecht, 27-31 August.
 —: Toxicological interactions of PCBs on biological systems: a lesson to be learnt. DGWRWS symposium 'North Sea Pollution', NIOZ, Texel, 14 September.
 —: A structure-activity relationship (SAR) for the influence of biotransformation of PCBs in organisms of different trophic levels. 4th International Workshop on QSAR in environmental Toxicology, Veldhoven, 16-20 September.
 —: (The diversity of toxicological interactions of different PCB congeners). Agricultural University Wageningen, 2 November.
 —: (The toxico-kinetics of chlorinated biphenyl congeners in fish, birds and marine mammals). University of Amsterdam, Dept. Environmental and Toxicological Chemistry, 30 November.
- BOOIJ, K.: Distribution of PCBs and some pesticides between sediment, water and colloids in North Sea samples and slurry incubations. 4th Workshop Sorption and Bioavailability, Bilthoven, 23 November.
- CADÉE, G.C.: (Trends in phytoplankton of the North Sea). Symposium Sea Mammals, Rotterdam, 3 February.
 —: Effects of increased nutrient loads in Dutch Coastal waters. Symposium Nutrients in the North Sea, Fertiliser Manufacturers Association, London, 21 February.
 —: *Phaeocystis* in the Marsdiep as compared with foregoing years. *Phaeocystis* Workshop, Plymouth, 6-9 March.
 —: (Taphonomy, information loss during fossilisation). Marine ecology course, Free University, Amsterdam, held at NIOZ, Texel, 12 April.
 —: Trends in Marsdiep phytoplankton. 7th International Wadden Sea Symposium, Ameland, 23 October.
- DAVIDSON, N.C., P.R. EVANS, J.P. MYERS, M.W. PIENKOWSKI & T. PIERSMA: Effects of habitat loss at migration staging posts on shorebird populations. Symposium Effects of habitat loss on shorebird populations, International Ornithological Congress, Christchurch, New Zealand, 2-9 December.

- DUINEVELD, G.C.A.: Epibenthos distribution in the North Sea. Annual Meeting ICES Benthos Ecology Working Group, Lisbon, Portugal, 10 May.
- DUYL, F.C. VAN: The reef environment from a bird's eye view. Pattimura University, Ambon, Indonesia, 11 April.
- : Mesocosm experiments show a direct response of benthic microbial processes to phytoplankton input. 5th International Symposium on the Interactions between Sediments and Water, Uppsala, Sweden, 9 August.
- : Shifts in North Sea small food webs in relation to water column structure. 4th European Marine Microbiology Symposium, Kiel, FRG, 8 October.
- EISMA, D.: (Marine Sedimentology). Lecture series University of Utrecht, February.
- : The EROS-2000 Program in the NW Mediterranean. Coop Meeting Ocean Margins, San Diego, USA, 10 July.
- : (Flocculation of silt in estuaries). Geochemische Kring, Utrecht, 5 October.
- : (Sedimentology, erosion, deposition in estuaries: consequences of management). 'Capita Selecta' lecture Nature Management, Wageningen, 12 October.
- : Aspects of suspended matter transport and deposition in coastal waters. Soviet National Meeting on Marine Geology, Gelendjik, USSR, 18 October.
- : In-situ particle size measurements of suspended material and comparison with other methods of size analysis. International Workshop Cohesive Sediments, Brussels, Belgium, 6 November.
- : Recent and subrecent changes in Amazon mud dispersal. International Symposium Evolution of the Guyanas and southern Caribbean coastal areas during the Quaternary, Cayenne, French Guiana, 11 November.
- : Flocculation and deflocculation of suspended matter in estuaries and coastal seas. Workshop Suspended Matter in Estuaries, University of Hamburg, FRG, 19 November.
- EVERAARTS, J.M.: Marine environmental research in the Netherlands. Environmental Science Division, Oak Ridge National Laboratory, Oak Ridge, TN, USA, 4 January.
- : idem. Gulf Coast Research Laboratory, Ocean Springs, MS, USA, 16 May.
- : idem. Environmental Research Laboratory (EPA), Sabine Island, Gulf Breeze, FL, USA, 20 June.
- : DNA strand-breaks and haematological parameters in the hardhead catfish *Arius felis* from contaminated and marine and inshore reference sampling sites. Gulf Coast Research Laboratory, Ocean Springs, MS, USA, 27 July.
- : (Sources and effects of pollution in the Wadden Sea and the North Sea). University of Wageningen, 2 November.
- FLACH, E.: (The influence of *Arenicola marina*, *Cerastoderma edule* and *Macoma balthica* on the abundance of *Corophium volutator*). Verwey-dagen, NIOZ, Texel, 26 February.
- FRANZ, H.G.: (Marine pelagic systems and models of marine pelagic systems). Lectures marine biology, University of Groningen, 8 June.
- : Grazers and coccolithophore blooms. Coccolithophore workshop, Château de Blagnac, Cabara, France, 2 September.
- : Life cycle and production in Antarctic epipelagic copepods. ICES Statutory meeting, session on secondary production, Copenhagen, Denmark, 8 October.
- : (The adaptation of Antarctic plankton to extreme seasonal variation in light and food supply). Arctic Weekend, Soest, 18 November.
- HELDER, W.: (Early diagenesis and sediment-water exchange). Geology course Free University, Amsterdam, held at NIOZ, Texel, 17 April.
- : Fluxes of solutes (nutrients and metals) at the sediment-water interface. Invited lecture at symposium 'Environnement des mers epicontinentales', Lille, France, 22 March.
- : (Chemical oceanography research at NIOZ). Erasmus University, Rotterdam, 22 June.
- HILLEBRAND, M.Th.J.: Marine pollution studies; the basis for protection of the marine environment. Curriculum course, UNESCO/UNDP/LIPI, Jakarta, Indonesia, 14 March.

- HILLEBRAND, M.Th.J.: Behaviour of non-polar organochlorines in the aquatic environment. Curriculum course, UNESCO/UNDP/LIPI, Jakarta, Indonesia, 23 March.
- : The dissolved phase; a troublesome compartment. Curriculum course, UNESCO/UNDP/LIPI, Jakarta, Indonesia, 31 March.
- : Gaschromatography; history, theory, practical aspects and applications. Third training session, marine pollution monitoring and training programme, UNESCO/UNDP/LIPI, Jakarta, Indonesia, 15 August.
- : Laboratory organisation; administrative concerns related to quality control and quality assurance. Third training session, marine pollution monitoring and training programme, UNESCO/UNDP/LIPI, Jakarta, Indonesia, 16 August.
- : The meaning of quality control and quality assurance. Third training session, marine pollution monitoring and training programme, UNESCO/UNDP/LIPI, Jakarta, Indonesia, 20 August.
- : Theoretical aspects of chlorinated hydrocarbons, emphasized on the structural and physico/chemical properties and environmental impact of polychlorinated biphenyls. Third training session, marine pollution monitoring and training programme, UNESCO/UNDP/LIPI, Jakarta, Indonesia, 22 August.
- JANSEN, J.H.F.: (Sediments of the Angola Basin as a document of the Quaternary climate of West Central Africa). Meeting INQUA- Nederland, KNAW, Amsterdam, 2 March.
- : (Land climate in deep-sea sediments). Department of Paleobotany and Palynology, University of Utrecht, 13 June.
- KAMERMANS, P.: (Food limitation and food competition of bivalve molluscs living in the Wadden Sea). Verwey-dagen, NIOZ, Texel, 26 February.
- KUIPERS, B.R.: The North Sea. Lectures held at the University of Groningen, June.
- LAVALEYE, M.S.S.: (Dredging off the coast of Mauritania, with special emphasis on the molluscan fauna). Meeting of the Dutch Malacological Society, Leiden, 31 March.
- LEOPOLD, M.: (Sea-mammal sightings in the Netherlands). Whaling Committee meeting 1990, Noordwijk.
- LINDEBOOM, H.J.: (Effects of fisheries: time to close areas in the North Sea). RWS/DNZ, The Hague, 23 February.
- : (Effects of fisheries on the North Sea ecosystem). North Sea Conference, press presentation, The Hague, 8 March.
- : (NIOZ phytoplankton research, future development). Opening of the climate chambers, NIOZ, Texel, 17 May.
- : (Ten recommendations for the management of the North Sea). BEON-policy presentation, The Hague, 31 May.
- : Benthic primary production: 4 lectures on techniques, data, problems and future research. Advanced course in shelf benthos, Galway, Ireland, 5-7 September.
- : (Effects of fisheries). Visserij dagen, Bergen, The Netherlands, 14-15 September.
- : (Eutrophication and the effects of fisheries: possible management strategies). Visit by personnel of the Ministry of Agriculture, Nature Management and Fisheries, NIOZ, Texel, 18 September.
- : Applied scientific research at NIOZ. Section Biology, University of Rostock, FRG, 25 October.
- : Relationship between benthos and fisheries. NOC-annual meeting, The Hague, 2 November.
- LOHSE, L.: Seasonal variation of denitrification rates and nitrous-oxide fluxes on intertidal flats in the western Wadden Sea. University of Aarhus, Institute for Ecology and Genetics, Aarhus, Denmark.
- MAREES, G.: Remote Sensing of Coastal Waters using the AVHRR scanner. Meeting of research group Optical Remote Sensing Water (ORWA), NIOZ, Texel, 10 January.
- : On the turbidity of the Dutch coastal waters. Meeting project group: Laser Bathymetry North Sea, Rijswijk, 24 April.
- MOODLEY, L.: (Biological aspects of foraminifera). Geology course of the Free University, Amsterdam, held at NIOZ, April.
- : Microhabitats of benthic foraminifera. Geomarine Centre, Free University, Amsterdam.

- MOOK, W.G.: Trends and variations in stable carbon isotopes of atmospheric carbon dioxide. IAEA, Vienna, Austria, 5 October.
- NOLTING, R.F.: Minor and major elements in suspended matter in the Rhine and Meuse rivers and estuary. University of Southampton, Southampton, UK, 16 January.
- : Distribution of nickel in sediments of the Golfe du Lion. EROS 2000 workshop, Blanes, Spain, 8 February.
- : The vertical and horizontal distribution of some trace elements in the southern ocean. Symposium: The biogeochemistry and the circulation of water masses in the Southern Ocean, Brest, France, 4 July.
- : On the effect of iron and manganese on phytoplankton from the Southern Ocean. Symposium: The biogeochemistry and the circulation of water masses in the Southern Ocean, Brest, France, 5 July.
- PIERSMA, T.: (Migratory behaviour and habitat choice of a globe-trotting wader: food and energetics of Knots in the Wadden Sea and elsewhere). Verwey-dagen, NIOZ, Texel, 26 February.
- : (Molluscs of the Banc d'Arguin, Mauritania). Spring meeting of the Netherlands Malacological Society, Leiden, 31 March.
- : (Spring migration of waders from West Africa to The Netherlands and beyond). National press conference and presentation of book 'Homeward bound', RIN, Leersum, 17 August.
- : Energetic constraints on wader migration. Annual conference of the Deutsche Ornithologen-Gesellschaft, Husum, FRG, 28 September.
- : Annual energetics of Knots: expenditure and intake studies. Annual Wader Study Group Conference, Comacchio, Italy, 7 October.
- : (Migrant birds of the Wadden Sea). Meeting of the Landelijke Vereniging tot Behoud van de Waddenzee, Den Helder, 13 October.
- : The energetics of intercontinental migrations: integrated field and laboratory studies on Red Knots *Calidris canutus*. Symposium 'New aspects of avian migration systems', 20th International Ornithological Congress, Christchurch, New Zealand, 3 December.
- : Foraging constraints in grebes. Round-table on piscivorous birds, 20th International Ornithological Congress, Christchurch, New Zealand, 2-9 December.
- RAAPHORST, W. VAN: Nutrient early diagenesis in the Southern Bight of the North Sea: Field data, mesocosm results, and mathematical modelling. 5th International Symposium on the Interactions between Sediments and Water, Uppsala, Sweden, 9 August.
- : (Estuarine eutrophication processes). Agricultural University, Wageningen, 26 October.
- RIDDERINKHOF, H.: Experiments with a one-dimensional mixed-layer model. JONSMOD meeting, Proudman Oceanographic Laboratory, Birkenhead, UK, 2-6 April.
- : (Residual currents and mixing in the Wadden Sea). WAQUA Users' Club, ICIM b.v., The Hague, 30 May.
- : Tidal exchange between the North Sea and Wadden Sea. Congress on Physical Processes in Estuaries and Bays, Gregynog, UK, 9-13 July.
- RIEGMAN, R.: (Structure and functioning of the pelagic foodweb). BION WGM Aquatic Ecology, 10 April.
- : (Structure and functioning of the pelagic foodweb). Departments of Microbiology & Marine Biology, University of Groningen, 7 May.
- SWENNEN, C.: (Bird studies on Texel). Vereniging van Plattelandsvrouwen, Den Burg, 19 February.
- : (Birds on the North Sea). The Hague, 6 March.
- : Dispersal and migration studied by bird banding. Kyung Hee University, Seoul, Korea, 27 June.
- TULP, I. & Y. VERKUIL: Fattening of Knots: a gourmet in spring? Annual Wader Study Group Conference, Comacchio, Italy, 7 October.

- VEER, H.W. VAN DER: Recruitment mechanisms in flatfish species. North Carolina State University, Raleigh, USA, 5 April.
- : Population dynamics and recruitment in the flatfish species plaice and flounder in the Dutch Wadden Sea. Marine Field Laboratory, Ruderger University, Tuckerton, USA, 8 April.
- : Recruitment mechanisms in the shore crab *Carcinus maenas* in the Dutch Wadden Sea. Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, USA, 12 April.
- VELDHUIS, M.J.W.: (Role of ultra/picoplankton in the marine carbon cycle). Nederlandse Oceanografen Club, Amsterdam, 29 May.
- VETH, C.: The structure and evolution of the top layers of the water column across the marginal ice zone during spring. Southern Ocean Symposium, Brest, France, 3 July.
- VOSJAN, J.H.: Marine microbial ecology. Lecture series at the Free University of Brussels, Belgium, October.
- WAL, P. VAN DER: *Emiliana huxleyi*: population dynamics and the cycling of CO₂. Château de Blagnac, Cabara, France, 2 September.
- : (*Emiliana huxleyi*: Population dynamics and the oceanic carbon cycle). Najaars-symposium van de Werkgemeenschap CO₂-problematiek, Utrecht, 23 October.
- WEERING, T.J.C.E.: On the tectonic position of the Island of Sumba, Indonesia. Congress: Orogenesis in Action, London, 18-20 April.
- : Forearc basin sedimentation in the eastern Sunda Arc, Indonesia. Geological Institute University of Bologna, Italy, 14 December.
- WIERSMA, P.: Living exposed and in the cold: thermostatic costs of Knots. Annual Wader Study Group Conference, Comacchio, Italy, 7 October.
- WILDE, P.A.W.J., DE: (Food supply to the benthos). Lectures, University of Groningen, 12 March.
- : (Introduction to the Frisian Front). Raad van State, The Hague, 23 March.
- : Interactions in burrowing communities and their effects on the structure of marine benthic ecosystems. Zoological Society of London Symposium 1990 'Environmental impact of burrowing animals and animal burrows', London, 3 April.
- : Introduction to mesocosm research. Annual meeting ICES Benthos Ecology Working Group, Lisbon, Portugal, 10 May.
- : Benthic mesocosm research: an essential contribution to management options for the marine environment. 8th Marine Technology Conference, Tokyo, 22 August.
- : Results from basic and applied research in intertidal mudflat mesocosms; fake or reality? 5th Intecol, Yokohama, 27 August.
- : (on behalf of G.C.A. Duineveld and G.J. van Noort): Geographical variation in the epifauna of the southern North Sea and adjacent regions. ICES Mini-symposium 'Benthic Ecology of the North Sea', Copenhagen, Denmark, 9 October.
- : (Experiments in artificial North Sea bottoms). Wetenschapsdag, NIOZ, Texel, 14 October.
- WITTE, J.I.J., H.W. VAN DER VEER & J. VAN DER MEER: The efficiency of intertidal fish traps for juvenile flatfish. International Flatfish Symposium, NIOZ, Texel, 21 November.
- ZIMMERMAN, J.T.F.: (Dynamical Oceanography). Lecture series, University of Utrecht, January-June.
- : (Physical Oceanography). Lecture Series Int. Inst. Hydraul. Environm. Eng., Delft, June.
- : (Long waves and tides). Lecture Series University of Utrecht, October-December.

2.2.2.2. Posters

- BERGER, G.W.: Processes controlling the regional distribution of ^{210}Po , ^{210}Pb , ^{226}Ra and Th isotopes in the river Rhine and its estuary. 6th International Symposium on Environmental Radiochemical Analyses, Manchester, UK, 18-22 September.
- BERGER, G.W. & B.P.R. CALINE: Estimation of sedimentation rate in the Bay of Mont Saint-Michel (France) by ^{210}Pb dating technique. Epicontinental Seas Environment, Lille, France, 20-22 March.
- BERGMAN, M.J.N. & M. HUP: Research on the effect of beamtrawl fishery on benthic fauna. North Sea Conference, The Hague, 5-8 March. In cooperation with RIVO and RWS/DNZ.
- BOOIJ, K., M.TH.J. HILLEBRAND & J.P. BOON: Fate of PCBs in the marine environment. North Sea Conference, The Hague, 7-8 March.
- BRUSSAARD, C., M.H.C. STOLL, J. HEGEMAN, J. SCHIJF & H.J.W. DE BAAR: JGOFS North Atlantic 1990: Dissolved Organic Carbon at the 47N, 17W station. JGOFS Symposium Washington DC, 26-28 November.
- CADÉE, G.C.: Bioturbation by birds, Dutch Wadden Sea. Section 'Organisms and Sediment' 13th Intern. Sedimentological Congress Nottingham, 26-31 August.
- : idem. 2nd Workshop on Palaeoenvironments, Heerlen, 8 November.
- CARPENÉ, E., J. ROOS, O. CATTANI, C.G.N. DE VOOYS & A. DE ZWAAN: Anaerobic metabolism of the erythrocytes of *Scapharca inaequivalvis*: uptake and effects of cadmium on energy metabolism. 12th Annual Congress European Society for Comparative Physiology and Biochemistry, Utrecht, 27-31 August.
- DUYL, F.C. VAN: Effect of eutrophication on North Sea bottoms: eutrophication experiments. North Sea Conference, The Hague, 5-8 March.
- FRANSZ, H.G., S. GONZALEZ, B.R. KUIPERS & H. WITTE: Zooplankton Biomass and Productivity. JGOFS Symposium Washington DC, 26-28 November.
- HELDER, W.: *In-situ* measured, high resolution, oxygen profiles in sediments from the North-East Atlantic Ocean. JGOFS Symposium, Washington DC, 26-28 November.
- KAMERMANS, P.: Growth rates of the bivalve *Macoma balthica* fed algal diets of diatoms and flagellates in the laboratory. 25th European Symposium on Marine Biology, Ferrara, Italy, 5-15 September.
- : Does flatfish predation influence feeding behaviour of a bivalve mollusc? Flatfish Symposium NIOZ, 19-23 November.
- KIESKAMP, W.M. & W. HELDER: Water and air distribution of nitrous oxide in the North-East Atlantic Ocean. JGOFS Symposium Washington DC, 26-28 November.
- KUIPERS, B.R.: 'Pelagia Cruises 1991-1992'. BEWON int. workshop North Sea Research, Texel, 5 June.
- MAAS, L.R.M. Diffusion in a strained flow field and the symmetry properties of the ocean's circulation. Eur. Geophys. Soc., Copenhagen, 23 April.
- : (Fractals and chaos). Open day NIOZ, Texel, 14 October.
- NOLTING, R.F.: The distribution of trace metals in the Southern Bight of the North Sea. North Sea Conference, The Hague, 5-8 March.
- SAAGER, P.M., R.F. NOLTING & H.J.W. DE BAAR: JGOFS North Atlantic Pilot Study: Distributions of dissolved metals Cd, Cu, Fe and Mn. JGOFS Symposium Washington DC, 26-28 November.
- STOLL, M.H.C., J.W. ROMMETS & H.J.W. DE BAAR: Determination of carbon dioxide in seawater by two independent methods. JGOFS Symposium Washington DC, 26-28 November.
- VELDHUIS, M.J.W. & G.W. KRAAY: Ultraplankton dynamics in the eastern North Atlantic. Individual Cell & Particle Analysis: Multidisciplinary Applications to Oceanography. Nato Advanced Study Institute, Aquafredda, Italy, 21-30 October.
- VELDHUIS, M.J.W., G.W. KRAAY & W.W.C. GIESKES: Ultraplankton abundance in the summer of 1989 in the eastern North Atlantic (JGOFS transect): community structure, primary production and growth response. JGOFS Symposium Washington DC, 26-28 November.

VETH, C.: The evolution of the upper water layer in the marginal ice zone. 22nd International Liège Colloquium on Ocean Hydrodynamics (Marginal ice zones), Liège, Belgium, 7-11 May.

VOSJAN, J.H.: Adenosine-tri-phosphate and respiratory electron transport system activity in waters W of the Antarctic Peninsula. Symposium: The Biogeochemistry and the circulation of water masses in the Southern Ocean. Brest, France, 3-6 July, 1990.

WEERING, T.J.C.E. VAN & A.R. FORTUIN: Large-scale slumping and sliding in the Neogene of Sumba, eastern Indonesia. Congress Orogenesis in Action, London, 18-20 April.

WESTALL, F., C. MONTY & S.J. VAN DER GAAST: Microbes and silica diagenesis: some preliminary evidence from South Atlantic biosiliceous sediments. 13th International Sedimentological Congress, Nottingham, UK, 26-31 August.

WILDE, P.A.W.J. DE, G.C.A. DUINEVELD, W.M. BERGHUIS & G. VAN NOORT: Two posters on research in benthic ecosystems in the North Sea. Open Day NIOZ, Texel, 14 October.

2.2.3. Advice offered

M.R. Wernand advised RWS on the implementation and use of the 'Portable Four Channel radiometer' (PFC), developed at NIOZ, in the Pollution Monitoring aircraft of RWS. The radiometer is used in the North Sea algal bloom project.

C. Swennen advised RWS North Sea Directorate on the danger of surface-active agents for sea-birds.

In anticipation of the NCP-atlas, preliminary summaries of sea-bird densities in the Dutch sector of the North Sea were offered to NMF for a 'Ruimtelijke Noordzeeatlas' (in cooperation with Henk Baptist, DGW); for the 'Nota Beschermde Gebieden Noordzee', again to NMF; to NAM for a book on the Frisian Front; and to TNO for the North Sea model 'Referee'.

In different lectures and papers H.J. Lindeboom advised the Dutch government on matters concerning the effects of fisheries on the North Sea ecosystem.

G. Marees advised RWS against further development of an airborne laser bathymetry system. The turbidity of the Dutch coastal waters was calculated to be too high for an economically sound use of such a system (see also H2-12).

As a member of the 'Commission for the Environmental Effect Reports', J.P. Boon advised the Dutch Government on guidelines for alternatives for future policy on the release of oil-containing fluids (oil-based muds, production water) from offshore mining platforms. This commission also gave advice for the official permission to use new (less toxic) types of oil-based muds.

Prof. Dr. R.P.M. Bak ontvangt de Cola Debrot prijs uit handen van de gezaghebber van Curaçao Drs. E. Wilsoe. Deze prijs werd Prof. Bak toegekend voor zijn bijzondere verdiensten op het gebied van de koraalrif-oecologie.
(Photo: S. Koelega)



2.3. SOME ACRONYMS USED IN THIS ANNUAL REPORT

ATP	Adenosine-Tri-Phosphate
AVHRR	Advanced Very High Resolution Radiometer
AWI	Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, FRG
BAH	Biologische Anstalt Helgoland, Helgoland, FRG
BCRS	(Beleids Commissie Remote Sensing) Netherlands Remote Sensing Board
BEON	(Beleidsgericht Ecologisch Onderzoek Noordzee en Waddenzee) Applied Ecological Research North Sea and Wadden Sea
BEWON	(Beleidsgericht Wetenschappelijk Onderzoek NIOZ) Applied Scientific Research NIOZ
BION	(Biologisch Onderzoek Nederland) Biological Research of the Netherlands
BOEDE	(Biologisch Onderzoek Eems Dollard Estuarium) Biological Research Ems-Dollard Estuary
BOA	(Biologie, Oceanografie en Aardwetenschappen) Foundation for Biological, Oceanographic and Earth Sciences
CREST	Comité de la Recherche Scientifique et Technique (EC)
CTD	Conductivity Temperature Depth (probe)
DGW	(Dienst Getijdewateren RWS) Tidal Waters Division RWS
DIHO	(Delta Instituut Hydrobiologisch Onderzoek) Delta Institute for Hydrobiological Research
DMS	DiMethylSulphide
DSDP	Deep Sea Drilling Project
EC	European Community
ECN	(Energieonderzoek Centrum Nederland) Energy Research Centre Netherlands
EMOWAD	(Ecologisch Model westelijke Waddenzee) Ecological Model western Wadden Sea
EON	(Ecologisch Onderzoek Noordzee en Waddenzee) Ecological Research North Sea and Wadden Sea
EPOS	European Polarstern Study
EROS-2000	European River Ocean System-2000
ESF	European Science Foundation
ETS	Electron Transport System
HRTEM	High Resolution Transmission Electron Microscope
IAPSO	International Association for the Physical Sciences of the Ocean
ICES	International Council for the Exploration of the Sea
ICSU	International Council of Scientific Unions
IFREMER	Institut Français de Recherche pour l'Exploration de la Mer
IGBP	International Geosphere Biosphere Program (under ICSU)
IUCN	International Union for the Conservation of Nature
JGOFS	Joint Global Ocean Flux Study
KNAW	(Koninklijke Nederlandse Akademie van Wetenschappen) Royal Netherlands Academy of Arts and Sciences
KNMI	(Koninklijk Nederlands Meteorologisch Instituut) Royal Dutch Meteorological Institute
LOICZ	Land Ocean Interaction in the Coastal Zone
MAFF	Ministry of Agriculture, Fishery and Food (UK)
MAST	Marine Science and Technology programme
MT-TNO	(Afdeling Maatschappelijke Technologie TNO) Division of Technology for Society TNO
NAM	(Nederlandse Aardolie Maatschappij) Dutch Oil Company

NERC	Natural Environment Research Council (UK)
NOAA	National Oceanographic & Atmospheric Administration
NOP	(Nationaal Onderzoeks Programma voor luchtverontreiniging en klimaatverandering) National Research Programme on Atmospheric Pollution and Climate Change
NWO	(Nederlandse Organisatie voor Wetenschappelijk Onderzoek) Netherlands Organization for the Advancement of Scientific Research
OIO	(Onderzoeker in opleiding) Ph.D. student
OPEX	Oil Pollution Experiment
PAGES	Past Global Changes
PCB	Polychlorinatedbiphenyls
POM	Particulate Organic Matter
RCG	(Rijks-commissie voor Geodesie) State commission for Geodesy
REE	Rare Earth Elements
RGD	(Rijks Geologische Dienst) National Geological Service
RIN	(Rijks Instituut voor Natuurbeheer) Research Institute for Nature Management
RIVO	(Rijks Instituut voor Visserij Onderzoek) Netherlands Institute for Fishery Investigations
RWS	(Rijkswaterstaat) Department of the Ministry of Transport and Public Works
SCOPE	Scientific Committee on Problems of the Environment
SCOR	Scientific Committee on Oceanic Research
SEAWAQ	Seawater Quality model
SEDEX	Sediment Experiments
SEM	Scanning Electron Microscope
SOZ	(Stichting Onderzoek der Zee) Netherlands Marine Research Foundation
STEP	Science and Technology for Environmental Protection
TECON	(Toegepast Ecologisch Onderzoek Noordzee) Applied Ecological Research North Sea
TNO	(Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek) Netherlands Organization for Applied Scientific Research
UGGI	(Union Geodesique et Geophysique Internationale) International Union of Geodesy and Geophysics
UNEP	United Nations Environmental Programme
VROM	(Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieuhygiëne) Ministry for Housing, Regional Development and the Environment
VVA	(Verstoring Van Aardsystemen) Netherlands Research Programme on changes of earth systems
WCRP	World Climate Research Programme
WOCE	World Ocean Circulation Experiment
WOTRO	(Wetenschappelijk Onderzoek Tropen) Netherlands Foundation for the Advancement of Tropical Research
XRD	X-Ray Diffraction

C

3. Nederlandse samenvatting van de wetenschappelijke resultaten en andere activiteiten

3.1. SAMENVATTING VAN DE WETENSCHAPPELIJKE RESULTATEN

3.1.1. Inleiding

Voor deze Nederlandse samenvatting zijn de resultaten niet per project maar per onderzoeksgebied (Estuaria, Noordzee, Oceaan en Speciale Projecten) samengevat.

3.1.2. Estuaria (w.o. de Waddenzee)

Onderzoek naar de seizoensvariatie in de stikstofcyclus toonde aan dat wadden in de Waddenzee gedurende de zomer, als het nitraatgehalte in het water laag is, N_2O (één van de broeikasgassen) opnemen. In winter en voorjaar, bij hogere nitraatgehalten, fungeren zij echter als N_2O -bron. Vergelijking van verschillende wadden (tussen Jade Busen en Texel) toonde aan dat er van plaats tot plaats grote verschillen bestaan in de N_2O -fluxen: in de Dollard zijn zij gemiddeld 10 maal zo groot als bij Texel.

Voor het onderzoek naar flocculatie/deflocculatieprocessen in estuaria was het van groot belang dat de op het NIOZ vervaardigde *in situ* suspensiecamera dit jaar is gecompleteerd met beeldanalyse-apparatuur. Deeltjesgrootte kan nu gemeten worden op de negatieven. Negatieven van Zaire en Schelde verzameld in 1989, maar ook oudere uit Gironde, Rijn en Eems-estuarium, tonen aan dat er geen verband bestaat tussen vloggrootte en zoutgehalte, organische-stofgehalte of vlok-samenstelling. Coultercounter- en pipetanalyse geven geen goed beeld van de *in situ* grootte van vlokken, wel van het totale volume. De camera wordt aangepast om *in situ* valsnelheden van vlokken te meten.

Temperatuur- en zoutgehalteverdeling in het Zaire-estuarium in 1989 was vergelijkbaar met die tijdens eerdere tochten (1976 en 1978), maar gehalten aan gesuspendeerd materiaal waren meer variabel. Alle gesuspendeerd materiaal bleek in vlokken voor te komen, faecal pellets waren zeldzaam; dit wijst op een geringe rol van grazers bij vlokvorming in de waterkolom. Vloggrootte bleek vnl. afhankelijk van de turbulentie; kleinere vlokken (0,5 mm) werden gevonden in de snelstromende rivier en grotere (tot 2 mm) in het estuarium waar de stroomsterkte minder is.

In de Dollard wordt gesuspendeerd materiaal met vloed over de platen naar binnen getransporteerd; een gedeelte hiervan gaat met eb via de geulen weer naar buiten. Het netto-effect is een accumulatie van 1 tot 2 mm per jaar. Asymmetrie van de getijcurve en erosie tijdens stormen spelen hierbij een belangrijke rol.

Onderzoek naar de buitendelta van het Marsdiep werd afgesloten. Veranderingen in de buitendelta vertonen een cyclisch patroon waarbij geulen en banken zich met de klok mee verplaatsen en zandbanken uiteindelijk aan Texel vastgroeien. Zo'n cyclus duurt ca. 70 jaar. Zandtransport in het Marsdiep wordt sterk beïnvloed door getijstromen parallel aan de kust en interferentie met getijstromen door het Marsdiep bepaalt de ligging van de hoofdgeulen. Daarnaast speelt de dominante richting van golven een belangrijke rol. Metingen in mei in het gat tussen Terschelling en Ameland toonden aan dat de zware winterstormen de morfologie hier sterk veranderd hadden sinds 1989.

Uit literatuuronderzoek bleek dat aanvoer en verspreiding van Amazonaslib gedurende de laatste 1000 jaar varieerde met het klimaat (drogere en nattere perioden). Recente veranderingen in sedimentatie van Amazonaslib langs de Surinaamse kust konden in verband gebracht worden met veranderingen in sterkte en richting van de passaatwinden.

Tijdens de Zaïre-expeditie (1989) waren gehalten opgelost ijzer in de rivier relatief hoog vergeleken met andere rivieren, in het estuarium en naar de open oceaan toe daalden de gehalten. In het interstitiële water werden meer dan 10 maal zo hoge waarden aangetroffen. Processen verantwoordelijk voor de verdeling van ijzer en andere gemeten metalen worden nog bestudeerd.

De diatomeeënpiek in het Marsdiep was dit jaar niet hoog, ook de hieropvolgende *Phaeocystis*-piek was minder hoog dan eerdere jaren. De jaarlijkse primaire productie bedroeg ca. 250 gC·m⁻², eveneens lager dan halverwege de jaren tachtig. Mogelijk heeft de eutrofiëring zijn maximum bereikt.

Phaeocystis, de belangrijkste algenbloei veroorzakende alg in ons kustwater, blijkt diverse organische fosfaatverbindingen als P-bron te kunnen gebruiken, één van de redenen van zijn succes. Tijdens de *Phaeocystis*-piek in het Marsdiep dit voorjaar was (voor het eerst?) N in plaats van P groei limiterend.

De belangrijkste copepode in het Marsdiep *Temora longicornis* bleek weinig *Phaeocystis* te eten tijdens de voorjaarsbloei: slechts 1%. Waarschijnlijk eet *Temora* tijdens de bloei heterotrofe organismen.

Tijdens de voorjaarspiek van kiezelwieren in het Marsdiep daalde de kiezelzuurconcentratie van winterwaardes van 4 µM tot 0.1 µM, maar er is niet altijd een duidelijk verband tussen kiezelzuur en de hoeveelheid kiezelwieren. Met radioactief ³²Si bleek het mogelijk de groei van alleen de diatomeeën in het fytoplankton te meten in Antarctische wateren met hoge kiezelzuurgehaltes. Het is de bedoeling deze methode ook in het Marsdiep te gebruiken om uiteindelijk een beter begrip te krijgen van de rol van Si in het ecosysteem.

Onderzoek aan de zwavelcyclus in algenmatten concentreerde zich op enkele functionele groepen van zwavelbacteriën. Polysulfiden bleken in het veld in supra-optimale hoeveelheden aanwezig, waardoor ze groeiremmend werken. *Thiobacillus thioparus* is de eerst bekende mariene bacterie die kan groeien op dimethylsulfide, een o.a. door mariene algen geproduceerde zwavelverbinding die bijdraagt aan de zure neerslag.

De zachte winters sinds 1987 hebben een spectaculaire wijziging in het macrobenthos in de Waddenzee tot gevolg gehad: dieren gevoelig voor strenge winters zijn nu zeer algemeen (bijv. de schelpkokerworm *Lanice conchilega*). Broedval van schelpdieren als kokkel en mossel is na zachte winters vaak minimaal; dit en de extra inspanning van mossel- en kokkelvissers maken dat er nu praktisch geen mossels en kokkels meer op de wadplaten zijn. Jaarlijkse groei van *Macoma balthica* is goed te correleren met de hoeveelheid diatomeeën in het plankton in het groeiseizoen, niet met de hoeveelheid *Phaeocystis*. Deze grote kolonies vormende alg is kennelijk moeilijk te begrazen. *Macoma* blijkt in

aquaria wel goed te kunnen groeien op losse cellen van *Phaeocystis*. Het door predatoren regelmatig 'afgrazen' van de sifon-uiteinden van *Macoma* is de oorzaak dat deze 'deposit-feeder' moet overgaan op 'suspension-feeding'.

Net als in 1989 trad hoge sterfte op onder de eidereenden in de Waddenzee t.g.v. van de darmparasiet *Polymorphus botulus*. De strandkrab, tussengastheer van deze parasiet, was sterker geïnficeerd dan in de jaren zestig.

Onderzoek is gestart in een broedkolonie (Shin eiland, Gele Zee) naar de met uitsterven bedreigde Chinese zilverreiger *Egretta eulophotes*. Voedsel voor de jongen (kleine vis en garnaal) wordt alleen op de wadden verzameld en niet op de rotskusten.

Van de twee ondersoorten van de kanoetstrandloper overwintert *canutus* in West-Afrika en *islandicus* in West-Europa. Onderzoek richt zich op de verschillen in energiebehoefte voor deze verschillende overwinterings-strategieën. Met kanoeten van koperdraad, omhuld met een kanoet-verenkleed, werd bepaald dat de energie nodig om in de Waddenzee 's winters op temperatuur (41°C) te blijven 1,5 tot 5,3 maal groter is dan voor het basismetabolisme nodig is; de laatst genoemde waarde is nabij het maximum wat een organisme kan presteren: overwinteren in de Waddenzee is dus een 'kostbare' strategie. Bij Texel overwinterende kanoeten (plm 10.000 stuks) fourageren v.n.l. op nonnetjes (*Macoma balthica*). Slechts de helft van de daarvan aanwezige biomassa kunnen zij eten (nl. alleen exx. < 16 mm en ondieper levend dan 35 mm). In de tweede helft van April neemt hun fourageeractiviteit met een factor 2,5 toe om voldoende 'op te vetten' voor de reis naar arctische broedgebieden.

Methoden zijn ontwikkeld waarbij continue meting van uitwisseling van ionen tussen de strandkrab en zijn milieu mogelijk is. Een verhoogde actieve flux van CO₂ als aanpassing aan verhoogde externe CO₂-waarden bleek onvoldoende als compensatie. Lange blootstelling aan verhoogde NH₄: concentraties leidt tot een hogere zoutflux; de energie hiervoor benodigd is een groter probleem voor de krab dan de toxiciteit van ammoniak.

Een nieuwe aanpak in het vervuilingsonderzoek is het bestuderen van zgn. 'biomarkers': het gebruik van biologische kenmerken indicatief voor sublethale effecten van antropogene verbindingen in het milieu. Deze kunnen dan gebruikt worden als vroege signalen voor mogelijke effecten op het ecosysteem. Zulke 'biomarkers' kunnen enzymen zijn die als bescherming tegen een giftige stof gevormd worden (bijv. MFO 'mixed function oxidase' het cytochroom P-450 mono-oxygenase systeem). Ook genetische beschadiging (bijv. breuken in het DNA) of carcinogene respons kan als 'biomarker' fungeren. Dit jaar werd ervaring hiermee opgedaan tijdens een langdurig bezoek aan de Verenigde Staten waar zowel laboratorium- als veldonderzoek werd uitgevoerd.

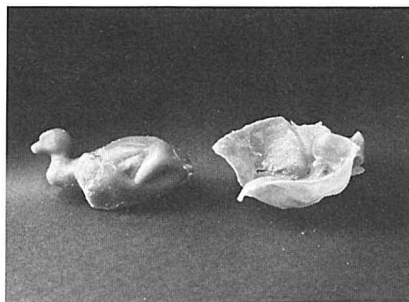
In water opgeloste contaminanten blijken snel te adsorberen aan teflonkorrels. Deze eigenschap kon gebruikt worden om in water opgeloste en aan zwevende deeltjes gebonden contaminanten te scheiden.

Bij fosfaatverwerkende industrieën in het Nieuwe Waterweg-gebied blijken radionucliden (²¹⁰Po, ²¹⁰Pb, ²²⁶Ra en Th-isotopen) vrij te komen, waarvan >75% geadsorbeerd aan deeltjes naar de Noordzee vervoerd wordt.

Effecten van het storten van havenslib op een kunstwad ('mesocosm') werden bestudeerd. Storten blijkt in eerste instantie eutrofiërend te werken, leidend tot algenbloeien in het water. Het meeste macrozoobenthos reageert hierop met snellere groei. Toxische stoffen leiden echter ook tot afwijkende groei, vooral bij de kokkel.

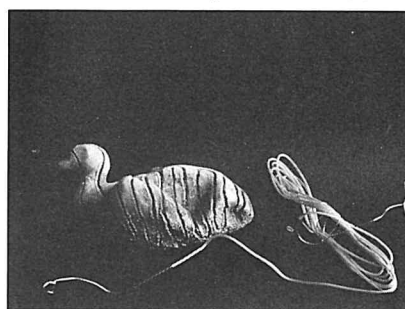
In wadorganismen van Thailand en Maleisië werden PCB's en pesticiden als dieldrin, DDT en derivaten aangetroffen. Verschillen van soort tot soort en van plaats tot plaats waren aanzienlijk.

HOE KOUD IS HET OP HET WAD EN OP DE TOENDRA Een koperen kanoet in de maak



Een rubberen mal van een huidloze kanoetstrandloper wordt gevormd rond een natuurgetrouw keramieken model.
(foto: P. Wiersma)

De rubberen mal wordt gevuld met bijenwas. Op het bijenwas-model brengen we twee laagjes koper aan, met een verwarmingsdraad er tussen.
(foto: P. Wiersma)



In een heet waterbad smelten we de bijenwas en laten het uit het koperen naaktmodel lopen. Een geprepareerde kanoeten-huid wordt strak om het koper heen gespannen, en het voltooide model wordt op een poot gezet. Op het strand bij Griend staan twee koperen kanoeten klaar om te meten hoe koud een kanoet het daar met hoogwater zou hebben.
(foto: P. Wiersma)

Vier koperen kanoeten op de toendra bij het weerstation van Rowley Island in de Canadese Arktis.
(foto: J. van de Kam)



3.1.3. Noordzee

Onderzoek in het Friese Front-gebied (60 km noord van de Waddeneilanden) toonde aan dat (lokale) wind slechts 5 tot 75% van de stromingen kan verklaren; horizontale dichtheidsgradiënten en interactie van getij en topografie verklaren de rest.

Dieptemeting vanuit de lucht m.b.v. laserstralen blijkt mogelijk in helder water, in ons kustwater dus slechts zelden, in het Doggersbankgebied vaker, maar toch zal deze goedkopere methode de conventionele dieptemetingen in ondiep Noordzeewater niet kunnen vervangen.

Toenemende trends in voedingsstoffen in de Noordzee blijken duidelijk uit vergelijking van fosfaatmetingen van Kalle in de winter 1935/1936 met NIOZ-wintermetingen uit de jaren zeventig.

Een onderzoek naar eventuele veranderingen in emissie en opname van z.g.n. broeikasgassen (CO_2 , CH_4 , N_2O , Dimethylsulfide) door de Noordzee, toonde aan dat eutrofiëring van het kustwater voor veranderingen zorgde, maar dat de C-balans voor de Noordzee (speciaal de rol van opgelost organisch koolstof) nog slecht bekend is.

Vergelijking van twee extractiemethoden voor PCB's uit de waterfase, vloeistof/vloeistof-extractie (LLE) en adsorptie aan XAD2, tijdens een Noordzeetocht bevestigde laboratoriumgegevens: de LLE-methode extraheert opgeloste en colloïdaal gebonden PCB's, de XAD2 hars alleen opgeloste. De LLE methode geeft dus de beste gegevens over het totale gehalte aan PCB's in oplossing.

De EDAX-microprobe op de scanning-electronenmicroscop is verder geautomatiseerd, waardoor een onbeperkt aantal deeltjes in een monster onder de microscoop eerst aangewezen kan worden en vervolgens automatisch doorgemeten.

Metingen van de verticale verspreiding van de isotopen ^{137}Cs en ^{210}Pb in sedimentkernen van Oestergronden en Outer Silver Pit wijzen op een aanzienlijke bioturbatie.

Het aantal eieren dat de copepode *Temora longicornis* dagelijks produceert is laag in de winter (5 tot 25 in november, 2 tot 10 van december tot februari) en neemt daarna toe tot een maximum van 65 tijdens de voorjaarsdiatomeeënpijk.

Centropages hamatus is als derde copepode (naast *Temora longicornis* en *Pseudocalanus elongatus*) nu in continu cultuur in de nieuw gebouwde klimaatkamers; de automatische voedseltoediening werd getest; er zijn nog systematische verschillen met de oudere methode.

De microbiële gemeenschap van zandige en slibrijke bodems in de Noordzee vertoont grote verschillen: heterotrofe flagellaten consumeren 10 tot 100% van de bacteriële productie in zandige bodems en slechts 1 tot 5% in slibrijke bodems. Met fluorescerend gemaakte bacteriën kon gemeten worden dat een flagellaat 8-96 bacteriën per uur eet.

Bioturbatie is een belangrijke factor bij de verticale verspreiding van levende foraminiferen in Noordzee- en Skagerrak-sedimenten. Bioturberende macroorganismen brengen lokaal zuurstof, dat normaal niet dieper dan enkele mm doordringt, tot grotere diepte, waardoor foraminiferen tot 15 cm diep kunnen leven.

De gegevens van het 'ICES Synoptic Mapping Programme' wijzen uit dat diepte en sedimenttype de belangrijkste factoren in de verspreiding van macrozoöbenthosgemeenschappen zijn, waarbij de 30-, 50- en vooral de 80-m dieptelijn een duidelijke grens vormen. Sessile epifauna komt in de Zuidelijke Bocht opmerkelijk weinig voor in vergelijking met de rest van de Noordzee, hoogstwaarschijnlijk een gevolg van de intense trawlvisserij hier.

Groeiringen in de schelp van de noordkromp konden m.b.v. ^{14}C -metingen inderdaad, zoals verondersteld, als jaarringen gedetermineerd worden. Dit maakt dit langlevende schelpdier (ca. 150 jaar maximaal) uitermate geschikt om jaar-op-jaar variaties in groei te meten en deze variaties te relateren aan trends in het milieu.

Verschillen in groeisnelheid werden gevonden bij de zeeëgel *Echinocardium cordatum* en de tweekleppige *Tellina fabula* verzameld op verschillende plaatsen rond de Doggersbank. Dit wijst op duidelijke verschillen in voedselaanbod.

Met behulp van een groot aantal (96) mesocosms werden effecten van eutrofiëring in de Noordzee bestudeerd. Toevoeging van diepgevroren *Phaeocystis*-materiaal bootste eutrofiëring na. Vertikale verdelingspatronen van microbiële biomassa (ATP) en respiratie (ETS) waren goed vergelijkbaar met die in de Noordzee-sedimenten buiten. *Echinocardium* bioturbeerde het sediment in de mesocosms tot 7 cm diep en vertoonde net als *Tellina fabula* een goede relatie tussen groei en toegevoegde hoeveelheid organisch materiaal. In de controlebakken zonder toevoer van *Phaeocystis*-materiaal namen zij af in gewicht.

In het kader van ICES-onderzoek naar biologische effecten van contaminanten werd een vervolgonderzoek ingesteld naar een sinds 1988 verlaten boorgebied, waar het NIOZ reeds eerder effecten van storten van met olie vervuilde boorspoeling onderzocht (TECON-project). Nog steeds bleken soorten die destijds nadelig werden beïnvloed afwezig te zijn in een gebied van 500 m rond de stortplaats en dieplevende soorten kwamen hier in lagere aantallen voor. In de nieuw afgezette toplaag van het sediment had de meiofauna zich echter hersteld.

Internationale contacten voor zeevogel- en walviswaarnemingen in het Noordzeegebied werden uitgebreid zodat er nu een goede uitwisseling van gegevens is. In de winter werden speciaal de zeeëenden overwinterend in de kustwateren geteld (in samenwerking met DGW-tellingen vanuit de lucht). Op de paaigronden van de haring ten oosten van Schotland en Engeland concentreerden zich wederom in de nazomer veel zeevogels samen met kleine en grote walvissen. Noordse stormvogels broedend op Helgoland voeden hun jongen vnl. met ca. 12 cm lange sprut die ze ten westen van Helgoland verzamelen.

3.1.4. Oceaanonderzoek

In het kader van verschillende internationale projecten werd in 1990 op het NIOZ oceaanonderzoek verricht. De afdeling fysische oceanografie heeft met de 'Tyro' een hydrografische opname in de Noord-Atlantische Oceaan uitgevoerd in het kader van het 'World Ocean Circulation Experiment' (WOCE), terwijl verschillende afdelingen betrokken waren bij de voortzetting van de Nederlandse bijdrage aan de multidisciplinaire 'Joint Global Ocean Flux Study' (JGOFS), eveneens uitgevoerd met de 'Tyro' van de Stichting Onderzoek der Zee. Ook werd nog bijgedragen aan de uitwerking van de 'European Polarstern Study' (EPOS), van het 'Greenland Sea Project' (GSP) en van het 'European River Ocean System' (EROS-2000).

Analyse van gegevens verkregen tijdens de JGOFS-tochten in de Noord-Atlantische Oceaan in 1989 en 1990 toont een hoge primaire productie noord van 52°N, met een belangrijke bijdrage door de z.g. nieuwe productie. Ten zuiden van 52°N is de lagere primaire productie meer van regeneratieve aard. Deze verschillen worden ook weerspiegeld in de koolstofmineralisatie in het sediment.

Metaalconcentraties van watermonsters verzameld tijdens JGOFS, vertoonden een afname, gaande van 60°N naar 33°N langs de 20°W meridiaan. Het diepe water bij Madeira vertoonde tussen 1989 en 1990 een sterke verandering in de concentraties van zowel cadmium als fosfaat. Heranalyse van gepubliceerde gegevens m.b.t. de cadmium-fosfaatratio toonde belangrijke verschillen tussen de oceanobekkens. Dit heeft belangrijke consequenties voor paleo-oceanografisch onderzoek.

Tijdens de tochten voor JGOFS zowel als voor WOCE werd onderzoek gedaan aan het CO₂-systeem. Continue registratie van het CO₂-gehalte van het oppervlaktewater toonde een duidelijke dagelijkse gang. In samenwerking met het KNMI is een begin gemaakt met de studie van de lucht-zee-uitwisseling van CO₂. Vergelijking met de analyseresultaten van Engelse en Amerikaanse collega's betrokken bij JGOFS tonen aan dat de NIOZ-bepalingen goed overeenstemmen met die van buitenlandse instituten.

Incubatie-experimenten met onverstoorde sedimentmonsters, verkregen tijdens de benthische JGOFS-tocht leverden schattingen op van de zuurstofconsumptie door benthische organismen. Deze blijkt op gematigde breedten bijna driemaal zo hoog als in de subtropen. Tijdens de JGOFS-tocht werd ook de benthische lander getest die dergelijke experimenten *in situ* moet uitvoeren. Hoewel nog enige kinderziekten optraden, is met een viertal lanceringen van dit instrument de bruikbaarheid voor onderzoek *in situ* bewezen.

De eufotische zone, zoals waargenomen tijdens de JGOFS-tochten, varieerde van 30 m bij IJsland tot 100 m bij Madeira. De primaire productie daarentegen was bij IJsland tweemaal zo groot als bij Madeira. Het overgrote gedeelte van de biomassa werd gevonden in de bovenste 100 m. Ook deze biomassa vertoonde een sterke meridionale variatie, met de hoogste waarden in het noorden.

Emiliana huxleyi, een coccolitofoor, is het belangrijkste CaCO₃ producerende organisme op aarde. Een bloei van *E. huxleyi* is op satellietopnames duidelijk te herkennen door de hoge reflectiviteit. Tijdens tochten met de 'Tyro' en de 'Challenger' in het kader van JGOFS werd een begin gemaakt met de studie van de populatiedynamica van dit organisme. Met behulp van voor *E. huxleyi* specifieke polysachariden konden verschillende lijnen van *E. huxleyi* in zee worden aangetoond. In een zeegebied blijken verschillende lijnen van *E. huxleyi* gelijktijdig te kunnen voorkomen.

Ten behoeve van het onderzoek naar spoorelementen werden in het kader van EROS-2000 met de Franse 'Marion Dufresne' sedimentmonsters verzameld in de westelijke Middellandse Zee. Ook werden in samenwerking met Franse en Spaanse instituten sedimentkernen verzameld waarvan, door middel van ²¹⁰Pb- en ¹³⁷C-isotopenanalyse, de sedimentatiesnelheid zal worden bepaald. De eerste resultaten tonen een hoge sedimentatiesnelheid bij de monding van de Rhône en lagere sedimentatiesnelheden in de diepere bekken.

Analyse van watermonsters, verzameld tijdens het EPOS-programma, toonden variaties in de verdeling van spoormetalen, gaande van de Weddellzee via de Weddell-Scotiaconfluentie naar de Scotiazee. Deze variaties bleken samen te hangen met verschillen in biogeochemische processen.

Voor de simulatie van de menglaag, zoals waargenomen tijdens de EPOS-tochten, werd een menglaagmodel ontwikkeld. De resultaten van dit fysische model zullen worden gekoppeld aan een ecofysiologisch model, ontwikkeld aan de Université Libre (Brussel). De analyse van de diepe CTD-waarnemingen toonde het belang van frontale wervels voor de laterale uitwisseling over de Weddell-Scotia-confluentie.

De oplossingskinetiek van biogeen silicium bij de Weddell-Scotia-confluentie werd bestudeerd aan netmonsters en aan monsters uit cultures. Kleine variaties in de aluminiumconcentratie blijken een negatieve correlatie te hebben met de oplosbaarheid van biogeen silicium. De lage aluminiumconcentratie wordt daarom verantwoordelijk geacht voor de hoge concentratie van opgelost silicium.

Radioactief ^{32}Si blijkt unieke mogelijkheden te bieden voor de studie van de siliciumcyclus. In samenwerking met de Rijksuniversiteit Utrecht is tijdens het EPOS-programma de productie van diatomeeën bestudeerd m.b.v. ^{32}Si . Dergelijke analyses zullen ook worden uitgevoerd in de Noordzee.

Grote verschillen wat betreft bacteria, flagellaten en biogeochemische parameters tussen de Weddellzee en Scotiazee werden aangetoond. Deze verschillen blijken samen te hangen met processen in het fytoplankton. In het sediment van de Weddellzee werden significante correlaties aangetoond in de verdeling van bacteria, flagellaten, meiofauna en een aantal abiotische factoren.

De dichtheid van verschillende planktonsoorten, verzameld tijdens de drie tochten van het EPOS-programma, werd m.b.v. clusteranalyse bestudeerd. Hoewel vier clusters konden worden onderscheiden was de belangrijkste tweedeling die tussen de Weddellzee en de Scotiazee. Deze laatste is veel rijker aan soorten. Een populatiemodel, waarmee de ontwikkeling van copepoden is bestudeerd, suggereert een tweejarige levenscyclus, samenhangend met een lage productie en een lage mortaliteit.

De ecofysiologie van Antarctisch fytoplankton is tijdens het EPOS-programma bestudeerd met laboratoriumincubaties onder verschillende lichtomstandigheden. De groeisnelheid blijkt niet te worden beïnvloed door het lichtregime (duur licht-donker) bij vergelijkbare lichtintensiteit. Cellen, aangepast aan lage lichtintensiteiten zijn veel kleiner dan cellen, aangepast aan hoge intensiteiten.

Tijdens een tocht van de 'Tyro' werd een hydrografische opname (CTD, O_2 , CO_2 , nutriënten) gemaakt van WOCE-sectie AR7E tussen Ierland en Groenland. Ook werden hydrografische opnames gemaakt van een drietal controle-volumes in het IJslandbekken, en werden aanvullende XBT-raaien gevaren. Op een viertal plaatsen in het IJslandbekken werden stroommeterverankeringen uitgezet en drie ARGOS-boeien werden gelanceerd. De oppervlakte-circulatie in het IJslandbekken blijkt te worden gedomineerd door meanders en wervels op het sub-arctische front. De hydrografie van het diepe en het tussenwater wordt sterk beïnvloed door water van zuidelijke oorsprong dat lateraal mengt met water van arctische origine.

Er is een aanvang gemaakt met de analyse van I.R.-remote-sensingbeelden van het IJslandbekken. Hoewel de hoge bewolgingsgraad de mogelijkheden beperkt is toch een aantal bruikbare beelden geïdentificeerd.

Analyse van stroommeterwaarnemingen, uitgevoerd tussen Jan Mayen en Groenland tijdens het GSP, toonde de passage van een koude wervel tussen 300 en 500 m. Ook werd een opmerkelijke versterking van enkeldagse interne getijden geconstateerd aan de voet van de continentale helling van Groenland.

De verdeling van opgeloste zeldzame-aardelementen in de Zwarte Zee, in 1989 verkregen met de 'Knorr', kan worden verklaard uit de kinetiek van adsorptie en desorptie aan kleine deeltjes. Voor Cerium speelt de redox-chemie hierbij een belangrijke rol. Voor de verwijdering van andere niet-redox-metalen zijn waarschijnlijk bacteriën ook van groot belang.

Theoretisch fysisch onderzoek naar de eigenschappen van de ontwikkeling en voortplanting van mesoschaal-wervels is aangevangen. In samenwerking met de universiteiten van Utrecht en Eindhoven zijn theoretische voorspellingen vergeleken met experimentele resultaten van een roterend hydraulisch model. Er bestaat een discrepantie tussen theorie en experiment m.b.t. de voortplantingsrichting van wervels.

De grootschalige circulatie als gevolg van oscillerende windvelden is theoretisch onderzocht. Er blijkt een verrassende overeenkomst te bestaan met de gelijkrichting van getijden.

Bij het theoretische onderzoek van interne getijden is aandacht besteed aan de dispersie ten gevolge van de aardrotatie en de rol hiervan bij het ontstaan van interne solitonen. Verschillende aspecten van de resulterende niet-lineaire evolutievergelijking zijn hierbij bestudeerd. De kunstmatige introductie van discontinuïteiten in de tweede afgeleide blijkt noodzakelijk voor een bevredigende beschrijving.

Opnames met behulp van een penetrerend echolood en analyse van sedimentkernen tonen aan dat de sedimentatie in de Rockall Trog wordt beheerst door de circulatie van 'Overflow Water' uit de Noorse Zee en van Noordoost Atlantisch Diep Water. Variaties in de sedimentatiesnelheid blijken samen te hangen met de afwisseling van glacialen en interglacialen.

De structurele positie van het Indonesische eiland Sumba en de samenhang hiervan met de sedimentaire geschiedenis van het Savubekken en het Lombokbekken is bestudeerd. Afzettingen op Sumba en afzettingen, waargenomen op seismische profielen wijzen op fragmentatie van de oceanische en continentale rand als oorzaak van locale ruggen en vouwen. De verdeling van diatomeeën in het sediment blijkt voornamelijk te zijn bepaald door de oppervlaktecirculatie.

De gegevens over planktonische foraminiferen, verkregen op verschillende niveaus in het oppervlaktewater tijdens de tocht naar het Angolabekken in 1989, zijn geanalyseerd. Onderscheid kan worden gemaakt tussen een subtropische verzameling, een open-oceaanverzameling en een sub-polaire overgangsverzameling. De verticale verdeling van deze verzamelingen blijkt kenmerkend voor verschillende typen gelaagdheid in het Angolabekken.

Microfossielen in sedimentkernen uit het Angolabekken zijn bestudeerd. De verticale verdeling van diatomeeën en opaal-fytolieten representeert 200.000 jaar oceanische en continentale klimaatprocessen. De variatie in de sedimentkernen geeft, in tegenstelling tot bestaande klimaatreconstructies, geen aanwijzing voor een noordwaartse verplaatsing van de Benguelastroom gedurende de laatste 200.000 jaar.

Een voorlopige analyse van de gegevens toont aan dat de relatie tussen temperatuur, saliniteit en concentratie van opgelost silicium in het Angolabekken tussen 1976 en 1989 nauwelijks is veranderd. Analyse van het interstitiële water

uit het sediment, nu uitgevoerd met een hoog verticaal oplossend vermogen, toont aan dat tot nu toe de siliciumflux uit het sediment is onderschat.

Veel tijd is het afgelopen jaar besteed aan de ontwikkeling van een nieuwe poeder-röntgendiffractometer. Dit nieuwe instrument zal worden gebruikt voor een betere analyse van krypto-kristallijne structuren in kleimineralen.

Onderzoek op Curaçao en Aruba toont aan dat de grootte van koraalkolonies nadelig wordt beïnvloed door de mate van antropogene invloeden. Aangebrachte beschadigingen aan koralen blijken snel te herstellen in ongestoorde gebieden, maar langzaam op plaatsen die aan verontreiniging bloot staan. De morfologie van koraalriffen blijkt samen te hangen met verschillen in ecologische karakteristieken. De resultaten van histo-compatibiliteitsexperimenten stemmen hiermee overeen. In Frans Polynesië is de rol van zeeëgels bij de bioerosie van koraalriffen bestudeerd.

Eind 1990 ging de Nederlandse expeditie naar het Poolse Arctowski-station op King George Island (Antarctica) van start. Hier worden de effecten van temperatuur en UV-b straling op het microbiële systeem van Admiralty Bay bestudeerd met nieuw ontwikkelde instrumenten.

3.1.5. Speciale Projecten

Het BEWON-project, op het NIOZ gestart in 1988, is een onderdeel van het Beleidsonderbouwend Ecologisch Onderzoek Noordzee (BEON) project, waarin 8 instituten samenwerken. Een groep van 17 medewerkers houdt zich op het NIOZ bezig met beleidskwesties betreffende eutrofiëring, verontreinigende stoffen en effecten van visserij op de bodemfauna. Er is een sterke nadruk op de modelmatige aanpak van deze problemen in het kader van het vervaardigen van ecosysteemmodellen voor Waddenzee en Noordzee

Het NIOZ krijgt een leidende rol in een samenwerkingsverband van 10 Europese mariene instituten bij de ontwikkeling van een ecosysteem-model voor de Noordzee, gefinancierd o.a. uit het EG MAST-programma. Voor een goede en snelle informatie uitwisseling tussen de instituten wordt electronic mail gebruikt. Het op het NIOZ ontwikkelde simulatiepakket (BAHBOE) is bruikbaar gemaakt voor alle deelnemers door het naar UNIX om te zetten.

Het mengingsproces in de Waddenzee werd bestudeerd d.m.v. een analyse van de Lagrangeaanse banen van groepen waterdeeltjes met verschillende uitgangsposities en afmetingen. Onregelmatigheden en het niet-willekeurige, deterministische snelheidsveld blijken zeer belangrijk voor de verspreiding van een watermassa. Deeltjesverspreiding t.g.v. het deterministische snelheidsveld kan chaotisch zijn.

Een één-dimensionaal stratificatiemodel voor de waterkolom is zover ontwikkeld dat geslaagde simulaties mogelijk waren met gebruik van meteorologische gegevens voor 1987 en 1988. Verschillen in wind leiden tot grote verschillen in de opbouw van de waterkolom. Stormen brengen voedselrijk bodemwater naar het oppervlak en drijven zo algenbloeien aan. Dit wijst op het grote belang van kortdurende gebeurtenissen voor de seizoenscyclus van fytoplankton.

Voor de studie naar vroege diagenese van mariene sedimenten en de nutriënten die hierbij vrij komen werden extractietechnieken verbeterd. De makkelijk extraheerbare fractie van P (0.2 tot $1.0 \mu\text{mol}\cdot\text{g}^{-1}$) blijkt de fractie die het snelst van het sediment weer in het water komt.

Phytoplanktononderzoek richt zich vooral op mechanismen achter de groottesamenstelling, met name de invloed van het nutriëntenaanbod.

Eutrofiëring werd onderzocht in mesocosm-experimenten waarbij toevoeging van extra organisch materiaal het uitzakken van algenmaterial na een bloei nabootste. De toegevoegde hoeveelheid ($32 \text{ gC}\cdot\text{m}^{-2}$) leidde tot een lagere bacteriële activiteit dan in de Noordzee gemeten; dit wijst er op dat de jaarlijkse toevoer van organisch materiaal naar de Noordzeebodem inderdaad 45 tot $145 \text{ gC}\cdot\text{m}^{-2}$ kan zijn zoals eerder geschat. Bacteriële activiteit neemt 75 tot 90% van de O_2 -consumptie voor zijn rekening. In een grootschalig nieuw experiment werd aangetoond dat materiaal van een uitzakkende *Phaeocystis*-bloei vooral in bakken met het sediment omwoelende macrofauna, snel geconsumeerd werd, ook O_2 -penetratie in het sediment was dieper in aanwezigheid van macrofauna.

Een vergelijking van de groeigegevens van de pitvis in de jaren vijftig en zeventig wijst uit dat de populatiestructuur sterk veranderd is: vroeger werden er tot 6 jaar oude exx. gevangen, in de jaren zeventig hooguit 3 jarige. Dit verschil hangt samen met de toegenomen visserij.

De scheidingsmethoden van de verschillende PCB's werden verder verfijnd en vergeleken met andere methodes. Van de giftige PCB's aangetroffen in zeehondenlever wordt slechts één (CB 118) regelmatig in monitoring-programmas gemeten.

Het immuunsysteem van de zeehond is mogelijk aangetast door PCB's; CB-77 kan de gehaltes aan vitamine A en thyroxine in het bloed verminderen (er wordt meer uitgescheiden). Beide stoffen spelen een belangrijke rol in het immuunsysteem. Zeehonden, in gevangenschap gevoerd met Waddenzeervis, hadden inderdaad belangrijk lagere gehaltes van deze stoffen in het bloed. Aanvullend zal onderzocht worden of ook de hogere parasitaire infectie van eerdere jaren in 1989 en 1990 samenhangt met aantasting van het immuunsysteem.

Onderzoek naar de gevolgen van lozing van oliehoudende boorspoeling sinds 1985 maakt het mogelijk macrobenthossoorten te scheiden op hun gevoeligheid hiervoor. De tweekleppige *Montacuta ferruginosa* is een van de meest gevoelige soorten. De zeeklit *Echinocardium cordatum* blijkt in box-cosm-experimenten het meest geschikte test-organisme. Nieuwe methoden om de boorspoeling schoner te maken bleken toch onvoldoende: op 250 m van het lozingspunt waren nog steeds effecten meetbaar.

Resultaten van het onderzoek naar effecten van trawlvisserij op de bodemfauna hebben enig stof doen opwaaien. Directe effecten zijn een duidelijke afname in dichtheid van macrobenthossoorten. De zeebodem wordt tot 6 cm diep omgeploegd. Van de macrobenthos gevangen in de 12 m boomtrawl met 10 'wekkers' van een tongvisser bleek na 2-3 dagen 10% (noordkromp), 60-70% (krabben), 60-80% (zeesterren) en 100% (wulk, heremietkreeft) te overleven. Trawlvisserij levert 0,2 tot 0,3 g asvrij organisch materiaal op aan dode organismen per trek, het meeste zal hiervan door zeesterren worden gegeten. Mede op grond van deze resultaten wordt op verzoek van het Ministerie van Landbouw, Natuurbehoud en Visserij meegewerkt aan het aanwijzen van beschermde gebieden in het Nederlandse deel van de Noordzee. Het gebied ten noorden van de Waddeneilanden komt hiervoor het meest in aanmerking.

Analyse van gegevens over de aanvoer van haaien en roggen in Den Helder sinds 1930 wijst op een sterke afname van deze soorten in de Noordzee.

De gebieden in de Waddenzee beneden de laagwaterlijn hebben een rijke macrobenthosfauna waarin vooral het wadslakje een belangrijke rol speelt. Biomassa in de winter is ongeveer de helft van die in de zomer.

De bodemfauna op de NEA-stortplaats voor laag-radioactief afval in de Atlantische Oceaan is niet significant verschillend van vergelijkbare gebieden er omheen; het dumpen had dus geen groot effect op het ecosysteem.

3.2. BEZOCHTE CONGRESSEN

- German-Dutch meeting on sea-level changes, Hengelo, 17-18 januari: J.J. Beukema.
- Symposium Onderzoek Neotropen, Werkgemeenschap Biologisch Aardwetenschappelijk Onderzoek in de Tropen, Amsterdam, 30 januari: R.P.M. Bak.
- Symposium Sea Mammals, Rotterdam, 3 februari: G.C. Cadée.
- EROS 2000 Workshop, Blanes, Spanje, 5-9 februari: D. Eisma, R.F. Nolting.
- Jaarvergadering ICES Marine Chemistry Working Group, Kopenhagen, 9-16 februari: J.P. Boon.
- Meeting of the Ocean Colour European Archive Network (OCEAN) Group, Joint Research Centre, Ispra, Italië, 12-14 februari: G. Marees, M.R. Wernand.
- Symposium 'Toxische effecten van stoffen op decompositie en mineralisatieprocessen', bijeenkomst oecologische kring en Nederlandse vereniging voor Microbiologie, Amsterdam, 13 februari: F.C. van Duyl.
- Symposium Nutrients in the North Sea, Londen, 21 februari: G.C. Cadée.
- Colloquiumdag over de EUZOUT-resultaten, Dienst Getijdewateren, Den Haag, 22 februari: F.C. van Duyl.
- Verwey-bijeenkomst, NIOZ, Texel, 26-27 februari: F.C. van Duyl, E. Flach, H.G. Fransz, P. Kamermans, M. Leopold, T. Piersma.
- Seasonal cycle workshop, NERC North Sea project, POL, Liverpool, 26-27 februari: M.A. Baars, J.W. Baretta, J.G. Baretta-Bekker.
- Workshop MARS network on European Marine Research Stations, EG Brussel, 5-6 maart: P.A.W.J. de Wilde.
- Phaeocystis* Workshop, Plymouth, Engeland, 6-9 maart: G.C. Cadée, R. Riegman.
- JGOFS-meeting on 'Modelling the physics, biology and chemistry of the upper ocean and its interaction with the atmosphere' met aansluitend een vergadering van de JGOFS modelling working group, Londen, 12-13 maart: H.G. Fransz, M.H.C. Stoll.
- JGOFS Data Workshop, Kiel, BRD, 15-20 maart: M.H.C. Stoll, G.W. Kraay, H.G. Fransz, H.J.W. de Baar, J. Stapel, T. Tahey, R.T.P. de Vries.
- Dahlem Conferentie on Ocean Margin Processes and Global Change, Berlijn, BRD, 19-23 maart: D. Eisma.
- Special Workshop on EPOS Flagellates, Kopenhagen, 19-23 maart: Gerard Nieuwland.
- Symposium 'Environnement des mers epicontinentales', Lille, Frankrijk, 20-23 maart: G.W. Berger, W. Helder.
- SCOR/JGOFS Committee fourth meeting, Kiel, BRD, 21-22 maart: H.J.W. de Baar.
- JONSMOD-meeting, Proudman Oceanographic Laboratory, Birkenhead, Groot Brittan- nië, 2-6 april: H. Ridderinkhof.
- Zoological Society of Londen Symposium 1990, Londen, 3 april: P.A.W.J. de Wilde.
- Seminar on monitoring, management and conservation of populations of dugong and their habitat in Aru, Indonesia. Pattimura University, Ambon, Indonesië, 11-12 april: F.C. van Duyl.
- Orogenesis in Action, London, 18-20 april: Tj.C.E. van Weering.
- European Geophysical Society, Kopenhagen, 23-27 april: H.M. van Aken, L. Maas.
- ICES working group Oceanic Hydrography, Kopenhagen, 28-29 april: A.J. van Ben- nekom, H. van Aken.
- ICES working group on the Statistical Aspects of Trend Monitoring, Kopenhagen, 30 april-4 mei: J. van der Meer.
- 22nd International Liege Colloquium on Ocean Hydrodynamics (Ice covered seas and ice edges: physical, chemical and biological processes and interactions), Luik, België, 7-11 mei: C. Veth.
- Symposium National Parken Wattenmeer, Wilhelmshaven, BRD, 7-8 mei: J.J. Beukema.
- Meeting ICES Benthos Ecology Working Group, Lissabon, 8-12 mei: P.A.W.J. de Wilde, G.C.A. Duineveld.
- PRO-MARE Symposium, Trondheim, Noorwegen, 11-16 mei: C. Veth.
- SCAR/SCOR Workshop on Ecology of the Antarctic Sea-Ice Zone, Trondheim, Noorwe- gen, 18-21 mei: C. Veth.

9th Meeting of the ICES Benthos Ecology Working Group, Lissabon, 18-21 mei: G.C. Duineveld.

EPOS-workshop Venetië, 19-24 mei: R.P.M. Bak.

WOCE Core Project 3, Wormley, Engeland, 21-23 mei: L. Otto.

Oceans from Space Symposium, Venetië, Italië, 21-25 mei: T.F. de Bruin.

Symposium Quality assurance of information from marine environmental monitoring in Europe (QUASIMEME), Noordwijkerhout, 21-23 mei: J.P. Boon, M.Th.J. Hillebrand.

Vergadering SCOR-commissie, Parijs, 22-23 mei: W.G. Mook.

EPOS-workshop Gent, 25-30 mei: R.P.M. Bak.

WAQUA-gebruikersclub, ICIM B.V., Den Haag, 30 mei: H. Ridderinkhof.

International Symposium on 40 years of Radiocarbon, Lake Arrowhead, California, USA, 4-8 juni: W.G. Mook.

INP-workshop (Integrated North Sea Programme), NIOZ, Texel, 6-8 juni: F.C. van Duyl.

EPOS-workshop Bremerhaven, BRD, 11-16 juni: J.H. Vosjan.

Nordsee-Symposium, AWI Bremerhaven, BRD, 26-29 juni: L. Lohse, E. Epping.

Colloquium JGOFS first results leg IV, Galway, Ierland, 27 juni: P.A.W.J. de Wilde, E.M. Berghuis.

VROM Mollusken Studiedag, Utrecht, 28 juni: J.P. Boon.

International Symposium on: The biogeochemistry and circulation of water masses in the Southern Ocean, Brest, Frankrijk, 3-6 juli: J.H. Vosjan, R.F. Nolting, C. Veth.

Visiting Committee Institut für Hydrologie, München, 5-6 juli: W.G. Mook.

COOP Meeting Ocean Margins, San Diego, USA, 9-12 juli: D. Eisma.

Tweejaarlijks congres 'Physical processes in estuaries and bays', Gregynog, Groot Britannië, 9-13 juli: H. Ridderinkhof.

5th International Symposium on the Interactions between sediments and water, Uppsala, Zweden: 6-9 augustus: F.C. van Duyl, W. van Raaphorst.

First International Symposium on Free-living Heterotrophic Flagellates, Helsingör, Denemarken, 6-11 augustus: R.P.M. Bak, B. Hondeveld.

Modelling of Marine Ecosystems (Summer course EIASO), Aix-en-Provence, Frankrijk, 11-29 augustus: H. Baretta, C. Veth.

Gutachtung Anita Künitzer, Bremen, BRD, 13 augustus: P.A.W.J. de Wilde, G.C.A. Duineveld.

EIASO-course on 'The structure and dynamics of shelf benthos', Galway, Ierland, 21 augustus-9 september: G.C. Duineveld.

Eighth Marine Technology Conference, Tokyo, 22 augustus: P.A.W.J. de Wilde.

Fifth International Congress of Ecology, Yokohama, 23-30 augustus: P.A.W.J. de Wilde.

12th Annual Congress European Society for Comparative Physiology and Biochemistry, Utrecht: 27-31 augustus: J.P. Boon, C.G.N. de Vooy.

11th International Sedimentological Congress, Nottingham, Engeland, 29 augustus-1 september: G.C. Cadée.

Coccolithophore workshop, Château de Blagnac, Frankrijk, 1-5 september: J.D.L. van Bleijswijk, H.G. Fransz, P. van der Wal.

Evolution of upwelling systems since the early Miocene, Geol. Soc. London Marine Studies Group Meeting, 3-4 september: Tj.C.E. van Weering.

Space Oceanography Course, Dundee, Scotland, 3-22 september: M.R. Wernand.

First International Conference on f-Elements, Leuven, België, 4-7 september: H.J.W. de Baar.

25th European Symposium on Marine Biology, Ferrara, Italië 5-15 september: J.J. Beukema, P. Kamermans.

4th International Workshop on QSAR in Environmental Toxicology, Veldhoven, 16-20 september: J.P. Boon.

6th International Symposium on Environmental Radiochemical Analyses, Manchester, Engeland, 18-22 september: G.W. Berger.

Annual meeting Deutsche Ornithologen-Gesellschaft, Husum, BRD, 28 september-3 oktober: T. Piersma.

SCOR 20th General meeting, Warnemünde, BRD, 1-3 oktober: L. Otto.

Workshop 'Potentiële effecten van klimaatsverandering', Wageningen, 2 oktober: J.J. Beukema.

ICES Statutory Meeting, Kopenhagen, 4-8 oktober: H.M. van Aken, H.G. Fransz, W. Helder, P.A.W.J. de Wilde.

Annual conference of the international Wader Study Group, Comacchio, Italië, 5-8 oktober: T. Piersma.

4th European Marine Microbiology Symposium, Kiel, BRD, 8-12 oktober: F.C. van Duyl, E. Epping, L. Lohse.

Meeting on the certification of trace elements in seawater (reference material) EG Brussel, 9 oktober: R.F. Nolting.

ICES Benthos Ecology Working Group, Kopenhagen, 6-9 oktober: M.J.N. Bergman.

Minisymposium on Benthic Ecology of the North Sea, Kopenhagen, 9 oktober: P.A.W.J. de Wilde.

Soviet National Meeting on Marine Geology, Gelendjik, Sovjetunië, 14-21 oktober: D. Eisma.

WOCE Scientific Steering Group, 15th meeting, Toulouse, Frankrijk, 16-19 oktober: L. Otto.

Individual Cell and Particle Analysis: Multidisciplinary Applications to Oceanography, Nato Advanced Study Institute, Aquafredda, Italië, 21-30 oktober: M.J.W. Veldhuis, G.W. Kraay.

Najaarssymposium van de Werkgemeenschap CO₂-problematiek, Utrecht, 22-23 oktober: P. van der Wal.

IOC, international WOCE Panel, Parijs, 22-25 oktober: L. Otto.

International Wadden Sea Symposium, Ameland, 22-26 oktober: J.J. Beukema, G.C. Cadée.

Symposium 'Long-term assays en het carcinogenenbeleid', RIVM, Bilthoven, 1 november: J.M. Everaarts.

International Workshop on Cohesive Sediments, Brussel: 5-7 november: D. Eisma.

2nd Workshop on Palaeoenvironments, Heerlen, 8 November: G.C. Cadée.

Evolution of the Guianas and Southern Caribbean Coastal Areas during the Quaternary. ORSTOM, Cayenne, Frans Guiana, 9-14 november: D. Eisma.

Annual Meeting of the International Society for Reef Studies, Noumea, Nieuw Caledonië, 14-19 november: R.P.M. Bak.

Workshop Suspended matter in estuaries, Hamburg, 19-21 november: D. Eisma.

International Flatfish Symposium NIOZ, Texel, 19-23 november: M.J.N. Bergman, M. Fonds, F. Hovenkamp, P. Kamermans, B.R. Kuipers, H.W. van der Veer, J.I.J. Witte.

Round Table discussion between Canadian and Dutch parliamentarians on the ecology effect of fisheries, Den Haag, 20 november: H.J. Lindeboom.

4th Workshop Sorption and Bioavailability, Bilthoven, 23 november: K. Booij.

JGOFS North Atlantic Pilot Study Symposium, Washington D.C., 26-29 november: H.J.W. de Baar, W. Helder, W.G. Mook, M.H.C. Stoll, M.W.J. Veldhuis.

C.E.C. Workshop Mediterranean Integrated Project, Brussel, 29 november: P.A.W.J. de Wilde.

Panel Meeting IAEA on Isotopes in atmospheric CO₂ and other trace gases, Wenen, 3-6 december: W.G. Mook.

20th International Ornithological Congress, Christchurch, New Zealand, 2-9 december: T. Piersma.

AGU Fall Meeting/Amasseds, San Francisco, USA, 3-7 december: D. Eisma.

Workshop 'Agrarwissenschaften' van de Deutsche Wissenschaftsrat, Berlijn en Rostock, BRD, 12-14 december: M. Fonds.

Consultative Meeting on Scientific Cooperation with the USSR, Bologna, Italië, 12-14 december: Tj.C.E. van Weering.

Meeting Southern Ocean Planning Group for JGOFS, British Antarctic Survey, Cambridge, Groot Brittannië, 13-15 december: C. Veth.

3.3. BESTUURSFUNCTIES

- E. van Abs
 - lid commissie zeegaand onderzoek Stichting Onderzoek der Zee (SOZ)
 - lid Overlegorgaan Faciliteiten Zeeonderzoek (OFZ)
- M.A. van Arkel
 - lid werkgroep Monitoring rond Mijnbouwininstallaties
- H.M. van Aken
 - lid Arctic Oceans Sciences Board
 - lid Working Group on Oceanic Hydrography ICES
 - lid Hydrographic Committee ICES
 - lid Scientific Steering Group Greenland Sea Project
 - lid beheersgroep CTD-systemen van SOZ
 - lid beheersgroep verankerde systemen van SOZ
- H.J.W. de Baar
 - voorzitter Wetenschappelijke Commissie voor Chemische Oceanografie NWO/SOZ
 - voorzitter werkgroep voor Joint Global Ocean Flux Study NWO/SOZ
 - docent Chemische Oceanografie, Instituut voor Aardwetenschappen, Vrije Universiteit, Amsterdam
 - lid programmeringscommissie Nationaal Onderzoeks Programma Mondiale Biosfeer
 - lid Scientific Program Committee 1990 JGOFS Symposium
 - lid internationale SCOR/JGOFS commissie
 - lid NWO DwarsverbandCommissie Verstoring van Aardsystemen
- M.A. Baars
 - coördinator BION-discussiegroep zoöplankton-FRIENDS
 - lid redactie Snellius II proceedings voor thema 3
 - lid Indische Oceaan Commissie
- R.P.M. Bak
 - bijzonder hoogleraar Tropische Mariene Biologie, Universiteit van Amsterdam
 - member Coral Reef Committee International Association of Biological Oceanography
 - bestuurslid werkgroep Biologisch Aardwetenschappelijk Onderzoek Tropen
 - lid redactieraad Marine Ecology Progress Series
 - lid redactieraad Coral Reefs
 - adviseur wetenschappelijke studiekring Nederlandse Antillen
 - docent (ad-honorem) University of Puerto Rico
- J.W. Baretta
 - lid MAST-commissie on Modelling Coordination
 - lid MAST-commissie on Marine Data Requirements
 - coordinator ERSEM-project

- A.J. van Bennekom
- lid Antarctica-commissie SOZ
- lid Committee Flux de Matières dans l'Océan
- lid Working Group on Oceanic Hydrography ICES
- lid redactie Circumpolar Journal
- J.J. Beukema
- hoofdredacteur van het Netherlands Journal of Sea Research
- J.P. Boon
- lid wetenschappelijke commissie voor Chemische Oceanografie NWO/SOZ
- lid Marine Chemistry Working Group ICES
- lid Working Group on the Biological Effects of Contaminants ICES
- lid wetenschappelijke begeleidingscommissie van het project Stresspar. MT
- lid werkgroep Regeling lozing oliehoudende mengsels vanaf mijnbouwinstallaties op zee van de Commissie voor de Milieueffectrapportage
- lid Editorial Board The Science of the Total Environment
- K. Booij
- lid begeleidingscommissie onderzoek Mobiliteit microverontreinigingen Universiteit Utrecht
- G.C. Cadée
- lid commissie voor buitenlandse marien-biologische stations KNAW
- lid DORA commissie (diepzee opberging radioactief afval)
- lid redactie Snellius II proceedings voor thema 3
- advisor Hydrobiological Bulletin
- associate editor Ichnos
- lid advisory council International Bryozoology Association
- lid redactie Netherlands Journal of Sea Research
- G.C.A. Duineveld
- lid ICES Benthos Ecology Working Group
- F.C. van Duyl
- lid protozoën werkgroep
- D. Eisma
- hoogleraar Mariene Sedimentologie, Rijksuniversiteit Utrecht
- lid wetenschapscommissie Laboratorium voor Sedimentologie en Milieuonderzoek in Meren en Kustwateren, Nanjin, China
- lid working group on marine sediments in relation to pollution ICES
- lid projectgroep slibeigenschappen en coördinatiecommissie slib, Raad van Overleg fysisch oceanografisch onderzoek Noordzee
- lid commissie geologische wetenschappen, KNAW
- lid beheerscommissie NWO laboratorium Isotopengeologie
- lid Steering Committee EROS 2000 Program
- adviserend hoogleraar East China Normal University, Shanghai
- J.M. Everaarts
- lid contactgroep ecotoxicologie van de commissie TNO/CNB voor onderzoek inzake nevenwerkingen van bestrijdingsmiddelen
- lid projectgroep Biologische Toxicologie; BION werkgemeenschap Stofwisselingsfysiologie
- lid Working Group on biological effects of contaminants ICES
- M. Fonds
- lid Mariculture Committee ICES
- H.G. Fransz
- voorzitter BEON werkgroep voor 'remote sensing'
- lid commissie mariene biologie SOZ
- lid begeleidingscommissie STW-project flowcytometrie
- lid stuurgroep Joint Global Ocean Flux Study Nederland
- voorzitter werkgemeenschap Aquatische Oecologie BION
- lid SCOR/JGOFS werkgroep Modelling

- L. Gerringa
- lid NNI subcommissie Chemisch Onderzoek in het kader van bodemkwaliteit
- lid NNI werkgroep Monsterneming in het kader van bodemkwaliteit
- W. Helder
- lid Commissie Chemische Oceanografie SOZ
- voorzitter Nederlandse Oceanografen Club
- lid committee on Marine Environmental Quality (ICES)
- lid Working Group on Marine Chemistry (ICES)
- voorzitter beheersgroep auto-analysers (SOZ)
- lid International JGOFS Task Team on Benthic Processes
- R.P. Heyman
- secretaris Stichting ter Bevordering Nederlandse Oceanografie
- J. van Iperen
- bestuurslid Nederlands-Vlaamse Kring van Diatomisten
- redakteur van het verenigingstijdschrift Diatomedelingen
- J.H.F. Jansen
- penningmeester Sedimentologische Kring, Koninklijk Nederlands Geologisch Mijnbouwkundig Genootschap
- bestuurslid AWON werkgemeenschap, Stratigrafie, Sedimentologie en Paleontologie
- W.C.M. Klein Breteler
- voorzitter/secretaris BION-discussiegroep Zoöplankton-FRIENDS
- M. Leopold
- bestuurslid Nederlandse Zeevogelgroep
- H.J. Lindeboom
- lid Commissie voor Milieueffectrapportage
- lid stuurgroep SEDEX
- lid coördinatiegroep ecologie Noordzee en Waddenzee
- lid commissie mariene biologie SOZ
- geëticteerde Hogeschool 'Noorderhaaks' studierichting milieu
- lid MER-werkgroep nieuwbouw Alde-Delfzijl
- lid MER-werkgroep gaspijpleiding door de Waddenzee
- lid redactie NSTF 'sub-regional assessments'
- G. Marees
- lid werkgroep Optische Remote Sensing Water (ORWA)
- J. van der Meer
- lid Working Group on the statistical aspects of trend monitoring (ICES)
- W.G. Mook
- hoogleraar Isotopen-Fysica, Rijksuniversiteit Groningen
- hoogleraar Toepassingen van isotopen in de exogene aardwetenschappen, Vrije Universiteit, Amsterdam
- lid klimaatcommissie KNAW
- lid Sectie Aardwetenschappen KNAW
- lid commissie van de Geologische Wetenschappen
- lid Academie Raad voor de Aardwetenschappen (KNAW)
- lid INQUA-commissie KNAW
- lid MAB/SCOPE/IGBP commissie (KNAW)
- lid bestuur Stichting Onderzoek der Zee (NWO)
- lid Programmacommissie CO₂ werkgemeenschap (NWO)
- lid Wetenschappelijk Begeleidingscommissie Mariene Biologie RUG
- voorzitter Curatorium van het Centrum voor Isotopen Geologisch Onderzoek, Vrije Universiteit Amsterdam
- lid PACT-commissie Raad van Europa
- lid Scientific Committee European Univ. Centre for the Cultural Heritage, Council of Europe at Ravella, Italy
- Coordinator International Association of ¹⁴C Laboratories
- lid Scientific Steering Committee IGBP core project PAGES
- Associate Editor Radiocarbon

- M. Mulder
- lid werkgroep Monitoring rond Mijnbouwinstallaties
- L. Otto
- lid Hydrography Committee ICES
- lid Working group on Shelf Seas Hydrography ICES
- lid European Science Foundation, Committee for WOCE
- lid Commissie voor Fysische Oceanografie SOZ
- lid Programmaraad Werkgemeenschap MFO-NWO
- nominated member SCOR
- lid IOC Technical committee on ocean processes and climate
- voorzitter WOCE werkgroep
- voorzitter IOC/WMD Intergovernmental WOCE Panel
- T. Piersma
- vice-chairman of the international Wader Study Group
- lid Grebe Specialist Group of the International Waterfowl and Wetland Research Bureau and the International Council for Bird Preservation
- lid ad-hoc redactiecommissie van de Banc d'Arguin-special van Ardea (wetenschappelijk ornithologisch tijdschrift NOU)
- W. van Raaphorst
- lid begeleidingscommissie Kwantitatieve aspecten van uitwisseling en diffusieprocessen van fosforverbindingen over het grensvlak sediment-water in de Loosdrechtse Plassen (Limnologisch Instituut, Nieuwersluis)
- lid begeleidingscommissie Vastlegging van fosfaat in sedimenten (DBW/RIZA, Lelystad)
- lid organisatie 3rd International Workshop on Phosphorus in Sediments, 1991
- R. Riegman
- secretaris BION WGM Aquatische Oecologie
- voorzitter Kontaktgroep Algenfysiologie (KAFEE)
- M.J. Rietveld
- lid Directeuren Overleg Beleidsgericht Ecologisch Onderzoek Noordzee/Waddenzee (BEON)
- D.H. Spaargaren
- secretaris commissie voor buitenlandse marien-biologische stations KNAW
- lid Council of Europe Working Group on Chemical Evolution, Early Biological Evolution and Exobiology, Strassbourg
- lid Groupement pour l'Avancement de la Biochimie Marine, Gif/Yvette, Frankrijk
- lid Society for Experimental Biology, London
- C. Swennen
- lid Stork specialist Group, ICBP
- lid jury Heimans & Thyse prijs
- lid werkgroep bijlage VEG-vogelrichtlijn
- lid Nederlandse sectie International Council of Bird Preservation (ICBP)
- lid nationaal kontaktpersoon sea duck branch, International Waterfowl Research Bureau (IWRB)
- H.W. van der Veer
- lid Organizing Committee First International Symposium on Flatfish Ecology, Texel
- lid Editorial Board of Netherlands Journal of Sea Research of the Proceedings of the First International Symposium on Flatfish
- lid Organizing Committee 6th International Conference of Coelenterate Biology, Noordwijk, 1993
- lid Working Group on Larval Fish Ecology ICES
- C. Veth
- lid coördinatiegroep WST van de Raad van Overleg voor het fysisch oceanografisch onderzoek van de Noordzee
- corresponding member of SCOR working group 69 (small-scale oceanic turbulence)
- lid programmaraad van de werkgemeenschap MFO-NWO
- lid gebruikersgroep van laser-doppler snelheidsmeettechniek

- lid Commissie voor Fysische Oceanografie SOZ
- lid Raad van Overleg voor het fysisch oceanografisch onderzoek van de Noordzee
- lid EPOS management group
- lid European Science Foundation's WOCE Committee's group of experts on calibrations
- lid Southern Ocean Planning Group for JGOFS
- voorzitter Beheersgroep CTD-systemen SOZ
J.H. Vosjan
- lid redactie NIOZ encyclopedie
- docent Vrije Universiteit Brussel, België
T.C.E. van Weering
- lid beheersgroep OPI van SOZ
- lid Indische Oceaan Commissie van SOZ voor planning programma 1991/1992
- lid werkgroep Bodem van de Raad van Overleg voor het Fysisch en Oceanografisch Onderzoek van de Noordzee
- lid redactiecommissie Snellius II proceedings voor thema 1
- gastdocent Mariene Geologische Methodes, Instituut voor Aardwetenschappen, Vrije Universiteit, Amsterdam
- lid ad-hoc commissie Nieuwbouw Noordzee vaartuig NIOZ
- alternate member ODP panel for West Pacific (WESTPAC)
- secretaris Ned. Oceanografen Club
P.A.W.J. de Wilde
- lid Nederlandse commissie voor internationale natuurbescherming
- lid stuurgroep/projectgroep SEDEX
- lid natuurbeschermingsraad, Ministerie voor Landbouw en Visserij
- lid North Sea Benthos Ecology Working Group, ICES
- lid Euromar Mesocosm Working Group
- lid SCOR working group 85, mesocosms
- lid Biological Oceanography Committee, ICES
P. de Wolf
- lid voorlopige commissie voor de milieueffectrapportage
J.T.F. Zimmerman
- hoogleraar Fysische Oceanografie, Rijksuniversiteit Utrecht
- lid redactie Netherlands Journal of Sea Research
- lid redaktieraad Continental Shelf Research
- IAPSO vertegenwoordiger nationaal UGGI comité
- lid van de subcommissie mariene geodesie van de RCG
- correspondent van Natuur en Techniek
- lid Commissie voor Milieueffectrapportage
- lid Nederlandse Commissie van Geodesie (KNAW)

3.4. STUDENTENONDERZOEK

T. Arp	VU Amsterdam	H3-06
O. Bokhove	TU Delft	H2-02
D. Bokma	RU Utrecht	H2-12
S. van den Brenk	VU Amsterdam	H2-07
C.P.D. Brussaard	RU Groningen	H3-13
N. Cadée	RU Leiden	B3-08b
A. Dekinga	van Hall Instituut, Groningen	B3-08b
M. Dekker	Hogeschool Alkmaar	H1-06
N. Fokma	Univ. Amsterdam	BEWON
G.J. Gast	Univ. Amsterdam	B1-06
H. de Haas	RU Utrecht	H3-02.1
B. Hondeveld	Univ. Amsterdam	B1-06/BEWON
R.J. van Hoogstraten	Hogeschool Alkmaar	H1-15
E. Huisman	Hogeschool Oost Nederland	BEWON
H.J. Huitema	RU Groningen	B3-03
S. Hulscher	RU Utrecht	H2-09
W. Kalsbeek	Hogeschool Oost Nederland	BEWON
H. Killich	LU Wageningen	BEWON
A. Koolhaas	van Hall Instituut, Groningen	B3-08b
A. Koopmans	Hogeschool Alkmaar	H1-09
V. Langeberg	Univ. Amsterdam	B1-05
J. Leloux	RU Utrecht	H3-13
E. van der Lubbe	Univ. Amsterdam	B1-05
A. Otten	Hogeschool Alkmaar	H1-15
P. Paffen	Univ. Amsterdam	B1-05
H.P.M. van der Pas	Hogeschool Oost Nederland	BEWON
M. Poot	RU Utrecht	B3-08b
M. Prins	RU Utrecht	H3-10
B. Roele	RU Utrecht	B3-08b
A. Rowe	Polytechnics, Hatfield, U.K.	BEWON
J. Samuels	Moller Instituut, Tilburg	B3-08b
S. van de Sant	KU Nijmegen	B3-08a
A. Scheele	Bakhuis Roozeboom Inst., Beverwijk	B3-08b
I. Schweimler	Universität Braunschweig BDR	BEWON
M. Snelders	Univ. Amsterdam	B1-05
T. Tahey	KU Nijmegen	B1-06
I. Tulp	RU Utrecht	B3-08b
Y. Verkuil	RU Utrecht	B3-08b
A. van der Wal	VU Amsterdam	H3-07
P. Wiersma	RU Groningen	B3-08b
O. Wijker	Bakhuis Roozeboom Inst., Beverwijk	B3-03/B1

3.5. CURSUSSEN, VERGADERINGEN EN EXCURSIES

3.5.1. NIOZ cursussen

De cursus 'Inleiding in de Oceanologie' werd gegeven van 5 februari tot 2 maart. Er waren 30 deelnemers, van wie het grootste deel afkomstig was van de RU Groningen. Deze cursus is een onderdeel van het tweede jaars curriculum mariene biologie in Groningen, waarvan het college van 5 tot 9 februari gegeven werd en het praktische gedeelte van 12 tot 23 februari plaats vond op het NIOZ. 55 medewerkers waren min of meer bij deze cursus betrokken. Twee vaardagen werden met de onderzoekschepen 'Navicula' en 'Aurelia' uitgevoerd.

De NIOZ-cursus 'Mariene Oecosystemen' omvatte dit jaar wederom een week van colleges op het Biologisch Centrum te Haren (5 t/m 8 juni), twee weken praktisch werk op het NIOZ (11 t/m 22 juni) en een week studietijd, waarna op 29 juni het schriftelijk tentamen volgde. In verband met de afwezigheid van P. de Wilde (JGOFs-vaartocht) werden de colleges verzorgd door Beukema (2 ochtenden), Riegman (1 middag), Kuipers (1 1/2 dag) en Fransz (1 dag), die ook de tentamenvragen opstelden, en de antwoorden naketen.

Aan de cursus namen dit jaar 23 studenten deel, uit Groningen (waaronder 2 uit Oldenburg), Wageningen, Leiden en het NIOZ. De tentamens en de cursusverslagen werden i.h.a. goed gemaakt, behoudens in enkele gevallen waar bleek, dat de cursus in zijn huidige vorm niet zonder een redelijke voorkennis van mariene biologie gevolgd kan worden.

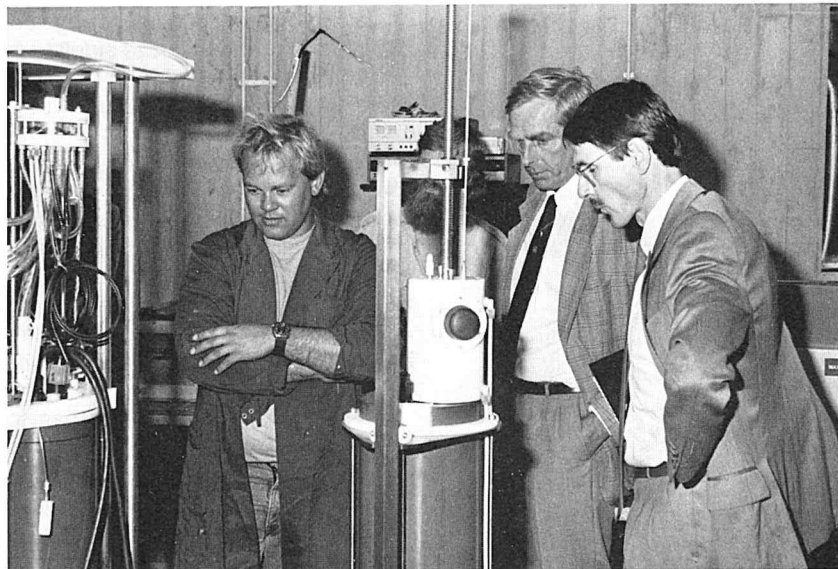
Op 14 november werd in Haren een nabespreking gehouden, waar duidelijk werd, dat dit jaar vooral de colleges nogal wat herhaling bevatten van reeds in Groningen behandelde stof. Er wordt gewerkt aan een nieuwe taakverdeling binnen de gezamenlijke blokken Mariene Biologie (8 weken) en Mariene Oecosystemen (4 weken), waarin het NIOZ voortaan de nadruk zou moeten leggen op het behandelen van structuur en functioneren van allerlei typen mariene oecosystemen die in de wereldzeeën worden aangetroffen.

3.5.2. Andere cursussen gehouden op NIOZ

8-10 januari	ERSEM-workshop
10 januari	Bijeenkomst werkgroep Optische Remote Sensing Water
26-27 februari	Verwey-dagen 1990; landelijke AIO-bijeenkomst Mariene Biologie
12 april	Cursus Mariene Oecologie VU, Amsterdam
16-21 april	Vaarcursus studenten Mariene Geologie VU
11 mei	Meeting Werkgroep Radon
14-15 mei	MAST-modelling coordination meeting
6-8 Juni	INP-workshop (Integrated North Sea Programme)
26 juni	Zaire-workshop
14 september	DGW/RWS Symposium North Sea Pollution

3.5.3. Ontvangen gezelschappen van aanverwante instituten, overheidsdiensten, e.d.

23 januari	Bewoners Jellinekcentrum, Texel
25 januari	School voor Lager Beroepsonderwijs, Texel
23 februari	Biologiestudenten, Freiburg
26 maart	Prof. H.C. van Hall Instituut, Groningen
20 april	Studenten Open Universiteit, Alkmaar
26 april	Rupprecht Gymnasium, München
7 mei	Studenten Natuur- en Sterrenkunde, Amsterdam
8 mei	Strijboschool, de Cocksdorp
11 mei	Studenten Natuurkunde, Utrecht
23 mei	C.V.O.-school, Den Burg
9 juni	NIVON, Den Helder
15 augustus	Minister van Onderwijs en Wetenschappen
5 september	Kottenpark College, Enschede
7 september	Commissie MER
11 september	Bestuur Gemeente Assen
14 september	Deelnemers North Sea Pollution Conference
25 september	Studenten Biologie, Braunschweig
28 september	AKZO, Sassenheim
28 september	Ver. van Noord-Hollandse Aannemers
1 oktober	Gymnasium am Wilteltor, Düren
5 oktober	Ned. Ver. van Baggeraars
10 oktober	Studenten Biologie, Zwitserland
11 oktober	Pedagogische Akademie, Sittard
30 november	Studenten Wageningen
21 december	Personeel Sociale Werkplaats, Den Burg



Tijdens zijn bezoek aan het NIOZ toonde de minister van Onderwijs en Wetenschappen, Dr. Ir. J.M.M. Ritzzen, veel belangstelling voor de instrumenten van het instituut waaronder de opstelling van de PCB extractor ontworpen en gemaakt door M.Th.J. Hillebrand en J. van Heerwaarden. (foto: NIOZ)

4. Hulpafdelingen

4.1. ALGEMEEN

Door de technische hulpafdelingen is dit jaar veel tijd en mankracht besteed aan onderhoud, ontwikkeling, innovatie en renovatie van het wetenschappelijk instrumentarium, SOZ-pool-apparatuur, technische installaties binnen de gebouwen, het in aanbouw zijnde Noordzee-onderzoekschip en de toekomstige uitbreiding van de haven.

Voor de oceaanexpedities met het ondezoekschip 'Tyro' zijn voorbereidende werkzaamheden en transporten verricht. Tijdens de expedities werd technische assistentie verleend.

De vacature, ontstaan door het vertrek van een 'varende' electronicus, werd ingevuld. Een nieuwe 'varende' medewerker werd aangetrokken voor de constructieafdeling. Deze zal zich ondermeer specialiseren in onderhoud en ontwikkeling van bodembemonsteringapparatuur.

4.2. TECHNISCHE HULPAFDELINGEN

Ontwikkelingen.—Voor de afdeling Bentische systemen is de z.g. bentische bodemlander, waarvan de ontwikkeling vorig jaar werd gestart, tijdens expedities met de 'Tyro' een viertal keren beproefd op dieptes van zo'n 4500 meter. Op deze diepte bleek het hydraulische besturingssysteem nog niet optimaal te functioneren. Proeven in een hoge-druktank bij de RUU toonden een onvoorziene drukafname in dit hydraulische systeem; aan dit probleem wordt druk gewerkt. Binnenkort wordt voor deze afdeling gestart met de bouw van een sedimentval.

Voor de afdeling Fysische Oceanografie is een begin gemaakt met de vervaardiging van een lichtmeter, de z.g. Transmisso-Advanced-Spectral-Irradiance meter (TRASIR).

Een voor de afdeling Pelagische Systemen bestemd Particle Control systeem kon worden gerealiseerd. In een proefopstelling op het laboratorium zijn een reeks van testprogramma's uitgevoerd om de apparatuur te optimaliseren.

Voor de afdeling Chemische Oceanografie is een microcomputer gestuurde micromanipulator vervaardigd, waarmee microelectrodes op nauwkeurige wijze in sediment gedreven kunnen worden.

Voor de afdeling Geologie is een nieuwe streamer-lier op het NIOZ gebouwd. Binnenkort wordt gestart met de bouw van een bodemlander voor deze afdeling.

Voor het project 'bepaling organische stikstof in zeewater' is in samenwerking met de Universiteit van Toulon en het DIHO een nieuw reactievat gemaakt. De resultaten zijn bemoedigend.

Een intensief gebruik van het Winkler-titrator-systeem, dat enkele jaren geleden met behulp van een eenvoudige microcomputer was geautomatiseerd diende gekoppeld te worden aan een moderne P.C. De bruikbaarheid van het systeem is op deze wijze, vooral vanwege de mogelijkheid van grafische presentatie, sterk verbeterd.

Aan de reeds eerder vervaardigde depth digitizer zijn enkele verbeteringen aangebracht.

Aan de Neil Brown C.T.D.'s zullen na een periode van intensief gebruik diverse modificaties moeten worden aangebracht.

Oceaanprogramma.—Ter voorbereiding en na afloop van de tussen maart en augustus 1990 gevaren expedities met het onderzoekschip 'Tyro' is het nodige onderhoud gepleegd aan de apparatuur en de gecontaineriseerde laboratoria en hulpcontainers. Voorbereidingen werden getroffen voor het ophalen, reviseren, en uitzetten van een aantal verankerde meetsystemen.

Onder toezicht van het NIOZ werd een C-container bestemd voor het werken met isotopen voor de SOZ gebouwd. Een container bestemd voor data-acquisitie-apparatuur werd voor het SOZ op het NIOZ aangeleverd.

Voor de aanvang van de expedities is het dek van 'Tyro' gegritstraald en geschilderd. Voor het vertrek werd een testdag ingelast om mankementen aan apparatuur op te kunnen sporen, waardoor de werking hiervan voor aanvang van de programma's redelijk zeker kon worden gesteld.

Technisch gezien zijn de programma's zeer voorspoedig verlopen mede dank zij de inzet van een tiental NIOZ- en twee RGD-technici, die bij toerbeurt bij de expedities betrokken zijn geweest.

Een viertal verankerde systemen voor het DUTCH-WARP-programma en één voor voor het JGOFs-programma zijn uitgezet om in 1991 weer geborgen te worden.

Haven en vaartuigen.—De 'Aurelia' heeft dit jaar 165 vaardagen gemaakt, met 179 opstappers.

Tijdens een slechtweelperiode is een lekke luchtkoeler van de hoofdmotor vervangen. Voor het scharrenonderzoek zijn dit jaar meerdere vistochten gemaakt.

De 'Navicula' heeft dit jaar 181 vaardagen gemaakt met 632 opstappers.

In de zomer is de 'Navicula' lek gestoten op een onder water geparkeerde baggerleiding bij de Napoleondam.

De 'Griend' heeft 104 vaardagen gemaakt.

De fuikvisserij werd weer voortgezet; eind maart werd de vangopstelling met de komfuik weer geïnstalleerd bij de stuifdijk. Hierin werd een zeepaardje gevangen. Ten gevolge van kwallen, grote grote hoeveelheden groen en slecht weer moesten enkele vangsten worden onderbroken.

Aan de uitbreiding van de haven is het nodige in voorbereiding. De verwachting is dat op korte termijn met de bouw hiervan kan worden gestart.

Nieuwbouw Noordzee-onderzoekschip.—Na een lange aanloopfase waarin, tijdens vele bouwvergaderingen bij Verolme te Heusden, het schip vorm en inrichting kreeg, werd in juli gestart met de bouw. Op 28 augustus werd de eerste sectie op de helling geplaatst. Inmiddels zijn alle secties in bewerking en zijn vrijwel alle machines en hulpwerktuigen in productie of gereed gekomen, afgenomen en bij de werf afgeleverd. Voor het einde van het jaar zullen zo veel mogelijk werktuigen in de secties worden geplaatst waarna deze op de helling aan elkaar worden gelast tot een geheel schip. Ten behoeve van de automatisering aan boord is een plan voor een z.g. universeel bekabelingssysteem uitgewerkt. Er is onderzoek gedaan naar de geschiktheid van diverse datanetwerken en acquisitiesystemen. In dit kader zijn contacten gelegd met Research Vessel Services van de National Environment Research Council in Engeland. Het nieuwe schip, dat de naam 'Pelagia' zal dragen, wordt in januari 1991 te water gelaten.

Magazijn, transport en inventarisbeheer.—Er zijn diverse administratieve wijzigingen doorgevoerd die moeten leiden tot een effectiever magazijn- en inventarisbeheer. Het magazijn bevat ca. 1500 verbruiks-artikelen er wordt jaarlijks voor ca. f 200.000,- omgezet. Naast ca. 2000 ontvangen zendingen voor de diverse instituutsafdelingen werden ca. 200 verzendingen ingepakt en transportklaar gemaakt, welke daarna grotendeels door de eigen transportdienst zijn vervoerd.

Een gewijzigd beheersysteem voor kapitaalgoederen met daarbij behorende codering, moet op termijn leiden tot een eenvoudiger administratie bij het inschepen voor vaartochten en bij verzending van deze goederen naar het buitenland met de daarbij behorende in- en uitklaringsadministratie t.b.v. de douane.

Gebouwen en installaties.—Door de technische hulpafdelingen is veel tijd besteed aan het verbeteren en in stand houden van de gebouwen en installaties.

In het aquariumgebouw werd de vorig jaar gestarte inrichting van de algenkweekklimaatkamers voor de BEWON- groep afgerond en officieel in gebruik genomen. Voor de afdeling Pelagische Systemen werden de oude, in verval zijnde algenkweekklimaatkamers gesloopt en vervangen door nieuwe. In de Noordzee-bakken werden diverse aanpassingen bewerkstelligd voor nieuw onderzoek. De oude telefooninstallatie werd na veel voorbereidend werk vervangen door een moderne doorkiesinstallatie.

Ten behoeve van een op termijn aan te leggen datanetwerk werd een onderzoek gestart naar de geschiktheid van verschillende netwerksystemen. Voor de persluchtvoorziening in het gebouw werd een nieuwe, grotere vriesluchtdroger geïnstalleerd, wegens ontstane ondercapaciteit van de bestaande droger. In het gasstation werden een drietal schakelautomaten voor stikstof en helium vernieuwd. Ten behoeve van de verwarming en luchtverversing zijn drie warmtewisselaars vernieuwd. Ter optimalisering van de verwarmingsinstallatie zijn drie extra expansievaten geïnstalleerd. De woning van de havenmeester werd van een nieuwe gasgestookte c.v.-ketel voorzien. In het logeergebouw 'In den Potvis' werd de warm-waterboiler vervangen. In de kantine van het instituut en in de keuken van de 'Potvis' werden nieuwe vaatwasmachines geïnstalleerd. Rond het aquariumgebouw werd een bestrating aangelegd, waardoor containeropslag aldaar mogelijk werd. De windgenerator heeft dit jaar zo'n 126.300 kWh bijgedragen aan de stroomvoorziening van het instituut.

Alle afdelingen hebben een bijdrage geleverd aan het welslagen van de op 14 oktober gehouden 'open dag van de wetenschap'. Gezien de massale belangstelling die de ondersteunende afdelingen genoten werd het ook hun open dag.

4.3. ADMINISTRATIEVE HULPAFDELINGEN

Algemeen.—De aanpassingen van de administratieve organisatie met betrekking tot het verwerven van goederen en diensten, inventarisbeheer en inrichting-begroting zijn met ingang van dit jaar ingevoerd. Dit jaar is met het bestuur gesproken over een herindeling van de administratieve hulpafdelingen onder de nieuwe direktiestructuur, hetgeen op 1 januari 1991 leidt tot het onderbrengen van de afdelingen: bibliotheek, redactie, rekencentrum, reprografie, audiovisuele afdeling en afdeling studiemateriaal bij de directeur algemene zaken terwijl de huishoudelijke dienst, de administratie, de receptie alsmede het logeergebouw bij de technisch financieel directeur blijven.

Bibliotheek.—Er werden 128 boeken aangeschaft en 5 atlassen. Het tijdschriftenbestand is per 1 januari 1990 uitgebreid met de volgende tijdschriften:

Chemical Speciation and Bioavailability 1(1),-
Journal of Marine Systems 1(1/2),-

Ruil:

Annual Report National Environmental Research Inst., Denmark, 1989,-
Jaarverslag Biologisch Station Wijster, Centrum voor Bodemecologie, 1988/1989,-

Umwelt Bundesamt: Jahresbericht 1988,-; Texte, 6/87,-
Zeitschrift für Geologische Wissenschaften Band 18(1) 1990,-

Uit de nalatenschap van de vorige directeur Professor Dr. J.J. Zijlstra ontving de bibliotheek een aantal boeken en publicaties, die intussen in de bibliotheek zijn opgenomen.

Redactie.—zie 2.1.1.

Reprografische afdeling.—In dit verslagjaar is door de repro-afdeling naast de gangbare opdrachten, veel tekenwerk verricht ten behoeve van een aantal Noordzee en Snellius uitgaven van het Netherlands Journal of Sea Research. De afdeling verleende haar medewerking bij de totstandkoming van een aantal exposities, o.a. Noordzee conferentie en Wetenschapsdag 1990.

De in 1989 aangeschafte ACAD-tekencomputer wordt steeds vaker gebruikt bij bepaalde onderdelen van het tekenwerk en het systeem is inmiddels uitgebreid met een inktjetprinter.

Ook is er een begin gemaakt met het vervangen van de verouderde expositieborden. De eerste nieuwe zelfgemaakte borden waren gebruikt bij de Wetenschapsdag 1990.

Administratie.—Eind 1989 heeft een extern bureau de administratieve organisatie doorgelicht en een aantal aanbevelingen gedaan. Deze zijn in samenwerking met een externe administratieve organisatie-deskundige gedeeltelijk doorgevoerd.

In overleg met N.W.O. is een nieuwe opzet van de begroting gemaakt. Ook in overleg met N.W.O. is het accountantsbureau N.B.C. gekozen voor de controle van de jaarrekeningen.

Huishoudelijke dienst/Logeergebouw 'In den Potvis'.—Begin 1990 werd er een nieuwe afwasmachine in de kantine geplaatst. Gelet op het toenemend aantal bezoekers dat van de diensten van de kantine gebruik maakt, kan gesteld worden dat de aanschaf van deze machine geen overbodige luxe was en zeker ten goede kwam aan de werkomstandigheden.

Veel werk werd verricht tijdens het in november georganiseerde 'Flatfish Symposium'. Aan de behoeften van de inwendige mens werd zeker niet voorbijgegaan en dit werd dan ook door een ieder zichtbaar gewaardeerd.

De bezetting van het logeergebouw was, evenals in 1989, vrijwel constant volledig. Overwogen werd om in het vervolg alleen maar huisvesting te bieden aan O.I.O. en studenten. Het toewijzingsbeleid ten aanzien van de 'beter betaalden' zal dan ook kritischer worden.



(foto: H. Höbbelink)

Biologisch Studiemateriaal.—De afdeling Studiemateriaal, gevestigd in de Petotjo-loods aan het Nieuwe Diep in Den Helder, leverde evenals voorgaande jaren levend en gefixeerd materiaal aan universitaire laboratoria, scholen en educatieve instellingen. Ondanks een groot gebrek aan doornhaaien — er is per 1-11-1990 een wachtlijst van 648 stuks — gingen er ca. 10 000 gefixeerde en 20 000 levende zeedieren de deur uit. In juni werd de afdeling verzocht onderdak te geven aan een vijftal *Raja clavata* (Stekelrog) van het Dolfinarium Harderwijk, welke deel uitmaakten van het in aanbouw zijnde 'Roggenrif'. Vier van de roggen zijn medio augustus handtam naar het Dolfinarium retour gegaan.

Technisch kregen we in 1990 enige tegenslagen te verwerken, zo waren we genoodzaakt de twee-cylinder compressor te vervangen, de verdamper van beide diepvriescellen grondig schoon te maken en de Opel-combi, vanwege aanrijding, te laten repareren.

Eind oktober is een aanvang gemaakt met een inpandige verbouwing ten behoeve van de afwerking van de Noordzeefilm.



Het gebouw van de afdeling studiemateriaal in Den Helder.

(foto: H. Höbbelink)

5. Sociaal jaarverslag

5.1. ALGEMEEN

In veel opzichten is 1990 een nieuwe start. In de eerste plaats vanwege de overgang van het instituut van de Nederlandse Dierkundige Vereniging (NDV) naar de Stichting NIOZ die door de Nederlandse Organisatie voor Wetenschappelijk Onderzoek (NWO) is erkend. Ook de completering van het directieteam houdt een nieuwe start in.

De overgang naar NWO is in goede harmonie en zonder problemen verlopen. De vergaderingen in het kader van het werkgeversoverleg en het georganiseerd overleg werden bijgewoond. Daarnaast is frequent overleg geweest dat diverse afdelingen van NWO betreffende financiële zaken, indeling begroting en jaarverslag, accountantscontrole, juridische aangelegenheden, personeelszaken en voorlichtingsaangelegenheden.

5.2. BEHEER

De overdracht van de onroerende goederen heeft formeel nog niet plaatsgevonden. De stagnatie ligt in de beslissing over de overdrachtsbelasting. De verwachting is dat e.e.a. begin 1991 afgerond kan worden.

Bestuur Stichting NIOZ (per 1-12-1990)

Voorzitter:

Prof. Dr. J.A. Battjes

Afd. Civiele Techniek, Technische Universiteit Delft

Secretaris/Penningmeester:

Ktz b.d. Th.G. Loeber

Hilversum

Prof. Dr. J.G. Kuenen

Vakgroep Microbiologie en Enzymologie, Technische Universiteit Delft

Vacature

Wetenschapcommissie NIOZ (per 1-12-1990)

Voorzitter:

Prof. Dr. J.E. van Hinte

Instituut voor Aardwetenschappen Vrije Universiteit, Amsterdam

Prof. Dr. B.L. Bayne

Plymouth Marine Laboratory, Plymouth, U.K.

Prof. Dr. R.H. Drent

Zoölogisch Laboratorium Rijksuniversiteit Groningen, Haren

Prof. Dr. J.C. Duinker

Institut für Meereskunde, Universität Kiel, Kiel, BRD

Prof. Dr. C.H.R. Heip

Delta Instituut voor Hydrobiologisch Onderzoek, Yerseke

Prof. Dr. W.P.M. de Ruyter

Buys Ballot Laboratorium Rijksuniversiteit Utrecht, Utrecht

Prof. Dr. V. Smetacek

Alfred-Wegener-Institut für Polar- und Meeresforschung, Bremerhaven, BRD

Prof. Dr. W.J. Wolff

Rijksinstituut voor Natuurbeheer, Leersum

5.3. WERKOVERLEG

In 1990 is 7 keer overleg gevoerd met de Ondernemingsraad, terwijl 1 keer is vergaderd met directie en een delegatie van het stichtingsbestuur. Belangrijke aandachtspunten waren het completeren van het arbeidsvoorwaardenreglement met een aantal uitvoeringsregelingen en functiebeschrijvingen.

5.4. PERSONEELSBELEID

Bevorderingen

In 1990 werden onderstaande personen bevorderd:

J.W. Baretta	BEWON
J.J. Blom	Werktuigbouw
A. Keyser	Administratie
W.C.M. Klein-Breteler	Pelagische Systemen
W. Koomen	Haven en vaartuigen
N. Krijgsman	Redactie
G.M. Manshanden	Electronica
R.F. Nolting	Chem. Ocean. en Zeeverontr.
E. Pauptit	Benthische Systemen
W. Polman	Werktuigbouw
R. Rebel	Haven en vaartuigen
H. Ridderinkhof	Fysica
M.M. Spel	Administratie
J.C. Tuntelder	Haven en vaartuigen
H.J. Witte	Pelagische Systemen
J.M.M. Hin-Zoetelief	Receptie

Toelage ex. artikel 19:

E. van Abs	Directie
H.J.W. de Baar	Chem. Ocean. en Zeeverontr.

Functioneringstoelage

A.J. van Bennekom	Geologie
J. van Heerwaarden	Instrumentmakerij
M.T. Jourdan	Huishoudelijke dienst
H. Spigt	Huishoudelijke dienst

Gratificatie

J.C. Groot	Haven en vaartuigen
J.G.M. Hart-Stam	Directie

Extra periodieke verhoging(en)

R.P.M. Bak	Benthische Systemen
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Mutaties In dienst

E. Flach	O.I.O.	Kustsystemen	01-01
A. de Graaf	reprografisch ass.	Reprografie	01-01
E. Ufkes	O.I.O.	Geologie	01-03
R.X. de Koster	data-analist	Fysica	01-03
W.G. Mook	wet. hfd. directeur	Directie	01-04
J.D.L. Bleijswijk			
Tierens Verhagen	O.I.O.	Pelagische Systemen	01-04
A. Kop	1 ^e lab. assistent	BEWON	01-08
W. Stolte	O.I.O.	Pelagische Systemen	01-08
H.M. Sleiderink	O.I.O.	Chem. Ocean. en Zeev.	01-09
B. Hondeveld	O.I.O.	Benthische Systemen	01-09
R. Witbaard	O.I.O.	Benthische Systemen	01-09
L. Lohse	O.I.O.	Chem. Ocean. en Zeev.	01-09
W.P. Eelman	matroos	Haven en vaartuigen	01-10
R. v.d. Toorn	O.I.O.	Fysica	01-11
A. Hillebrand-Kikkert	telefoniste	Receptie	01-12

Uit dienst

A. Cramer	promotie-assistente	Benthische Systemen	01-01
C. Westra	promotie-assistent	Chem. Ocean. en Zeev.	01-01
T. Schuhmacher	promotie-assistent	Geologie	01-01
L. Gerringa	promotie-assistente	Chem. Ocean. en Zeev.	01-03
A.A. Balk	matroos-motordr.	Haven en vaartuigen	01-10
R.P. Heyman	promotie-assistent	Benthische Systemen	01-03

5.5. PERSONEELSLIJST (per 31-12-1990)

Direktie:	Secretaresse:	Assistentie:
Wet. hfd. dir.: Prof. Dr. W.G. Mook	J.M.G. Hart-Stam	J.W. Rommets

Direkteur: Drs. M.J. Rietveld	J.W. Schröder- ter Avest	I.I.J. Witte
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Techn.- Adm. dir.: Ing. E. van Abs

Statisticus: Drs. J. v.d. Meer

Onderzoekafdelingen

afd. chemische oceanografie en
onderzoek zeeverontreiniging

onderzoeker:	Assistentie:
Dr. W. Helder	K.M.J. Bakker
Dr. Ir. H.J.W. de Baar	M.Th.J. Hillebrand
Dr. K. Booij	R.F. Nolting
Dr. J.M. Everaarts	H.T. Kloosterhuis
Drs. L. Lohse	R.T.P. de Vries
Drs. H.M. Sleiderink	

afd. fysische oceanografie

Drs. C. Veth	R.X. de Koster
Dr. H.M. van Aken	S. Ober
Dr. L.R.M. Maas	M.R. Wernand
Drs. R. v.d. Toorn	M.W. Manuels
Prof. Dr. J.T.F. Zimmerman	

afd. mariene geologie en geochemie

Prof. Dr. D. Eisma	G.W. Berger
Drs. A.J. van Bennekom	S.J. van der Gaast
Dr. J.H.F. Jansen	J. van Iperen
Drs. L. Moodley	J. Kalf
Drs. E. Ufkes	E. Okkels
Dr. Tj.C.E. van Weering	J. Schilling
Drs. Z. Zuo	

afd. benthische systemen

Dr. P.A.W.J. de Wilde	E.M. Berghuis
Prof. Dr. R.P.M. Bak	A. Kok
Drs. G.C. Duineveld	G. Nieuwland
Drs. B. Hondeveld	G. van Noort
Dr. J.H. Vosjan	E. Pauptit
Drs. R. Witbaard	

afd. pelagische systemen

Dr. Ir. H.G. Fransz	S.R. Gonzalez
Dr. M.A. Baars	G.W. Kraay
Dr. W.C.M. Klein Breteler	S.S. Oosterhuis
Dr. B.R. Kuipers	N. Schogt
Drs. W. Stolte	H.J. Witte
Dr. M.J.W. Veldhuis	
Drs. J.D.L. Bleijswijk Tierens Verhagen	

afd. kustsystemen

Dr. J.J. Beukema
Dr. G.C. Cadée
Drs. E. Flach
Dr. M. Fonds
Drs. P. Kamermans
Drs. M. Leopold
Dr. D.H. Spaargaren
C. Swennen

W. de Bruin
P. Duiven
J. Hegeman
P. van der Puy
J. Zuidewind

afd. Beleidsgericht Wetenschappelijk
Onderzoek NIOZ (BEWON)

Dr. H.J. Lindeboom
Drs. J.W. Baretta
Ir. M.J.N. Bergman
Dr. J.P. Boon
Dr. F.C. van Duyl
Dr. Ir. W. van Raaphorst
Dr. H. Ridderinkhof
Dr. R. Riegman
Drs. P. Ruardij
Dr. Ir. H.W. van der Veer

Drs. M.A. van Arkel
A.C. Bol-den Heijer
A. Kop
W. Lewis
J.F.P. Malschaert
M. Mulder
~~A. Kop~~

Rekencentrum

R. Dapper
F. Eijgenraam

Hulpafdelingen

Hoofd administratieve hulpafdelingen tevens personeelschef: P.C. Vooy

redactie

Dr. J.J. Beukema

B. Bak-Gade
J.P. Mulder-Starreveld
N. Krijgsman

bibliotheek

J. v.d. Wal-Doornekamp

M. Bruining-du Porto

administratie

vakature

I. Wernand-Godee
D.J. Bruin
A. Keijzer
M. Spel

reprografie

H. Hobbelink

R.P.D. Aggenbach
R. Nichols
B. Verschuur
A. de Graaf

telefoon/receptie

M. Zonnenberg

J.M.M. Hin-Zoetelief
A. Hillebrand-Kikkert

biologisch studiemateriaal (Den Helder)

J.M. Nieuwenhuizen

huishoudelijke dienst en
logeergebouw 'de Potvis'

G.H. Steenhuizen
H. Spigt

T. Steenhuizen-Borkulo
M.T. Jourdan

hoofd technische dienst

C. Bakker

werktuigbouwkunde

T. Buisman

S. Gieles
S.D. Groot
H.H. de Porto
F.J. Parlevliet

houtbewerking

L. Heerschap

R.M. Daalder

electrotechniek	F.J. Schilling		
magazijn	A. Ran	S.W. de Porto	J. Visser
instrumentmakerij/aquariumtechnische afdeling	H.J. Boekel	J. van Heerwaarden E. Keijzer T. Kuip	R. Lakeman A. Vaars
elektronica	Ing. R.L. Groenewegen	Ing. H. Franken G.M. Manshanden	M. Laan
haven en vaartuigen	C. van Zwieten C. Wisse C. Gerssen E. Adriaans W.P. Jongejan	R.J.R. Anthonijsz J.C. Groot W.J.M. Koomen W.P. Eelman	C.J. Mozes J. Pieterse R. Rebel J. Seepma A.J. Souwer J.C. Tuntelder

5.6. TIJDELIJKE PERSONELE ONDERSTEUNING

S.M. Jansen	analist	Chem. Ocean. en Zeever.	01-01 tot 01-06
K.M.J. Bakker	analist	Chem. Ocean. en zeever.	01-01 tot 01-07
W. Hart	assistent	Reprografie	01-01 tot 31-12
B. Koster	electronicus	Geologie/Electronica	01-01 tot 01-02 05-03 tot 05-08 15-09 tot 31-12
W.J. Kieskamp	wet. onderz.	Chem. Ocean en zeev.	01-01 tot 01-05
E. van Arnhem	analiste	BEWON	01-01 tot 23-10
A.M. Noordeloos	analiste	BEWON	01-07 tot 31-12
W.P. Eelman	matroos	Haven en vaartuigen	01-02 tot 01-10

Overplaatsing

	van:	naar:	per:
H.T. Kloosterhuis	BEWON	Chem. Ocean. en zeev.	01-05

Stagiaires

Het NIOZ stelt studenten, die in het kader van hun middelbare of hogere beroepsopleiding stage moeten volgen, in de gelegenheid praktische ervaring op te doen op het instituut. In sommige gevallen dient de stage-periode te worden afgesloten met een afstudeeropdracht. De volgende stagiaires waren tewerkgesteld:

E.N. Bakker	Energietechniek	MTS Alkmaar e.o.	01-01 tot 20-01
M. Driesprong	Energietechniek	MTS Alkmaar e.o.	22-01 tot 16-06
R. Klok	Electronica	MTS Alkmaar e.o.	01-01 tot 10-01
H.F. de Vet	Electronica	MTS Alkmaar e.o.	02-01 tot 16-06
T. Kater	Werktuigbouw	MTS Noorderhaaks	01-01 tot 02-03
D. Heerschap	Energietechniek	MTS Noorderhaaks	01-01 tot 13-01
D.W. Hogerveld	Energietechniek	MTS Noorderhaaks	14-01 tot 16-06
N. v. Heerwaarden	Electronica	MTS Noorderhaaks	01-01 tot 13-01
D. Deykers	Electronica	MTS Noorderhaaks	14-01 tot 16-06
J.J.M. Belgers	Benthische Syst.	Hogeschool Wag.	01-01 tot 15-02
A. Dekinga	Kustsystemen	Hogere Agr. School	01-01 tot 01-04
J.M.C v. Osch	Instrumentmakerij	KMBO	08-01 tot 23-03
O. Wijker	Kustsystemen	BRI	01-02 tot 01-07 01-08 tot 31-12
R.W. Bakker	Geologie	HTS Alkmaar	01-02 tot 01-07

J. v. Heukelom	Administratie	De Schalm	23-04 tot 14-06
M. Dekker	Chem. Ocean.	HLO Alkmaar	01-07 tot 31-12
E. Huisman	BEWON	Hogesch. Enschede	01-04 tot 01-07
H.P.M. v.d. Plas	BEWON	Hogesch. Enschede	01-04 tot 01-07
W. Kalsbeek	BEWON	Hogesch. Enschede	01-09 tot 31-12
E. Bosch	Energietechniek	MTS Noorderhaaks	13-08 tot 31-12
G.J. Drenth	Energietechniek	MTS Alkmaar e.o.	13-08 tot 31-12
R. Kortenhoeven	Werktuigbouw	MTS Noorderhaaks	13-08 tot 01-12
S.A de Groot	Electronica	MTS Noorderhaaks	13-08 tot 31-12
A.J.E. Otten	Chem. Ocean.	Hogesch. Alkmaar	21-08 tot 31-12
R.J. v. Hoogstraten	Chem. Ocean.	Hogesch. Alkmaar	21-08 tot 31-12
A.A. Scheele	Kustsystemen	BRI	01-09 tot 31-12

5.7. PROJECTEN/DETACHERINGEN

Het NIOZ verleent zijn medewerking aan de uitvoering van speciale projecten, bijv. ter onderbouwing of uitvoering van het beleid van overheden en van het bedrijfsleven. Het stelt hiervoor ruimte en wetenschappelijke kennis ter beschikking. In principe worden slechts projecten aangenomen die samenhangen met of nauw aansluiten bij de taak van het instituut. De looptijd van de projecten varieert van enkele maanden tot vele jaren. Het personeel voor deze projecten wordt op kosten van de opdrachtgever op tijdelijke basis aangesteld. Het NIOZ-personeel dat de eigenlijke taak van het instituut —fundamenteel onderzoek— uitvoert, is hierbij slechts in een adviserende rol betrokken. Er waren de volgende speciale projecten:

Remote sensing (RWS - BCRS)			
Dr. G. Marees	wetenschappelijk onderzoeker		01-01 tot 31-12
Drs. T.F. de Bruin	wetenschappelijk onderzoeker		01-10 tot 31-12
RENA			
C. Fischer	analist		01-01 tot 15-12
Boorspoeling V (Verkeer en Waterstaat)			
Dr. R. Daan	wetenschappelijk onderzoeker		01-01 tot 31-12
A. Keijser	analist		01-10 tot 01-04
Boorspoeling VI			
J. v.d. Hoek	analist		01-10 tot 31-12
EROS-2000			
L. Lohse	analist		01-10 tot 01-05
			01-06 tot 01-09
J. de Jong	analist		01-01 tot 01-07
			01-08 tot 31-12
A.J.M. Gieles-Witte	analiste		15-08 tot 31-12
Monitoring bodemfauna westelijke Waddenzee			
R. Dekker	wetenschappelijk onderzoeker		01-07 tot 31-12
NAZORG			
M.S.S. Lavaleije	wetenschappelijk onderzoeker		01-05 tot 15-11
<i>Phaeocystis</i>			
W. van Boekel	O.I.O.		01-01 tot 31-12

SOZ Antarctisch Onderzoek A. Buma	wetenschappelijk onder- zoekster	01-01 tot 01-11
Klimaateffecten (VROM) J.M.J. Hoppema	wetenschappelijk onderzoeker	18-06 tot 31-12
NAM Friese Front A. de Gee	wetenschappelijk onderzoeker	16-06 tot 01-11
<i>Emiliana huxleyi</i> E.S. Kempers	analist	01-07 tot 31-12
DNZ zeldzame vis C.G.N. de Vooyo	wetenschappelijk onderzoeker	01-09 tot 31-12
Vaarplan SOZ P.R. Alkema M.G. Bakker K.M.J. Bakker J.J. Blom E.B.M. Bos J. Nieuwenhuis L.M. Oost W. Polman R.J.C. Witte	technicus electrotechnicus analist technicus technicus electronicus electronicus technicus technicus	01-01 tot 31-12 01-01 tot 31-12 01-07 tot 31-12 01-01 tot 31-12 01-05 tot 31-12 01-01 tot 31-12 01-04 tot 31-12 01-01 tot 31-12 01-01 tot 31-12

Er zijn op het instituut onderzoekers werkzaam die elders een dienstverband hebben en op gesubsidieerde basis een promotie-onderzoek verrichten. Tevens zijn er onderzoekers aangesteld op basis van een samenwerkingsovereenkomst of andere afspraken met een universiteit of instituut.

Samenwerkingsovereenkomst Gastonderzoekers Onderzoekers met een NWO-aanstelling:	J. Gutt	wet. onderz.	SOZ	01-07 tot 31-12	Kustsystemen
	C. de Boer	O.I.O.	NWO	01-01 tot 31-12	Fys. Ocean.
	M. Stoll	O.I.O.	NWO	01-01 tot 31-12	Chem. Ocean.
	P. v.d. Wal	wet. onderz. (post-doc)	NWO	01-03 tot 31-12	Pelagische Syst.
	Th. Gerkema	O.I.O.	NWO	01-09 tot 31-12	Fys. Ocean.
	R.W.J. Dirks	wet. onderz. (post doc)	NWO	01-01 tot 01-04	Fys. Ocean.
	W. v.d. Werf	O.I.O.	KVA/NIOZ	01-01 tot 31-12	Geologie
	L. Otto	wet. onderz.	KNMI/NIOZ	01-01 tot 31-12	Fys. Ocean.
	Th. Piersma	O.I.O.	RUG/NIOZ	01-01 tot 31-12	Kustsystemen
	F. Schut	O.I.O.	RUG/NIOZ	01-01 tot 31-12	Pelagische Syst.
H.G. Epping	O.I.O.	NIOZ/NWO	01-01 tot 31-12	Chem. Ocean.	
Gedetacheerd door TNO:	P. de Wolf	tot 01-07			
	A. Stam	tot 01-06			
	A. Kop	tot 01-08			
Vrijwilligers:	S.H. Hashemi Saleh			01-01 tot 31-12	Bibliotheek
	P. Lock			01-02 tot 31-12	Kustsystemen
	W. Frankema			01-01 tot 31-12	Geologie
Gewetensbezwaarden:	J. Beks			01-01 tot 31-12	Geologie
	M. Rozemeyer			01-01 tot 31-12	BEWON
	M. Hup			01-01 tot 31-12	BEWON

5.8. DEELTIJD

Onderstaande personen vervulden in 1990 een part-time dienstverband:

J.W. Schröder-ter Avest	32 uur	directie-secretaresse
T.C. Steenhuizen-Borculo	19 uur	huishoudelijke dienst
J. van der Wal-Doornekamp	33.25 uur	bibliothecaresse
B. Bak-Gade	19 uur	redactie-assistente
L. Gerringa	32 uur	promotie-assistente (tot 01-03)
A.C. Bol-den Heijer	25.5 uur	secretaresse
R.P. Heyman	32 uur	promotie-assistent (tot 01-03)
J.M.M. Hin-Zoetelief	8 uur	telefoniste/receptioniste
J.M. van Iperen	8 uur	laboratorium-assistente
P. Kamermans	32 uur	promotie-assistente
W.C.M. Klein-Breteler	32 uur	wet. onderzoeker
M. Leopold	32 uur	promotie-assistent
W.E. Lewis	34 uur	laboratorium-assistente
G.M. Manshanden	32 uur	electronics
L. Moodley	32 uur	promotie-assistent
E. Okkels	32 uur	analiste
M. Bruining-du Porto	33.25 uur	bibliotheek-assistente
M.M. Spel	36	adm. medewerkster
J.P. Mulder-Starreveld	30 uur	redactie-assistente
J.T.F. Zimmerman	26.6 uur	sen. wet. onderzoeker
M. Zonnenberg	35.15	telefoniste/receptioniste
Z. Zuo	32 uur	promotie-assistente
N. Krijgsman	36 uur	redactie-assistente
A. Hillebrand-Kikkert	8 uur	receptie
A. de Graaf	30 uur	repro
B. Verschuur	36 uur	repro
W.G. Mook	36 uur	Directie

5.9. VERSLAG VAN DE PERSONEELSVERENIGING

Begin januari werden de prijzen uitgereikt die verbonden waren aan de, door de redactie van 'Tussen de Skeape', in 1989 uitgeschreven fotowedstrijd. De twee winnaars werden verrast met een twee uur durende privé-skiles op de borstelbaan in Bergen.

'Comedia de la NIOZ' voerde vrijdag 27 april voor de Texelaars en zaterdag 28 april voor het NIOZ-publiek het toneelstuk 'Table Manners' van Alan Ayck-bourne op. De laatste avond werd afgesloten met het traditionele personeelsfeest dat van muzikale luister werd voorzien door de 'Johan Stapel Band' uit Groningen. Een aantal medewerkers, onder leiding van de kantinebeheerder, verzorgde hierbij een koud buffet.

Op 27 september was het weer tijd voor de tweejaarlijkse personeelsreis. Deze keer richting oosten van ons land. Onderbroken door een bezoek aan een bekend etablissement in Oranjewoud werd een lange busreis ondernomen naar Barger Compasuum. Doel was het Veenmuseum 't Oale Compas'. Een Grieks etentje in Sneek vormde de afsluiting van deze, bij het personeel in de smaak gevallen, onderneming.



Edzard van Abs werd op het matje geroepen door de Sint.
(Foto: NIOZ)

Op de verjaardag van Sinterklaas kwam de goedheiligman, zoals door vrijwel iedereen verwacht, dit jaar langs om tenminste kennis te maken met de nieuwe leden van de directie. Vrij ongewoon is dat hij, sinds zijn eerste bezoek aan het instituut, niet van gezicht en stem veranderd is, en dat er sterke overeenkomsten te bespeuren zijn met een zeker personeelslid.

Diverse personeelsleden, die een langere perioden door ziekte afwezig moesten zijn, kregen een fruitmand aangeboden.

