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NETHERLANDS INSTITUTE FOR SEA RESEARCH (NIOZ)

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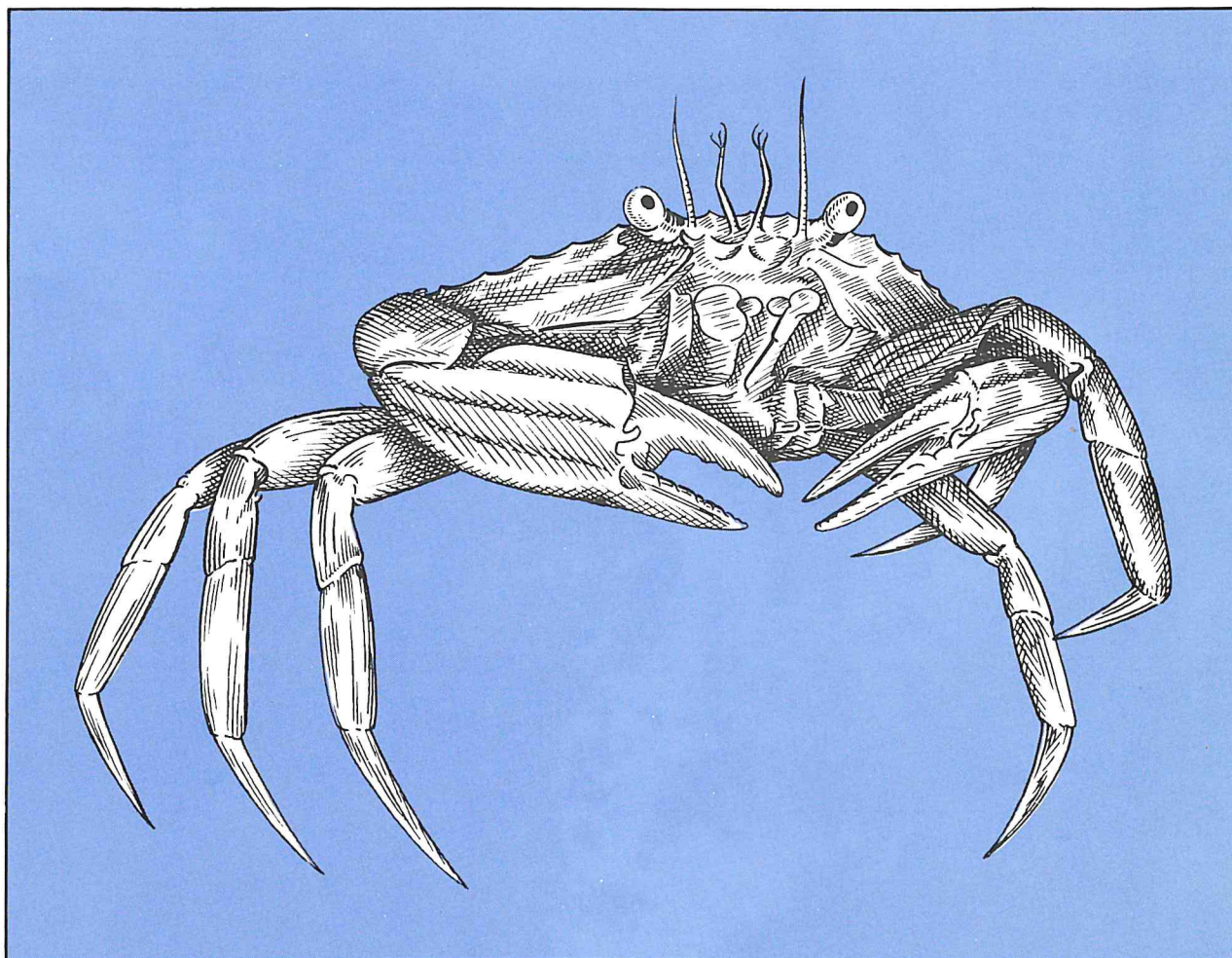
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(Photo: Pim Wolf)

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1. Scientific activity

1.1. INTRODUCTION

The year 1989 will be remembered as a tumultuous one marked by many changes and far-reaching events for the Netherlands Institute for Sea Research (NIOZ). Only a few months after his early retirement, prof. dr. J.J. Zijlstra died on 2 August 1989, at the age of 63. NIOZ lost not only its general director, but also an inspiring scientist of international fame and a wise and amiable person. The scientific work presented here was initiated under his leadership and bears the mark of his influence not only at the level of scientific definition but also in its organization.

Also prof. dr. E.K. Duursma, since 1986 scientific director, and after prof. Zijlstra's retirement his successor as general director, left the Institute for an early retirement on 1 December 1989.

On both directors leaving shortly after each other, the Board of the Institute decided to opt for a different division of tasks within the directorate and appointed ms. drs. M.J. Rietveld as per 1 September 1989 as director of NIOZ in charge of all general and policy affairs, and to search for a scientific head and chief director of the Institute. As such prof. dr. W.G. Mook has been appointed, who will join NIOZ as from 1 April 1990. Dr. P.A.W.J. de Wilde has acted as scientific director ad interim.

Not only a complete change in leadership, but also a complete change in the structure of the organization was implemented. On 29 September 1989 the Stichting NIOZ was founded, a foundation to belong as from 1 January 1990 under the Netherlands Organization for Scientific Research (NWO) for obtaining its funds. The foundation NIOZ belongs under the science board for Biological, Oceanographic and Earth sciences (BOA). It is a relatively independent foundation having a Board, a Science Committee and an institute with its own personnel. The bond of NIOZ with the Netherlands Zoological Society (NDV) which has existed since 1876, will formally be broken and the NDV will turn over the Institute to the NWO foundation NIOZ as from 1 January 1990. That the Netherlands Institute for Sea Research (NIOZ) will operate under the NWO umbrella means that in The Netherlands sea research has been recognized as 'big' science. Moreover, sea research meets a growing interest of society and the general public, not only for its intrinsic value, but also because of the growing consciousness of society that the seas and oceans are essential factors influencing the environment and that the health of the seas is a subject of great concern. This recognition and awareness demand a forceful impetus and new energy from all people working at NIOZ, scientists and non-scientists, to expand its scientific work, based on its long, respectable and fruitful tradition.

Having such a long tradition and being in a period of change, NIOZ seemed to have reached the stage for a thorough evaluation. The Board of NIOZ requested three experts to form an international Evaluation Committee to express its views on all aspects of the Institute's scientific research and organization in the broadest sense, and to make the recommendations it considered necessary and useful. The experts were prof. dr. R.P. Chesselet, from the Centre National de la Recherche Scientifique (CNRS) in France, prof. dr. G. Hempel, from the Alfred-Wegener-Institut für Polar- und Meeresforschung (AWI) in the Federal Republic of Germany, and prof. dr. G. Kullenberg, from the Intergovernmental Oceanographic Commission (IOC) of UNESCO, Paris. Their Peer-Review report was finalized in November 1989. The report has been well received by the authorities and will play an important role for NIOZ when planning for its future. The Long-Term Plan 1991-1994, which the foundation NIOZ submitted to NWO together with its draft budget 1991, already took into account several of the peers' recommendations. In 1990 the foundation NIOZ will publish its formal reaction and point of view as to the Peer-Review report.

In his last years prof. Zijlstra was very active in the planning of a new and larger research vessel for the Institute, to replace the present North Sea RV 'Aurelia'. Thanks to his powers of persuasion to convince authorities to provide funds for such a large investment, in October 1989 the contract could be signed by his successors with Verolme Shipyard Heusden (VSH) for the building of this vessel to be ready in March 1991. With its length of 66 m and equipped with up to six convertible laboratory containers, this North Sea research vessel will have research capabilities also during severe weather conditions and be fit for longer cruises.

Collaboration of NIOZ with universities involved in marine research has been intensified. To the already existing agreement with the University of Groningen (Marine Biology) some new ones were added. The agreement with the University of Utrecht (Physical Oceanography, Sedimentology, Marine Geochemistry) has been signed. An agreement with the Free University (Marine Geology) is still in preparation. Apart from NIOZ scientists undertaking lecture series at universities in this country and abroad, in 1989 four part-time professorships were occupied by NIOZ scientists: two at the University of Groningen, marine zoology and general oceanology, one in Utrecht, physical oceanography, and one at the University of Amsterdam, tropical marine biology. The foundation NIOZ will seek for expansion of its involvement and cooperation with universities in the near future.

The major scientific activities of NIOZ in 1989 concerned research in the Wadden Sea and other estuaries, North Sea, Atlantic Ocean and Antarctic waters. Research was carried out on board Dutch RVs 'Tyro', 'Aurelia', 'Navicula' and 'Griend'. In addition, NIOZ scientists took part in cruises on the German RVs 'Polarstern', 'Meteor', 'Valdivia', 'Victor Hensen' and 'Friedrich Heincke' and the British RVs 'Challenger' and 'Discovery'.

In the Dutch Wadden Sea, long-term studies, mainly concerning phytoplankton and zoobenthos populations, were carried out aimed at revealing structure and functioning of the benthic ecosystem and quantifying processes of food chains and production. Determination of denitrification and fluxes of N_2O in the sediment of the intertidal zones of the Wadden Sea reveals that during the summer and autumn the sediment acts as a sink for nitrogen oxides, instead of a source.

The correlation between hydrodynamics and exchange of organic contaminants in the water-sediment boundary layer indicates that the time that near-shore sediments can release organic contaminants to the water column can be estimated at several centuries.

Investigations regarding flocculation of suspended matter followed by deposition and erosion took place in several coastal and estuarine regions throughout the world.

In the Ems-Dollard estuary deposition rates were measured indicating that this region can be regarded as an accumulation area for small-size material and mud. Flocculation research was greatly stimulated by the development of an *in situ* underwater suspension camera, allowing the study of flocculation and aggregation of particles in their natural environment. Moreover, measurements on natural and artificial isotopes appeared to be an important tool to gain insight into the time scales of the sedimentation and flocculation processes.

Research on bird populations indicated a high mortality in 1989 of Eider ducks due to intestinal parasites. This mortality remained high during the summer and autumn. This may indicate the presence of a stress factor lowering the resistance of the birds. Further research must reveal whether the high amounts of PCB in the Wadden Sea have reached a critical level.

The North Sea remains a main area of investigation for NIOZ. North Sea programmes were concentrated on cruises with our own RV 'Aurelia', on participation in the British North Sea Project on board RV 'Challenger' for zooplankton research, and on investigations of pelagic microorganisms together with German scientists on board RV 'Friedrich Heincke'. Further research on the data from the Frisian Front Study revealed that sedimentation is concentrated in a narrow area more or less on the Frisian Front itself. Here about 2 million tonnes of suspended matter are yearly deposited out of a total of 45 million tonnes for the North Sea. An explication for the relatively high respiration of the bottom fauna in the Frisian Front area can be the high input of organic matter.

Analysis of the benthic samples of the internationally coordinated ICES Synoptic Mapping programme has been completed. A synthesis of all data from all participants will follow in 1990. The BEWON-group is concentrating a lot of effort on making a North Sea Ecosystem Model operative, applying the experience gained in the western Wadden Sea and the Ems-Dollard estuary. This means a successful coupling of physical and ecological modelling and field research, leading to new theories on the functioning of the real ecosystem. Although model systems have considerable limitations, they can contribute towards a better understanding of the complicated North Sea ecosystems, and help answer questions on marine environmental management problems put by the responsible authorities.

In cooperation with the Netherlands Institute for Fishery Investigations (RIVO) and the research divisions North Sea and Tidal Waters of the Ministry of Transport and Public Works, a pilot study has been completed on the effects of beamtrawl fishery on the bottom organisms in the North Sea. The results indicate that short-term effects are substantial. Further research to investigate long-term effects on the North Sea ecosystem of this type of fishing is imperative. For this purpose it is necessary that fishing should be banned in a large representative area. Studies should go on for at least 10-20 years. Future work should be carried out in an international framework (e.g. EC research programme).

Ecotoxicological research indicates that normal procedures for the assessment of PCBs are unable to distinguish/separate the most poisonous congeners. A new separation method implementing further methodological changes has been developed successfully and applied on samples from seals and seabirds. The most poisonous congeners have so far not been included in the international monitoring programmes.

A major research programme started at NIOZ is experimental research in a number of special contained laboratory and semi-scale basins. Indoor North Sea mesocosms and boxcosms became operative, while NIOZ participated in joint outdoor projects in the large basins of the Research Institute for Nature Management, RIN, our neighbour on Texel.

Open ocean research was this year dominated by participation in cruises and elaboration of three major projects: the European Polarstern Study (EPOS) in the Antarctic waters, the pilot programme of the Joint Global Ocean Flux Study (JGOFS) in the North Atlantic Ocean and the project on palaeoclimatological and palaeoceanographic processes in the Angola basin and the South Atlantic Ocean.

NIOZ participated with 14 scientists and technicians in the three legs of EPOS. EPOS was initiated and organized by the European Science foundation (ESF) to study the ecology of the Southern Ocean. RV 'Polarstern' was made available by the FRG. The EPOS cruise was very successful. New data on Antarctic zooplankton life cycles, biomass and grazing activity may lead to completely new concepts on productivity and food chains in the Southern Ocean, in particular with respect to the role of krill and copepods. Physical-oceanographic research on the structure and evolution of the water column near the Weddell-Scotia confluence gave evidence on the factors limiting phytoplankton growth. Studies on the silicon cycle showed the great influence of the recycling of silicic acid on the composition of the phytoplankton populations. Moreover silicic acid appears a very effective tracer for deep water masses.

JGOFS is focusing 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 constitutes the oceanic part of the International Geosphere Biosphere Programme and operates under the aegis of the Scientific Committee for Oceanic Research (SCOR). NIOZ scientists and technicians participated with RV 'Tyro' in the 1989 pilot study. Investigations were carried out on nutrient chemistry and carbon mass balance in the water column, as well as on diagenetic processes in the sediment. During the 1989 cruises a benthic lander, developed and built at the NIOZ, and equipped with a self-contained oxygen-profiling instrument, was successfully deployed at a water depth of over 4600 m in the northeast Atlantic. The shipboard application of flow-cytometry provided the excitingly detailed information on algal composition and distribution.

During the 1989 JGOFS cruise extra days were scheduled for a preliminary hydrographic survey for the DUTCH-WARP programme. This is the contribution of the Netherlands to the World Ocean Circulation Experiment (WOCE). The acronym stands for Deep and Upper Transport, Circulation and Hydrography, WOCE Atlantic Research Programme. WOCE is part of the World Climate Research Programme. Its goals are to supply a high-quality hydrographic description of the world oceans in order to calibrate and validate coupled global

ocean-atmosphere models which are expected to be available between 2005 and 2010. Another aim is to supply adequate physical models for a number of key processes in the oceanic branch of the climate system.

The relation between climatological and palaeoceanographic processes has been studied in the South Atlantic Ocean and the Angola basin. Geochemical parameters have been developed to estimate palaeoproductivity in the water column. Geological cores have been sampled with a total length of 350 m. With an X-ray fluorescence instrument recently developed and constructed at NIOZ it was possible to measure the chemical composition of these cores on board.

The Netherlands Journal of Sea Research appeared in two volumes (23 and 24). Four issues were part of the special series of six issues containing the Proceedings of the Snellius-II Symposium, which was held in Jakarta, November 1987. Moreover, 3 normal issues appeared.

E.K. Duursma

M.J. Rietveld

P.A.W.J. De Wilde

E. van Abs

1.1.1. New multidisciplinary programmes

H. de Baar

North Atlantic pilot study of the Joint Global Ocean Flux Study

The Joint Global Ocean Flux Study is focusing on the role of the oceanic carbon (C) cycle in regulating the atmospheric CO₂ content and has a strong emphasis on biological and chemical processes in the world oceans, where of course physical and geological interactions also take place. The first JGOFS project is the North Atlantic Pilot Study in 1989-1991 incorporating several RV 'Tyro' cruises. In 1989 ships of six countries (FRG, Canada, France, UK, USA, The Netherlands) were occupying stations throughout several seasons along the 20°W section in the North Atlantic, stretching roughly from Madeira to Iceland. Selected sites at 60°N, 20°W; 47°N, 20°W and 33°N, 20°W were occupied by subsequent ships in such a way that almost continuous coverage was established. Aboard each ship a suite of 20 standardized measurements were executed in order to arrive at one compatible data set.

The first RV 'Tyro' JGOFS leg in July-September 1989 was focusing on the pathways and fixation of C in the upper ocean. Throughout the expedition 76 stations were occupied at or near the 20°W section of the JGOFS Pilot Study. From 33°N to 47°N coverage was as planned, but due to storms and technical problems coverage was less from 47°N to 61.5°N. In total 106 CTD/Rosette casts and over 100 net tows were done. The WOCE current meter mooring was deployed at 61.5°N, 20°W in conjunction with several densely spaced hydrographic stations. One JGOFS sediment trap mooring was recovered with 100% success at 47°N, 21°W. Among 18 scientists some 16 of the 20 JGOFS standard measurements were accomplished routinely; in addition, some related studies were undertaken. Shipboard data were recorded in the CTD data system as well as the new SHIPMAN programme. On 6 August an intercalibration exercise was done at 60°N, 20°W between 'Discovery', 'Meteor' and 'Tyro'. First results of 'Tyro' are promising. Preliminary hydrographic results show fronts in the upper 500 m of the water column throughout the North-South section. The accurate (0.2%) data set of dissolved oxygen ties in with abundance of chlorophyll and other pigments. At 60°N most phytoplankton was found in the well-mixed upper 40-60 m. At 47°N and 33°N there exists a deep maximum instead, increasing in depth southwards where it was eventually located below the thermocline. At the 33°N station flowcytometry revealed great abundance of Prochlorophytes in the deep fluorescence maximum, further confirmed by HPLC determination of their characteristic divinyl-chlorophyll *a* and chlorophyll *b*. Quite remarkably the same pigments were also found throughout the overlying surface waters, suggesting that Prochlorophytes do after all also exist in the

high light levels of very surface waters. At all stations bacterial production is very closely linked with overall phytoplankton biomass rather than phytoplankton production. Mesozooplankton biomass in terms of carbon was found to be in the 0.1 - 0.5 mg/m³ (C) range, generally decreasing southwards. Egg production was also very low and virtually nil at the most southern station. The determinations of total dissolved CO₂ by two independent techniques show excellent agreement, typically within one per cent. Preliminary assessment of Dissolved Organic Carbon (DOC) by two methods yields concentrations ranging from 80 to 160 µM with some indication of higher values in surface waters.

The second JGOFS leg in September 1989 mostly investigated the impact of productivity on the early diagenesis and C preservation within the sediments. Along the 20°W transect, the 33-50°N section was chosen as it represents a major shift in biological productivity, hence sedimentary processes. At several stations study of the hydrographic regime was combined with *in situ* photography of particles in the water column, determination of the occurrence and abundance of pelagic Foraminifera as well as assessment with sediment traps of the variation in time/space of vertical fluxes settling within the deep water column. Distributions of several natural radionuclides were studied in both the water column and the sediments. Early diagenesis in boxcores was assessed in relation to rates of sedimentation and bioturbation to be determined afterwards from radiometric measurements. Utilization of a high resolution *in situ* oxygen profiler yielded mineralization rates of organic C considerably higher than previously assumed. The distribution of nitrous oxide (N₂O, one of the greenhouse gases) was determined in the water column with an eye towards its ocean/atmosphere exchange.

Throughout both cruises many samples were collected for later analyses in the shore laboratories. These efforts as well as shipboard preliminary results of the 1989 expeditions are laid down in two cruise reports (NIOZ 1989-9 and 1989-10). Three data reports will be issued in early 1990. Results are to be presented at an international JGOFS workshop in Kiel, March 1990. A similar suite of two RV 'Tyro' cruises is scheduled for spring 1990.

In JGOFS, NIOZ cooperates with the University of Groningen, the Free University, Amsterdam, and the University of Utrecht.

Expedition to Guinea and Angola Basins

During October-November a joint (palae)oceanographical-geochemical expedition was undertaken by NIOZ and the Institute for Earth Sciences of the University of Utrecht to the Guinea and Angola Basins. The main objective of the research programme is to study the meaning of oceanographic parameters and palaeoceanographic signals and their alterations within the sediments before they will be buried for a long time. Special attention is directed to Al-rich opal and its influence on the silica cycle, and the deep-water circulation of the basins. Diagenetic alterations and element fluxes into and out of the sediment are studied in alternate oxic/anoxic sediments in relation to conversion processes of organic compounds. The final aim is to make the results applicable for palaeoceanographic studies, in particular of the history of the deep-ocean waters, and for studies of the terrestrial climate.

During the expedition, 40 stations were visited to collect water, bottom and plankton samples with a CTD/Rosettesampler combination, a boxcorer and

pistoncorer, and a vertical plankton net. The sample locations were selected with a 2.8 kc echosounder. At the final station a 24.85 m long pistoncore was obtained, which is a national record. In total 359.81 m of core samples were collected during the cruise, with an average length of 15.23 m. Three selected stations, T89-19, T89-28 and T89-42, were occupied for more than 24 hours. Here, we took extra CTD casts, and we applied an *in situ* filtration instrument, a large-volume water sampler (1 m³), and shallow sediment traps (24 hours, just below the euphotic zone). While sailing, we pumped plankton samples from the water inlet at 5 m below the water surface in the bow of the 'Tyro' three times a day, and eolian dust was collected continuously.

The activities on board included the measurement of nutrients in the water column, opening and description of a few selected pistoncores and a number of subcores out of the boxes, XRF analyses of these cores with an automatized core scanner, and squeezing and chemical analyses of the pore water. ATP was measured in the water column and the pore water.

At the beginning of the cruise, a subprogramme was carried out around the Romanche Fracture Zone with the aim to collect the deep water (Antarctic Bottom Water) that enters the Angola Basin in this area.

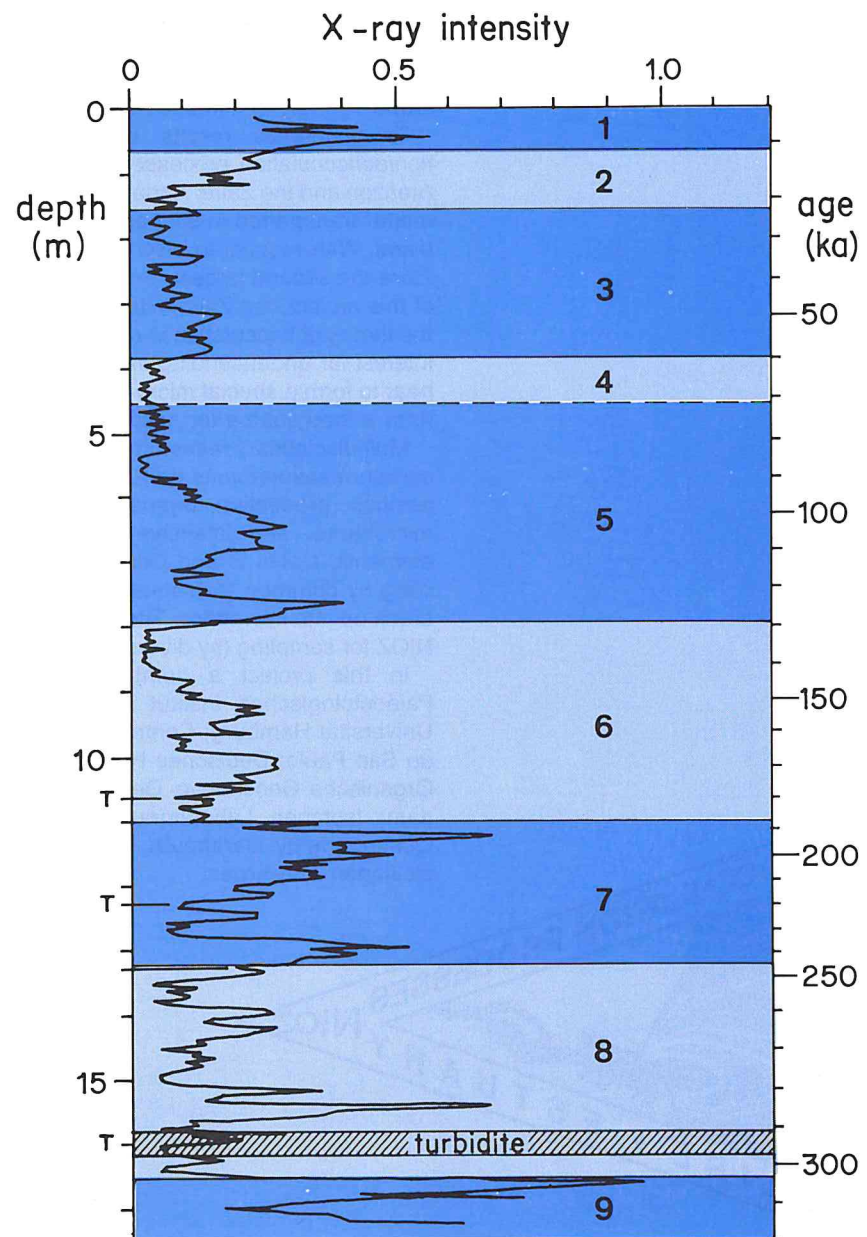
Three tracks perpendicular to the African coast could be carried out, one north of the Zaire River mouth, one south of it, and one around 15°S, off the Angolan coast.

A novelty was the application of the XRF core scanner. This X-ray Fluorescence (XRF) instrument, developed and built at NIOZ, appeared to be able to provide detailed scans of the elements heavier than K within half an hour of the opening of a core section.



Piston coring. As soon as a core is taken it is thermally insulated on deck with Jacosol pipe insulation, a polyurethane-foam tube which is covered with PVC foil with aluminium coating. The tube protects the cores from heating by the tropical sun until the core is divided into sections and stored or handed to the geochemists.

(photo: J.H.F. Jansen)



X-ray fluorescence scan for Ca of core T89-32 from the Angola Basin (14°58'S 10°42'E, 3330 m water depth). The curve, representing the calcium carbonate concentrations, allows us to apply the carbonate stratigraphy which is known for this region. The large-scale decrease downward is due to decreased water contents resulting from compaction.

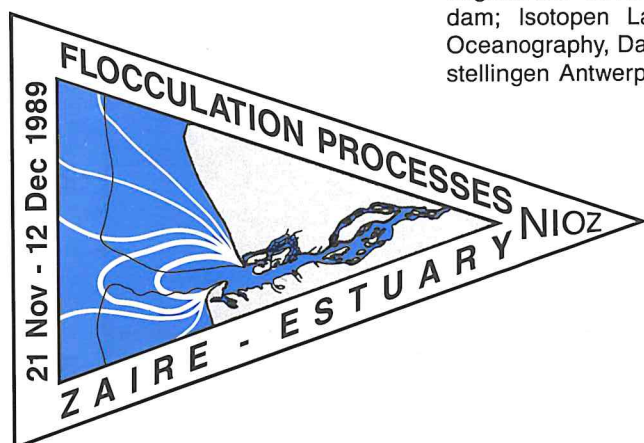
Flocculation and deflocculation processes in the Zaire estuary

The long-held opinion that clay-size particles transported by rivers flocculate in estuaries due to salt influence has been proved to be wrong. A number of studies in temperate estuaries—in which NIOZ played a leading role—have changed this idea. Clay-sized particles are already flocculated in rivers, and within the estuary active deflocculation and flocculation take place. Other processes than salt flocculation are important, such as turbulence, differential settling of particles, Brownian motion which results in particle collisions, and organisms clogging particles together. Particularly the organic geochemistry was found strongly to influence the flocculation processes in temperate estuaries.

To generalize results obtained in temperate estuaries on flocculation/deflocculation processes, two tropical estuaries have been selected: the Amazon and the Zaire. About 2/3 of the world river discharge and of the organic matter transported in suspension by rivers are carried into the sea by tropical rivers. With respect to discharge, the Amazon is the world's largest river, the Zaire the second largest. From 19 November to 12 December, as the first part of this project, the Zaire estuary was studied. The over-all aim is to generalize the theory of flocculation in rivers, estuaries and coastal waters. This is of prime interest for understanding sedimentation processes. Moreover, macroflocs appear to form a special micro-environment for organisms, and as such they also form a food source for suspension feeders.

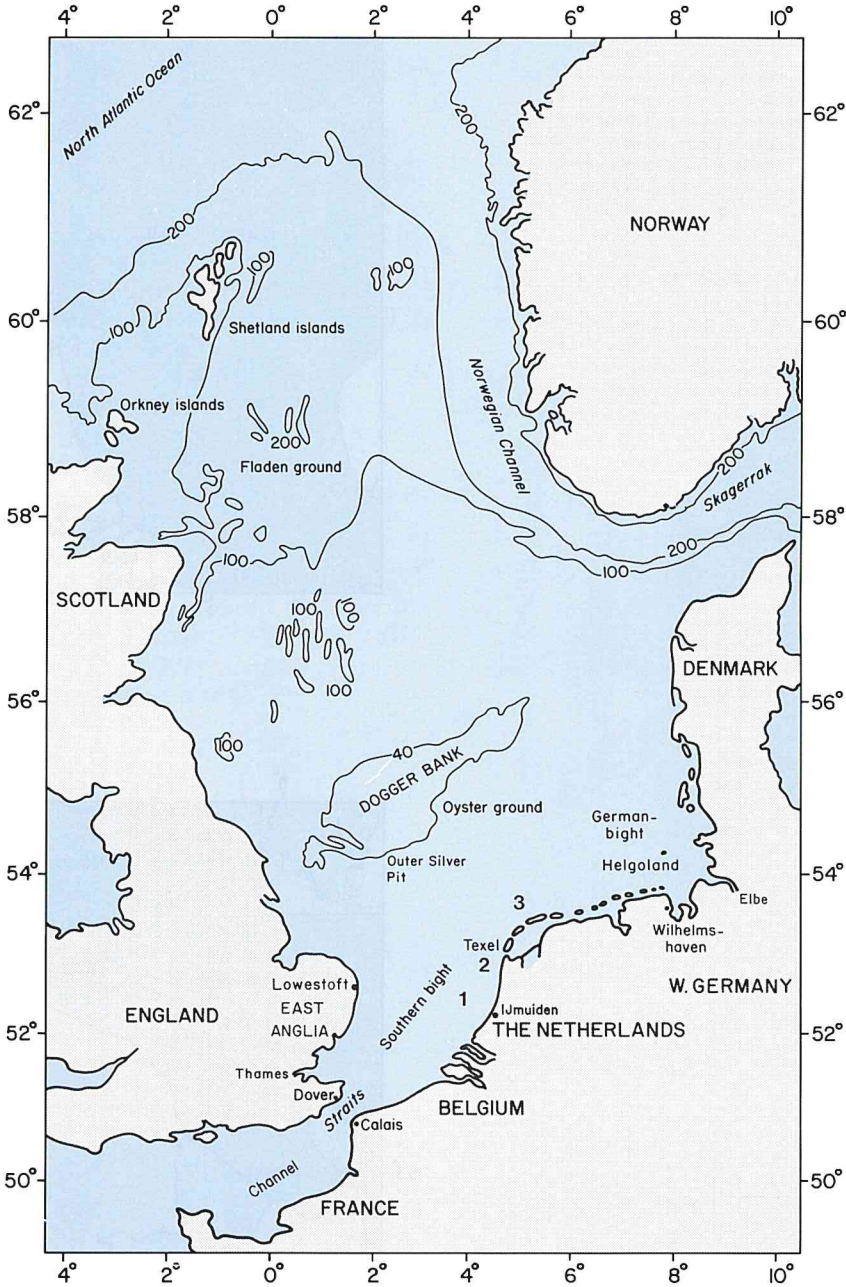
Multidisciplinary research in the Zaire estuary involved hydrography, organic carbon measurements (POC, DOC, sugars, fulvic acids), phytoplankton (composition, production, pigment-analysis, flow-cytometry), benthic macro- and microfauna, and intensive studies of suspended matter (amount, trace-elements, stable C and O-isotopes, grain-size, aggregate size). During sampling by common techniques (with water bottles) the large fragile macroflocs break up into microflocs. Therefore special techniques have been developed at NIOZ for sampling (by divers) and *in situ* photographing of (macro)aggregates.

In this project a number of other Institutes cooperate: Geologisch-Paläontologisches Institut Universität Hamburg; Institut für Microbiologie Universität Hamburg; Centro de Energia Nuclear na Agricultura Universidade de Sao Paulo; Deutsches Hydrographisches Institut, Hamburg; Instituut voor Organische Geochemie, Delft; Palyologisch Instituut Universiteit van Amsterdam; Isotopen Laboratorium Universiteit Groningen; Bedford Institute of Oceanography, Dartmouth, Canada; Department Scheikunde Universitaire Instellingen Antwerpen.

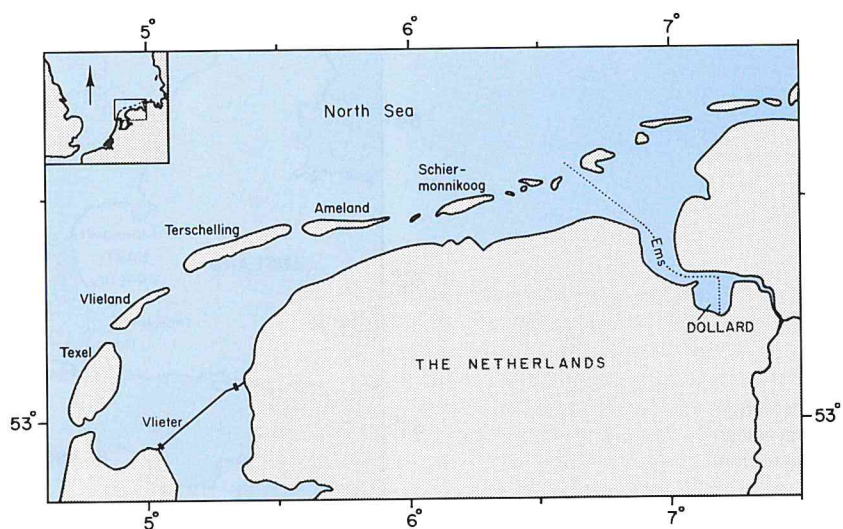
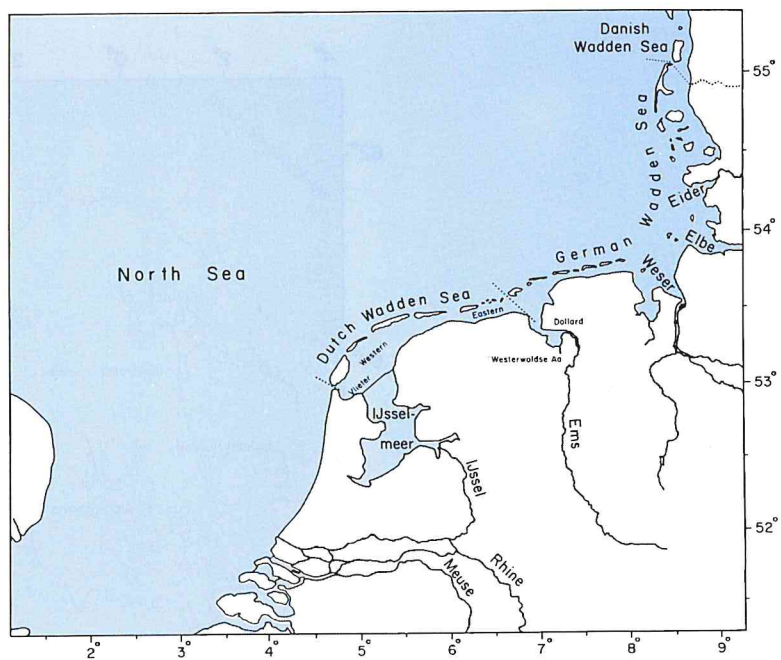


1.1.2. Maps

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

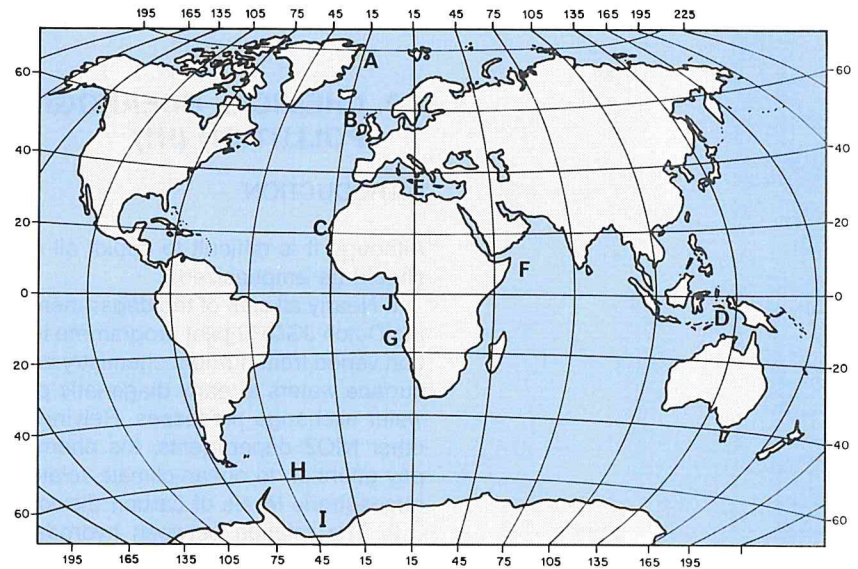


North Sea with geographical names mentioned in this report.



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=NW Indian Ocean
- G=Angola Basin
- H=Scotia Sea
- I=Weddell Sea
- J=Zaire Estuary



1.2. CHEMICAL OCEANOGRAPHY AND MARINE POLLUTION (H1)

INTRODUCTION

Although it is difficult to depict all research highlights in the last year, a few should be emphasized:

1. Nearly all staff of the department participated in the execution of the ongoing Dutch JGOFS pilot programme in the North Atlantic Ocean. Their contribution varied from nutrient chemistry and carbon mass balance studies in pelagic surface waters to early diagenetic processes in the sediments and sediment-water exchange processes. Relying on the multidisciplinary cooperation with other NIOZ departments, the chemical oceanography group will continue to pay attention to ocean-climate related processes as influenced by increasing atmospheric levels of carbon dioxide and nitrous oxide.

2. The relation between hydrodynamics and solute-exchange across the sediment-water interface was studied in a microcosm with calibrated flow regime. The results of these studies can be extrapolated to the behaviour of solutes in general.

3. During the JGOFS cruises in 1989 a free-falling lander equipped with O_2 micro-electrodes for measurements of *in situ* O_2 profiles in pore water was successfully deployed and recovered. This was possible only by close cooperation with the NIOZ workshops (mechanics and electronics).

4. Application of ultra-clean methodology made it possible to analyse low-level metal concentrations in open-ocean waters. The newly built ultra-clean facility in our department and the acquisition of a new 'Zeeman' atomic absorption spectrophotometer warrant high-quality low-level metal data in the near future.

Apart from 'general' oceanography in usually a multidisciplinary approach (analyses of nutrients and oxygen) in coastal and open-ocean water bodies (see H1-01), in recent years attention has shifted to more detailed fundamental aspects of chemical oceanography, such as:

a) Biogeochemical cycling in the sediments and sediment-water exchange of nutrients and metals and org. pollutants (projects H1-02, H1-03, H1-04, H1-05, H1-09).

b) Early diagenetic processes focussing on the relative importance of the different electron-acceptors (O_2 , NO_3^- , MnO_2 , $FeOOH$, SO_4^{2-}) in the oxidation of org. C deposited at the sediment surface and the degradation pattern of organic substances (project H1-04, H1-13).

c) The occurrence and distribution of low level trace metals and rare earth elements in the open ocean (project H1-14, H1-15).

d) Identification, quantification of metals and chlorinated hydrocarbons and their effects on marine animals (projects H1-06, H1-07, H1-08, H1-11, H1-12).

e) Transport processes at the sediment-water interface (project H1-10).

f) High precision studies of the CO_2 system in the oceanic water column (H1-17).

H1-01 PRODUCTION/CONSUMPTION OF OXYGEN AND NUTRIENTS NORTH OF THE FRISIAN ISLANDS, NORTH SEA

C. Westra

Emphasis lay on further elaboration of the data collected during the 1986 and 1987 Frisian Front project cruises. In most series of oxygen determinations a day-night rhythm was observed in the upper 15 m. This rhythm is a consequence of phytoplankton oxygen production by day and biological oxygen consumption both day and night. However, in some cases, mainly in the 1986 series, the rhythm was not observed because of unstable hydrographic conditions. Below 15 m, tides sometimes even led to a higher oxygen content in the morning than in the afternoon, the opposite of a biologically induced oxygen rhythm.

During primary production, nutrients are consumed. In a few cases also a day-night rhythm of inorganic nitrogen compounds exists. During the cruises in May and June 1986, a dramatic decrease in nutrient concentrations was observed because of a phytoplankton bloom. In August 1987, inorganic nutrients were almost exhausted. Because of the highly variable hydrographic conditions in the Frisian Front area, research has been continued with monthly series of measurements from March 1988 on. These are collected in the WAWAMO programme of the North Sea Directorate of the Ministry of Transport and Public Works. Temperature, salinity and oxygen measurements are made by assistants on board RV 'Holland'. Nutrient analysis is performed at NIOZ. Seasonal cycles of temperature and nutrients are very clear. Sometimes a difference between coastal water and central North Sea water is distinct; this was especially so during the strong stratification in summer 1989.

In late 1989 a visit was paid to the Biologische Anstalt Helgoland for elaboration of last year's oxygen and nutrient determinations in the Frisian Front and German Bight. Relations to hydrography, phytoplankton and microbiological results were discussed.



R.V. 'Holland'
(Photo: RWS, Dir. North Sea)

H1-02/H1-03 NITROGEN

W.M. Kieskamp, W. Helder, E. Epping

In March determination of denitrification rates and N_2O -fluxes in the sediment of the intertidal zone of the Wadden Sea was started with a measurement frequency of approximately twice a month (in cooperation with L. Lohse, a student of Oldenburg University). Preliminary results show that the denitrification rate decreases in spring after a drop in water nitrate concentration. This drop coincides with the spring algae bloom. The flux of N_2O , up till then an efflux, becomes an influx: during summer and autumn the sediment acts as a sink for N_2O , instead of a source.

The chemical reduction of nitrite by iron (II) ions was studied (F. van Rijn, Agriculture University Wageningen). The reduction rates were slow in demineralized water and even slower in artificial seawater ($S=30$), probably due to ion-activity. In the presence of catalytic surfaces the rates would increase dramatically.

Investigations on the inhibition of denitrification by sulphide-ions is continued.

On the North Atlantic JGOFS cruise in late summer, water samples were taken to determine the N_2O -profile in the water column and to calculate the N_2O -flux across the air-water interface. Due to faulty equipment the samples had to be stored for future analysis (January 1990).

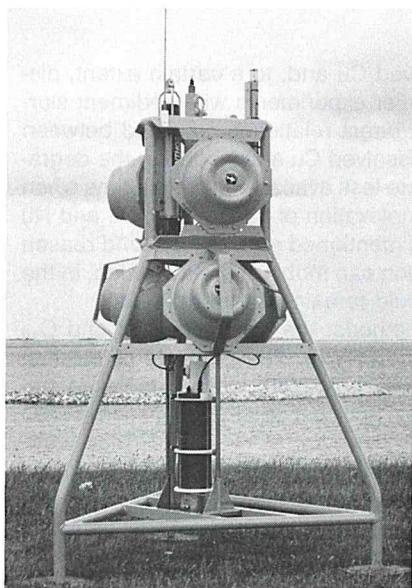
Another aim of this project is to study the effects of reduced sulphur compounds on micro-organisms and processes related to the nitrogen cycle. Sampling sites are the intertidal flats south of the 'Schorren', Texel. By means of a simplified continuous culture system, nitrate-reducing and denitrifying micro-organisms could be enriched under nitrate limitation and excess of volatile fatty acids (formate, acetate and propionate). Dilution rates of five different vessels were in the range of 0.005 to 0.06 per hour. Nitrate-reducing bacteria appeared to dominate the microbial population at high growth rates, whereas at lower growth rates denitrifying bacteria were more abundant. This was also indicated by biomass determinations, as molar growth yields on nitrate reduction to nitrite are much lower than nitrate reduction to nitrous oxide and/or dinitrogen. Organisms have been stored for further identification and continuous culture experiments.

A field study programme has been started to gain information on nitrogen- and sulphur-related processes in marine sediments on a seasonal basis. The programme consists in the assessment of the vertical distribution of denitrifying and nitrate-reducing micro-organisms, nitrate, nitrite, ammonia, nitrous-oxide, oxygen, sulphide, thiosulphate, dimethylsulphide and potential denitrification. In collaboration with L. Lohse, nitrous-oxide dynamics and actual denitrification in intact sediment cores are under investigation.

H1-04 EARLY DIAGENETIC PROCESSES AND ORG. C MINERALIZATION IN MARINE SEDIMENTS

W. Helder, P. Kieskamp, E. Epping

Main emphasis was put on the construction of a benthic lander equipped with a self-contained oxygen-profiling instrument. The construction was carried out by the NIOZ mechanical and electronic workshops. The instrument was tested in the Wadden Sea, and, after some small modifications in the original concept had been made, used for the first time at deep-water stations during the JGOFS benthic cruise (11-28 September).

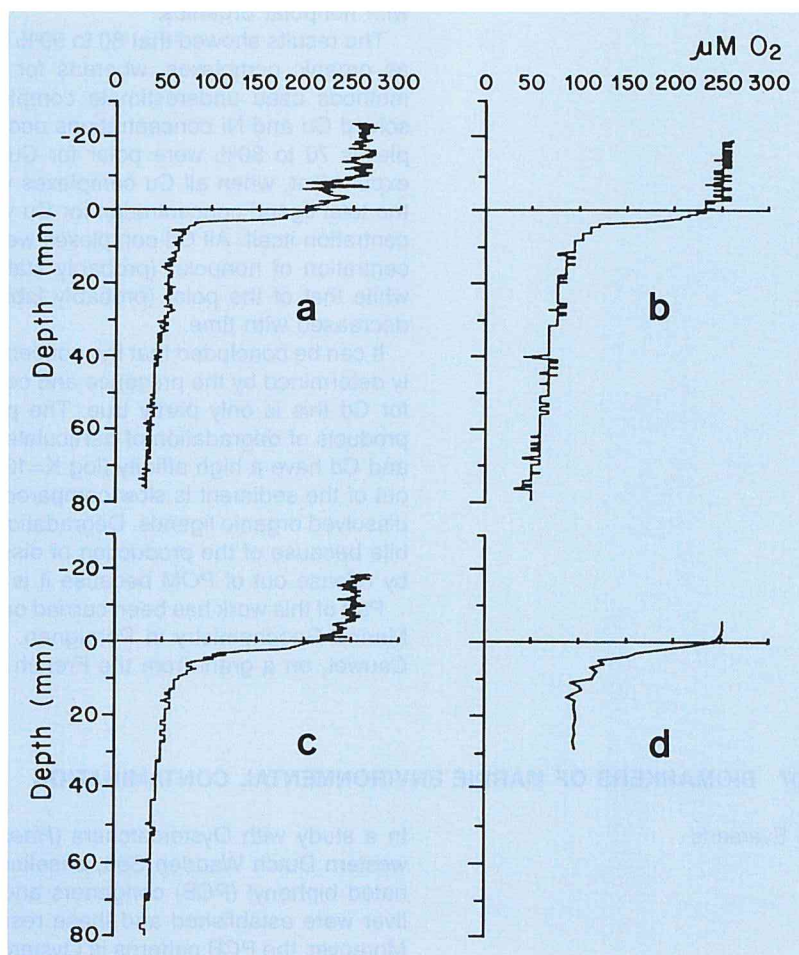


The TROL (Temperature Resistivity Oxygen Lander). The free-falling lander contains in its centre the oxygen profiling instrument. (Photo: W. Helder)

It was successfully deployed at a water depth of 4640 m in the northeast Atlantic. The data clearly indicate the importance of the very active surface sediments (0-6 mm) in org. C mineralization. Below this depth interval, oxygen uptake in the sediment is much more restricted, obviously owing to the decrease in degradability of the org. C sources.

Apart from *in situ* oxygen profiles, these were also, for comparison, made in the low-temperature lab container on board RV 'Tyro'. Pore waters were analysed on board for NO_3^- , NO_2^- , NH_4^+ , diss. Si, diss. Fe, and diss. Mn. Solid phase parameters (org. C, carbonate, trace metals) will be analysed in the laboratory.

The participation in the JGOFS cruise of Kirk Cochran (Stony Brook, USA) will probably result in the availability of ^{210}Pb data from the JGOFS stations, which will help us to model org. C mineralization in these northeast Atlantic sediments.



In situ oxygen profiles in sediment of the North Atlantic (a, b, c) and the oxygen profile measured on board the ship in a box-core sample.

H1-05 EXCHANGE OF TRACE METALS

L. Gerringa

From the literature it is known that dissolved Cu and, to a certain extent, dissolved Ni exist as organic complexes. Earlier experiments with sediment slurries at 100% O₂ saturation proved that a direct relationship existed between the concentrations of DOC and those of dissolved Cu and Ni during the degradation of organic matter. Because metals are less available for organisms when they occur as organic complexes, the complexation of metals (Cu, Cd and Ni) was studied in relation to the experiments mentioned above. A second reason for this study was that this complex formation can mobilize metals which, in the absence of dissolved organic ligands, would remain in the sediment.

Complexation was measured by two methods: the MnO₂ method and C₁₈ reverse phase extraction with SEP PAK cartridges. The principle of the first method is that added MnO₂ particles adsorb free metals, while complexed metals remain in solution; SEP PAK cartridges, however, retain metals complexed with nonpolar organics.

The results showed that 80 to 99% of the total dissolved Cu and Ni occurred as organic complexes, whereas for Cd this was 50 to 40%. However, the methods used underestimate complexation; probably 99% of the total dissolved Cu and Ni concentrations occur as organic complexes. Of these complexes 70 to 80% were polar for Cu and Ni, apart from the first day of the experiment, when all Cu complexes were nonpolar. During the first two days, the total ligand concentration for Cu was 2 to 3 times higher than the Cu concentration itself. All Cd complexes were polar. During the experiment the concentration of nonpolar (probably stable) ligands was more or less constant, while that of the polar (probably labile) ligands increased and subsequently decreased with time.

It can be concluded that the concentrations of dissolved Cu and Ni are largely determined by the presence and concentration of dissolved organic ligands; for Cd this is only partly true. The polar ligands are probably newly formed products of degradation of particulate organic matter (POM), for which Cu, Ni and Cd have a high affinity (log K=12, 10.3 and 10.7 resp.). The release of Cu out of the sediment is slow compared with Ni in the presence of an excess of dissolved organic ligands. Degradation of POM enables metals to become mobile because of the production of dissolved ligands, and only for a minor part by release out of POM because it is degraded.

Part of this work has been carried out at the Laboratory of Sedimentology and Marine Geochemistry in Perpignan, France, under the supervision of Dr. G. Cauwet, on a grant from the French government.

H1-07 BIOMARKERS OF MARINE ENVIRONMENTAL CONTAMINATION

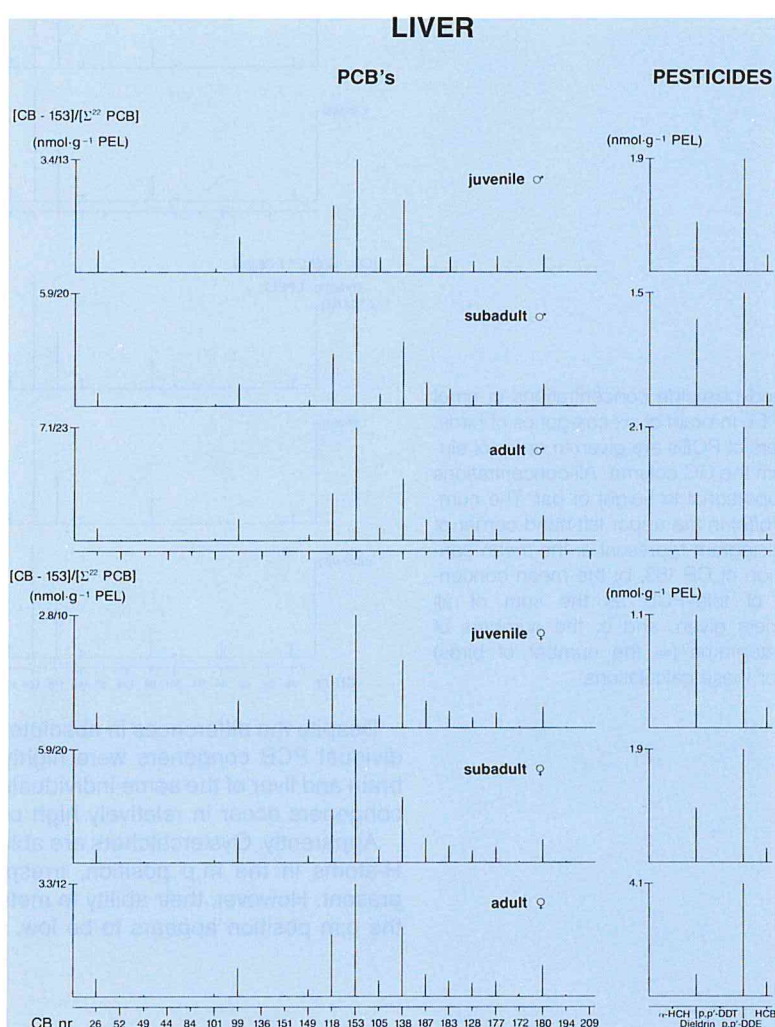
J.M. Everaarts

In a study with Oystercatchers (*Haematopus ostralegis*) originating from the western Dutch Wadden Sea, baseline concentration levels of selected chlorinated biphenyl (PCB) congeners and organochlorine pesticides in brain and liver were established and these residue levels were related to age and sex. Moreover, the PCB patterns in Oystercatchers were compared with those in important food sources, such as the bivalve mollusc *Macoma balthica* and the lugworm *Arenicola marina*, in relation with biotransformation processes. The

birds were well fed and in good condition and therefore could be considered healthy individuals. However, the birds died as a consequence of a combination of flood, fog and absence of wind. The birds could not maintain their body temperature because an oily layer at the surface of the water dissolved the lipids on their feathers, causing loss of hydrophobic properties, and owing to the fog they were unable to flee.

In brain and liver of Oystercatchers, PCB concentrations increased in a very similar way in males and females until sexual maturation. In adult males the concentrations were higher than in subadults, whereas in adult females the concentrations were lower than in subadults.

Absolute PCB, dieldrin, and DDE concentrations were higher in liver than in brain. Compared with these compounds, α -HCH was relatively enriched in brain.

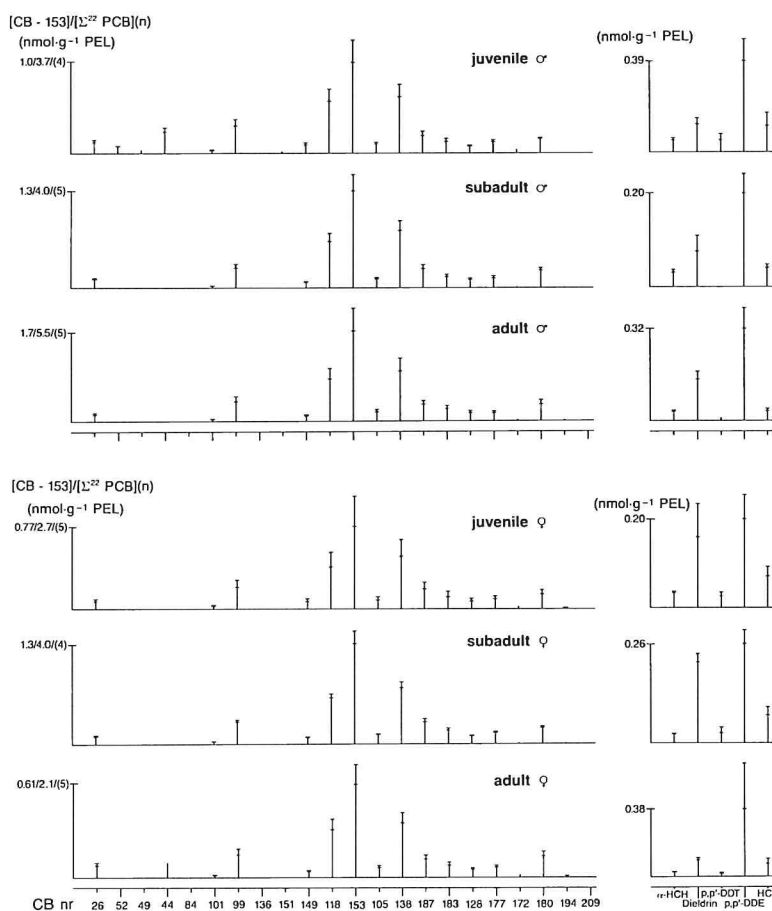


PCB and pesticide concentrations in nmol per g PEL (pentane extractable lipids) in liver of six categories of birds. Each histogram represents one chromatogram from a homogenate of five livers.

BRAIN

PCB's

PESTICIDES



PCB and pesticide concentrations in nmol per g PEL in brain of six categories of birds. Numbers of PCBs are given in order of elution from the GC column. All concentrations are proportional to height of bar. The numbers a/b/(c) in the upper left-hand corner of each histogram represent a: the mean concentration of CB-153, b: the mean concentration of total-PCB as the sum of all congeners given, and c: the numbers of chromatograms (= the number of birds) used for these calculations.

Despite the differences in absolute PCB concentrations, the pattern of the individual PCB congeners were highly similar in all categories of birds and in brain and liver of the same individuals. Only in brain of juvenile males did some congeners occur in relatively high concentrations.

Apparently, Oystercatchers are able to metabolize CB congeners with vicinal H-atoms in the m,p position, irrespective of the number of ortho-chlorines present. However, their ability to metabolize congeners with vicinal H-atoms in the o,m position appears to be low.

H1-11 EXCHANGE OF ORGANIC CONTAMINANTS BETWEEN SEDIMENT AND WATER

K. Booij

Sediments are important sites of accumulation of organic contaminants. Once the primary sources are closed down, sediments can release the contaminants to the water column. The release process is opposed by the sedimentation of uncontaminated sediment. The relative magnitude of upward fluxes and sedimentation rates determines the time that sediments can act as secondary sources of contamination.

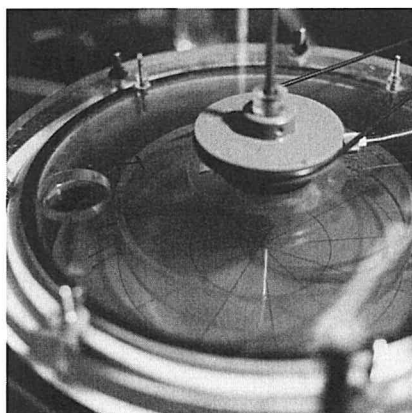
Release fluxes of organic contaminants were measured in a set-up that combines a microcosm with calibrated flow regime and a continuous liquid-liquid extractor. The results could be described by a diffusion model using an effective diffusion coefficient of $3 \times 10^{-8} \text{ m}^2 \text{ s}^{-1}$. The time that near-shore sediments can release organic contaminants to the water column can be estimated at several centuries.

H1-13 TRANSPORT PHENOMENA NEAR THE SEDIMENT-WATER INTERFACE

K. Booij, W. Helder

Solute fluxes between sediment and water have been reported to increase when water flow rates increase. Mechanisms to explain this include: decrease in resistance posed by the benthic boundary layer, increased diffusion in the pore water, irrigation of burrows, and resuspension of the sediment top layer. Despite the reported impact of hydrodynamics on solute exchange, only a few microcosms are hydrodynamically calibrated. Previously, a microcosm with a calibrated, user-selectable flow regime was developed at NIOZ. Water flow is induced by a rotating disc and a water pump.

Additional measurements on the flow regime in this microcosm have shown that a vertical velocity component exists above the sediment-water interface. The rotating flow in the microcosm causes a radial pressure gradient of 3 to 130 Pa m^{-1} . As a result, a radial velocity towards the centre of the microcosm is generated near the bottom. The radial flow, in turn, induces an upward velocity. Transport by the upward flow is expected to overrule transport by diffusion between the sediment water interface and the water column. This artifact is common to all microcosms in which rotating flows are present. (This research is carried out in collaboration with B. Sundby, Maurice Lamontagne Institute for Marine Research, Mont Jolie, Quebec, Canada.)



A benthic chamber with calibrated flow regime.
(Photo: K. Booij)

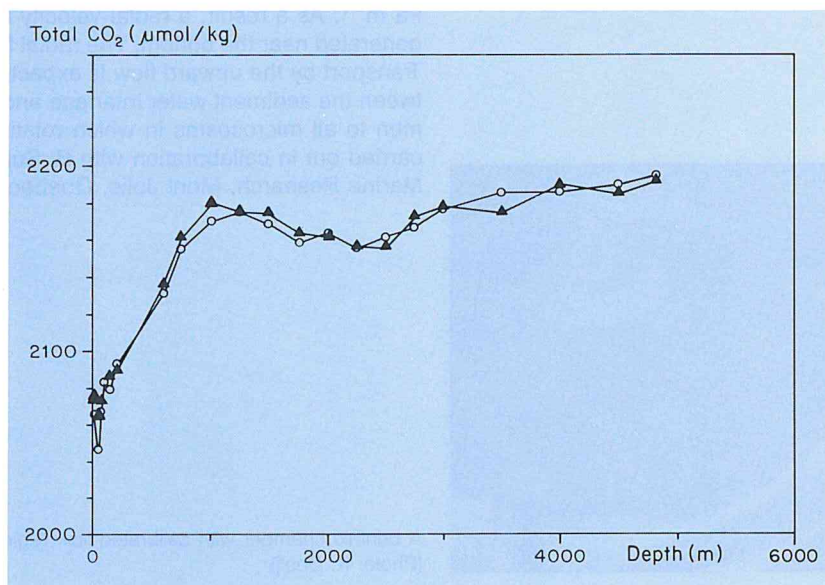
H1-15 TRACE METALS IN THE OCEANS

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

Trace metal distribution in the Southern Ocean (EPOS)

So far very little is known about the actual concentrations of copper, zinc, cadmium and iron in the Southern Ocean. In this study we present new data of these trace metals on a horizontal and vertical distribution. Samples were collected during the EPOS-Polarstern Cruise leg 2, November-December 1988. The area studied was mainly the 49° W line from 57-62°S, but some additional stations were included. Deep-water concentrations of cadmium are 0.6-0.7 nM in the Scotia Sea, 0.75 nM in the Confluence and again 0.6-0.7 nM in the Weddell Sea. These concentrations are intermediate between values found in the Pacific, Indian Ocean and North Atlantic. In the Scotia Sea cadmium shows a nutrient-like profile, while in the Confluence and Weddell Sea concentrations are more patchy in the first 100 m. This may be caused by melting ice. Copper concentrations are 3-4, 3 and 3 nM, respectively. Surface concentrations of copper are 1.9-2.5 nM in the Scotia Sea, increasing to 3-4 nM in the Confluence, and decreasing again to around 2 nM in the Weddell Sea. Zinc concentrations below 500 m are 10-12, 12 and 6-7 nM in the Scotia Sea, Confluence and Weddell Sea, respectively. This element also shows a patchy pattern in the first 100 m. The iron profiles show an increase in concentration towards the south, starting in the Scotia Sea with 2-4 nM and ending in the Weddell Sea at 6-8 nM. Very high iron values are found in the vicinity of Signy Island (50-60 nM), probably released from the sediments in these shallow 200-m-deep waters.

Total Dissolved Inorganic Carbon at JGOFS 47°N, 20°W as determined by two independent methods:
○ = total CO₂ by coulometry
▲ = total CO₂ by acid titration



Trace metal interactions with the biota in the Southern Ocean (EPOS)

H.J.W. de Baar, A.G.J. Buma,
R.F. Nolting

During EPOS Leg II we investigated the interaction of trace metals with biota. In the Scotia/Weddell Seas we executed a suite of five experiments testing the classic hypothesis of limitation by Fe (iron) of Antarctic productivity. We always observed Fe additions to stimulate synthesis of chlorophyll and nutrient assimilation. In four out of five experiments the final Particulate Organic Carbon levels were also higher in the Fe-enriched cultures than in the controls. However, the controls were also found to outgrow typical Chl *a* and POC levels found in ambient waters. Extrapolation to the *in situ* ecosystem suggests that Fe is one of several factors, but not the single factor, controlling phytoplankton in this area. Similar experiments showed little effect for additions of Mn, Cu and Zn. The extended shelf area around nearby islands may in this area, through diagenetic mobilization, contribute significantly to the Fe levels within the euphotic zone, hence sustaining productivity.

Trace Metals in the North Atlantic Ocean (JGOFS)

R.F. Nolting, H.J.W. de Baar,
P.M. Saager

Upon extensive design and preparations our new clean-air facility was installed at NIOZ during April-June 1989. An ultraclean Class 100 laboratory of about 20 m³ with three laminar flow cabinets is complemented by a new Zeeman Graphite Furnace Atomic Absorption Spectrophotometer. Design, construction and installation of various special bench-top apparatus (teflon evaporators, quartz destillators etc.) are still in progress.

During both JGOFS legs, filtered seawater samples were collected for determination of trace-metal concentrations in the new shore laboratory. One objective is the accurate assessment of Cd/phosphate concentration ratios in the water column. This ratio is crucial for the newly started thesis research of Saager at the Free University, Amsterdam, in collaboration with Dr. Ganssen (also Free University, Amsterdam). Here we intend to employ the Cd/Ca elemental ratio in shells of pelagic Foraminifera as a (palaeo)oceanographic indicator of ambient phosphate levels, the latter thought to control shifts in oceanic productivity which in turn govern the atmospheric CO₂ shifts responsible for the severity of glacial/interglacial transitions of the climate.

River inputs to the Mediterranean (EROS 2000)

R.F. Nolting

The data obtained during the EROS 2000 cruise in the Golfe du Lion have been further worked out. Depth profiles as well as the horizontal distribution of cadmium, lead, nickel and copper in the sediments are now completed. Lead and cadmium show the same trend as zinc: highest values in near-coastal areas decreasing in offshore direction. Depth values for cadmium are rather constant, 0.3 µg·g⁻¹, but in most cores there is an increase to 0.6 µg·g⁻¹ in the 6-8 cm slice. This must be a historical phenomenon, but at the moment there is no plausible explanation for this increase. In some profiles farther from the coast, the lead contents show a sharp decrease, sometimes already at 2 cm, others at 6 cm or 8 cm, reaching a constant low value of 5-6 µg·g⁻¹. Calculations of

sedimentation rates with ^{210}Pb , which are for example $0.02 \text{ cm}\cdot\text{y}^{-1}$ at station 72, $0.04 \text{ cm}\cdot\text{y}^{-1}$ at stations 61 and 96, $0.14 \text{ cm}\cdot\text{y}^{-1}$ at station 44, and the depth at which the lead content at these stations increases show that this increase started about 60 to 80 years ago. Zinc shows the same trend as lead at stations 61, 72 and 96. Copper shows a pattern different from that of the other metals. The leachable fraction increases in an offshore direction from 8 to $20 \mu\text{g}\cdot\text{g}^{-1}$, so that the highest concentrations are found at the stations in the deeper parts of the bay. This does not necessarily mean that the total copper content is higher in these cores, but is perhaps an indication that the source is not the river Rhone. It is also possible that in altered sediment, copper becomes more available in the easily leachable fraction. In all cores there is little variation in the nickel content with depth. Nickel is low close to the coast of Spain ($17 \mu\text{g}\cdot\text{g}^{-1}$). In the vicinity of the Rhone delta its concentration lies between 30 and $40 \mu\text{g}\cdot\text{g}^{-1}$. At one station, between the Rhone delta and the Spanish coast, we found the highest nickel concentration ($60 \mu\text{g}\cdot\text{g}^{-1}$). The enrichment factors of Zn, Pb, Cd, Ni and Cu in sediments close to the Rhone delta, compared to those in the deeper parts of the gulf, are 7, 4, 2, 1.3 and 0.7 respectively. We conclude that the completely different element concentrations in the sediments in the different parts of the Golfe du Lion show that sediment supplied by the river Rhone is restricted to a small area around its estuary. This is in agreement with findings in other parts of the world such as Indonesia. In the deeper parts of the gulf, transport of particles by air, and a subsequent burying in the sediment, may play a major role.

Trace Elements in the Indian Ocean

P.M. Saager, H.J.W. de Baar

The first study of Mn and Fe in the water column of the Indian Ocean has been published. Measurements of Cd, Cu and Ni are now also completed and the ensuing manuscript on distributions of Ni, Cu and Cd in the Northwest Indian Ocean upwelling area is in preparation. The dissolved Cd exhibits an almost perfect correlation with phosphate, where the ratio Cd/PO_4 in the deep water is 0.50 and 0.87 at offshore and nearshore stations 5 and 8, respectively. This is well above the 'typical' oceanic ratio of about 0.3 and may well be caused by the unusual upwelling conditions.

H1-16 RARE EARTHS AND OTHER METALS IN ANOXIC BASINS

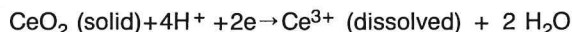
H.J.W. de Baar

The determination of Mn, Fe and the Rare Earths in seawater collected (RV 'Tyro', 1987) from hypersaline, anoxic Bannock Basin and overlying oxygenated Mediterranean waters is now completed. The Fe and Mn were measured by GFAAS at NIOZ. The Rare Earths were assessed very accurately with Isotope Dilution Mass Spectrometry at the NWO Laboratory for Isotope Geology in Amsterdam.

The Rare Earths contents of filtered seawater taken from the Black Sea (RV 'Knorr', July 1988) were also determined by IDMS. In 1988 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.

Concentrations of Rare Earths in the deep anoxic Black Sea are about an order of magnitude higher than in normal open ocean waters. From a minimum at about 107 m depth, the concentrations increase strongly to a maximum at about 400 m depth. Concentrations of Ce range from 3 pM (10⁻¹² Mol/litre) at 107 m to 200 pM at 400 m depth, due to its own oxidation/reduction chemistry:



very similar to the chemistry of better-known Mn (manganese). From the Ce distribution within the suboxic zone we can now place the onset of Ce reduction very close to reduction of Mn and nitrate in the 'classic' redox sequence. The other Rare Earths exhibit similar maxima and minima, albeit not as dramatic as found for Ce. The dissolved Rare Earths minima at 107 m are situated at the onset of the sulphide waters, coinciding with a strong particle maximum. Later particles were reported (Dr. Repeta, Woods Hole) to be dominated by large numbers of obligate phototrophic, sulphide-oxidizing, bacteria, also characterized by great abundance of bacterial chlorophyll *e*. The secondary particulate Mn maximum at the same depth may hint at a thin coating of surface-active Mn-oxides on bacterial cell walls. Apparently these bacteria act as adsorbing scavengers for the dissolved Rare Earths. (This project is carried out in cooperation with J. Schijf, University of Utrecht/Free University, Amsterdam.)

H1-17 MASS BALANCE OF CARBON IN PELAGIC SURFACE WATERS

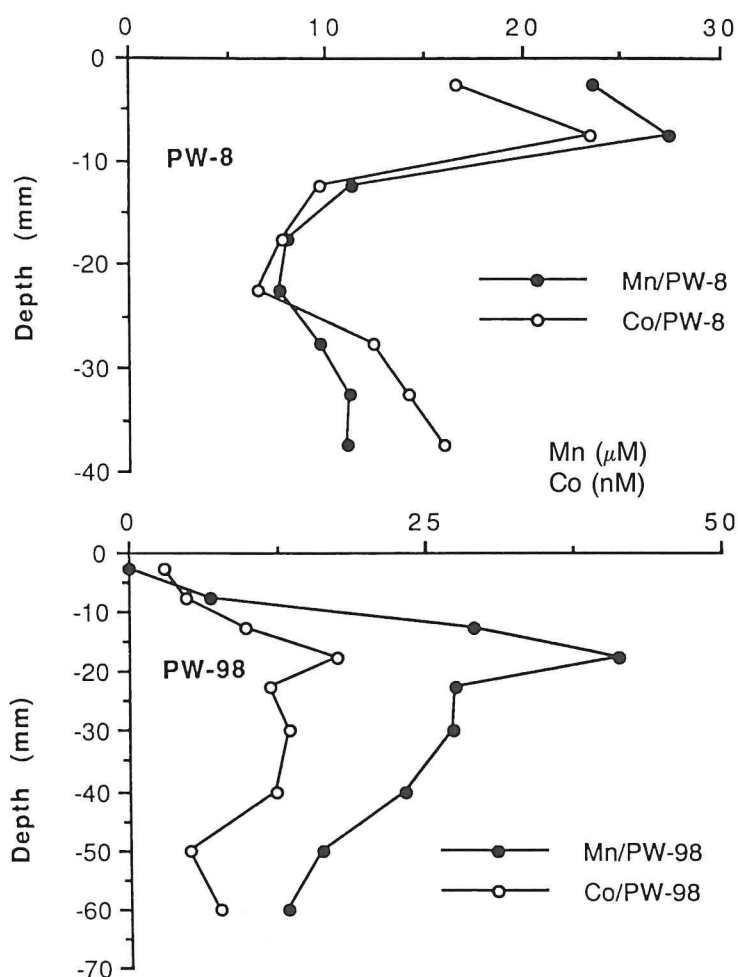
M.H.C. Stoll, H.J.W. de Baar,
G.C. Cadée, J. Rommets,
J. Hegeman

This JGOFS project started in February 1989 with the appointment of Stoll by the NWO CO₂ Working Group. Instrumentation was purchased or specially constructed and implemented with financial support from NWO/CO₂, VROM and NWO/SOZ. For total inorganic CO₂, a coulometric device was built for us by Prof. Williams and associates at the University of Wales, where Stoll received training in June 1989. The already operational acid titration units for CO₂ and alkalinity (Rommets) were upgraded after design and advice of Bradshaw and Brewer (Woods Hole). Communications with Bradshaw and Brewer (Woods Hole) led to the acquisition of a novel high-temperature combustion instrument for Dissolved Organic Carbon (Hegeman/Cadée) analysis. At the Center for Isotope Research (University of Groningen) shipboard extraction systems were built for C isotopic determinations (Kers, University of Groningen). During the expedition the two independent methods for CO₂ determination gave good agreement typically within one per cent. Shipboard results are further processed onshore where the various available algorithms and sets of dissociation constants were compared to further improve overall accuracy. One manuscript has been prepared. The Dissolved Organic Carbon was found to be in the 100 μM range, in keeping with unpublished data of our US JGOFS counterparts but much higher than previously believed. This would suggest that the DOC pool is quite significant for the overall oceanic C budget, but the accuracy of the DOC method leaves room for improvement. (This project is carried out in cooperation with W. Mook and B. Kers, University of Groningen.)

H1-18 TRACE METALS IN SANDY SEDIMENTS OF THE DOGGER BANK, NORTH SEA

P.M. Saager, H.J.W. de Baar,
H.T. Kloosterhuis, W. van Raaphorst

This joint project between the BEWON group and the Chemistry Department was largely implemented by Saager during an 18-month appointment. The field programme was executed during the 1988 WINDOW cruise. The trace element composition of the sediments, the overlying waters and the suspended particulate matter did not reveal large-scale anthropogenic inputs. It is as yet not possible to distinguish between natural (background) levels and man-made additions. Interstitial water concentrations of Mn, Co and Fe (and Si, P) are high in comparison with the very low levels found in the overall sandy sediments. The pore water profiles of Co are among the first ever reported. The large dissolved gradients near the sediment-water interface may yield substantial fluxes into the overlying North Sea waters. This project was completed mid-1989.



Concentration profiles of Mn and Co in interstitial water of sediment at the Dogger Bank.

1.3. PHYSICAL OCEANOGRAPHY (H2)

INTRODUCTION

The theoretical research on non-linear dynamics is mainly directed towards the study of non-linear tidal dynamics. The work on Euler-Lagrange transformation was finished during this year, whereas the work on solitary waves continued. Cooperation between theoretical dynamics and modelling took shape in the study of Lagrangian chaos and tidal stirring and morphodynamics.

The ocean-going physical research has been started in the project DUTCH-WARP with the first measurements and the deployment of a mooring in the Iceland Basin. Cooperation with Germany in the field of physical oceanography is continued in the Greenland Sea Project and in the EPOS project near the Weddell-Scotia-Confluence.

In the field of small-scale turbulence studies no new research has been started.

The Frisian Front Project in the North Sea has been continued and is now coming to an end. Physical measurements have been carried out in the WINDOW project.

In the field of optics and remote sensing a number of cruises have been made to investigate relationships between optical properties of the seawater and the composition (algorithms) in coastal areas. A new project has been started to apply infrared and optical remote sensing in physical and biochemical oceanography.

H2-02 NON-LINEAR TIDAL DYNAMICS

a: Non-linear internal tides and solitons

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

It is common practice to divide (the 2D) current measurements obtained with a number of moored current meters, or a set of drifting drogues, into an ensemble averaged part, linearly varying deformation fields (the shear matrix terms) and a turbulent part. It has been suggested in the literature that a combination of three shear matrix terms versus the fourth will provide information on the stability of the observed velocity field, *i.e.* determine whether a group of particles will converge or diverge. Analysis along these lines of Eulerian and Lagrangian current measurements obtained in the southern North Sea indicates the existence of the material conservation of a new quantity, as the observed values in this parameter plane collect around the line separating stable from unstable regions. This quantity is a combination of the four shear matrix terms: the vorticity, divergence and stretching and shearing deformation - divided by total

depth. Indeed it can be shown that this quantity satisfies a conservation equation in which the local variation of a 'density' is balanced by the divergence of a 'flux'. Therefore, the suggested stability diagram loses its value. In a sense the derived conservation law is trivial, since the 'density', referred to above, can itself be written as the divergence of a vector, so that the divergence operator can be eliminated. On the other hand, it implies that the four shear matrix terms do not evolve independently, but rather are constrained so that only three of them do so.

One of the most challenging and successful subjects of modern physical oceanography is the observation and description of solitary waves and solitons. Its fascinating developments are completely in tune with the interests of a broader community of physicists and mathematicians who study the rapidly expanding field of non-linear dynamical systems. Indeed the first solvable non-linear evolution equation in this field, the Korteweg-de Vries equation, was formulated precisely in this hydrodynamical context. A small number of alternative evolution equations for other circumstances have been advocated since. None of these, however, include the dispersive properties of the Coriolis force. Therefore, a non-linear evolution equation has been proposed in which solitary waves are determined by a balance between non-linear advection and a dispersion mechanism related to this Coriolis force. A number of fundamental properties of this equation have been ascertained:

- (1) A closed form solitary wave appears to exist as a downwardly peaked wave.
- (2) The wave obtains a finite wave length for increasing non-linearity.
- (3) The internal length scale drops to zero, so that, in the previous limit, relative to this scale, the wave length becomes infinite.
- (4) At least two conservation equations can be derived.
- (5) The invariance of the equation under a Galilean transformation leads to a non-linear, ordinary differential equation.

A tidal wave propagating over a slope in the topography generates an appreciable amount of vertical motions which tilt isopycnals and which alternately compress and stretch vortex tubes. The periodic advection of periodically stretched/compressed vortex tubes leads to the generation of topographically bounded residual currents. The pressure gradients, related to the differentially tilted interfaces, result in the propagation of an internal tidal wave which acquires higher harmonics due to the advection by the incoming, external tidal wave motion. It turns out that the series of harmonic waves appearing in the far field can (for certain parameter values) be summed as a Kapteyn series, which demonstrates the bore-like structure of the propagating internal tidal front. This is in correspondence with field observations and other mathematical descriptions of the wave-field. In the near field (the generation area) the waves are of a standing type, due to a combination of leftward and rightward propagating waves. It is argued that these correspond to the trapped waves and residual currents earlier described.

H2-03/H2-04 NON-LINEAR TIDAL DYNAMICS

H. Ridderinkhof, J.T.F. Zimmerman

b: and c: see BEWON project S-01f.

H2-05 DUTCH-WARP (DEEP AND UPPER TRANSPORT, CIRCULATION AND HYDROGRAPHY-WOCE ATLANTIC RESEARCH PROGRAMME)

H.M. van Aken, C. de Boer, L. Otto,
C. Veth

During the JGOFS-cruise of RV 'Tyro' in August-September 1989 extra days were scheduled for a preliminary hydrographic survey for the DUTCH-WARP programme. Along the 20°W meridian north of 60°N, 8 stations were occupied where CTD-casts to the bottom were recorded and where water samples were taken at 12 different depths. At 61°35'N 20°W, a mooring with 4 self-recording current meters was deployed.

Preliminary results indicate that along the 20°W section in the Iceland Basin two different types of Bottom Water and two types of Intermediate Water are found. Whereas the T-S-properties in the different Bottom Water types and in the Intermediate Water types can hardly be discriminated, considerable differences are observed in the concentrations of biogeochemical tracers. At 60°N, bottom water has been observed with relatively low concentrations of oxygen and relatively high concentrations of dissolved silicate and nitrate, probably due to admixture of water of southern origin, *i.e.* Antarctic Bottom Water. Between 60°30'N and 62°N, slightly colder bottom water with higher oxygen concentrations and lower nutrient concentrations has been found. This water is assumed to originate from overflow near the Faroes of water from the Norwegian Sea. At intermediate depths the water south of 62°N has higher nutrient concentrations than the Intermediate Water north of that latitude at the same potential density levels. Probably the high nutrient Intermediate Water originates from deep convection in the Labrador Sea, while the lower nutrient Intermediate Water originates from winter-time convection in the nearby Irminger Sea.

Between 47°N and 32°N, 20°W thermohaline staircases have been observed below the core of Mediterranean Water. The steps in these staircases increase in intensity towards the south. These staircases are probably generated by salt finger convection, which releases the potential energy of the salinity stratification in the Mediterranean Water. Given the correlation of salinity with other tracers, it is expected to be possible to calculate vertical diapycnic fluxes of oxygen and nutrients from the empirical 4/3 law of salt convection.

During a meso-scale survey near 33°N 20°W, a thermohaline front has been observed in the upper 300 m. Across this front also a strong nutrient signal has been observed. Since this front extends well into the photic zone, it is expected to have a clear effect on the lateral variation of the primary productivity.

H2-06 GREENLAND SEA PROJECT

H.M. van Aken

In February 1989 H.M. van Aken participated in cruise VA 78/1 of the German RV 'Valdivia' in the Greenland Sea. The Arctic Frontal zone in the West Spitsbergen Current was surveyed along a hydrographic section at 74°45'N, from 0° to 14°30'E. Every 10 km a CTD-cast to a depth of 1000 m was recorded.

In the frontal zone, 4 different frontal interfaces have been observed, separating 5 distinctive water masses. The Jan Mayen Current, transporting Jan Mayen Polar Water northward was bounded by fronts at 2°30'E and at 5°40'E. East of the latter front a sub-surface core of Jan Mayen Atlantic Intermediate Water has been observed. The hydrographic properties of this water type can be explained by modification of return Atlantic Intermediate Water from the East

Greenland Current due to double diffusive convection in the diffusive sense. East of a front at 8°E, two cores of Atlantic Surface Water were discerned, separated by a front at 12°30'E. The different hydrographic properties of these bodies of Atlantic Water are attributed to water mass modification in different branches of the Norwegian Atlantic Current, which are formed by topographic steering. From these results it has become clear that, in order to understand the role of the Arctic Front for the hydrography of the Greenland Sea, it is necessary to study this frontal zone in the context of the large-scale circulation of the Greenland and Norwegian Seas.

The 4 moorings, containing 12 NIOZ current meters deployed in 1988 on a section between Jan Mayen and Greenland, were recovered in September 1989 by the Icelandic RV 'Bjarni Saemundson'. At the time of writing this report, no data have been processed yet.

H2-08 EPOS-LEG 2 (EUROPEAN POLARSTERN OCEAN STUDY) (physical part)

C. Veth

During the EPOS-cruise (leg 2) in the Weddell-Scotia confluence area a large number of CTD-measurements have been carried out. The results are used to study the hydrographical structure of the water masses near the confluence and the frontal zone forming the interface between the Scotia Sea and the confluence area. Strong gradients are visible and south of the front is a highly dynamical and hence variable transition zone consisting of meso-scale water masses and eddies in different stages of evolution. The behaviour of the eddies is studied in cooperation with the University of Gothenburg.

The temporal and spatial behaviour of the upper part of the water column across the marginal ice zone in spring is determined by the counteracting influences of the wind force and the stabilizing forces of ice melting and solar heating. Because the knowledge of the structure and evolution of the water column is of fundamental importance for modelling of the phytoplankton growth, extensive CTD-measurements have been carried out during the EPOS-project (leg 2) in the area south of the Weddell-Scotia confluence. Repeated measurements of the same sections during the spring allow this evolution of the top layers in time and space to be studied, giving quantitative information on the relative importance of the influence of the determining parameters. This study is done in cooperation with the Université Libre de Bruxelles.

H2-09 FRISIAN FRONT PROJECT (physical part)

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

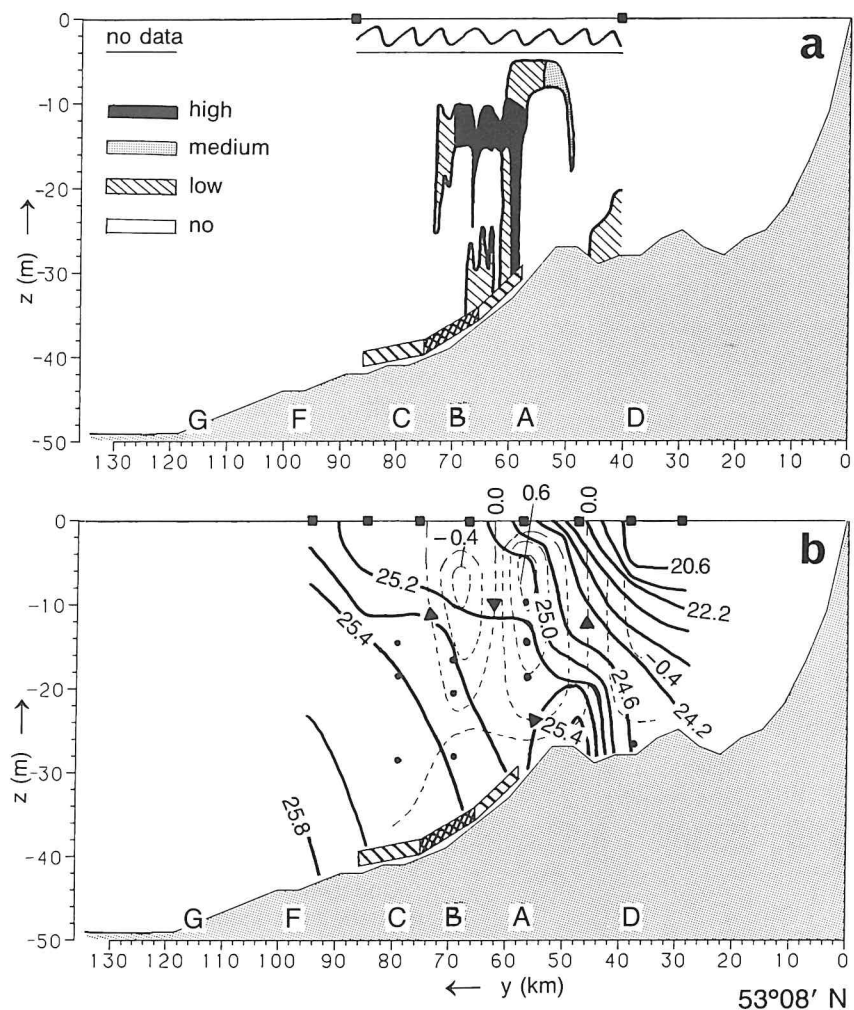
The subtidal current field in the area 60 km north of the Dutch Wadden Islands has been investigated for its horizontal and vertical variability by confronting the data with a number of modelled generation mechanisms. Generally the current is found to be in (near-) geostrophic balance, whereby the sea surface slope is caused by the local along-isobath directed wind stress. During passages of depressions the observed along-isobath current component is largest (25 cm/s) 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 re-

maining part is, within rather large uncertainty bounds, about equally explained by horizontal density gradients and by rectification due to the non-linear tide-topography interaction.

The observed harmonic tidal constituents have been compared with a theoretical non-linear analysis describing local and remote generation of higher (M_2 -generated) harmonics. The results reveal that for M_4 the sea level is remotely forced, but the current components are mainly locally forced as they are phase-locked to the M_2 tide. These results are used to compare a Fourier expansion with the data. By parameterizing the bottom friction by a quadratic law, the drag coefficient is found to change rapidly over the steep bottom slope, which is related to the sudden change in bottom roughness.

Echosound reflections (top figure), water circulation (dashed lines in bottom figure) and density distribution (solid lines in bottom figure) recorded simultaneously in a plane perpendicular to the coast during the Frisian Front Project in August 1987. The top figure is an interpretation in four grey tones of the original scan, which is thought to be an image of the distribution of small fish (sprat). The circulation is interpolated from current measurements below 10 m depth at the stations indicated by letters (small dashed) and further interpolated towards the surface and the coast to satisfy the boundary conditions (long dashed). At the bottom the area is marked by a zone with relatively large mud content between moorings A and F (the shaded bars near the bottom line in either figure).

Between A and D the reflections closely follow the isopycnals. The most intense reflections are found at a level near 12 m depth corresponding to the position of a weak pycnocline. Although less clear, the area in which reflections are found is bounded by upwelling zones near A and between B and C. It would be natural for fish to follow the highest food supplies, phytoplankton, which is more or less subject to the water circulation. A tentative conclusion is that the (phytoplankton) particles well up at least near A and then settle between A and C.



H2-10 WINDOW PROJECT (physical part)

H. Ridderinkhof, C. Veth

See BEWON project S-01e

H2-12 OPTICAL REMOTE SENSING OF COASTAL WATERS

G. Marees, R.W.J. Dirks

The research on the optical properties of the North Sea with respect to remote sensing applications was continued. The emphasis of this research was on the turbid waters near the Dutch coast. Several surveys were carried out over the year with RV 'Aurelia' in sea areas with large horizontal turbidity gradients, *i.e.* areas with large variations in the seawater composition. The data sets obtained were used to investigate the relationships (algorithms) between the optical properties of the seawater (spectral reflectance, irradiance attenuation coefficient, beam attenuation coefficient, etc.) and the seawater composition (total suspended matter concentration, chlorophyll concentration, phaeophytine concentration, yellow substance concentration). Our main interest concerned the relationships suited for the interpretation of (optical) remote sensing imagery, *i.e.* the mapping of biomass, total suspended matter load etc. The extensive data set on the optical properties of the North Sea will also be used, in cooperation with Rijkswaterstaat, for a pre-feasibility study on an airborne laser bathymetry system.

The research cruises were spread over the year to investigate the temporal changes of the relationships of interest (influence of algal blooms etc.). Significant changes over the year have indeed been found. The effect of solar altitude and of the tide on the spectral reflectance of the seawater was investigated at some anchor stations. An extensive data report on the optical properties of the North Sea is in preparation.

Within the framework of a national remote sensing programme one of the research cruises near Texel was combined with an actual airplane remote sensing experiment. We also participated in a similar international airplane remote sensing campaign (the European Imaging Spectrometer Aircraft Campaign (EISAC)) over the German Bight and the Skagerrak. Regional similarities and differences between the remote sensing algorithms are investigated.

Several satellite (AVHRR) remote sensing images of the North Sea obtained during our cruises were processed and will be used for interpretation, and for comparison with the aircraft imagery.

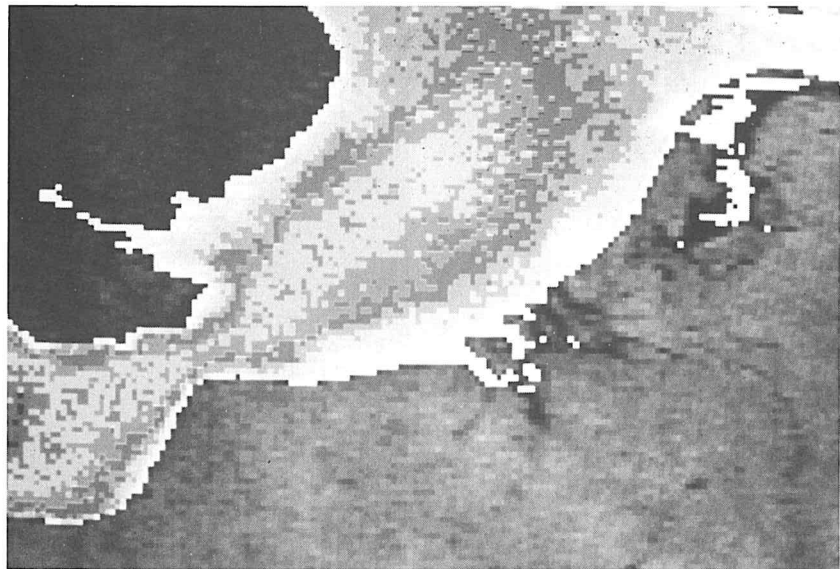
These investigations were performed within the framework of the Netherlands Remote Sensing Programme (NRSP) and were financially supported by the Netherlands Remote Sensing Board (BCRS).

Investigations of light transfer in the sea have been continued. The existing two-flow model has been enlarged with inelastic scattering processes (fluorescence, Raman scattering). Comparisons with measurements as well as with rigorous models demonstrate the applicability of the two-flow model in sea waters.

Underwater spectral irradiance measurements performed in the Madura bay (eastern Java, Indonesia) have been used to retrieve average absorption and backscattering spectra. Measurements of irradiance can be affected considerably by the shielding of the irradiance collector. A correction method has been proposed and will be tested. The Secchi visibility depth in clear waters appears

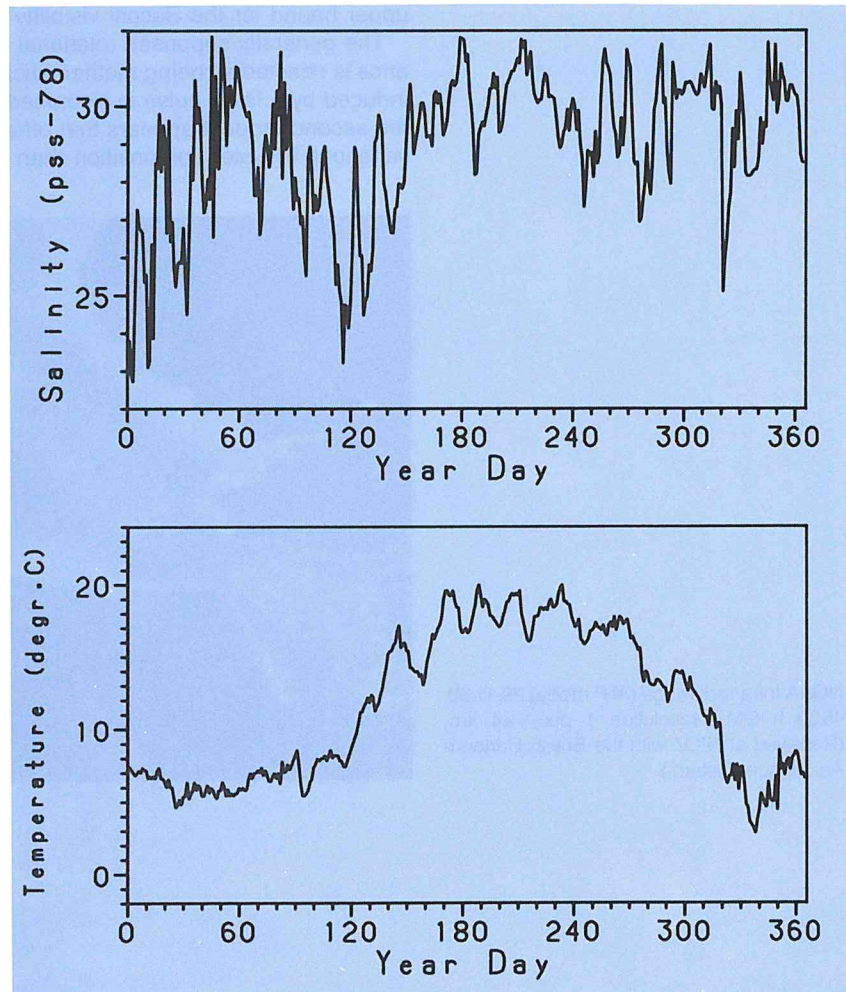
to depend on the colour filters used. Applications will be tested. A theoretical upper bound for the Secchi visibility depth amounts to up to 130-150 m.

The generally supposed rotational symmetrical form of the asymptotic radiance is rejected as being mathematical evidence. The underwater light field as induced by a laser pulse is examined by a multiple scattering approach up to the second order. It appears that off-axis measurements are more sensitive to variations in water composition than the (classical) on-axis measurements.



NOAA Infra-red image (ATP mode) 29-11-89, 15.30 h GMT, resolution 1 pix=4×4 km. (Received at NIOZ with the British Dartcom Aerospace System.)

Daily observations (08.00 local time) of temperature and salinity of the Marsdiep near the institute have been recorded since 1983. The record for 1989, shown here, shows the relatively fast increase in temperature in spring, coinciding with a low salinity event. The signals show a 14-day-period oscillation due to the interaction of the observation time with the tidal period.



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 and in the Zaire river mouth (see 1.1.1. New Multidisciplinary Programmes), 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), 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, and the naturally radioactive isotopes used for dating and tracing sediment transport and erosion (resuspension) (H3-19). 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 1.1.1. New Multidisciplinary Programmes).

H3-01 FLOCCULATION PROCESSES

D. Eisma, T. Schuhmacher

A start has been made to measure *in situ* size distributions of suspended particles in West European estuaries with an image analysis system using the benthos plankton camera photographs made in previous years. Particles larger than 80 μm could be measured reliably. The data for the Gironde estuary show a predominance of flocs of several hundred μm diameter. Data are still too few to indicate relationships of *in situ* floc size with salinity, water depth or suspended matter concentration.

H3-02.1 SUSPENDED SEDIMENT ACCUMULATION IN THE DOLLARD

D. Eisma

D. Eisma and J. Kalf, with the assistance of H. van Haren (Physics department), measured current velocity and direction in combination with suspended matter concentrations at a number of stations in the Dollard. The ebb was stronger than the flood, and through the channel export of suspended matter dominated. This can be a seasonal effect —measurements were made during the winter— but it is also possible that inward transport of mud is concentrated on the flats. Because of the deposition rates measured in the Dollard and the outward growth of the salt marshes, the Dollard has been considered a mud accumulation area.

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

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

In eight short sediment cores and along a 5-m high cliff section of the southern Hangzhou Bay, sedimentary structures and sedimentation rates were measured. These studies were complemented with an experimental, comparative study of mixing and exchange of tracer isotopes in sediments from the Wadden Sea.

The tidal flats of southern Hangzhou Bay are exclusively composed of well-sorted silts and clayey silts. Mud flats consisting of clayey silts form the high tidal flat zone, located near the coast; they are also found at the low tidal zone in eastern Hangzhou Bay. Dominant structures are laminated 0.1-2.0 cm thick silts/mud couplets with rare traces of bioturbation and occasional intercalations of fine sand. They appear to have been generated in response to semi-diurnal tides.

Well-sorted silts with a median grain size of 30 μm form the dominant sediment type from the low tidal zone towards the high tidal flats. Because of the strong hydrodynamic influence on sedimentation processes, the typical sedimentary structures consist of a sequence of erosional bed - flat bed - low angle cross lamination - mud laminae.

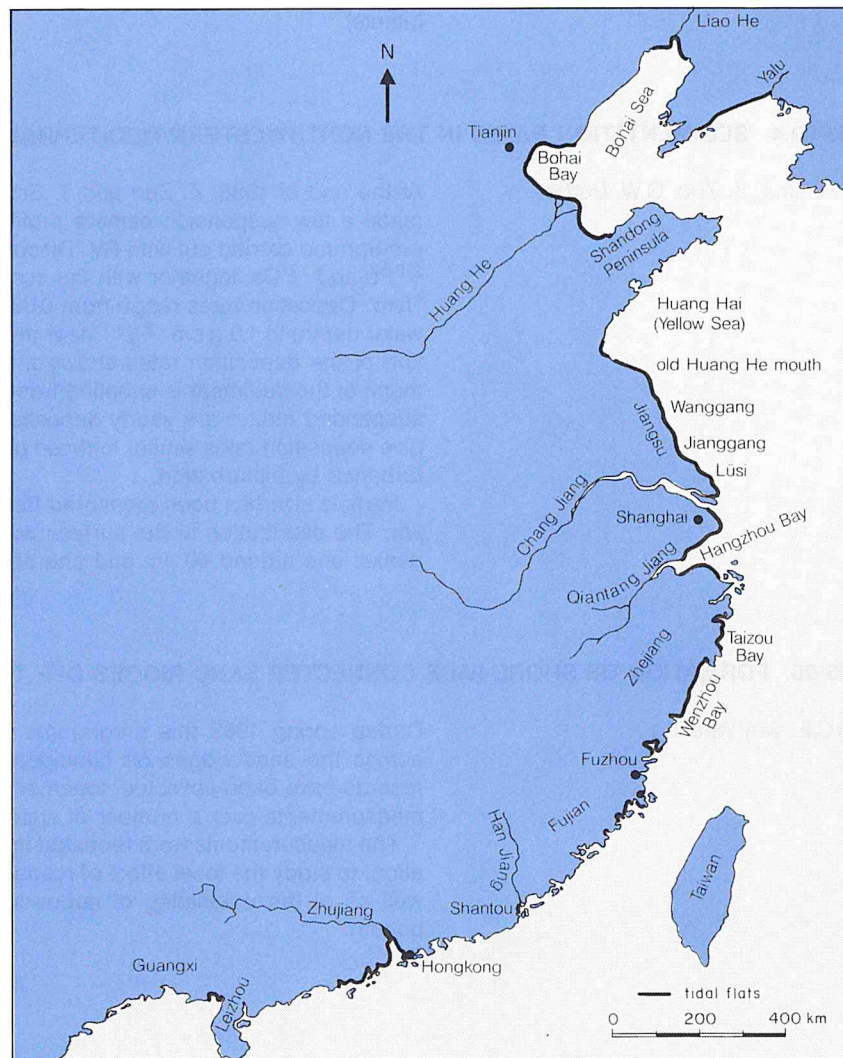
A typical sequence is formed by scour and fill structures, presumably caused in response to storms, or caused by shifting of tidal channels. Such structures are present particularly in western Hangzhou Bay and have a typical sequence of: erosional bed - mud ball or slump-like deposits - homogeneous layering-mud beds and mud/silt couplets.

The downcore ^{210}Pb profiles of the cores show a characteristic zig-zag pattern. Sedimentation rates vary between 34 cm/yr and 1 cm/yr, evidently a mean which is strongly influenced by catastrophic events and long-term vs short-term residence of the particles. These rates are in the same order of magnitude as those found in the Chang Jiang estuary off Shanghai.

Chen Shumin (East China Normal University, Shanghai) has completed XRD analysis on fine-grained sediments collected along the Chinese coast and on the shelf of the East China Sea during the Chinese - West German cooperative programme carried out by RV 'Sonne'. In the shelf samples also deposition rates have been determined. It appears that mud from the Huang He does not come south of the Chang Jiang river mouth. The large mud patch in the East China Sea largely comes from the Chang Jiang. The Chang Jiang mud is trapped in the large gyre in that area. CaCO_3 -content is found not to be a reliable indicator of origin.

Xia Fuxing (East China Normal University, Shanghai) carried out Coulter Counter and SEM analyses of suspended matter collected in the Chang Jiang river mouth in 1986 and 1988 as part of the Sino-French cooperative programme in that area. The suspended matter is rather uniform but flocculation occurs only in the outer estuary, where more dissolved organic matter is present.

Zhang Jing (Shandong College, Qingdao), following earlier work on suspended matter and bottom sediment samples from the Huang He delta and Bohai Bay, has carried out Coulter Counter, XRD and SEM analyses on suspended matter and bottom sediment from the Huang He river and on some loess samples. Loess is predominantly eroded and carried seaward by the Huang He. The data allow a study of the sorting of material during transport from the source to deposition downstream and in the Bohai Sea.



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

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

Z. Zuo has continued measurements of ^{210}Pb and fall-out isotopes in cores of the southern North Sea. An additional series of cores has been collected, as well as suspended matter and water samples, to study the ^{210}Pb and ^{210}Po systems. Deposition of suspended matter in the Oyster Grounds is located in a narrow zone approximately following the frontal zone that regularly develops in that area in spring and summer. An average of ca 2×10^6 tonnes of suspended matter is yearly deposited in that area (not including an unknown amount of organic matter that is mineralized again). This amount is small compared with the total of ca 45×10^6 tonnes yearly deposited in the North Sea area. Outside the zone of deposition there is probably exchange of old (resuspended) mud with recently supplied mud, resulting in an admixture of ^{210}Pb (and presumably pollutants).

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

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

At the end of 1988, Z. Zuo and T. Schuhmacher collected bottom cores and made a few suspension camera profiles in the Golfe du Lion, as part of the programme carried out with RV 'Discovery'. The cores have been analysed for ^{210}Pb and ^{137}Cs , together with the cores collected earlier in that area with RV 'Tyro'. Deposition rates range from $0.03 \text{ g cm}^{-2} \text{ y}^{-1}$ in the deep parts (2230 m water depth) to $1.0 \text{ g cm}^{-2} \text{ y}^{-1}$ near the shore (73 m water depth). The distribution of the deposition rates shows a tongue-like shape, which suggests that much of the sediment is supplied from the Rhône river. Ca 0.3×10^6 tonnes of suspended matter are yearly deposited in the Golfe du Lion. ^{137}Cs analyses give deposition rates similar to those obtained with ^{210}Pb and indicate little disturbance by bioturbation.

Particle size has been measured from the photographs from $3 \mu\text{m}$ up to $500 \mu\text{m}$. The distribution in the surface water as well as in deeper water has two peaks: one around $40 \mu\text{m}$ and one above $150 \mu\text{m}$.

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

Tj.C.E. van Weering

During spring 1989 this programme started with a survey of two transects across the sand ridges off IJmuiden. Echosounder profiles and side scan records have been collected, together with box-core data and current and tide measurements over a number of successive tidal cycles.

The measurements were repeated in autumn 1989, in an expected storm situation, to study the local effect of resuspension and reworking of sediments, as well as of the upbuilding of larger-scale sedimentary structures at the sea bottom.

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

This study forms the subject of the Ph.D. thesis of Shah Li Ping, University of Utrecht. The main results indicate that in the SW ebb-tidal delta sand transport and sediment exchange occur via the flood and ebb dominated channels of Texel inlet. There is no significant, wave-induced, net northward longshore drift in this area. It is clear that the differences between the development of the ebb-tidal delta of the Texel inlet and the other inlets of the Frisian Islands are related to the size of the tidal prism and the wave-induced longshore transport rate.

The annual eastward migration rate of the 'Razende Bol', the main ebb-tidal delta shoal, is 60-70 m, which involves an annual sediment transport rate of $\sim 0.6 \cdot 10^6 \text{ m}^3$.

The data collected in the tidal inlet between Ameland and Terschelling are inconclusive and need further elaboration.

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

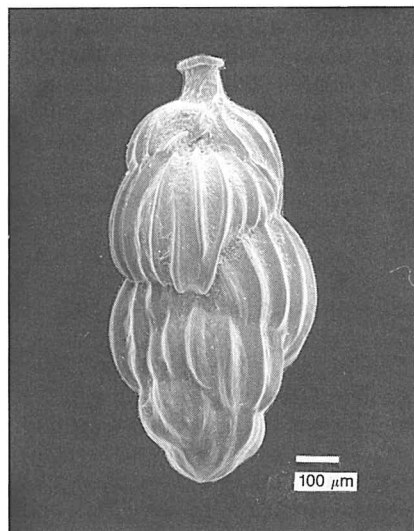
Tj.C.E. van Weering, L. Moodley

The sediments collected with box-cores in the Norwegian Channel sector between Egersund and Bergen have been studied for their sedimentation rate, using ^{210}Pb and ^{137}Cs isotopes. Initial data show that sedimentation is highest near the central and western parts of the Channel, but that non-deposition or possibly erosion prevails underneath the Norwegian Coastal Current. The latter is also shown on bottom photographs.

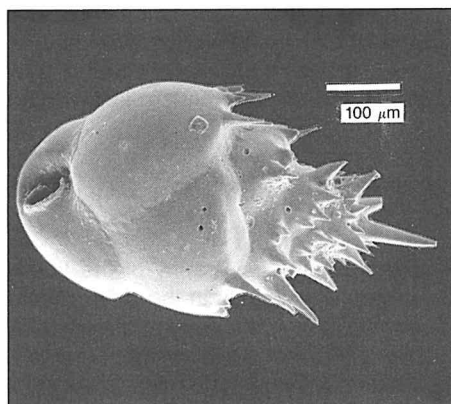
The distribution of benthic Foraminifera in the surface sediments shows a dependence on organic matter and a strong relation with water mass properties. This is particularly evident in the sediments underlying the Atlantic Current along the western flank of the Norwegian Channel.

The downcore distribution of benthic Foraminifera has been studied in about 20 piston cores. The comparison between the living and the dead assemblages is in progress, and will form the basis for a palaeoceanographic study of the Norwegian Channel since the deglaciation.

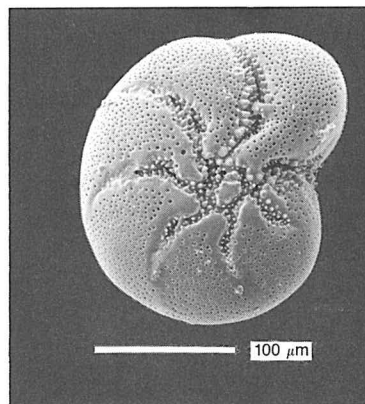
(Photos: L. Moodley)



Uvigerina peregrina Cushman



Bulimina marginata d'Orbigny



Elphidium excavatum (Terquem)

H3-09 SEDIMENTATION BY SLOPE-PARALLEL BOTTOM CURRENTS

Tj.C.E. van Weering

The seismic and acoustic profiles obtained from the Feni Ridge section enclosed by 54-56°N/12-16°W show that Feni Ridge crest is absent in the north of the study area and increases in height and steepness of the flanks to the SW. Sediment waves along the flanks have vertical amplitudes up to 45 m high; they are significantly lower in the north (less than 15 m) than in the southwest. The southernmost transects show distinct erosion of the lower slope of Rockall Plateau and migration of sediment waves towards the crest.

These observations indicate that drift development has been initiated in the SW of Feni Ridge and now proceeds to the north. The same is shown by the sediment waves.

In the seismic profiles five regional reflectors and three seismic facies constituting the Neogene drift complex can be recognized. The yellow reflector of latest late Miocene age marks the onset of a different sedimentary regime characterized by intensified bottom currents. Above this reflector early stages of the development of sediment wave formation can be recognized. The associated seismic facies is even and wavy, parallel bedded, with continuous high amplitude reflectors (facies A) on top of high amplitude, discontinuous, wavy reflectors with transparent intercalations (facies B). The distribution of the seismic facies is diachronous and again marks that development of sediment waves started earlier in the SW than in the N.

Piston-cores from Feni Ridge crest and flank show the presence of glacial and interglacial cycles in the sediments, characterized by low C org. (1-3%) and CaCO₃ (below 30%) contents and high C org. (3-6%) and CaCO₃ (30-60%) contents, respectively.

Cold, glacial periods show dominance of a polar planktonic foraminiferal assemblage composed of *N. pachyderma(s)* and *G. quinqueloba*. Interglacial periods have a subpolar assemblage of *G. bulloides*, *N. pachyderma(s)* and *G. inflata*. Sedimentation rates measured by oxygen isotope determination show that during isotope stage 1 sedimentation was 17.1 cm/ka, for stages 2 to 4 the rate was 7.8 cm/ka and for stage 5a to e 6.1 cm/ka.

The glacial periods are marked by absence of diatomaceous sediments; this is followed at the onset of deglaciation by a 'bloom' in the Faroer-Shetland Channel, and by a gradual development of diatoms in the Feni Ridge area.

The water-column studies during the Tydeman cruise and the distribution of diatoms in recent box-core samples indicate resuspension and up-slope transport of diatoms by bottom currents.

A start has been made with the purchase of equipment for the lander-tripod, and first tests with bottom lander operations were successful.

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

Tj.C.E. van Weering

The seismic stratigraphy of the Lombok Basin has been compared with the seismic sequences in the Savu Basin. This indicates that prior to the uplift of Sumba Island, these two basins were connected as a fore-arc basin *in statu nascendi*. This interpretation supports the idea that Sumba was in its present position before the onset of collision of the Australian and Eurasian plates, and afterwards became fragmented due to the collision process.

Recent sedimentary deformation along the Savu-Sumba ridge and sediment mass transport into the Savu basin may form the contemporary equivalent of the processes that formed the Bobonaro scaly clay in Timor.

A field campaign was held from 30 October to 5 December on the island of Sumba to study the oceanographic setting of the sediments that now establish the seismic sequence stratigraphy in the Savu and Lombok forearc basins and to correlate the uplifted part of the fore-arc basins with the submerged sectors.

H3-12/H3-13/H3-14

J.H.F. Jansen

see 1.1.1. New Multidisciplinary Programmes

H3-15 THE SILICA CYCLE

A.J. van Bennekom

Work on the cycles of Si and Al has been carried out in the Weddell-Scotia confluence in the framework of EPOS (European Polarstern Study). The use of ^{32}Si (β -emitter, $t_{1/2}$ about 170 years) as tracer for the biogenic uptake of silicic acids (in cooperation with P. Tréguer, Brest and L. Lindner, NIKHEF, Amsterdam) offers unique possibilities for the study of Si-uptake and diatom growth. The tracer is available in nearly carrier-free form, and because of the high H_4SiO_4 concentrations in Antarctic surface waters (13-83 mmol m^{-3}), the natural nutrient ratios were only slightly disturbed during incubations. The increase in H_4SiO_4 , caused by the tracer addition, was usually 3-10%, and in one case 20%. The method is much more sensitive and much easier than the incubations with stable Si-isotopes used so far.

The results show a slow-growing diatom-dominated community in the Scotia Sea, whereas in the marginal ice zone growth rates of the diatoms are higher; however, in December diatoms form only a small part of the phytoplankton and are responsible for only a small part of the organic carbon production.

In the current silica budgets of the world ocean it is assumed that all phytoplankton production in Antarctic waters is in the form of diatoms; as a consequence, the Southern Ocean is thought to be responsible for about 2/3 of the total biogenic silica production. Extrapolation of our results shows that the Antarctic contribution to the Si budget of the world ocean is much smaller than previously assumed, and also that the total biogenic silica production is lower.

At NIOZ a computer program has been developed to separate the various deep water masses with S, T and H_4SiO_4 as tracers. South of the Scotia front (the northern limit of the confluence) upwelling of Scotia Sea Water from large depths is clearly shown. Repetition of the same section shows that the upwelling is not a continuous process but occurs in the form of 'rising balloons'. This mechanism plays an important role in the very sharp increase of H_4SiO_4 concentrations south of the Scotia Front.

The concentrations of dissolved Al, determined on board by the fluorimetric Lumogallion method, ranges from 1-3 nM in surface water, with a tendency towards increase in the ice-covered waters. Samples of snow present on top of the ice had higher and variable concentrations of dissolved Al. In subsurface waters Al is 1.5-2 nM; there is a slight increase to 2.5-3 nM in deep waters.

These concentrations are low compared with other oceanic regions; especially the very slight increase with depth seems characteristic of the Southern Ocean.

In cooperation with A. Buma, extensive use was made of the expertise on culturing under clean conditions available at NIOZ. For incubation experiments dissolved Al has been added to surface water samples.

The yield of the cultures has proved to be insufficient for kinetic studies of biogenic silica; the yield has been increased by adding deep-sea water. The apparent uptake of Al is low; processing of samples for kinetic studies is still in progress. An interesting result is that in Scotia Sea water, with initially relatively low H_4SiO_4 concentrations, this nutrient was the first to reach near-zero concentrations, whereas in Confluence and Weddell Sea waters only about half of the H_4SiO_4 was consumed during the incubations, and NO_3 was the first nutrient to be depleted.

The trends of nutrient concentrations in the Southern Bight of the North Sea and the eastern Channel were further investigated, with emphasis on the high-salinity offshore regions. A rising trend is apparent for PO_4 , less distinct for NO_3 and very small for H_4SiO_4 .

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

S.J. van der Gaast

When basalt weathers at the earth surface and in seawater, smectite develops. This is a clay mineral with large surface areas and thus a high exchange capacity for dissolved matter. Not all types of basalt, however, weather at the same rate. A method has been developed to estimate the stability of several types of basalt in weathering processes.

After this we want to determine the origin of smectite which comes from basalts below the sea surface, and eventually its contribution to sediments, using differences in crystal structure and chemistry.

Crypto-crystalline structures in clay minerals are studied with low-angle X-Ray powder Diffraction (XRD) and cryo-High Resolution Transmission Electron Microscopy (HRTEM). Allophane and imogolite, which are both clay minerals with a spherical shape, are hollow and have channels and pores (zeolitic structures). Because of the shape and the small size of these minerals, it is difficult to determine their crystal structure. Fortunately, comparable structures are formed during the heating of kaolinite and dickite. These minerals are studied with low-angle XRD and cryo-HRTEM. Spacings found by the two techniques agree fairly well.

Indications have been found that such zeolitic structures, which have specific absorption sites and which are able to catalyse upgrading and downgrading reactions, are present in most types of clay minerals. These structures can shed light on geochemical processes in sediments and soils.

H3-19 DATING WITH ISOTOPES

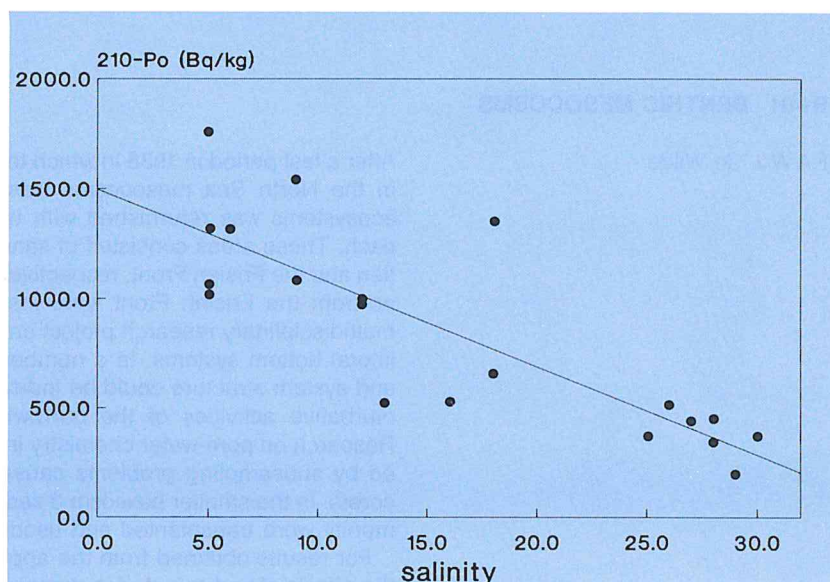
G.W. Berger

After publication of the NIOZ Report ' ^{210}Po in Dutch coastal waters' a new project was started at the request of the Ministry of Public Health. The aim of this project (financed by the Ministry and EC) is to get insight into the radiological impact of the releases of the non-nuclear industries (mainly the phosphate-processing industry) with emphasis on the behaviour of the radionuclides in the estuary of the Nieuwe Waterweg. Two surveys were carried out (20 days' ship-time). The aim of the first survey was to locate the sources, of the second to study the distribution of the radionuclides in the estuary. Besides ^{210}Po , the nuclides ^{210}Pb , ^{226}Ra , ^{231}Pa and ^{230}Th were studied, in dissolved state as well as absorbed on suspended material. The first results show ^{210}Po concentrations in suspended matter of up to 50 times above the 'natural' level.

Cores taken by the University of Nijmegen in the Sabaki river estuary off the coast of Kenya have been analysed. Although the quality of the sampling methods is poor, the results indicate that an increase in erosion of the drained area is a serious threat to the coral reefs near the coast.

In cooperation with the University of Utrecht and Center for Marine Research in Rovinj, Yugoslavia, dating of cores taken off the Italian coast in the Adriatic Sea has been started. The aim is to give a time scale to eutrophication processes as reflected in sediments by changing foraminifera and plankton composition.

Cores taken in 1988 in Hangzhou Bay, China, have been analysed in cooperation with visiting scientists from the 2nd Institute of Oceanography in Hangzhou. In the same framework a project has been set up to compare these tidal sediments with the Balgzand area and the Mokbaai. Besides, laboratory experiments have been set up to study residence time/salinity/grain-size dependencies of K_d values of ^{210}Po and ^{210}Pb .



^{210}Po -salinity relationship in suspended matter in the Rhine estuary. Natural background concentrations of $50 \text{ Bq}\cdot\text{kg}^{-1}$ are normal. The high concentrations measured here can be related to the disposal of phosphogypsum by phosphate-processing plants 20 km upstream of the river.

1.5. BENTHIC SYSTEMS (B1)

INTRODUCTION

The Department of Benthic Systems focusses its research on the elucidation of the structure and functioning of marine benthic ecosystems and on assessing their relations with environmental conditions (biotic and abiotic). Since the benthic system is in many cases fed by sedimentation of organic matter from the overlying water column, some studies of the water column are also included.

With experimental ecosystems (benthic mesocosms) studies have been executed on the effect of harbour-sludge dumping in the sea (B1-01/S-06). In the North Sea a benthic front is studied on a smaller scale (B1-11), while on a larger scale the synoptic mapping of the North Sea Benthos is continued (B1-07). To demonstrate variation in time, long-term trends in benthic fauna of the North Sea are studied (B1-10). Work on expeditions is continued: Mauritania (B1-08), Angola Basin, Zaire river (1.1.1. and B1-02) and Antarctica (B1-02, B1-06). Studies on more or less specific groups are the projects on microorganisms (B1-02), protozoans (B1-06) and coral reefs (B1-05).

B1-01 BENTHIC MESOCOSMS

P.A.W.J. de Wilde

After a test period in 1988 in which the success of transplanted bottom sections in the North Sea mesocosms was demonstrated, one of the experimental ecosystems was refurnished with two uninterrupted sediment areas of 3 m² each. These areas consisted of sandy and silty sediments from the Breeveertien and the Frisian Front, respectively. In the second mesocosm sediment boxes from the Frisian Front were installed separately. These efforts served a multidisciplinary research project on the effects of organic food supply on sublittoral bottom systems. In a number of cases distinct relations between food and system structure could be indicated. Special attention was paid to the bioturbative activities of the burrowing crustacean *Callinassa subterranea*. Research on pore-water chemistry in the sandy bottoms, however, was frustrated by subsampling problems caused by reshuffling of the sediments in the corers. In the smaller boxcosm 3 sediment sections from a rich *Amphiura* community were transplanted and used for eutrophication experiments.

For results obtained from the applied SEDEX experiments, which deal with the effects of harbour-sludge dumping in the open sea on intertidal mudflat systems, see B1-01/S-06.

B1-01/S-06 SEDIMENT EXPERIMENTS (SEDEX)

R. Dekker, G.W.N.M. van Moorsel,
P.A.W.J. de Wilde

At the end of 1989, the 3-year SEDEX programme expired, which investigated the effects of harbour-sludge dumping in the North Sea on tidal flat ecosystems. The set-up was the same as in 1987 and 1988, viz. MOdel DUMP Sites (MODUSes) connected to MOdel Tidal Flats (MOTIFs) containing macrofauna. In 1989 one MODUS containing clean sand was used as a control, and a second one was furnished with a fresh load of Delfzijl harbour sludge. The two other MODUSes were provided with a bottom layer of Rotterdam and Delfzijl sludge, respectively, retained from the previous year. These latter sludges, however, were thoroughly dried before they entered the mesocosms in order to remove, by mediation of microbiological processes, part of the nitrogen.

As in the previous years the effects on macrofauna were investigated by NIOZ, other system parameters by TNO, RIN and DGW.

By far the highest primary productivity was observed in the system with the fresh harbour sludge from Delfzijl. Large and long-lasting phytoplankton biomasses were also present in the two other systems treated with sludge during the experiment. The observed high densities of *Corophium volutator* and the increased growth and higher condition indices in *Macoma balthica* and *Cerastoderma edule* in the treated basins are related to the enhanced food levels. Shell deformations in *Cerastoderma edule* were found again in the MOTIFs where fastest growth occurred, i.e. with fresh Delfzijl sludge and oxidized Rotterdam sludge. Dramatic mortalities in any other macrobenthic species did not occur. In general, the observed differences in ecosystem development in the various treated basins are attributed to eutrophication effects rather than to toxic effects. Similar conclusions resulted from the 1987 and 1988 experiments.

Further improvements of the water supply resulted in an almost perfect distribution of larvae originating from the Marsdiep over the different mesocosms.

B1-04 COMMUNITY METABOLISM OF BENTHIC SYSTEMS AND FRONTS

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

During the benthic leg of the Joint Global Ocean Flux Study, North Atlantic pilot programme, the structure of the benthic system of the deep ocean bed was investigated. Faunal groups contributing to the benthic community were analysed. Oxygen demand of the sea bed was estimated from undisturbed sediment sections incubated on deck under *in situ* conditions. In the fourth year (last stage) of the Ph.D. study of Sandra Cramer the results of the Frisian Front project and Window project have been elaborated. The enhanced respiration at the Frisian Front can be explained by the rate of carbon input, which determines the level of mineralization throughout the year, and by the annual variation in temperature, which is reflected in the seasonal fluctuation of respiration.

The Window project provided good insight into the distribution of the benthic respiration in the central part of the North Sea. An estimate was made of the contribution of macrofaunal biomass and aerobic bacterial production (in cooperation with F.C. van Duyl) in total community respiration.

B1-11 BENTHIC FRONT SYSTEMS OF THE DOGGER BANK

R. Heyman

The investigation of the benthos on the Dogger Bank has so far not revealed any enriched benthic communities along the northern slope and at the eastern part of the bank. The bottom there is uniformly composed of sand with a very low mud content. In 1989 the rich benthic fauna in the southwestern part of the bank has been mapped in greater detail by means of box-core samples. Sediment samples have been collected to complement the sediment map. A start has been made with a study of the population dynamics of the sea urchin *Echinocardium cordatum* from the Dogger Bank. This ubiquitous species is found in all sediment types and at all depths in the Dogger Bank area. Comparison of the growth rates of *E. cordatum* from these different habitats may show differences in the benthic food supply. The year-to-year variation in growth will be analysed to evaluate the stability in food supply. Some first results indicate that growth of *E. cordatum* living in the shallow sandy part of the bank has increased continuously over the past 6 years.

B1-07 SYNOPTIC MAPPING OF THE NORTH SEA BENTHOS

G.C.A. Duineveld

The analysis of the samples from the Dutch Sector was completed, and the resulting data were combined with those obtained by the participants who covered the adjacent areas. A final synthesis of the complete data set is scheduled for 1990. This analysis was preceded by a taxonomic revision of the species lists contributed by the participants.



(Photo: NIOZ)

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

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

A retrospective study on the growth of the long-living mollusc *Arctica islandica* has been undertaken in search of historical fluctuations in the growth rate of this suspension-feeding mollusc. Synchronized fluctuations in one or more populations may indicate large-scale environmental fluctuations. The first results with young specimens from the Fladen Ground show that congruent fluctuations do occur. The time-span covered by these young animals is, however, only one decade. The long time-span covered by adult specimens (up to 100 years according to literature data) offers the opportunity to look further back in history. A preliminary analysis of adult *Arctica* from the Fladen Ground reveals distinct fluctuations in their growth rate, which are strikingly similar in several specimens. Before this work can proceed, the assumption of the annual formation of growth rings must be verified. Using the different levels of ^{14}C to which the environment has been exposed during the present age, viz. low levels during the pre-bomb period, peak levels in the 1960s and elevated levels in the post-bomb period, it may be possible to delimit the corresponding sections of the shell and hence to establish if the number of rings is an accurate measure of age. These ^{14}C analyses are at present being carried out in cooperation with Dr. K. van der Borg of the Physical Laboratory of Utrecht State University.

B1-08 MAURITANIA EXPEDITION

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

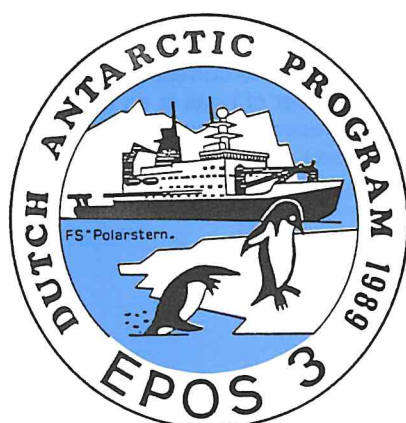
The beam-trawl and box-core samples collected during the Dutch Mauritania I expedition to the offshore Mauritanian shelf have been analysed. In total 17 epibenthos samples, 27 macrobenthos samples (1 mm fraction), 30 mesobenthos samples (0.4 mm fraction) and 8 meiobenthos samples have been processed. All specimens have been counted, weighed and, if possible, identified to species level. The samples reveal a remarkably rich and diverse offshore benthic fauna both at the shallow and the deeper stations. At most stations, biomass levels equal or surpass the levels found in the North Sea. Also distinct faunal trends are visible which partly coincide with gradients in sediment composition. To be able to relate these characteristics of the benthic fauna and its community metabolism (measured by *in situ* and shipboard methods) with the amount and quality of the food, the algal pigments in the sediment have been quantified by the HPLC technique.

B1-02 MICROBIAL BIOMASS AND ACTIVITY IN MARINE ECOSYSTEMS

J.H. Vosjan, P. Visscher

Measurements of ATP as relative biomass parameter and of ETS-activity as potential respiration rate were carried out in water and sediment in various climatic zones.

Some results of earlier expeditions to tropic regions (Snellius II) were worked out. Deep-sea observations in East Indonesian deep-sea basins proved that the amount of ATP in the upper cm of the sediment is several thousand times



higher than in the surrounding water, e.g. at 7300 m depth the Weber deep showed 0.3 ng ATP per litre in the water phase and 0.8 ng ATP per ml in the upper cm of the sediment. An expedition to tropical regions off West Africa, the Angola Basin and the Zaire (Congo) river was executed in October-November-December; the distribution of microbial biomass in water and sediment was described.

In temperate zones such as the North Sea and Dutch Wadden Sea similar measurements were carried out and elaborated. Distribution patterns of ATP and ETS-activity in the Frisian Front region in August 1987 showed the highest concentrations just south of the front. During this cruise (FFP4) in August, the weather was very stormy so that resuspension and sedimentation may have influenced the distribution of import of organic matter to the benthic ecosystem and consequently the distribution of ATP and ETS-activity.

An expedition to the inner Weddell Sea (Antarctica) was made in the framework of the European Epos-3 expedition (January-February-March). In the water column through the Weddell-Scotia Sea confluence zone the biomass and respiration was described. It appeared that in the productive summer season the ATP values are clearly higher than in winter. Values of over 1000 ng ATP per litre were found, whereas during the Antarctic winter expedition in 1986 maximal values of 200 ng per litre were found. In the inner Weddell Sea near Halley Bay and Kapp Norvegia similar research was done in water and sediment. In the sediment very high values of ATP, about 200 times higher than in the water column, were found. Integrated over a 5-cm sediment column Halley Bay gave values of 2.6 mg ATP per square m and Kapp Norvegia 3 mg ATP. ATP tends to decrease with increasing depth.

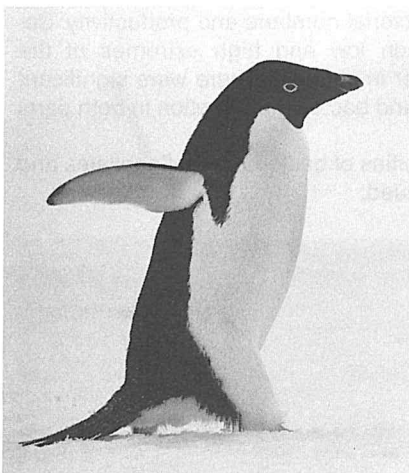
Observations on ratios between biomass and respiration gave ratios of 10 to 12 days; for tropical waters we found ratios of 1 day. This means that the turnover of organic matter in polar regions is much slower than in the tropics.

Physiological experiments on the effect of UV-b radiation on the microbial system of Antarctic waters showed a 75% decrease of the ATP content within 5 hours of UV irradiation.

As part of the BION-project 427.022 BO (Van Gernerden (University of Groningen), Vosjan, Visscher) research on laminated microbial ecosystems was carried out in the Slufter area on Texel. Every six weeks cores were taken along a transect through a microbial mat and depth profiles of twelve sulphur compounds (S^{--} , FeS , FeS_2 , SO_4^{--} , $S_2O_3^{--}$, $S_2O_6^{--}$, Sx^{--} , dimethylsulphide (DMS), methylmercaptane (MSM), dimethyldisulphide (DMDS), dimethylpropiothetine (DMPT), S^0) were established. Time-serial microelectrode studies revealed diurnal changes in oxygen and hydrogen sulphide profiles. Biological parameters included MPN counts (Most Probable Number) of sulphate-reducing bacteria, anoxygenic phototrophs, chemolithotrophs and denitrifying chemolithotrophs. Chlorophyll a and, bacteriochlorophyll a profiles were taken to quantify oxygenic and anoxygenic phototrophic organisms. Turn-over studies of thiosulphate indicate that this sulphur compound might play a key role in the sulphur cycle, especially since it can be utilized by all functional groups mentioned above. Seasonal variations appeared to be rather extreme, but spatial heterogeneity for most parameters studied was not dramatic. Meanwhile, laboratory studies are under way which focus on the sulphur metabolism of several bacterial strains isolated from the Slufter mat. Both field and lab data elucidate microbial sulphur cycling, including for the first time both organic and inorganic sulphur compounds.

B1-06 PROTOZOANS

R.P.M. Bak



(Photo: G. Nieuwland)

Small protozoans ($< 20 \mu\text{m}$) are of keystone importance in alternative pathways for energy transfer in marine systems (microbial loop, small food web), and to understand basic processes such as the utilization of bacterial production, characteristics of the protozoan populations must be understood. Investigations of characteristics of populations of auto- and heterotrophic flagellates, whenever possible in relation with relevant variables such as bacterial production, ciliates or meiofauna densities, were initiated in Antarctic habitats and North Sea mesocosm systems. Such studies were continued in Wadden Sea and Marsdiep.

A diversity of Antarctic habitats were studied during EPOS leg 3: the water column along a 47°W transect from $57-61^\circ 30'\text{S}$ through the Scotia-Weddell Sea confluence area, a water column transect off Kapp Norvegia in the Weddell Sea and two benthic transects, off Halley Bay and off Kapp Norvegia.

Nanoplankton-sized protists occurred in extremely high densities, $5-12 \cdot 10^3$ cells ml^{-1} , along the $57-61^\circ 30'\text{S}$ transect. A vast majority of those cells were in the size class $< 5 \mu\text{m}$ and a substantial part of the autotrophs $< 2 \mu\text{m}$. There was a change along the transect in relative abundance of auto/heterotrophic flagellates, of taxonomic groups and in bacterial density/biomass. For example heterotrophs (such as choanoflagellates) showed high and prymnesiids low densities in Scotia water. In Weddell Sea water prymnesiids, cryptomonads and prasinomonads occurred in high numbers. Also heterotrophic flagellate and bacterial densities were high ($5 \cdot 10^3$ and 10^6 cells ml^{-1} , respectively) in the southernmost part of the transect. Abundances were much lower along the pelagic transect in the eastern Weddell Sea.

There are few data available on benthic nanoflagellate populations, and at this time we can only compare our data of Antarctic bottoms with data from the Wadden Sea. Densities in sediments from 200-800 m appear to be an order of magnitude lower. Samples from deeper bottoms (1200, 2000 m) yield very few flagellates.

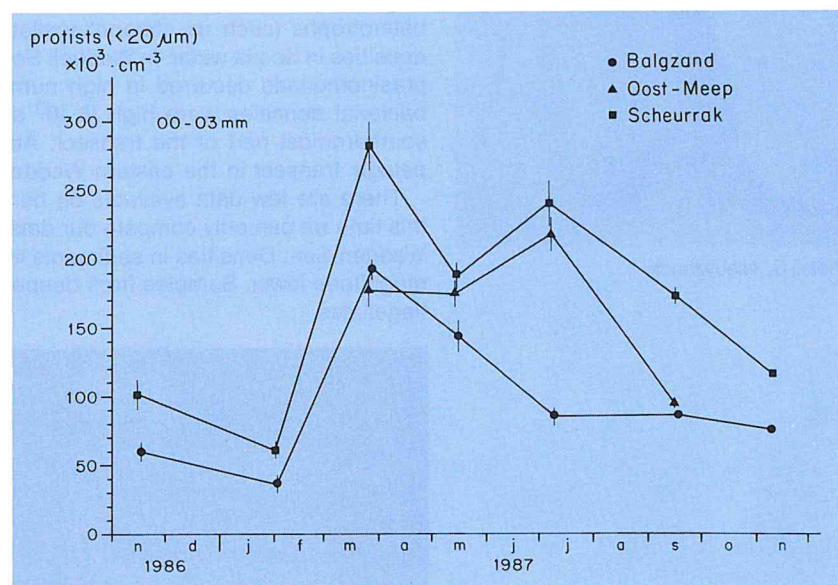


(Photo: G. Nieuwland)

The North Sea mesocosm experiment is still running and data are yet to be processed. However, it is already obvious that there are significant differences between the flagellate populations in sandy Breeveertien and silty Frisian front bottoms. Studies on pelagic flagellates in the North Sea water column show correlations between bacterial characteristics such as production and growth, and hetero/autotrophic nanoflagellates to be different in mixed waters, stratified waters and over fronts.

Repeated sampling in the Wadden Sea over tidal cycles in different parts of the year have shown two main differences between spring and summer. First, in summer tidal cycles mirrored each other perfectly over 24 hours for bacterial number, biomass, cell volume and productivity as well as for flagellate densities. In spring, water masses that have been in residence over the tidal flats in the afternoon showed relatively higher bacterial numbers and productivity. Second, the tide-related amplitude, between low and high extremes of the microbiological variables, was much larger in summer. There were significant correlations between densities of protists and bacterial production in both parts of the year.

The study of fluctuations in the communities of bacteria, nanoflagellates and ciliates in Marsdiep water is being continued.



Densities of small protists in the surface sediment layer at Balgzand, Scheurak Omdraai and Oost Meep.

B1-05 CORAL REEFS

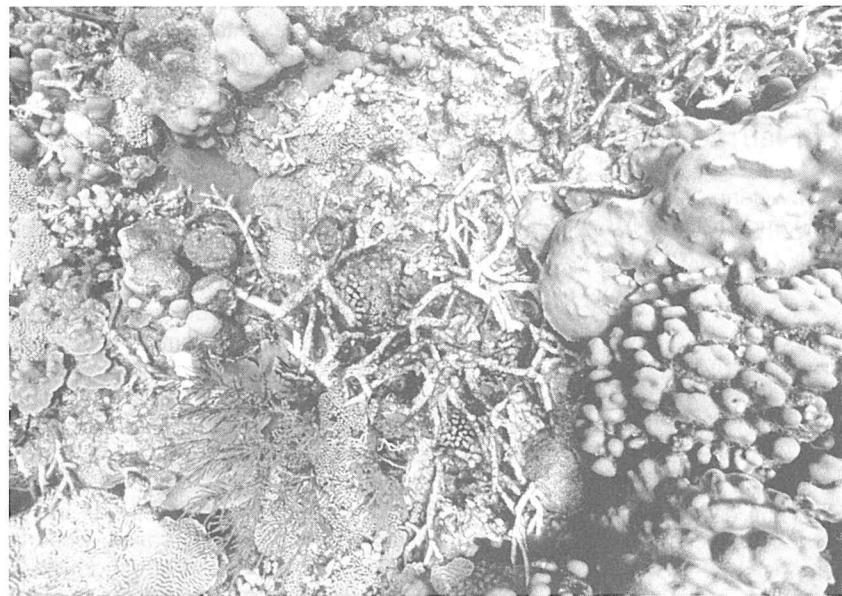
R.P.M. Bak

Stony corals (Scleractinia), of basic importance in the structuring and maintenance of reef habitats, are clonal organisms. Essential aspects in the ecology of such organisms are the distorted relation between size and age, partial mortality, processes of fission and fusion of individual colonies and extreme longevity. Short-term experimental studies as well as long-term analyses of changes in *in situ* communities are needed to understand the basic processes.

The most dominant coral of Caribbean reefs, *Montastrea annularis*, has the potential to live at least hundreds of years and to build calcium carbonate colonies of enormous size and mass. However, populations vary significantly in terms of colony size and shape, possibly in relation with human activity. A study is initiated to study *M. annularis* populations, relating biological characteristics and environmental variables (including pollution) to colony size and shape.

Permanent quadrats on the reefs in Curaçao and Bonaire, at depths of 10, 20, 30 and 40 m, have been re-surveyed and photographed. There appear to be large changes in the shallower parts (10, 20 m) of the reefs, especially along the less exposed part of the coast. At greater depths blooms of the alga *Lobophora variegata* have occurred. The result is an increase in spatial competition and overgrowth of the living coral colonies. Analyses of exact changes in the photographs will elucidate the differentiation in life history strategies between corals. Changes in cover of different corals and other bottom components are indicative of the condition of the reef communities.

Studies on the bio-erosion of reef structures by echinoids and on life histories of larger reef sponges are being continued.



Part of permanent quadrat in the Curaçao underwater park (depth 8 m). Centre shows dead fragments of branched *Acropora palmata*. Changes in bottom components elucidate the differentiation in life history strategies between corals as well as environmental degradation.
(Photo: R.P.M. Bak)

1.6. PELAGIC SYSTEMS (B2)

INTRODUCTION

This year was dominated by participation in cruises and elaboration of three major projects: the European Polarstern Study (EPOS) in Antarctic waters (October 1988 to January 1989), the pilot programme of the Joint Global Flux Study (JGOFS) in the North Atlantic Ocean (August), and the Challenger expeditions in the North Sea in the framework of the British North Sea Project. A worldwide expansion of the work in international approaches to study and compare the functioning of marine ecosystems seems to be a main tendency.

In general it can be stated that the cruises were successful. The shipboard application of flow-cytometry provided excitingly detailed information on algal composition and distribution. New data on Antarctic zooplankton life cycles, biomass and grazing activity may lead to completely new concepts on productivity and food chains in the Southern Ocean, in particular with respect to the roles of krill and copepods. In cooperation with BEWON, laboratory facilities for continuous culture experiments with algae were built. The study of algal competition and succession at different nutrient regimes in the field can be backed up now by laboratory experiments on growth kinetics. Further progress very much depends on a careful analysis of samples and results.

B2-01 EUTROPHICATION AND PHYTOPLANKTON IN DUTCH COASTAL WATERS

M.J.W. Veldhuis
R. Riegman (BEWON)

Three sampling stations, one located in the inner Wadden Sea, one in the inlet, and one 5 to 10 miles off the coast in the North Sea, were visited *ca.* 10 times in the first half of the year. Sampling for zooplankton lasted until the end of the year. The spring bloom started in early March with a dominance of diatoms, later followed by an outburst of *Phaeocystis*. However, during the presence of *Phaeocystis* the diatoms never really disappeared. The highest biomass values, expressed as chlorophyll *a*, were observed in the inner Wadden Sea with values of up to 50 $\mu\text{g/l}$, decreasing towards the North Sea station. Concurrently with the increase in phytoplankton biomass the nutrient concentrations declined, gradually in the case of nitrogen and phosphate but rather sharply in the case of silicate. Really depleted nutrient concentrations, however, were not observed. Together with the increase in phytoplankton biomass, the total primary production increased, while the ratio protein/total primary production decreased. At the start of the growth season up to 60% of newly fixed carbon was found in the protein fraction but in June less than 20%.

In the experimental aquarium of the institute, continuous culture facilities were constructed in cooperation with BEWON to study algal growth under fixed nutrient and temperature conditions. (This project is carried out in cooperation with W. van Boekel, University of Groningen and EG.)

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 sorting of zooplankton samples collected in the Frisian Front area in 1987 was completed. The extensive data on seasonal variation in zooplankton species abundance, developmental structure and growth rate for 1986 and 1987 are now available in computer data bases. Differences between the mixed southern, the stratified northern, and the transitional frontal stations will be studied in the course of the winter 1989/90. Preliminary results show a gradual shift in predominant species composition in the transect perpendicular to the front. The Frisian Front project may clarify which population and transport processes cause the difference in zooplankton community of mixed and stratified areas. Signs that the frontal system influenced secondary production during the observed periods in 1986 and 1987 are only weak, as is the accumulation effect of sedimentation areas on the hatching of nauplii from resting copepod eggs in the sediment.

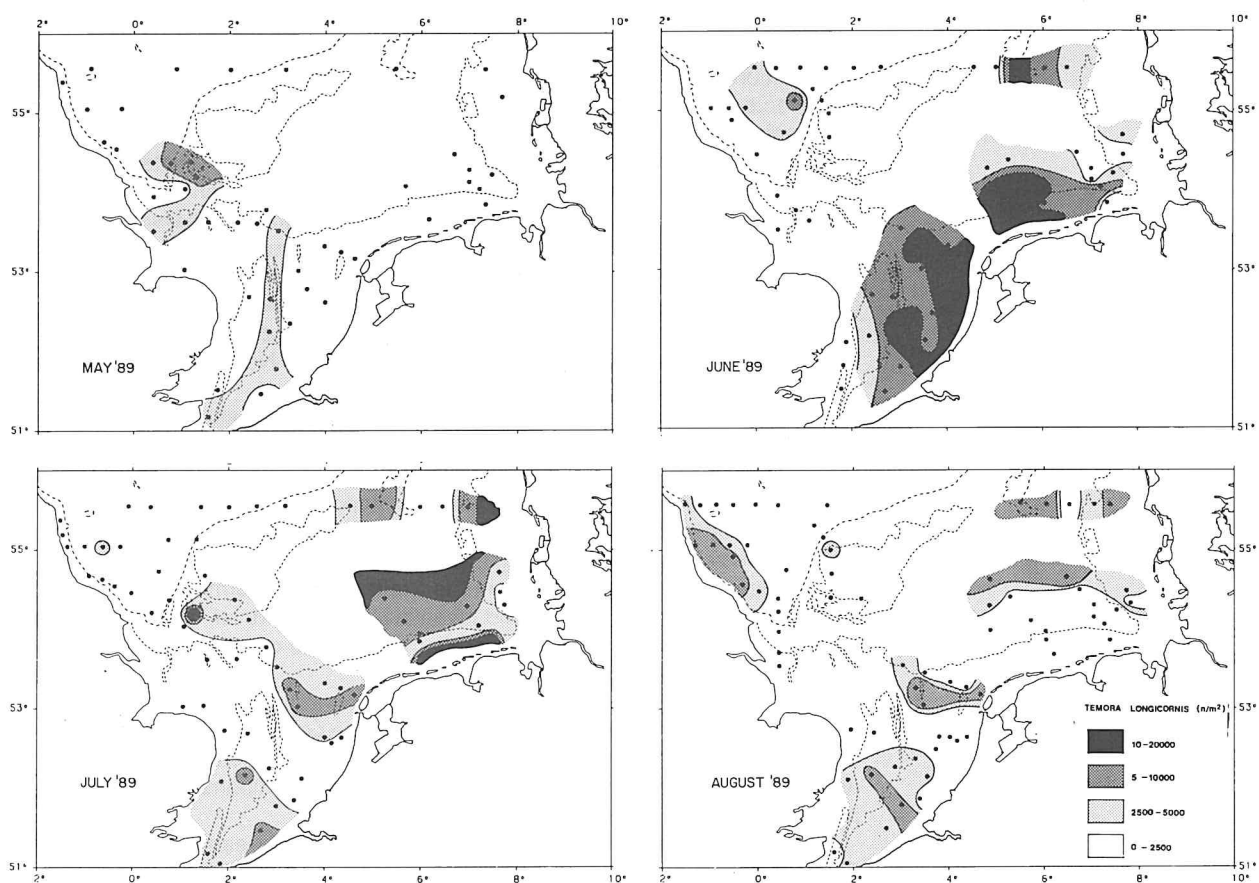
Zooplankton sampling in the whole of the southern part of the North Sea, up to 55°30'N, was continued from January to August 1989. This work is the Dutch contribution to the British North Sea Project, in which multidisciplinary studies are directed towards a better understanding of physical, chemical, biological and sedimentary processes. During the monthly surveys by RV 'Challenger', vertical hauls were made with a 300 μ m net at most of the CTD stations. First, the samples of 13 surveys, over 800 in total, will be analysed on adult copepods and other large zooplankters, and contour plots of the numbers per square metre from August 1988 to August 1989 will be prepared. For a better description and understanding of the seasonal patterns obtained, the CTD data will be used for a cluster analysis of stations within and between surveys, to define geographically flexible 'provinces'. Then zooplankton species may be used as water-mass tracers, some being typical of the northern North Sea, others of the English Channel and the Southern Bight.

Additional aims comprise a comparison between the densities of copepods and of their invertebrate predators, to examine controversial opinions with regard to zooplankton dynamics in the Dutch coastal waters and in the German Bight. Further, the timing and duration of copepod reproduction in spring and autumn will be studied. For this topic, hauls from bottom to surface with a small 50 μ m net have been taken during (parts of) all surveys. In this additional sample set, especially the samples from the Southern Bight form a complete year-series for the densities of eggs and juvenile stages. However, analysis of these samples will take an extra 1-2 years after completion of the processing of the main catches in summer 1990.

The study of seasonal variation in fecundity in the copepod *Temora longicornis* was continued from October onwards. Adult females collected in the Marsdiep are incubated at prevailing food and temperature conditions to estimate egg production during autumn and winter.

The comparison of food conditions of herring larvae sampled by RIVO at different spawning areas and in different years was continued in an undergraduate study of food selection in herring larvae. This study showed that the diet of the larvae consists of copepod eggs, nauplii and copepodite stages, and also mollusc veliger larvae and algae. Copepod nauplii were selected, particularly those of *Pseudocalanus* species, and the largest larvae (>10 mm). Two

daily periods of maximal feeding activity were observed between 10.00- 12.00 and 20.00-22.00 o'clock. Food densities were low in 1983 to 1986, but there was an improvement of food conditions at the end of this period.



Distribution of adult copepods of *Temora longicornis* in the North Sea during May-August 1989. Numbers above 10 000 per m^2 occurred in the Dutch sector in June, and in the German Bight in July.

(Former B2-01d MORTALITY IN PLAICE EGGS AND LARVAE, project now ended)

F. Hovenkamp

As in 1987 and 1988 plaice larvae were sampled during their pelagic phase and during immigration into the Wadden Sea. Actual and previous growth rates were estimated by the otolith increment technique and RNA/DNA ratios. RNA/DNA ratios were converted into protein growth rates, using an established relationship, and compared with the relative width of the five marginal otolith increments. A highly significant correlation was found. Growth rates calculated from size-age relationships were correlated with protein growth rates and otolith growth rates. It takes less time to establish the latter two, which thus provide good possibilities for further research. Data collected over three years were used to find a relationship between growth rates and seawater temperature. The project ended in 1989 and further processing of the data is now well under way.

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

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

Preliminary results show considerable differences in the physical and chemical properties of the water masses at the three superstations. First the surface water temperature increased gradually from the north towards the south. In addition, the water temperature at the 60°N, 20°W station remained fairly constant over the whole water column, while there was a sharp thermocline at the two other stations. Secondly, the light penetration increased towards the south as can be derived from the attenuation coefficient (K_d) as well as the 0.1% irradiance level, representing the euphotic zone. This zone is ca. 60 m deep at the 60°N, 20°W station, ca. 65 m deep at the 47°N, 20°W station and at the 33°N, 20°W station it extends to 150 m. A third difference between the three stations is the nutrient profile. While the nitrogen concentration (nitrate plus nitrite) was almost constant and relatively high in the north, at the other two stations nitrogen was nearly depleted in the upper half of the euphotic zone.

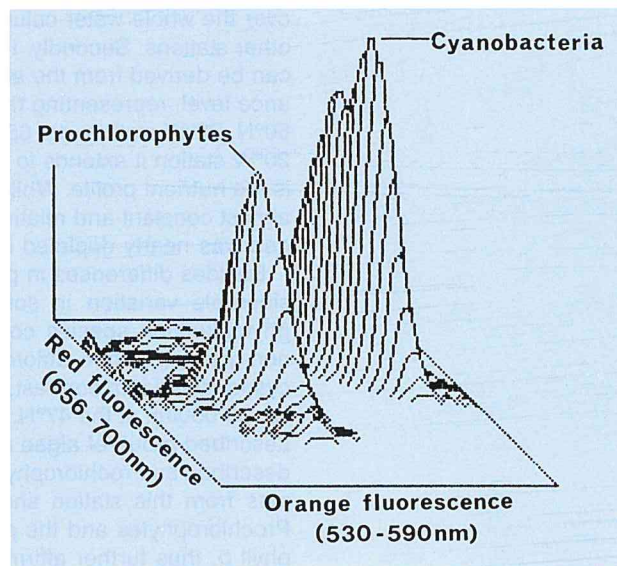
Besides differences in physical and chemical parameters there is also considerable variation in some of the biological properties. In the north the phytoplankton species composition was predominantly a mixture of various non-green (*i.e.* non-Chlorophyll *b* containing) algae with a small number of cyanobacteria. In contrast, these cyanobacteria dominated in numbers of up to ca. 30 000/ml at the 47°N, 20°W station, and at the southern station a recently described group of algae dominated the phytoplankton community, tentatively described as Prochlorophytes. Additional HPLC pigment analysis of algal samples from this station showed a clear relationship between the number of Prochlorophytes and the presence of so-called divinyl-chlorophyll and chlorophyll *b*, thus further affirming that this unknown algal group must have been Prochlorophytes. Identification and quantification of the algae was partly carried out with a flow-cytometer. The numbers of these Prochlorophytes in the upper part of the euphotic zone are not known, since the flow-cytometer in its present configuration is not capable of distinguishing this low abundance signal.

The total phytoplankton primary production, expressed as carbon fixation per cubic metre per day, rapidly decreased with depth as a result of a decreasing irradiance. Though the light penetration is much deeper at the southern station than at the 60°N, 20°W station, the total daily primary production at the latter

station was higher, probably mainly because of the different algal species composition.

Finally, in contrast to what is generally asserted, the bacterial growth rate, expressed as thymidine incorporation rate, appears not to be related with the primary production, but rather with the phytoplankton numbers.

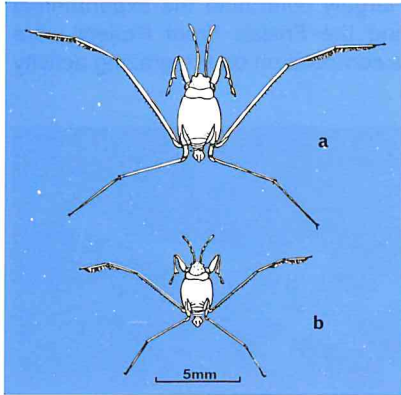
The 600-700 zooplankton samples collected will need the usual microscopic sorting before anything can be said about species and densities, but dry weight samples of size fractions were filtered on tared filters; hence biomass estimates can be obtained relatively rapidly. Preliminary estimates of biomass based on volumes caught indicate that mesozooplankton amounted to about 0.1 to 0.5 milligram C per m³ in the upper 200 m, which is a factor of 1000 lower than in the North Sea. The same amount was roughly estimated for macrozooplankton, which is only a factor of 10 lower than in the North Sea. These values seem typical of the late summer situation with decreasing and unproductive herbivorous copepod populations, and carnivorous macrozooplankton at about its maximum. The predominant autotrophs smaller than 6 μ m may be rather unsuitable as food for copepods, and preparations for overwintering include migration to deeper layers and internal storage of food rather than reproduction. Copepod daily fecundity was extremely low. Copepod densities decreased from Iceland towards the south, but macroplankton (amphipods feeding on copepods) increased considerably in the middle of the transect.



An example of a flow-cytometer three-dimensional histogram showing two of the dominant algal groups found during JGOFS leg 1.

B2-05 EASTERN INDONESIAN WATERS

M.A. Baars



a: *Halobates micans*, b: *Halobates sericeus*

In cooperation with Lanna Cheng (Scripps, USA) results on the sea-skater *Halobates* collected in the eastern Banda Sea during the Snellius-II Expedition in August 1984 (SE monsoon) and February/March 1985 (NW monsoon) were worked out. About 200 specimens were caught in 18 tows at offshore sites in August, in the upwelling season, but more than 1000 in 18 tows in February, when the mixed layer was nutrient-depleted and chlorophyll-poor. The Indo-Pacific species *H. germanus* predominated in the catches during both cruises, its density being inversely related to surface chlorophyll concentration. Reproductive activity of *H. germanus* was highest in oligotrophic conditions, the relative abundances of nymphs and of cast skins being much higher in February than in August. Shifts in the population structure in February suggested a development time of about 7 days or less per stadium at a surface seawater temperature of 29°C. The cosmopolitan *H. micans* and the coastal *H. flaviventris* and *H. princeps* were absent or rare in August but present in most catches in February; some specimens of the latter two species were found at stations more than 150 km from the nearest shore.

B2-10 POPULATION DYNAMICS AND BIOENERGETICS IN EXPERIMENTAL PELAGIC ECOSYSTEMS

W.C.M. Klein Breteler, M.J.M. Reichert

The experimental research on zooplankton centres on the influence of significant 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.

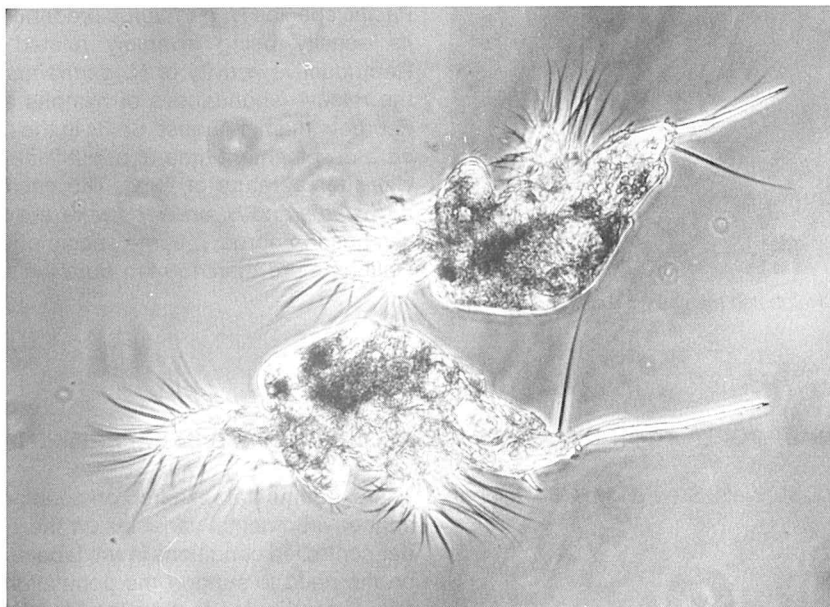
Since copepods have a major share in the total biomass of zooplankton, the experimental work is concentrated on this group. Two common species of the North Sea, *Temora longicornis* and *Pseudocalanus elongatus*, were cultivated through 118 and 70 successive generations, respectively. Unfortunately the culture of the former species was lost; analyses for toxic organic and inorganic compounds are being carried out in search of possible causes of the loss.

The quality of the food algae largely determines the growth characteristics of copepods. The role of the food algae used as a mixture in the standard culture technique was studied. The small *Isochrysis galbana* was somewhat inferior to the moderately sized *Rhodomonas* sp. or the complete mixture, including the heterotrophic *Oxyrrhis marina*. Rate of development and/or final body size were reduced, apparently the result of the small size of *Isochrysis*, especially during the later stages of development.

Body size of adult *Temora* appeared to decrease during prolonged cultivation in the laboratory. Interbreeding experiments with large or small males collected in the field resulted in recovery of the original size, which shows that genetic factors are involved in the production of small individuals during cultivation. The size of the field-collected males had no influence, which indicates that seasonal changes of body size in the field are determined phenotypically.

Experiments on grazing of copepods on diatoms in the presence of clay minerals were continued. These experiments study the influence of grazing on the ratio of aluminium/silica in remains of diatoms in copepod faecal pellets.

The results of grazing experiments over the past 4 years are being worked out. Preliminary results point towards the conclusion that cultivation conditions and physiological changes of food algae in the time span of a grazing experiment are detected by the copepods and largely determine the experimental results. Samples of algae collected during the Frisian Front Project were processed to study the influence of species composition on the grazing activity of copepods in the North Sea.



Two third-stage nauplius larvae of *Temora longicornis*, which is under continuous cultivation in the laboratory.

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

We participated in EPOS leg 2 to the Weddell-Scotia Confluence area from November 1988 to January 1989. On board RV 'Polarstern' samples were taken to study the phytoplankton community structure by means of a combination of pigment identification and microscopic counts. Surface samples and profiles were taken regularly along a transect on the 49°W meridian (from 56 to 62°S), in total four times during the two-month cruise. The HPLC pigment measurements analyses showed that the phytoplankton community shifted from a diatom-dominated community towards a nanoplankton community dominated by flagellates belonging to different taxonomical groups. High numbers of Cryptophyceae were found, as well as Prymnesiophyceae and Prasinophyceae. Zooplankton grazing seems largely responsible for the disappearance of diatoms from the water column in this area.

On the same transects, depth-integrated mesozooplankton samples were collected with a finely meshed (50 µm) net in the upper 300 m. Most samples were sorted on board to count the numbers per species and, in copepods, also per developmental stage including eggs. Size fractions were incubated to

estimate rates of development, and adult females to estimate daily fecundity (egg production). Samples collected on legs 1 and 3 by German participants were also analysed. Sorting was completed this year, except for the growth rate samples. In addition, zooplankton from bottles used for grazing experiments (Dr. E. Granéli, Lund, Sweden) was analysed and its biomass estimated. Species diversity decreased from north to south and was highest in the Scotia Sea. Small-sized copepod species and stages, in particular of *Oithona similis*, were numerically very dominant. Total copepod dry weight ranged from 1 to 15 mg per m³, about half of which consisted of small organisms (<1 mm). Highest biomass was found in the Scotia Sea and the Confluence. There was no evident rise in abundance over time, nor any consistent depth distribution pattern or diurnal change in the upper 300 m. Daily fecundity was high (about 15 eggs) in the dominant larger species *Calanoides acutus* in the Scotia Sea and the Confluence, but *Calanus propinquus* seemed more active in the poorer Weddell Sea and the Confluence. During December, *Oithona* showed a shift in peak density from copepodite stage 4 to 6 (adult), and in nauplii from 2 and 3 to 5 and 6. The egg/female ratio seemed to decline. This slow growth of about 2 to 3 stages per month, and the declining reproduction point to a 2-year life cycle with two overwintering periods, in naupliar stage 2 to 3 and copepodite 4, respectively.

B2-12 ECOPHYSIOLOGY OF ANTARCTIC PHYTOPLANKTON

A.G.J. Buma

In cooperation with H.J.W. de Baar and R.F. Nolting (See H1-15) experiments were carried out on board RV 'Polarstern' during EPOS leg 2 with natural phytoplankton populations to test the hypothesis that Antarctic primary productivity suffers from a lack of essential trace elements, notably Fe and Mn. Therefore water samples were incubated under controlled conditions for a maximum of 10 days with and without the addition of traces of Fe and Mn. The results show that in four out of five experiments chlorophyll synthesis as well as total carbon accumulation was enhanced by the addition of Fe. However, control bottles also grew well, leading to the conclusion that *in situ* Fe and Mn concentrations can support moderate growth. These findings were supported by the fact that levels of dissolved Fe and Mn measured during the cruise were not as low as can be found in open ocean systems. It seems that, although Fe and Mn are potential limiting factors, the actual phytoplankton stock is controlled by other factors, notably zooplankton grazing. On board several algal species have been isolated and cultured, which are now kept in the laboratory under simulated Antarctic conditions. In the near future continuous culture experiments will be started to study the effect of changing light intensity and light quality on physiological properties of different Antarctic algal species.

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 chains 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). The only 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, B3-08), autecology (e.g. B3-07, B3-09) and ecophysiology (e.g. B3-10) are indispensable parts of the programme of the department.

B3-01 PRODUCTION AND TRANSPORT OF ORGANIC CARBON

G.C. Cadée

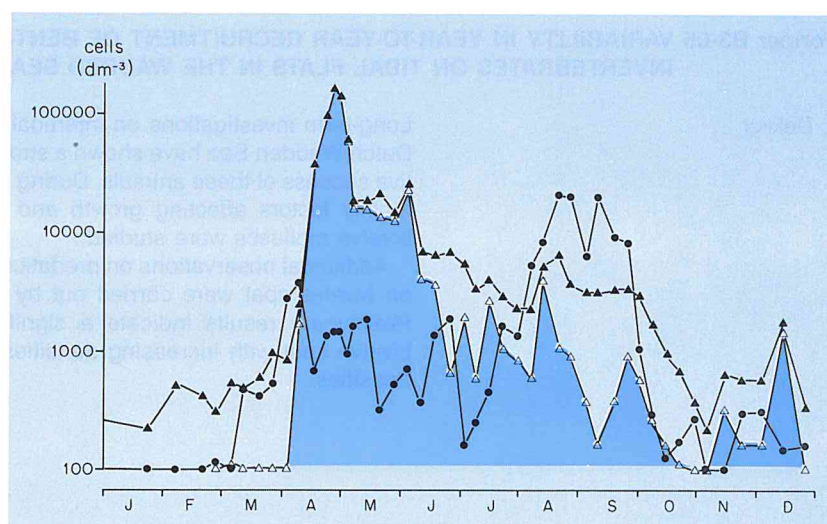
The regular high-water phytoplankton sampling programme at the NIOZ Marsdiep pier was continued. The spring diatom peak, so far observed every year, occurred in early April. It was not very pronounced and comparable in size to 1988. As usual, a peak of the colonial flagellate *Phaeocystis* followed about 3 weeks later. Cell numbers counted at the peak (on April 27) were 168 000 per cm³. Only during the peak of 1985 were higher numbers counted (190 000 per cm³, 10 May). The length of the *Phaeocystis* spring peak (measured as the period with more than 1000 cells per cm³) was almost 80 days, about the average over the last 4 years, but longer than before that period. During the rest of the year *Phaeocystis* was less abundant than in 1988, up to now a *Phaeocystis* top year.

An interesting feature in the seasonal cycle, never observed before, was a peak in diatom cell numbers in August/September with higher values than during the spring peak. Particularly high numbers of the small chain-forming diatom *Leptocylinndrus minimus* accounted for this late-summer peak. Though a late-summer diatom peak is a normal feature of the seasonal succession of Marsdiep phytoplankton, our data now seem to indicate an increase of this diatom peak over the years. Continuation of the sampling programme is necessary to substantiate this. Diatoms are usually more suited as food for suspension feeders than the colonial *Phaeocystis*. This might indicate that the phytoplankton in 1989, with more diatoms and fewer *Phaeocystis* in summer, provided better food conditions for the next step in the food chain than in 1988. Indeed mussel growth in the Wadden Sea in 1989 seems to have been better than in 1988 (RIN communication). In other bivalves (*Macoma*, *Cerastoderma*) the same appears to be true (pers. comm. Beukema).

Bioturbation studies, started to assess the role of bioturbation in the vertical distribution of benthic diatoms on a tidal flat, were continued with a 14-month study of bioturbation by birds. Particular attention was paid to feeding traces of gulls, mainly the Black-headed gull (*Larus ridibundus*), and of the Shelduck (*Tadorna tadorna*). The many footprints and peckmarks of birds were not measured. A tidal-flat area in the Mookbay, Texel, was visited 70 times in this period and in a marked area the daily bioturbation rate by birds was measured. Annually ca 30% of the area studied was reworked by gulls and ca 15% by Shelducks. The annual sediment reworking rate equalled a sediment layer of ca 2.5 cm. This is about one order of magnitude less than the ca 35 cm reworked annually by the most important deposit feeders of this tidal flat studied earlier, the polychaetes *Arenicola marina*, and *Heteromastus filiformis*, and the bivalve *Macoma balthica*. Particularly Shelducks, which produce up to 20-cm-deep feeding craters, may play a role in bringing benthic diatoms to deeper layers.

Marsdiep phytoplankton:

diatoms ●—●
non-diatoms ▲—▲
Phaeocystis △—△
(dark blue)



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

J.J. Beukema

Long-term investigations (started in 1969) on 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 1988-89 was exceptionally mild. Consequently, species sensitive to low winter temperatures showed high survival rates. The shrimp *Crangon crangon* (which in winter lives mostly in deeper waters) arrived on the tidal flats exceptionally early in spring and in May was more numerous than ever. Shore crab (*Carcinus maenas*) recruits appeared on the tidal flats several weeks earlier in summer, and were more numerous than in more 'normal' years. The high abundance of these predators during the period of bivalve recruitment on the tidal flats will have contributed to the recruitment failure of the bivalves in the summer of 1989.

As in 1988, the tidal flats experienced a short high-summer period of mass mortalities in the cockle (*Cerastoderma edule*). Lack of oxygen appears to be the most likely cause and may in its turn be a consequence of the ongoing eutrophication of the western Wadden Sea.

Special attention was paid this year to an operational definition of longevity. Usual estimates of longevity are bound to be underestimates, because any increase in sampling effort will lead to higher estimates. A 20-year data set on a tidal-flat population of the cockle has clearly shown that larger or more samples, higher abundance of cockles and a longer period of observation (including more year classes and thus an increased chance of sampling an abundant year class) all enhance the estimate of cockle longevity.

With financial support from Rijkswaterstaat a twice-annually executed sampling programme for subtidal macrozoobenthos in the western half of the Dutch Wadden Sea was started.

(Former B3-05 VARIABILITY IN YEAR-TO-YEAR RECRUITMENT OF BENTHIC INVERTEBRATES ON TIDAL FLATS IN THE WADDEN SEA, project ended)

R. Dekker

Long-term investigations on intertidal soft-bottom benthic invertebrates in the Dutch Wadden Sea have shown a strong year-to-year variation in the reproductive success of these animals. During this study, which came to an end in 1989, mainly factors affecting growth and survival of the early benthic stages of bivalve molluscs were studied.

Additional observations on predation impact by the shrimp *Crangon crangon* on bivalve spat were carried out by means of enclosure cage experiments. Preliminary results indicate a significant increase in predation impact on bivalve spat with increasing densities of shrimps within the natural range of densities.

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

P. Kamermans

Results of earlier research indicate that food availability can limit growth rates of bivalve molluscs living in the Wadden Sea. The growing season of several bivalves appears to be almost limited to the algal blooming period in spring. The growth rate of some bivalves has increased over the last few decades, together with an increase in primary production and the size of algal stocks, as a consequence of eutrophication.

Indications of food competition between bivalves were also found in the field. Animals living in the centre of *Cerastoderma edule* or *Mytilus edulis* banks grow more slowly than animals on the fringes. Years with a high *Cerastoderma edule* abundance show retarded growth of *Cerastoderma edule* and *Macoma balthica*.

These last two species belong morphologically to different groups. *Cerastoderma* is a suspension feeder and *Macoma* a deposit feeder. One would expect them to use different food sources (water column and surface of the sediment). Fieldwork was carried out in 1988 to find out if these morphologically different groups can be competitors. The species composition of algae in the stomachs of five species of bivalves (two deposit-feeders and three suspension-feeders) living in the same place were compared with algal composition in water and sediment samples. A considerable overlap in diet for all species studied was found. Therefore competition can occur between morphological deposit feeders and suspension feeders. Stomach contents of all five species showed more similarity with water samples than with sediment samples. This indicates that morphological deposit feeders can behave as suspension feeders.

In 1989 more extreme environmental situations (high tidal flat, muddy tidal flats, presence of mussel bank) were studied in the field to investigate whether *Macoma* behaves primarily as a suspension feeder in all situations. Algae in stomachs, water and sediment were sampled for species composition. Also the chlorophyll contents of the stomachs of different species of bivalves were measured monthly in 1988 and 1989 to investigate relations with tide, food supply, temperature, current speed and salinity. Stomachs of animals collected on the drained tidal flat at low tide contained low chlorophyll concentrations. These concentrations rapidly increased when the tidal flat was covered with water. In 1989 the evacuation rates of the stomachs of *Macoma* and *Cerastoderma* were measured monthly to compare the food intake of the different species in relation to season.

During the growing season of the bivalves, experiments were carried out in mesocosms to study the influence of density on growth. These experiments gave an indication of a positive influence of the density of *Cerastoderma* on the growth of *Macoma*. *Macoma* showed intraspecific competition. Growth of *Cerastoderma* was not influenced by individuals of the same species. The growth of *Macoma* and *Cerastoderma* was also studied at different positions in a mussel bank placed in an outdoor basin with a unidirectional flow of seawater. Growth of both species was highest in the front part of the mussel bank and decreased towards the end.

Field and laboratory experiments were conducted to study if siphon-predation by flatfish can induce suspension feeding in *Macoma*.

Feeding behaviour of *Macoma* was observed in laboratory experiments with various levels of food supply in the water column and at the sediment surface. *Macoma* showed deposit feeding as well as suspension feeding behaviour at all levels of food supply.

B3-04 INTERACTIONS BETWEEN MACROZOOBENTHIC SPECIES ON TIDAL FLATS

J.J. Beukema

In a high number of intertidal plots (either made azoic or with the undisturbed fauna) densities of lugworms (*Arenicola marina*), cockles (*Cerastoderma edule*) or *Macoma balthica* were enlarged by adding various numbers of adults of these species. Their fates and those of other species (particularly the small crustacean *Corophium volutator*) were followed during spring through summer and autumn.

Particularly evident was the strongly negative influence of even relatively low densities of adults of the lugworm *Arenicola marina* on their own juveniles and on *Corophium volutator*. Cockles exerted such an influence on *Corophium* only at high densities not frequently occurring on tidal flats in the western Wadden Sea.

B3-05/B3-06 POPULATION DYNAMICS OF 0-GROUP FLATFISH/FISH BENTHOS INTERACTIONS IN THE WADDEN SEA

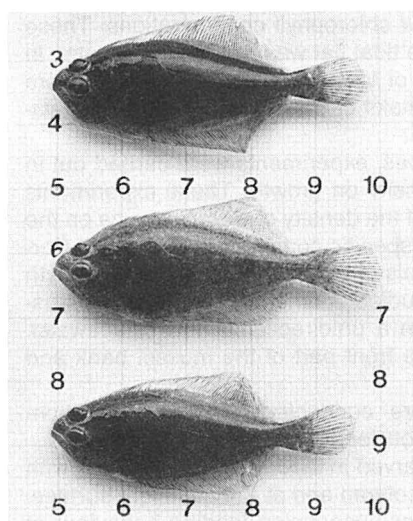
H.W. van der Veer

In cooperation with L. Pihl (Kristineberg Marine Biology Station, Sweden) an analysis has been made of the dynamics and recruitment of 0-group plaice in a number of coastal nursery areas around the North Sea. In the areas considered, two types of predation could be distinguished: predation by crustaceans on up-to-3-cm-long plaice in spring and predation by fish on larger plaice in summer. Depending on the hydrography and morphology of the various nurseries, the ultimate effect on the recruitment of plaice varied. Fish predation in summer never had any impact on the recruitment of plaice. Predation by crustaceans seemed to be the key-factor in all areas. Depending on the variation over the years especially in the abundance of shrimps in spring, either a reduction or a generation of the between-year variation in recruitment of plaice could be found.

An international research programme is developing, to study the population dynamics and recruitment mechanisms in flatfish species in other areas, to see to what extent predation by crustaceans regulates flatfish populations worldwide. In cooperation with M. Tanaka (Kyoto University, Japan) the ecology of Japanese flounder *Paralichthys olivaceus* will be studied. For an analysis of the field data, laboratory experiments on maximal growth, food intake and food conversion are essential. Since these data were not available for Japanese flounder, laboratory experiments were performed at NIOZ this year in close cooperation with M. Fonds (B3-07). An analysis of field data, possibly together with additional field work in Japan, is planned for 1990.

In cooperation with M. Fonds the fish-benthos interactions in the Wadden Sea were worked out in further detail for 0-group plaice. A comparison of field data on abundance and growth of juvenile plaice and growth data obtained in the laboratory showed that in contrast to previous research, growth of plaice was food-limited in some areas. However, since settlement of 0-group plaice proved to be positively related with benthos richness, this food-limited growth was restricted to only 5-10% of the whole 0-group plaice population. In areas with maximal growth, the limiting factor in the use of the nursery by plaice still seems to be the larval supply from the open North Sea. The next step will be a detailed analysis of abundance and growth of I- and II-group plaice in the Wadden Sea.

(Photo: H.W. van der Veer)



B3-07 ENERGY BUDGETS IN BENTHIC CARNIVORES

M. Fonds

For calculations of the annual food consumptions of populations in the sea it is necessary to know the maintenance food requirements in relation to temperature and the net conversion of food into growth. In cooperation with H.W. v.d. Veer (BEWON) laboratory measurements have been carried out on the energy budget of some common benthic predators: the shorthorn sculpin (*Myoxocephalus scorpius*) and eelpout (*Zoarces viviparus*), and the starfish *Asterias rubens*.

For all three species the measurements indicate that metabolism, maximum daily food consumption and maximum daily weight increment are proportional to the metabolic weight of the animals, *i.e.* weight to the exponent 0.8 or $w^{0.8}$. Hence, for estimations of annual food consumption of populations in the sea it is necessary to estimate the 'metabolic biomass' ($\Sigma w^{0.8}$).

Both sculpin and eelpout are common and locally abundant in subtidal mussel beds of the Wadden Sea, while starfish are abundant throughout the Wadden Sea and the North Sea.

From the results of measurements of the energy budget of these species and from available data on distribution and biomass in the sea, the annual food consumption was calculated. According to these estimates, shorthorn sculpin and eelpout together consumed 2.5 to 4.5 gram ash-free dry weight of food per m^2 in the subtidal part of the Wadden Sea, comparable to the annual food consumption of young flatfish on the tidal flats.

Maximum growth rate (in diameter) of the common starfish *Asterias rubens* increased with temperatures from 2 to 14°C, reaching a maximum value of about 0.6 mm per day at 14°C, and declining rapidly at higher temperatures. The effect of temperature on maximum growth rate can be described for temperatures of up to 15°C by the linear equation: $mm/day = 0.046 T(^{\circ}C)$. The net conversion efficiency of food into growth for starfish fed with mussel meat (76% food into growth) appears to be much higher than the net food conversion efficiency estimated for fish (47% food into growth). Starfish probably spend less energy on activity.

Growth of starfish in the Wadden Sea appears to be nearly maximal (approximately 0.4 mm per day in summer) and is probably not food limited, while growth in the North Sea appears to be low (0.2 mm per day in summer) and is probably food limited. The question arises whether discard fish from commercial trawling in the North Sea can be an additional food supply for starfish populations.

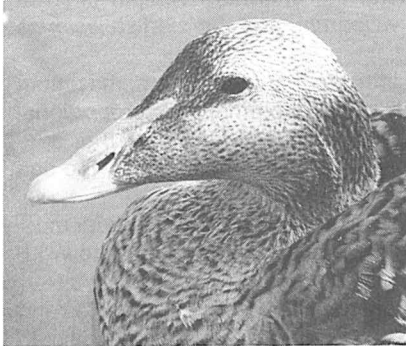
B3-08a DYNAMICS AND FEEDING OF SEA-BIRDS IN THE WADDEN SEA AND TROPICAL TIDAL-FLAT AREAS

C. Swennen

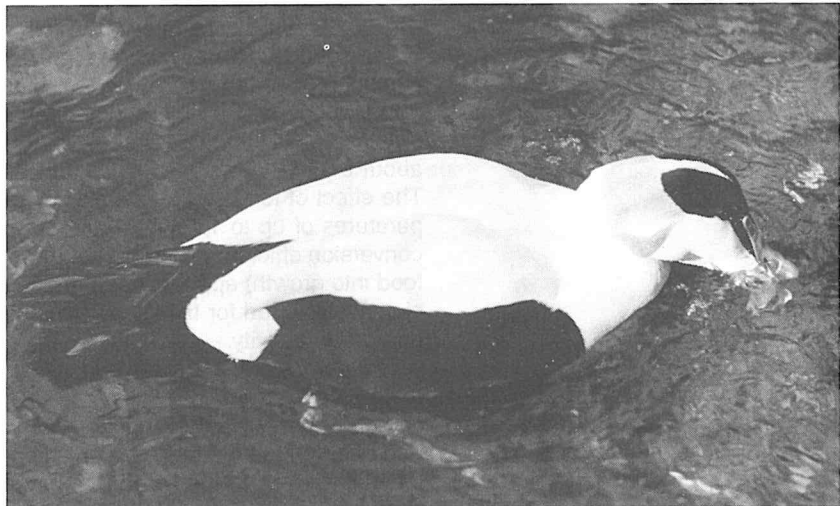
Possible variation in the quality of Eider ducklings at hatch was studied by measuring egg sizes over a number of years. Egg size determines the size of a chick. Earlier research had shown that Eider ducklings weakened and died when the intertidal zone did not provide a high density of small food items. The density of such food items varied considerably from year to year and duckling survival varied accordingly. As a logical continuation of this work it was investigated whether or not high food supplies made females produce better eggs. Eggs of several marked females were measured over a number of years. Mean

egg size did not differ between years, although severe and mild winters with quite large differences in the benthic fauna were included in the series of observations. It was further studied whether or not Eiders are able to change the number of eggs produced if eggs are removed or extra eggs added to the nest. It appeared that Eiders are 'determinate' layers, laying a clutch of a certain size independent of the circumstances during laying.

Eiders suffered a high mortality due to intestinal parasites during 1989, a year starting with an exceptionally mild winter. Heavy infestations with acanthocephalic worms causing deaths had earlier been noticed after mild winters. Shorecrabs, which act as intermediate host for the parasite *Polymorphus botulism*, are abundant then and meat content of bivalves is low. However, this Eider mortality was usually limited to subadults in spring. This year, a remarkably high percentage of adults were involved and the mortality remained high throughout the summer and part of the autumn (into October). This may indicate the presence of a stress factor lowering the resistance of the birds. Earlier NIOZ experiments showed that the PCB-level in Eiders is positively related with the percentage of cystocanth of the parasite that successfully establishes itself in the Eider. In view of the high PCB-level in the Wadden Sea, this Eider mortality may well indicate that the pollution has reached a critical level.



Female Eider duck
(Photo: NIOZ)



Eating male Eider duck. (Photo: NIOZ)

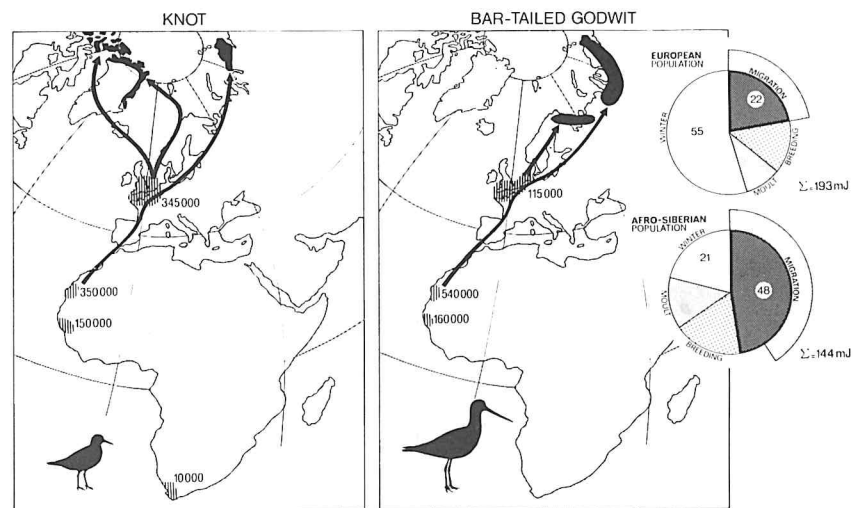
During a survey of intertidal flats along the Yellow Sea in Korea, feeding behaviour in a few specimens of the Spotted Greenshank *Tringa guttifer* was studied. These rare and endangered birds feed on the mudcrab *Macrophthalmus japonica*. They detect the crabs by eye and catch them by running and sometimes even flying. Several species of *Macrophthalmus* crabs live in high densities in the intertidal zone of the non-breeding range of *T. guttifer*, extending from Korea to the Malay Peninsula. Therefore, food seems not to be a limiting factor in winter. Probably this relict bird species has suffered biotope deterioration in the breeding area, which is limited to Sakhalin Island. The Asian Wetland Bureau estimates the total population at much less than 1000 individuals, and Russian workers recently reported that there are probably only about 30 breeding pairs left.

B3-08b ANNUAL ENERGETICS OF LEAPFROG MIGRATING WADERS

T. Piersma

Most wader species show large intra-specific variations in the latitudes at which they breed and at which they winter, the Knot *Calidris canutus* being no exception. Differences in frequented latitudes lead to considerable variation, among individuals of one species, in the total distance migrated per year and in the climatic regimes encountered. In turn, such differences must lead to important intra-specific differences in the structure of the annual energy budgets. Two populations of Knot, each with subspecific status, visit the Wadden Sea: a population breeding in Greenland and Canada winters in the Wadden Sea, and a population breeding in northernmost Siberia winters in Africa and passes through the Wadden Sea in spring and autumn. A promising avenue for evaluating the role of the Wadden Sea for these two highly migratory Knot populations appears an empirical reconstruction and comparison of their annual energy budgets. Realistic energy budgets can indicate where the birds' capabilities and options are limited, and the contribution of the Wadden Sea-ecosystem to the energy budgets can be highlighted. To evaluate the approach, a theoretical examination of the annual energy budgets of two populations of a better-studied wader species with a simpler migration pattern, the Bar-tailed Godwit *Limosa lapponica*, was made. One godwit population breeds and winters in Europe, the other breeds in Siberia and winters in West Africa. Although their total annual energy expenditure figures do not differ much, the European birds spend only a quarter of their annual budget on migration, whereas the Afro-Siberian godwits spend almost half on it. However, the European godwits face a much harsher winter climate by remaining in the north, spending about half of their annual budget on winter survival, than the Afro-Siberian birds which winter in a more benign climate and incur only small costs of thermoregulation.

Diagram of the main breeding and wintering areas of two populations of Knots (left: Euro-Canadian and Afro-Siberian birds resp.) and two populations of Bar-tailed Godwits (right: European and Afro-Siberian birds resp.). The provisional annual energy budgets of the two Bar-tailed Godwit populations (for males only) are collected in the pie diagrams at right, where the percentages of annual metabolizable energy are shown for the calendar periods concerned with migration, breeding, moult and winter. For migration the proportion of the annual time budget is indicated on the outer circle.



Contrasts between the annual energy budgets of two leapfrogging populations, such as shown for the Bar-tailed Godwits, must also occur in Knots, and it is likely that the costs of thermoregulation and flight are the two main explanatory variables. In 1988 we started a study on the seasonal changes in the cost of thermoregulation. We redeveloped the technique of 'heated taxidermic models' to measure, from the Knot's point of view, heat loss under different climatic regimes. 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 40°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, nestcup, feeding area in marsh), can be measured in an integrated way. Under standardized laboratory conditions the power consumption of copper Knots can be verified with that of live birds. Four such models were built and successfully employed on the breeding sites of Knots in arctic Canada. They are now used in the Dutch Wadden Sea, supplemented by studies of time, activity and diet.

We have continued the studies on captive Knots at the Zoological Laboratory (Univ. of Groningen), starting a new experiment with a flock of Wadden Sea-wintering birds under controlled constant conditions, in an attempt to show their circannual clock. The studies of prey choice in relation to the availability of benthic prey in autumn on the island of Griend in the Wadden Sea were continued. A series of laboratory experiments on the digestive efficiencies of Knots fed on a variety of prey was carried out at NIOZ.

B3-09 DISTRIBUTION PATTERNS OF SEA-BIRDS IN THE NORTH SEA

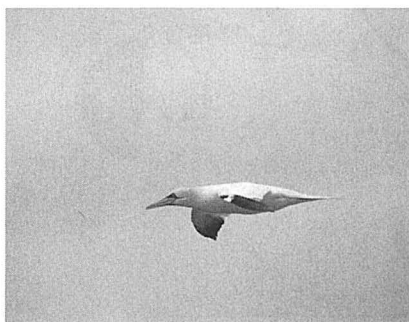
M.F. Leopold

Sea-bird distributions were recorded throughout the North Sea in 1989, with RVs 'Aurelia' and 'Tridens'. In addition, RV 'Tridens' was used for sea-bird counts in the area of the Bay of Biscay and approaches.

From January to April, most effort was devoted to the area of the Brown Ridge, west of IJmuiden. Preliminary work in 1988 on the patterns of wind direction and strandings of oiled birds suggested that a concentration of Alcids occurs here this time of year. Indeed, large, diffuse concentrations of both Razorbills and Guillemots were found in the area, in contrast to waters west of Texel, where few of these birds were found. In addition, large numbers of Fulmars were found in the Brown Ridge area. The main concentration of all three species coincided with the area where plankton growth in the southern North Sea usually starts (van Bennekom, pers. comm.).

June and July were mainly spent on counting in the waters south of Ireland, a large area between northern Spain, western France and western Ireland being covered. The counts revealed an unheard-of number of British Stormpetrels spending the summer in those waters. Around 1 000 000 of these smallest sea-birds, both breeders and non-breeders, were estimated to live in the area in summer. This number equals the total known European breeding population. Most birds were found over the continental shelf, with densities decreasing in waters deeper than 200 m. In November, a second cruise was made through these waters. Contact has been made with a French group of 'Sea-birds at Sea' workers, to join forces in this area.

(Photo: M.F. Leopold)



September was devoted to the waters off the British east coast, where important concentrations of sea-birds are found at this time of the year. Adult herring spawn here, attracting large numbers of fish-eating predators. In the past two years, we have visited the same area in September, so with this year's data we have counts over three consecutive years. These waters hold the majority of all North Sea Alcids in late summer, and are worth visiting each year. Our results on distribution patterns closely resemble the distribution maps made by the British Sea-birds at Sea Team, drawn over the years 1979-84.

The remainder of the year was mainly spent in the Frisian Front area and German Bight. Contacts have been made with the newly formed German Sea-birds at Sea Team, based on Helgoland, which will start work at sea in 1990. Sea-bird numbers of the shallow waters off the German Wadden Islands are still poorly known, so this new possibility for cooperation is warmly welcomed.

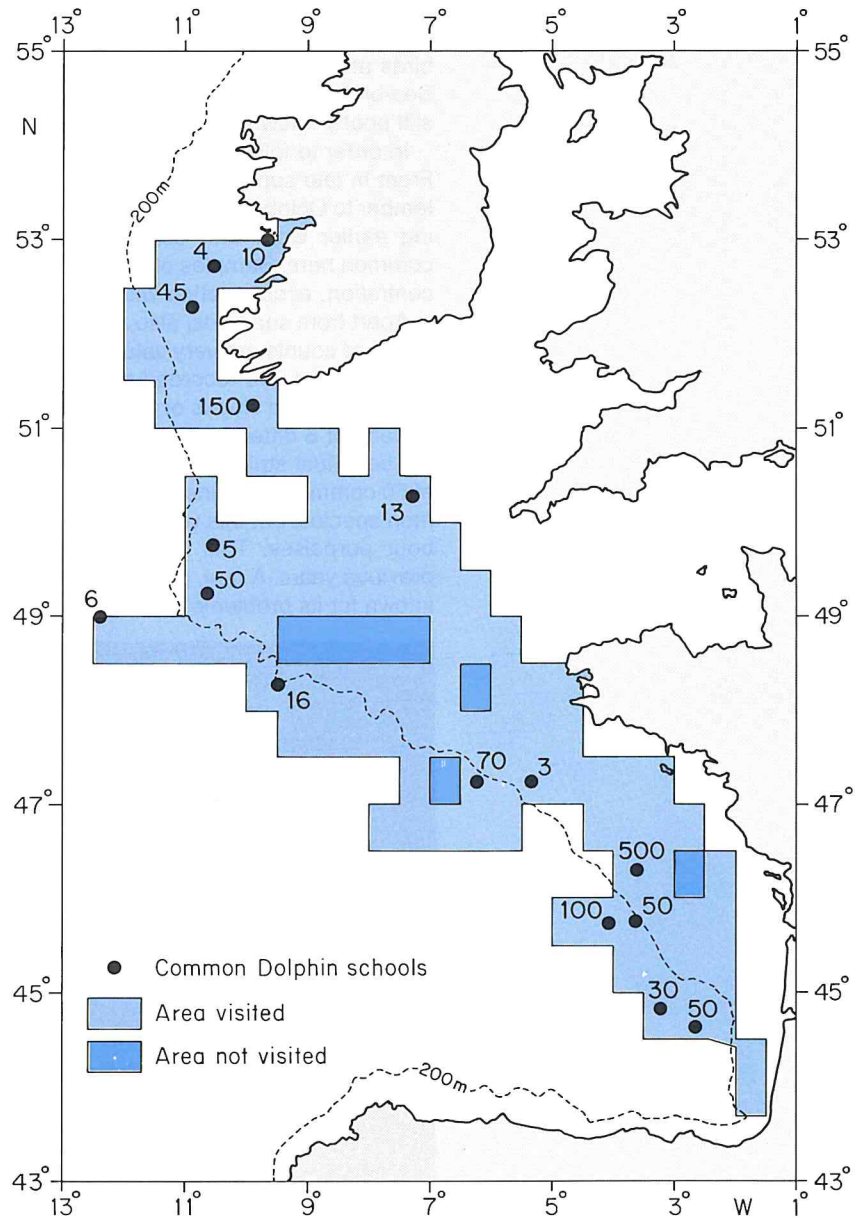
In order to follow the growth of chicks of the two Alcids that visit the Frisian Front in late summer, small numbers were collected under licence, from September to October. In September, the diet was almost exclusively sprat, confirming earlier work with echosounders which suggested that sprat were very common here. Samples of liver and body fat are currently studied for PCB concentration, accumulation with age, and metabolism.

Apart from sea-birds, also mammals are registered at sea during our counts. Sea-bird counts are very valuable for work on cetaceans, because observer effort is known. We recorded relatively large numbers of white-beaked dolphins on the northern slopes of the Dogger Bank in summer, and very large concentrations of 6 different species on the herring-grounds east of England in September. Most striking were records of pilot whales, minke whales and a group of 50 common dolphins. The white-beaked dolphin was as usual the most common species, but this year also white-sided dolphins were seen, as well as harbour porpoises. This year we have seen more cetaceans than in the two previous years. A rare, positive message from the North Sea, which is normally known for its problems with pollution, over-fishing, and toxic plankton blooms?



(Photo: M.F. Leopold)

In Irish, French and Spanish waters, common dolphins were regularly observed. Most records come from a narrow zone around the shelf edge. The animals were often seen foraging, probably chasing mackerel and horse mackerel, which spawn in the area in summer. In waters southwest of Ireland, large-scale migration of harbour porpoises was observed, with 345 animals seen in one day. During that cruise, in total 7 different species of cetaceans, as well as two species of seals were seen.



B3-10 CHEMICAL INTERACTIONS BETWEEN MARINE ORGANISMS AND THEIR ENVIRONMENT

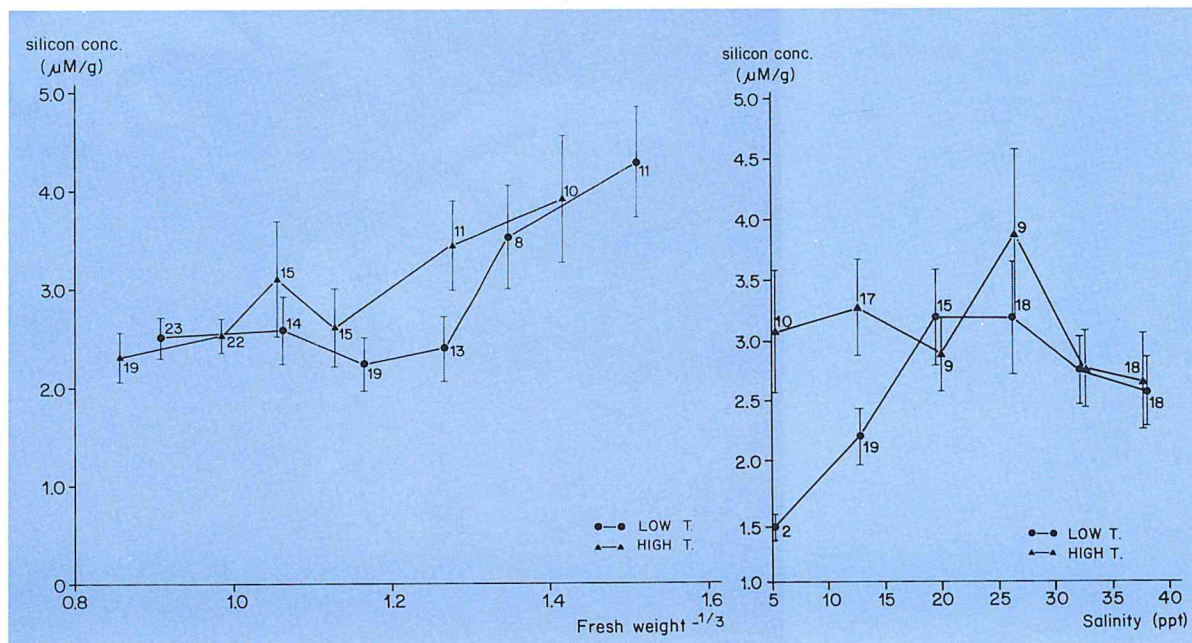
D.H. Spaargaren

A study was undertaken on the utilization of silicon in the brown shrimp, *Crangon crangon*. Generally, silicon in living organisms contributes to mechanical rigidity. The function of this element in an intertidal species was investigated to assess its role in improving the mechanical properties of the integument.

Decreasing whole animal silicon levels in larger animals indicate relatively high silicon concentrations to be present in the exoskeleton. The high silicon concentrations in males must be ascribed to this size effect. Ovigerous females also showed high silicon concentrations, but this is probably related to the presence of eggs (and a high silicon content of the egg shells).

Internal silicon concentrations increased with temperature. In response to environmental salinity, the internal silicon concentrations were highest at normal seawater salinities and lower at more extreme salinities. Hence, as a rule, unfavourable circumstances are associated with reduced silicon levels. These effects of temperature and salinity made clear that in *Crangon crangon* silicon not merely has a function in improving the mechanical rigidity of the exoskeleton, but that it is also an essential element with a metabolic function.

A second study concerned the significance of body size for adaptation to estuarine conditions in the shore crab, *Carcinus maenas*. The motivation here was the question why small animals, despite their unfavourable surface area/volume ratio, are often found in abundance in unstable estuarine waters.



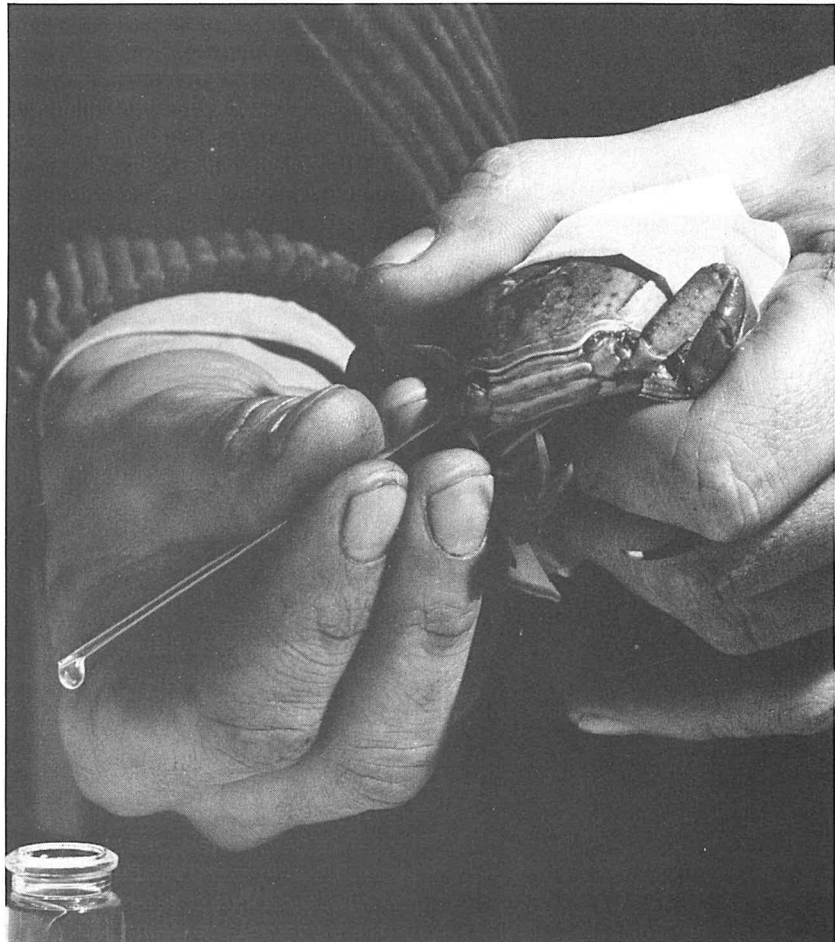
Whole animal silicon concentration in *Crangon crangon* in relation to size (fresh weight to the power $-1/3$) and temperature.

Whole animal silicon concentrations as a function of the adaptation salinities at low (7-10°C) and high (16-20°C) temperatures.

Analysis of the salt kinetics in a closed medium where shore crabs were exposed to changes in salinity yielded information on the permeability and the half-time value for salinity adaptation. The latter value represents an index of the extent to which an animal is adapted to salinity fluctuations in its environment.

At brackish-water salinities the permeability to salt appeared to be inversely related to the external salinity. Sudden changes in the medium salinity resulted in rapid, temporary reductions of the permeability, clearly with an adaptive value.

The permeability appeared to be linearly related to animal weight. In small animals the area-specific permeabilities tended to be lower than those of larger ones. The half-time value for salinity adaptation was found to be independent of animal weight or external salinity. Hence, small animals will have no disadvantage in the passive internal damping of fluctuations in environmental salinities. This clarified why young animals, despite their high surface area/volume ratio, can survive in shallow coastal waters where environmental conditions are highly unstable.



(Photo: NIOZ)

1.8. SPECIAL PROJECTS (S)

APPLIED SCIENTIFIC RESEARCH NIOZ (BEWON)

The BEWON-project is part of the larger BEON-project (= Applied Ecological Research North Sea and Wadden Sea), a cooperative effort between 8 Dutch institutes. Its 17-member staff are executing a scientific research programme to provide answers to management questions concerning eutrophication, organic and inorganic micropollutants and the effects of demersal fisheries on the benthic ecosystem. In close cooperation with other Dutch institutes, the research programme focuses on the effects of external phosphorus and nitrogen loads, and changes thereof, on: the oxygen balance, the growth of algae and higher trophic levels. This year small laboratory experiments, larger mesocosm experiments and modelling efforts have been carried out. The micropollutant programme focuses on the effects of PCBs and PAHs on higher trophic levels such as fish and birds. A pilot project has been executed to investigate the availability of techniques to study the effects of beam trawls on the benthic ecosystem. During workshops organized by the BEON-secretariat specialists from the group gave advice on questions concerning the management of the North Sea and Wadden Sea.

S-01 EUTROPHICATION S-01a NUTRIENT CHEMISTRY

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

In collaboration with H.W. van der Veer the contribution of the North Sea to the phosphorus budget of the Marsdiep basin in the western Wadden Sea during the period 1950-1986 has been quantified. This study has indicated that this contribution is much less pronounced than previously documented. The most important P-source to the basin seems to be the adjacent Lake IJssel.

Sediment samples obtained during the WINDOW cruise (July-August 1988) were further elaborated. Nutrient pore water data from the Dogger Bank area, North Sea, were evaluated with one-dimensional steady-state models. According to these models, 60-75% of the organic nitrogen and 20-30% of the organic phosphorus being mineralized in the sediments of this area is regenerated to the water column. During the WINDOW cruise, the benthic fluxes were found to contribute less than 15% of the silica, 2% of the nitrogen and less than 1% of the phosphorus demand by the phytoplankton. Measured nutrient fluxes across the sediment-water interface were negatively related to measured bacterial production (data from F.C. van Duyl & A.J. Kop, S-01c) in the oxic layer of the sediments (significant at $p < 0.01$), suggesting that these bacteria are inefficient nutrient remineralizers or may even be net nutrient consumers.

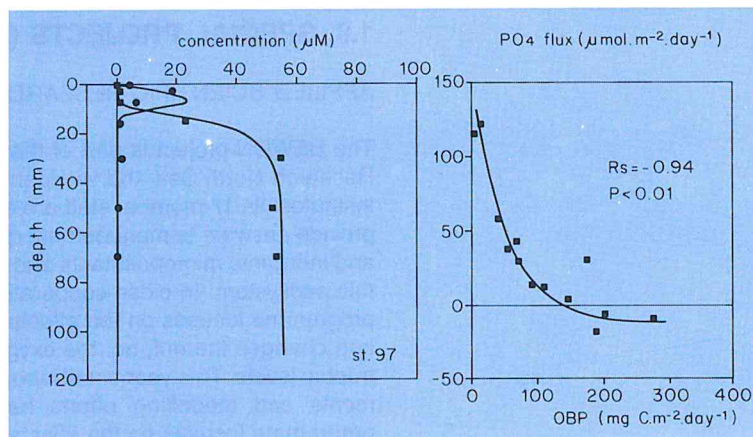
Nutrient early diagenesis processes were studied in two coastal North Sea stations and in North Sea mesocosms. Every two months samples were collected. The first results indicate that denitrification at these stations is very low, probably due to minor nitrification activity in these sediments resulting in low ambient nitrate pore-water concentrations. The sampling programme and the accessory laboratory experiments will be continued next year.

Left figure:

Ammonium (■) and nitrate (●) pore-water concentrations at st. 97 in the Dogger Bank area (WINDOW cruise). Solid lines are model predictions. Calculated nitrification at this station is $480 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{day}^{-1}$, denitrification $296 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{day}^{-1}$.

Right figure:

Phosphate sediment-water exchange as function of the bacterial production in the oxic layer of the sediment (OBP) at the Dogger Bank area (WINDOW cruise). The covariation as tested with a Spearman ranking test is negative and significant ($R_s = -0.94$, $n=13$, $p<0.01$). This suggests that these bacteria are inefficient nutrient remineralizers.



S-01b PRIMARY PRODUCTION

R. Riegman, J.F.P. Malschaert

Much effort has been put in the development and installation of continuous cultures for the cultivation of phytoplankton.

The data of the WINDOW cruise to the Dogger Bank area (1988) have been worked out in three different papers, which have been submitted to scientific journals.

In cooperation with the working group Pelagic Systems, an AIO proposal on nutrient-phytoplankton interactions has been written and submitted to BION. In addition, BEWON has participated in the submission of a MAST-proposal to the EC, entitled: 'Biological, chemical and physical factors controlling the initiation, succession and fate of planktonic blooms in near-coastal and offshore northern european seas' (EUROBLOOMS).

Considerable progress was made with the construction of a North Sea ecosystem model. At the moment a satisfactory simulation of the development of phytoplankton during the various growth seasons can be achieved.

The results of research on phytoplankton in the Marsdiep (1989), performed in cooperation with the NIOZ working groups Pelagic Systems, Coastal Systems and the department of Marine Biology of the State University of Groningen, have been worked out in a separate paper. These results emphasize the importance of microzooplankton in the grazing on *Phaeocystis* and nutrient recycling.

In the laboratory a new method was developed to identify nutrient-limitation for natural phytoplankton. An important contribution to this project was made by H. Danel, a student from the State University of Groningen.

H. Killich, a student from the University of Wageningen, has studied the effects of nutrient-limited growth on the survival of phytoplankton.

S-01c MICROBIOLOGY

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

To investigate the applicability of mesocosms for eutrophication studies in sediments, a North Sea mesocosm experiment was set up in cooperation with Benthic Systems (B1-01). The seasonal development of microbenthos in sandy Breeveertien and silty Frisian Front bottoms in mesocosms was compared with its development *in situ*. One series of bottoms was supplied with organic matter (ca $10 \text{ gC}\cdot\text{m}^{-2}$) in spring (April-May) and another series was starved during the sampling period.

Preliminary results show that bacterial productivity in the sediment surface under *in situ* and mesocosm conditions was comparable from January to April. In spring (between April and June) a steep increase in bacterial productivity was observed *in situ*, reflected to a lesser extent in the eutrophicated mesocosms, which received only a fraction of the C supposed to be deposited annually in the North Sea benthic system. Such an increase in bacterial productivity was not found in the starved bottoms. This suggests that the C-supply directly controls seasonal variations in bacterial productivity in North Sea sediments, implying that the mesocosms are suitable for microbenthos eutrophication studies.

Bacterial production rates in North Sea surface sediments (0-5 mm depth) range from $5\text{-}200 \text{ mg C}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$. Frisian front sediments are at least twice as productive as Breeveertien sediments throughout the year. Benthic bacterial production appeared to be related to inorganic nutrient exchange (N and P) between sediment and water, particularly in sediments poor in organic matter.

Studies on pelagic bacterial production, bacterial and nanoflagellate abundances in the North Sea water column rendered distinct distribution patterns and correlations. Distribution and size of variables changed horizontally and over the depth profile and differed between coastal waters, offshore mixed watermasses, fronts and stratified waters. The Frisian front and the front along the north side of the Dogger Bank were characterized by enhanced bacterial production and/or enhanced specific bacterial growth rates. In fronts as well as in mixed waters, nanoflagellate densities covaried with specific bacterial growth rates (μ) and reached highest numbers over the total water column in fronts. For instance, heterotrophic nanoflagellate densities peaked in the Frisian Front with 6000 to $>10.000 \text{ cells}\cdot\text{cm}^{-3}$. These high densities were accompanied by low bacterial abundances ($0.45\times10^6 \text{ cells}\cdot\text{cm}^{-3}$) suggesting a regulation of bacterial numbers by heterotrophic nanoflagellates. A comparable pattern was found in the Dogger Bank front. The highest bacterial numbers ($4.5\times10^6 \text{ cells}\cdot\text{cm}^{-3}$) were established in the coastal zone. Here bacterial biomass exceeded nanoflagellate biomass. Further offshore nanoflagellate biomass exceeded bacterial biomass. In stratified waters nanoflagellate abundances were highest in the lower part of the thermocline. Particularly autotrophic nanoflagellates reached their highest densities here.

Tidal cycles of bacterial production, bacterial and nanoflagellate abundance and biomass were analysed in the Wadden Sea water column. Covariation between bacterial production and nanoflagellate abundance was found analogous to such relationships in mixed waters of the North Sea.

S-01d HIGHER TROPHIC LEVELS

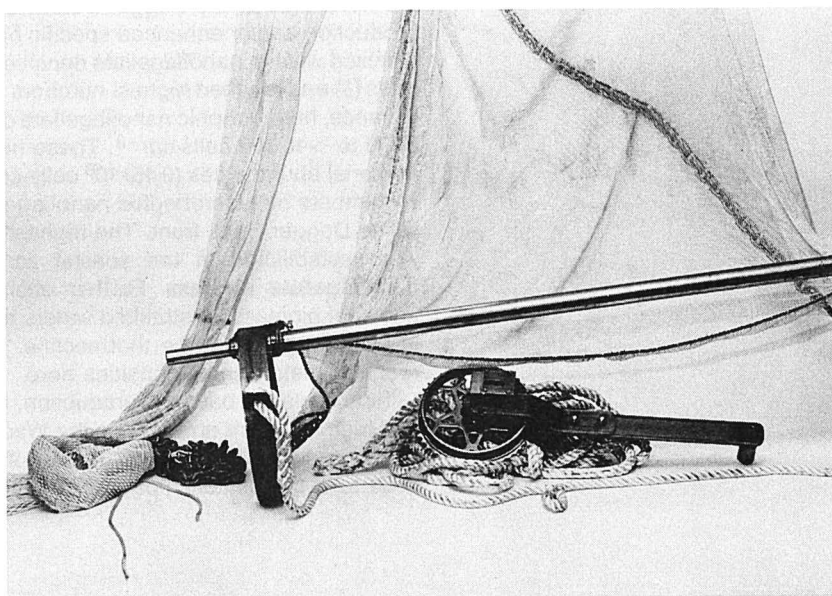
H.W. van der Veer, A. Stam

Research on higher trophic levels concentrates on demersal predators. The main topic is the impact of eutrophication on the amount of food available to the benthic community and to epibenthic predators.

Data on abundance and growth of juvenile plaice in the coastal zone were analysed in detail. The abundance and growth of 0-group plaice proved to be positively related to the macrobenthic biomass. No density-dependent growth could be found. In contrast, at higher plaice densities growth also increased, due to higher food abundance. As a consequence, predation pressure of 0-group plaice on the benthic community increased exponentially at higher benthos biomass. This means that the share of the macrobenthic production taken by 0-group flatfish will increase with benthos richness.

Based on these results in the coastal zone, a similar programme will be started in 1990 in the North Sea. Research efforts will first concentrate on the dab *Limanda limanda*, since this species is common in large parts of the North Sea. The central theme will be the benthos-fish interactions in various areas of the North Sea in relation to the population dynamics of dab. Subsequently, a first attempt will be made to study the impact of micropollutants in dab on its population dynamics. Groups of dab will be studied in the laboratory for the effect of micropollution on growth and reproduction capacity. The whole project will be carried out in cooperation with J. Boon (BEWON), G. Duineveld (Benthic Systems), M. Fonds (Coastal Systems) and A. Rijnsdorp (Netherlands Institute for Fishery Investigations, IJmuiden).

Simultaneously, data on fish abundance and distribution in the North Sea collected in the 70s by Creutzberg and his coworkers (Aurelia cruise reports) will be analysed on abundance and growth of dab during that period. Together with the data collected in 1990, these data may give insight into possible changes over the last 10 to 15 years.



Flatfish sampling gear:
Beam-trawl, net and meter wheel are
designed and constructed by the technical
department of the institute.
(Photo: NIOZ)

S-01e MODELLING

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

Physical oceanography

As part of an ecosystem model the development of a one-dimensional mixed layer model has been started. This module, which is forced by irradiance, wind and tide, simulates the vertical temperature profile, the thickness of the upper and bottom mixed layer and the position of the non-turbulent thermocline.

Data obtained during the WINDOW cruise suggested that north of the Dogger Bank the non-turbulent thermocline could be replaced by a discontinuity-like interface. However, first model simulations showed the necessity of including the non-turbulent thermocline.

The large temperature gradients in a relatively thin layer, suggesting a minimal distance between the upper and bottom mixed layer, are most likely caused by short duration events with strong winds. During periods with weak winds the depth of the upper mixed layer decreases, whereas the thin layer with large temperature gradients persists. To simulate these weak wind periods it is necessary to include the non-turbulent thermocline.

The data set from the WINDOW cruise only covers a few weeks. To test and improve simulations on a seasonal scale other data sets will be used (obtained during the Natural Environmental Research Council (NERC North Sea Project)).

Ecological modelling

During 1989 the main focus has been on the transport and pelagic submodel, parts of a model which describes the behaviour of the ecosystem in an arbitrary area in the North Sea comprising one or more water columns. The transport model has been so modified that the whole model can easily be adapted to different areas: the number of vertical compartments in a column as well as the number of columns can now easily be changed without rewriting the source code of the model. Also, it is possible now to vary the thickness of the vertical compartments continuously and still retain mass balance to ease the modelling of temperature stratification. The pelagic model is now working sufficiently well to apply to different situations in the North Sea. The attention in the last quarter has been shifted to the benthic system, especially to the nutrient regeneration modelling. A workshop with Delft Hydraulics has been held in which our column model was compared to theirs. Our model, originally developed for an oligotrophic situation near the Dogger Bank, was applied to several coastal regions. Both models produced similar carbon budgets for the various functional groups. Comparing both versions with field observations shows that especially during the summer months the models need to be improved, chiefly with respect to the (re-)supply of nutrients to primary producers, which is determined by the nutrient regeneration.

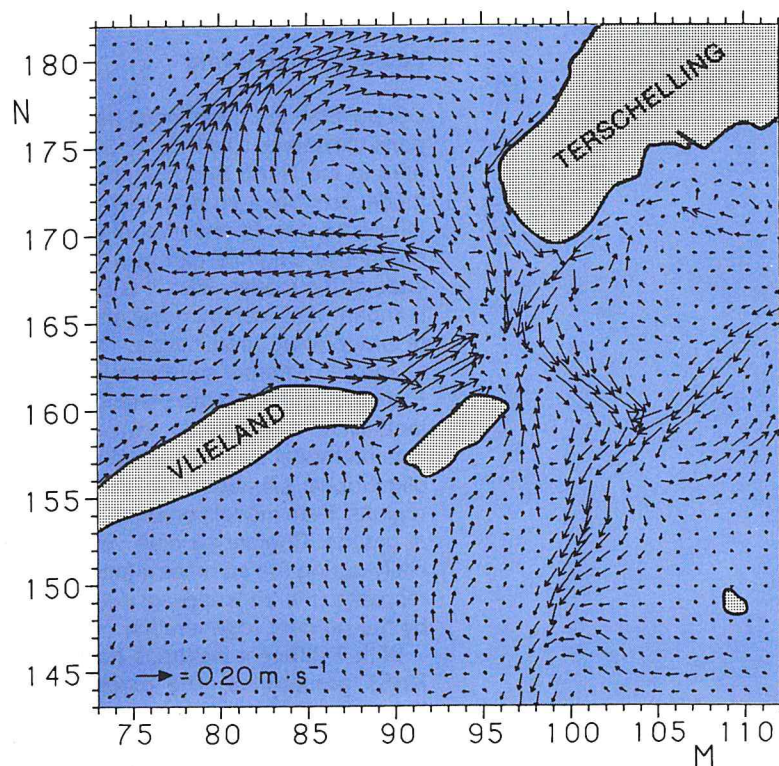
With 7 different institutes from 5 countries a proposal was submitted to the MAST programme. The proposal, called ERSEM (European Regional Sea Ecosystem Model), has as its objective to provide a scientific basis to support decision making in environmental quality and biological resource management by developing suites of modules for combination into models aimed at answering particular biological and environmental questions.

In the framework of the NERC North Sea project on the seasonal cycles of numerous physical, chemical and biological entities, J.W. Baretta and J.F.P. Malschaert have taken part in survey cruises with RV 'Challenger' in the Southern Bight. During these surveys vertical zooplankton hauls were taken. The NIOZ participation in this project will give access to the resultant, very large data set. This data set together with data from NIOZ cruises will form the basis for testing and improving our North Sea column model.

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

H. Ridderinkhof

The hydrodynamical model of the western Dutch Wadden Sea has been used to study the origin of the small-scale residual eddies in this area. A vorticity balance showed that tidal vorticity is mainly produced by differential bottom friction along the side walls of the channels. Advection of this tidal vorticity outside the source regions results in relatively large residual eddies all over the area. The same numerical model has been used to analyse the tidal exchange between North Sea and Wadden Sea basins. Relating this tidal exchange to the tidal prism entering a basin during a flood period shows that the exchange ratio through the Eierlandse Gat is substantially larger than its value for the other tidal inlets. Differences in bathymetry around the inlets cause the differences in exchange ratio.



Residual velocities in the area near the Zee-gat van het Vlie.

S-01g WADDEN SEA ECOSYSTEM MODEL

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

The Ems model and our simulation package BAHBOE will be used by the Instituto Superior Technico in Lisbon, Portugal, for an ecosystem project in the Tagus estuary. Therefore Ruardij has installed the package on their VAX-VMS computer in Lisbon. The same package will be used by Marion Stössl of the GKSS in Hamburg to model benthic suspension feeders in the Rømø-Sylt area. Relevant parts of the pelagic and benthic submodel, the EMOWAD model, have been used to describe model tidal flats (MOTIFS) used in the SEDEX project (B1-01).

Together with German and Danish institutes an EC-MAST proposal on Wadden Sea modelling (WASP=Wadden Sea Project) was written. If funded, different institutes, including WL, RIN, DGW and NIOZ from the Netherlands, will model surface waves, currents, erosion, sedimentation, transport and biological and chemical processes for the entire Wadden Sea.

S-02 MICROPOLLUTANTS

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

J.P. Boon, M.Th. J. Hillebrand,
S. Jansen, M. Roozemeijer

The toxicity of chlorobiphenyl (CB)-congeners is determined by their chlorine substitution pattern. The most toxic PCBs closely resemble the molecular shape of 2, 3, 7, 8-tetrachlorodibenzodioxin and contain chlorine atoms at least at both para positions and two meta positions, but the latter not necessarily at the same ring. Since planarity of the molecule is an important factor, the toxicity of PCBs decreases with an increasing degree of ortho-substitution. Yet, the mono-ortho derivatives of the most toxic CB congeners still show many of the toxic responses of the non-ortho substituted PCBs fulfilling the Cl-substitution requirements mentioned above.

The normal procedure of quantifying PCBs by single capillary columns does not allow the determination of several of the most toxic CBs, since these are still not separated from other —less toxic— congeners. To determine the most toxic congeners either a special multidimensional gaschromatograph is necessary, or CBs can be separated according to molecular planarity on active carbon columns. The latter was described in the literature by TANABE *et al.* (1987, Intern. J. Environ. Anal. Chem. 29) for the separation of the three most toxic PCBs (with numbers 77, 126 and 169) from other congeners.

An adaptation of this method using toluene instead of the carcinogenic benzene as a solvent was set up and the behaviour of 65 PCB congeners with varying degrees of overall- and ortho-chlorine substitution was tested on active charcoal columns. It appeared that for the retention of CB congeners the degree of ortho-chlorination was of major importance: Retention decreased in the order: non-ortho > mono-ortho > di-ortho > tri-ortho = tetra-ortho. In case of di-ortho congeners, no differences existed between molecules with both their ortho-chlorines at the same ring or one at each ring. Thus, it can be concluded that toxicity of PCBs is proportional to planarity if the Cl-substitution requirements at the meta and para positions are fulfilled.

The method described above was used to separate the most toxic PCBs from their co-eluting congeners after capillary-column GC on a SE-54 column in tis-

sue samples from a bird and a harbour seal, but only after the use of the newly developed HPLC clean-up to get rid of interfering substances such as animal lipids.

A preliminary 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 environmental hazard decreased in both samples in the order: CB-105 > CB-126 > CB-77 > CB-118 = CB-156 > CB-169. Surprisingly, only CB-118 is regularly involved in international monitoring programmes.

S-02b BIOMARKERS OF MARINE ENVIRONMENTAL CONTAMINATION

J.P. Boon, M. Fonds, H.W. van der Veer, J.M. Everaarts, M. Roozemeijer

See also project H1-07

PCB mixtures are able to induce several hepatic enzyme systems involved in biotransformation, among them the mixed-function oxygenase (MFO) system and the phase-II enzyme glutathion-S-transferase (GST). PCBs can also interfere in the synthesis of haem-groups and with cytochromes involved in electron-transport chains, among them the MFO-system.

Female plaice injected with a gelatin capsule containing a solution of the technical PCB-mixture Clophen A40 in sunflower oil were compared to plaice injected with a gelatin capsule containing only the sunflower oil on days 9/10 and 15/16 after injection.

On both days, total cytochrome P450 levels were higher, while blood haemoglobin concentration had decreased in fish treated with Clophen A40. Haematocrit values did not differ between the two groups of fish.

Enzym Linked Immuno Sorbent Assay (ELISA) showed increased concentrations of the 3-MC inducible Cytochrome P450IA subfamily in PCB-treated fish, but surprisingly ethoxyresorufin-o-deethylase (EROD-) activities did not differ between the two groups. This may be due to substrate inhibition.

The activity of (GST) was significantly higher in PCB-treated fish on days 15/16 than on days 9/10. A larger time interval between injection with PCBs and induction of GST compared to MFO-enzymes has been reported earlier and may indicate that in fish both groups of enzymes are regulated individually and not as an Arylhydrocarbon-gene battery as appears to be the case in mammals.

Effects are related to increases in PCB-concentrations in muscle; especially those of the congeners showing a 3-MC and mixed 3-MC and PB induction types of MFO-enzymes in rats.

This experiment was executed in collaboration with Dr. R. Mohan (Applied Sciences Project, NIOZ), M.L. Eggens and J. Peijnenburg (Tidal Waters Division of Rijkswaterstaat), Dr. B. van Ommen (CIVO-TNO) and Dr. A. Gokøyr (Institute of Biochemistry, University of Bergen, Norway).

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

M. Mulder, W.E. Lewis, R. Daan,
I. Schweimler

Biological research around drilling locations in the Dutch section of the continental shelf has been continued. The question underlying this study is to what extent discharges of oil-based muds during drilling activities injure the structure of the benthic community, on a spatial as well as a temporal scale. The current field monitoring programme concerned drilling locations in areas with different sediment types and with different loads of pollution. Prolonged analysis of macrofauna samples collected during the 1988 surveys has confirmed earlier results, viz. that effects of discharges can be detected by changes in the faunal composition within some hundreds of meters of drilling locations, even after several years. In May 1989 a new location was surveyed where drilling activities had recently been performed and where advanced methods had been applied to wash the drill grit before it was discharged.

Experimental methods for active biological monitoring are of growing interest. In particular the potentialities of 'boxcosms', consisting of intact *in situ* collected bottom cores, have been explored. For 4 months, 17 cores were incubated in an indoor basin under semi-natural conditions. Test-animals of some common macrofauna species were used to study their behaviour and mortality in severely polluted, slightly polluted and clean sediments. In addition, survival of the natural infauna in the boxcosms was determined in all three sediment types after the period of incubation. Echinoderms, especially *Echinocardium cordatum* responded quite clearly, both by behaviour and mortality, to pollution by oil-based muds. Moreover, survival of the total natural infauna was significantly lower in the boxcosms with polluted sediments. In September a new series of experiments with 14 boxcosms was started.

All investigations are executed in close cooperation with MT-TNO, Den Helder, and RWS, North Sea Directorate.

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

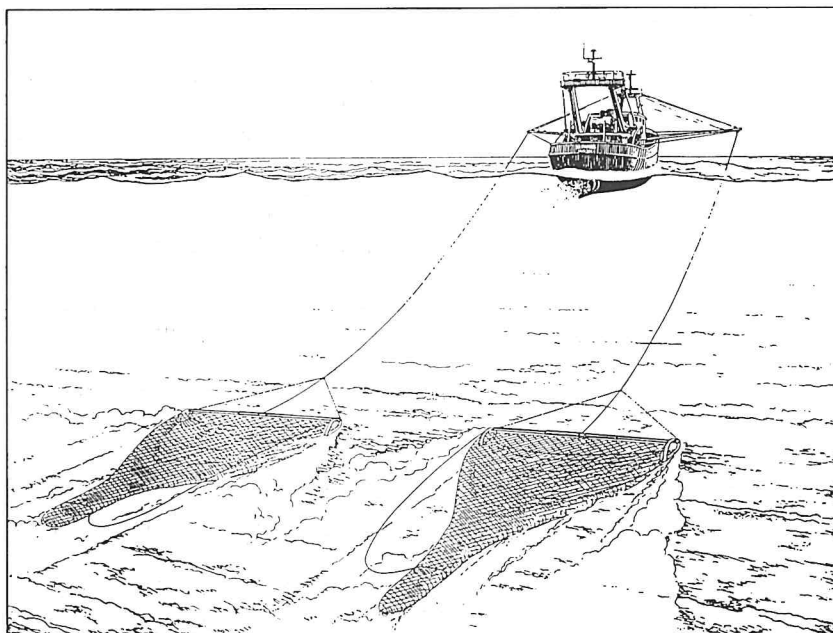
M.J.N. Bergman

In August 1989 a study was carried out on the short-term effects of beam-trawl fisheries on the benthic fauna of a sandy area in the North Sea with a rather compact sediment structure.

In an area which in the preceding 4 months had been closed to all fisheries, except with small trawlers, the benthic community was sampled before and after a commercial beam trawler had fished the area. The effects of this beam trawling on density and biomass of the meiobenthos and macrobenthic in- and epifauna will be determined.

The data were gathered with support of the RWS-Directorate North Sea and in close cooperation with the Netherlands Institute for Fishery Investigations (RIVO).

Beam-trawl fishery.
(RIVO report MO89-201, Drs. H. Welleman)



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

M.J.N. Bergman

A contribution was made to the Environmental Impact Study by preparing a report describing the biological impacts of waste disposal during exploration and exploitation of gas- and oil-producing platforms in the North Sea. The report will include a summary of the environmental effects of both the present regulations applying to offshore activities and possible future alternative regulations.

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

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

M.S.S. Lavaleye

The NAZORG project, started at the end of 1987, is a continuation of 2 years of the biological part of the DORA-project (Deep-Sea Disposal of Radioactive Waste), which gave a detailed description of the bottom fauna of the NEA-dumpsite in the NE Atlantic Ocean ($\pm 46^\circ\text{N}$, 17°W).

An important aim of the project is to compare the meio- and macro-benthos of the dumpsite with surrounding areas. The meiofauna densities of the 4 stations sampled, ± 100 km apart on a transect from the site towards the north, are of the same order. Their mean is even somewhat higher than the already high DORA-project data (excluding the Protozoa). In part this is caused by the sampling with a multiple corer. A comparison with the Scripps boxcorer has shown that in sampling the meiofauna, the multiple corer gives a somewhat

better result (higher densities), but especially the large and significant difference in amounts of Copepoda and nauplii is striking. An explanation could be that harpacticoid Copepoda and nauplii, presumed to be fairly good swimmers, take off from the sediment into the water column when disturbed. So, because of the larger bow effect of the Scripps boxcorer and the discarding of most of the water over the sediment on board before the necessary subsampling, the animals can escape sampling. Special attention (in contrast to the former project) has been paid to the benthic Foraminifera. They appeared to occur in very high densities, in most cases even higher than those of the Nematoda, with a record maximum of 1.85 million/m². The macrofauna and larger meiofauna (> 0.5 mm) gave data comparable to those of the DORA-project and no significant difference in densities was found between the stations of the transect.

The role of the different taxonomical groups in the food-web was studied, and as expected most are deposit feeders. Additional sampling of the megabenthos was carried out during a two-day expedition with the RV 'Tydeman' at the transect stations. Two good trawl catches of megafauna were hauled in, and the material will be analysed for gamma radiating radionuclides and ²³⁹+²⁴⁰Pu, ²⁴¹Am, ²¹⁰Pb at the ILMR (=International Laboratory of Marine Radioactivity) in Monaco.

S-06 SEDIMENT EXPERIMENTS (SEDEX)

R. Dekker, G.W.N.M. van Moorsel, see B1-01
P.A.W.J. de Wilde

S-07 POLLUTION RESEARCH IN THE ADRIATIC SEA

C.G.N. de Vooy

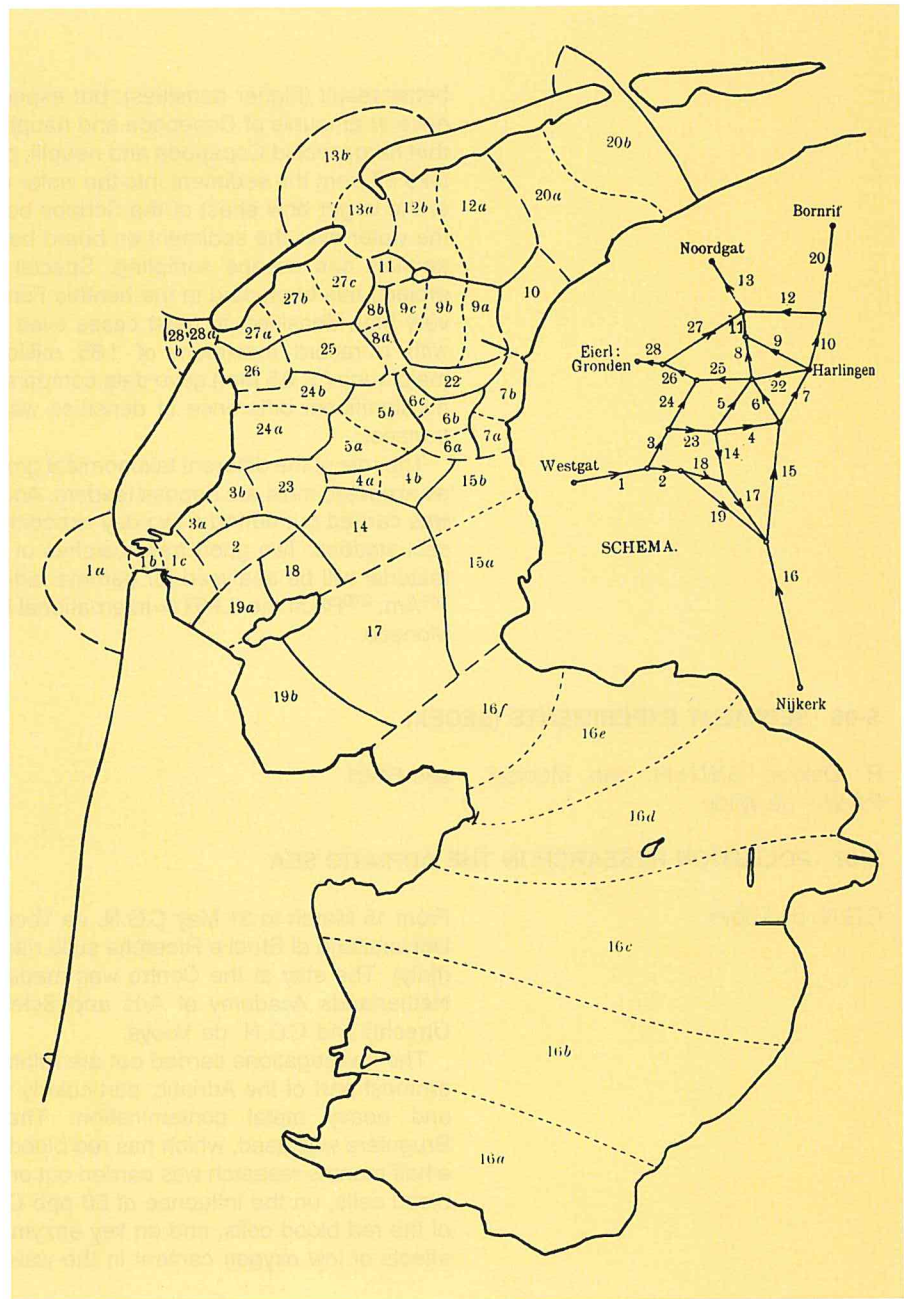
From 15 March to 31 May C.G.N. de Vooy carried out research at the Centro Universitario di Studi e Ricerche sulle risorse Biologiche marine at Cesenatico (Italy). The stay at the Centro was made possible by a grant from the Royal Netherlands Academy of Arts and Sciences to A. de Zwaan (University of Utrecht) and C.G.N. de Vooy.

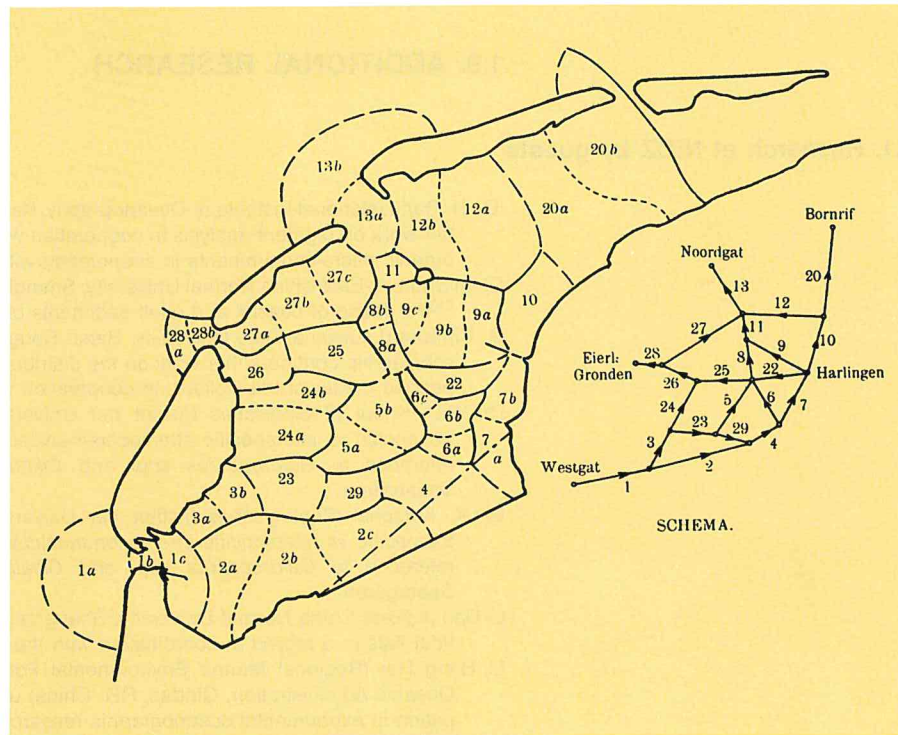
The investigations carried out are related to pollution problems in the northernmost part of the Adriatic, particularly very low oxygen content of the water and heavy metal contamination. The bivalve *Scapharca inaequivalvis* Bruguière was used, which has red blood cells with haemoglobin. For two and a half months research was carried out on the anaerobic metabolism of the red blood cells, on the influence of 50 ppb Cd⁺⁺ in the water on the metabolism of the red blood cells, and on key enzymes of anaerobic metabolism, and the effects of low oxygen content in the water on the metabolism.

S-08 POSSIBLE BIOLOGICAL EFFECTS OF LONG-TERM CHANGES IN TEMPERATURES OF DUTCH COASTAL WATERS

C.G.N. de Vooy

Based on a literature review on the possible biological effects of long-term changes in temperatures of Dutch coastal waters, a chapter was prepared for the Proceedings of the workshop held at NIOZ from 11 to 15 November 1988.





The hydrodynamics of the tidal motion is now studied at NIOZ by means of computer models. But already in 1926 the Zuiderzeecommissie, under the leadership of Nobel Laureate Lorentz, published tidal studies of the Wadden Sea made by means of a simple numerical model. In this model a number of boxes were connected with a system of gullies. Because no electronic computers were available in those days, even these simple calculations formed a laborious task. We have here reproduced pictures of the boxes and the gully system used in 1926 to predict the change of the tides in the Wadden Sea due to the closure of the Zuiderzee.

(Verslag van de Staatscommissie Zuiderzee 1918 - 1926, 's-Gravenhage, Algemeene Landsdrukkerij, 1926).

1.9. ADDITIONAL RESEARCH

1.9.1. Research at NIOZ by guests

- Dr. N. Bano (National Institute of Oceanography, Karachi, Pakistan) in February finished her work on pigment analysis in cooperation with A.G.J. Buma and her analysis of organic micro-contaminants in cooperation with M.Th.J. Hillebrand.
- Chen Shumin (East China Normal University, Shanghai, P.R. China) carried out XRD and ^{210}Pb dating of coastal and shelf sediments of the East China Sea.
- G. Chmura (Louisiana State University, Baton Rouge, USA) on the basis of a Fulbright scholarship continued her work on the distribution of pollen in sediments and suspended matter of the Dollard, in cooperation with D. Eisma.
- Dr. W.D. Knaut (Zoologisches Institut der Universität Salzburg, Austria) studied intraspecific vs interspecific chemocommunication in marine teleosts, with special reference to *Gaidropsarus* spp. and *Ciliata* spp., in cooperation with D.H. Spaargaren.
- Dr. K. Korschal (Zoologisches Institut der Universität Salzburg, Austria) studied intraspecific vs interspecific chemocommunication in marine teleosts, with special reference to *Gaidropsarus* spp. and *Ciliata* spp., in cooperation with D.H. Spaargaren.
- Li Dao Ji (East China Normal University, Shanghai, P.R. China) studied the ecology of tidal flats in a project in coordination with the Department of Marine Geology.
- Li Hong Hai (Regional Marine Environmental Forecasting Observatory of the State Oceanic Administration, Qindao, P.R. China) until 1 October continued his participation in experimental oceanographic research in cooperation with H. van Haren and H.M. van Aken.
- Dr. M.I. Jenness (Davis & Elknins College, USA) from 15 May to 15 August participated in the study on the growth of *Arctica islandica* and the biology of *Echinocardium cordatum*.
- Dr. R. Mohan (Department of Zoology, University of Madras, Madras, India) stayed at the Department of Chemical Oceanography and Marine Pollution from 18 January to 13 July to carry out research on the influence of polychlorinated biphenyl congeners on the activity of the mixed function oxygenase enzyme in flatfish (*Pleuronectes platessa*) under the supervision of J.P. Boon and J.M. Everaarts.
- Dr. R.C. Peters (Department of Comparative Physiology, University of Utrecht) studied intraspecific vs interspecific chemocommunication in marine teleosts, with special reference to *Gaidropsarus* spp. and *Ciliata* spp., in cooperation with D.H. Spaargaren.
- Ir. Xia Fuxing (East China Normal University, Shanghai, P.R. China) carried out Coulter Counter and SEM analyses of suspended matter collected in the Chang Jiang river mouth in 1986 and 1988.
- Dr. Zhang Jing (Shandong College, Qingdao, P.R. China) carried out Coulter Counter, XRD and SEM analyses on suspended matter and sediment samples from the Huang He river and on some samples of loess.

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/POSEIDEON satellites.
- G. Marees and M.R. Wernand participated in a national remote sensing programme in cooperation with Rijkswaterstaat and the National Aerospace Laboratory
- G. Marees and M.R. Wernand participated in the 'European Imaging Spectrometer Aircraft Campaign (EISAC)' together with about twenty other research institutes in Europe, with the purpose to participate in the joined data analysis of the international airborne remote sensing experiments over the German Bight and the Skagerrak.
- As in previous years, part of the macrozoobenthos research (B3-02) is incorporated in the European Community project COST-647, an international long-term programme to assess and correlate fluctuations in numerical densities of selected species of benthic animals in European coastal areas. Data were made available to authors of reviews of dynamics in bivalve species along the Atlantic coasts of Europe, presented at an ECSA symposium.
- M. Fonds participated in a pilot study of the effect of demersal fishery on the bottom fauna of the southern North Sea, in cooperation with RWS, RIVO, BEWON.
- EPOS, European Polarstern Study of the ESF (European Science Foundation) in Antarctic waters on board RV 'Polarstern': H.J.W. de Baar, A.J. van Bennekom, A.J.G. Buma, G.C. Cadée, H.G. Fransz, S.R. Gonzalez, R.F. Nolting, S. Ober, R. Schmidt and C. Veth took part in Leg 2 to the Weddell-Scotia Confluence area, which ended in January 1989. R.P.M. Bak, G. Nieuwland and J.H. Vosjan participated in Leg 3 to the Weddell-Scotia Confluence and the inner Weddell Sea, from January to March. G.W. Berger was invited by the Alfred Wegener Institut (Bremerhaven) to participate in Ant VIII/3 in the polar front area, from October to December.
- M.F. Leopold helped found the Seabird Group, a working group of all Dutch participants in work on seabirds.



Royal Research Ship 'Challenger' continuously worked in the southern half of the North Sea during the British North Sea project between August 1988 and October 1989. NIOZ did the zooplankton sampling during most surveys within the project.
(Photo: M. Baars)

Together with the British 'Seabirds at Sea team', an initiative was launched to co-produce an atlas of the birds of the North Sea, within 5 years. Ideally, data bases of the British, Dutch, Danish, Norwegian and (new) German teams should be incorporated.

JGOFS (Joint Global Ocean Flux Studies): see 1.1.1. New Multidisciplinary Programmes.
ICES: M.J.W. Veldhuis and G.W. Kraay participated in the ICES primary production work-group. R.F. Nolting took part in the ICES trace metal intercomparison exercise.

Angola Basin and Zaire river cruise: see 1.1.1. New Multidisciplinary Programmes.

D.H. Spaargaren, in the framework of an exchange programme between French and Dutch marine scientists, continued work on amino acid and fatty acid dynamics in Crustacea and visited the Lab. Ecol. Mar. CNRS/IFREMER in La Rochelle, France, for discussions with J.-L. Martin, S. Maestrini, R. Gallois and P. Richard.

G.C. Duineveld, in the Joint Dutch-German mapping programme of North Sea benthic metabolism, worked on the synoptic mapping of North Sea benthos.

Members of Pelagic Systems and BEWON continued participation in the British North Sea Project, coordinated by the Proudman Oceanographic Laboratory, Liverpool. B.R. Kuipers, H.J. Witte, M.A. Baars, S.S. Oosterhuis, J.W. Baretta and J.F.P. Malschaert sampled zooplankton during surveys by RV 'Challenger' (RV, Barry) in the southern half of the North Sea (see B2-03). During her last survey in 1989, the 'Challenger' called at Den Helder on 25 September. The crew made a trip to the Institute and in return people from NIOZ visited the research vessel. A workshop on processing and modelling of the first results of the North Sea project was attended by J.W. Baretta, Liverpool, 5-6 September.

EROS-2000: D. Eisma attended steering group meetings in Brussels on 24-25 January and at Plymouth on 30-31 May. Coring and sampling material was sent to Livorno to be used on RV 'Bannock' and bottom cores were collected in the Golfe du Lion.

From 7 to 9 March, D. Eisma, W. Helder and R.F. Nolting attended a symposium in Paris where the first results of EROS-2000 were discussed.

T. Piersma participated in a Canadian Wildlife Service expedition to Rowley Island, Foxe Basin, Northwest Territories, Canada, to study the breeding season energetics of Knots and Turnstones on their tundra breeding haunts (June-July).

T. Piersma, in cooperation with Dr. N.C. Davidson of the Nature Conservancy Council, Petersborough, UK, organized an international workshop on 'Recent advances in understanding Knot migrations' during the Ecology Symposium of the International Waterfowl and Wetland Research Bureau, at Ribe, Denmark, on 21-22 September. The proceedings of the workshop will be edited by T. Piersma and N.C. Davidson and published in 1990 by the international Wader Study Group.

J.H. Vosjan cooperated with Prof. Dr. G. Döhler of the Botanical Institute of the University of Frankfurt in the study on the effect of UV-b radiation on the microbial ecosystem.

J.H. Vosjan was lecturer in the International Postgraduate Training Course on Fundamental and Applied Marine Ecology of the Free University of Brussels (16 lectures).

J.H. Vosjan participated as lecturer in the Interuniversity Postgraduate Third Cycle Marine Ecology of the Institute for Marine Scientific Research (IZWO), Bredene, Belgium.

J.H. Vosjan, together with Dr. W. Gunkel, Helgoland, FRG, participated in a study on microbial activities in coastal waters of the Netherlands and Germany.

1.9.3. Visitors from abroad

Prof. Dr. A.J. Baker, Royal Ontario Museum and Dept. of Zoology, University of Toronto, Canada.

Dr. H. Boyd, Canadian Wildlife Service, Ottawa, Canada.

Mr. D. Brew, University of East Anglia, Norfolk, UK.

Dr. K.O. Cochran, State University of New York, USA.

Dr. A. Cruzado, CEAB, Blanes, Spain.

Dr. M. Currin, North Carolina State University, Raleigh, USA.
 Dr. M.J. Dekkers, Observatoire de Grenoble, France.
 Prof. Dr. W. Donderski, Microbiological Laboratory, Copernicus University, Torun, Poland.
 Prof. Dr. Q. Du, Geography Institute, Academica Sinica, Nanjing, P.R. China.
 Dr. J.P. Dupont, Université de Rouen, France.
 Prof. Dr. W. Ebenhoh, University Oldenburg, FRG.
 Dr. J. Gromadzka, Ornithological Station, Polish Academy of Sciences, Gdansk, Poland.
 Dr. M. Heath, MLA, Aberdeen, Scotland.
 Dr. G. Hilgerloh, Dept. of Zoology, W. Goethe University, Frankfurt/M, FRG.
 Prof. Dr. D. Jablonski, Dept. of Geophysical Sciences, University of Chicago, USA.
 K.A. Johannesson, FAO, Rome, Italy.
 Prof. Dr. S. Kidwell, Dept. of Geophysical Sciences, University Chicago, USA.
 Dr. R. Lafite, Université de Rouen, France.
 Dr. C. Lancelot, Free University, Brussels, Belgium.
 Mr. B.A. Lane, Dept. of Zoology, University of Melbourne, Australia.
 Dr. D.B. Lank, Dept. of Biology, Queen's University, Kingston, Canada.
 Dr. T. Legovic, CIM, Belgrade, Yugoslavia.
 Mr. Li Bogen, Second Institute of Oceanography, Hangzhou, P.R. China.
 Mr. Li Yan, Second Institute of Oceanography, Hangzhou, P.R. China.
 Dr. A. Malmgren-Hansen, WQI, Denmark.
 Dr. A. Manahan, EC, Brussels, Belgium.
 Prof. Dr. Meng Hsien-Chun, Director Office National Science Council, Taipei; in Europe:
 Frankfurt/Bonn, FRG.
 Dr. J.M. Miller, North Carolina State University, Raleigh, USA.
 Prof. Moeljono S. Trastotenojo, MD, Diponegoro University, Semarang, Indonesia.
 Dr. M. Mohanti, Bhubaneswar, Orissa, India.
 Miss P. de Lange, Direktoraat Seevisserije, Dept. Land en Natuurbewaking, Windhoek,
 Namibia.
 Dr. L. Pihl, Kristineberg Marine Biology Station, Fiskebäckskil, Sweden.
 Prof. Dr. P. Pu, Geography Institute, Academica Sinica, Nanjing, P.R. China.
 Mrs A. van Put, Universitaire Instelling Antwerp, Belgium.
 Dr. Q.S. Quaraishee, Director NIO, Karachi, Pakistan.
 Dr. P. Radford, PLM, UK.
 Dr. G. Radach, IFM, Hamburg, FRG.
 Drs. Rahardjo, Diponegoro University, Semarang, Indonesia.
 Dr. P. Regnier, Université Libre de Bruxelles, Belgium.
 Dr. Ir. Sahala Hutabarat SMC, Diponegoro University, Semarang, Indonesia.
 Mr. S.A. Shaikh, Ambassador of Pakistan, The Hague.
 Dr. V. Smetacek, Alfred Wegener Institut, Bremerhaven, FRG.

2. Publications, lectures etc.

2.1. PUBLICATIONS

2.1.1. Netherlands Journal of Sea Research and other series issued

In 1989, two volumes (23 and 24) appeared of the Netherlands Journal of Sea Research, whereas one issue was published of the NIOZ Publication Series (viz. no 16: the Annual Report 1988).

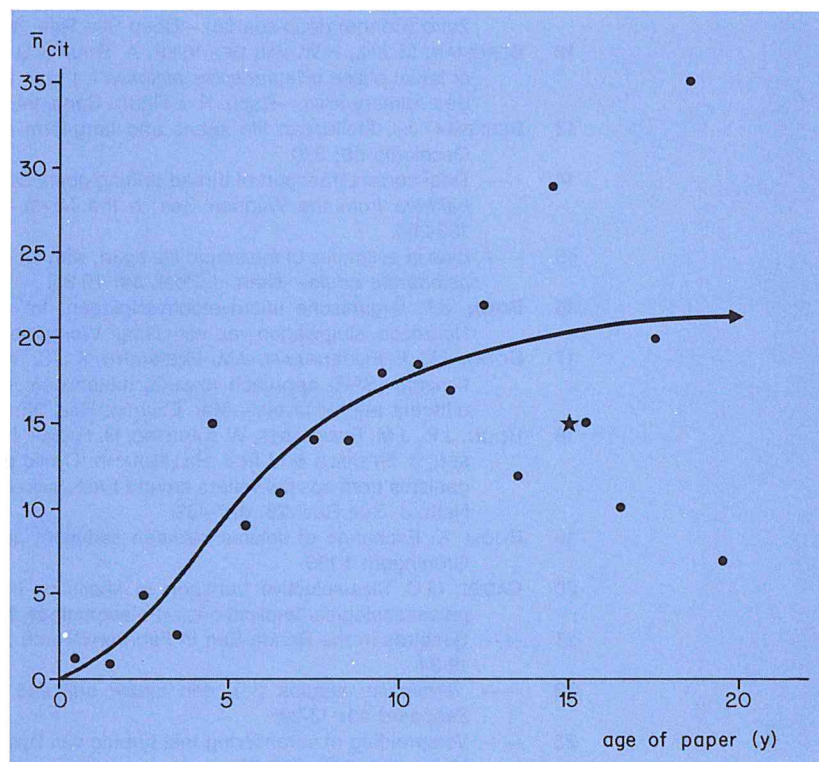
The Neth. J. Sea Res. continued the publication of the Proceedings of the Snellius-II Symposium. Vol. 23 (2) contains 16 papers on the theme 'Coral Reefs' (edited by J. van der Land), vol. 23 (4) 16 papers on the theme 'River inputs into ocean systems' (edited by J.C. Duinker & J.M. Everaarts), vol. 24 (2/3) and 24 (4); 22 and 23 papers, respectively, on the theme 'Geology and geophysics of the Banda Arc and adjacent areas' (edited by J.E. van Hinte, Tj.C.E. van Weering & A.R. Fortuin). J.G. Baretta-Bekker assisted in the editing of all Snellius-Proceedings issues. The publication of the final issue of these proceedings (on the theme 'Pelagic Systems') is planned for 1990.

During 1989, three normal issues of the Neth. J. Sea Res. appeared, viz. 23 (1) with 9 papers, 23 (3) with 10 papers and 24 (1) with 7 papers. Out of these 26 papers in normal issues, 18 were on marine biology, 5 on marine chemistry, 2 on physical oceanography and 1 on marine sedimentology.

According to the Science-Citation-Index statistics, an average-cited article published in 1973 in a SCI-covered source journal was cited ~15 times between 1973 and 1988. The Neth. J. Sea Res. belongs to these source journals, both for the field of oceanography (see E. Garfield in Current Contents of 30 November 1987: 3-11) and marine biology (see E. Fuseler-McDowell in Current Contents of 8 May 1989: 4-13).

How close do papers published around 1973 in the Neth. J. Sea Res. come to this average of 15 citations over the last 15 years?

On the occasion of a recent peer review of the Neth. Inst. for Sea Res., lists were compiled of all papers published by present and former staff members of the Institute with the numbers of citations these papers have so far received according to the SCISEARCH files (Institute of Scientific Information) during the 1974 to early-1989 period. Almost 200 of such papers appeared in the Neth. J. Sea Res. (out of a total of 631 papers published up to and including 1988 in the Journal). The numbers of citations these papers received varied strongly: between 0 and 104. As one would expect, recently published papers have received only few citations, whereas the most-cited papers are 10 or more years old. The mean number of citations per article for each year class increased rapidly up to an age of ~11 years (see figure) to reach an average of ~18 citations at this age. Even older (12+ years) papers received an average number of 19.6 citations (n=90, s.e.1.9). With a number of ~19 citations at an age of 15 years, the average NIOZ-authored NJSR-published paper thus meets the general mean of ~15 citations for the periodicals selected by SCI to serve as source journals.



The mean numbers of citations (vertical axis) received by papers of different age (years, horizontal axis) published by NIOZ staff in the Netherlands Journal of Sea Research (source: SCISEARCH files). The total of 192 of such publications received a total of 2772 citations during the 1974-1989 period. For reference the * point is included: it is the mean number of citations of a 15-year-old paper in a SCI-covered source-journal (see text).

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- 8 SHIPBOARD PARTY. Joint Global Ocean Flux Study. RV TYRO Leg 1. Den Helder-Reykjavik-Funchal. NIOZ Report 1989-9. Also listed as SOZ Cruise Report 1989-1.
- 9 ——. Joint Global Ocean Flux Study. RV TYRO Leg 2. Funchal to Funchal. NIOZ Report 1989-10. Also listed as SOZ Cruise Report 1989-2.
- 10 WITBAARD, R. De verspreiding van een aantal macrobenthos soorten in de Noordzee, met het oog op het bestuderen van een visserij-effect. NIOZ Report 1989-1.

2.1.4. Cruise Reports 1989

The following chapters were contributed by NIOZ participants in Expedition Antarktis VII/3 (EPOS LEG 2) of RV 'Polarstern' in 1988/89, all in Ber. Polarforschung 65, edited by I. Hempel, P.H. Schalk and V. Smetacek:

- ALDER, V., J. CUZIN-ROUDY, H.G. FRANSZ, E. GRANÉLI, J. LARSEN, M. RABBANI & H.A. THOMSEN. Macro- and micrograzing effects on phytoplankton communities: 123-130.
- BAAR, H.J.W. DE, A.G.J. BUMA, G. JACQUES, R.F. NOLTING & P.J. TRÉGUER. Trace metals - iron and manganese effects on phytoplankton growth: 34-44.
- BENNEKOM, A.J. VAN, A.G.J. BUMA, L. GOEYENS, L. LINDNER, J. MORVAN, R.F. NOLTING, M. PANOUSE, F. SORENSSON & P.J. TRÉGUER. Uptake and regeneration of nitrogen, silica and phosphorous: 56-60.
- BENNEKOM, A.J. VAN, F. DEHAIRS, L. GOEYENS, M. PAMATMAT & P.J. TRÉGUER. Barium bi-chemistry: 44-46.
- BENNEKOM, A.J. VAN, M. ESTRADA, L. GOEYENS, B. MAGAS, A. MASSON, J. MORVAN, P.J. TRÉGUER, A. SVANSSON & C. VETH. Distribution of nutrients in surface, subsurface and deep layers: 47-55.
- BUMA, A.G.J. & J. LARSEN. Phytoplankton pigment measurements by HPLC: 76-77.
- BUMA, A.G.J., M. ESTRADA, J. LARSEN, U. RIEBESELL, I. SCHLOSS & H.A. THOMSEN. Unicellular organisms studied alive using photographic and video techniques: 102-110.
- CADÉE, C.G. Particulate and dissolved organic carbon: 101.
- CADÉE, C.G. & H. GONZALEZ. Faeces sedimentation: 165-166.
- CADÉE, C.G., J. COUZIN-ROUDY, H. GONZALEZ, E. GRANÉLI, L. LINDNER, U. RIEBESELL, P.H. SCHALK, S. SCHIEL & I. SCHLOSS. A multiparameter approach to krill ecology: an attempt to summarize: 167-171.
- CEDERLÖF, U., S. OBER, R. SCHMIDT, A. SVANSSON & C. VETH. Hydrography: 14-19.
- FRANSZ, H.G., S.R. GONZALES, E. MIZDALSKI & S. SCHIEL. Mesozooplankton - distribution and development of copepods: 165-166.
- SMETACEK, V. & C. VETH. INTRODUCTION: 1-7.
- ENS, B.J., T. PIERSMA, W.J. WOLFF & L. ZWARTS. Report of the Dutch-Mauritanian project Banc d'Arguin 1985-1986.—WIWO-report 25/RIN rapport 89/6, Texel:
- DUIVEN, P. Oystercatcher (*Haematopus ostralegus*): 236-238.
- . Whimbrel (*Numenius phaeopus*): 320-322.
- DUIVEN, P. & T. PIERSMA. Wader catchers: methodology: 77-84.
- PIERSMA, T. Knots (*Calidris canutus*): 264-275.
- . Bar-tailed Godwit (*Limosa lapponica*): 315-319.
- . Redshank (*Tringa totanus*): 323-326.
- PIERSMA, T. & T.M. VAN SPANJE. Wader catches: capture totals, resightings and recoveries: 85-92.
- PIERSMA, T., A. GUEYE & C. MBARE. Wader and waterbird counts 1985: 57-67.
- WOLFF, W.J., A. GUEYE, A. MEIJBOOM, T. PIERSMA & M.A. SALL. Distribution, biomass, recruitment and productivity of *Anadara senilis*: 220-221.

2.2. LECTURES, etc.

2.2.1. Colloquia and workshops at the institute

(titles translated)

20 January	J.J. Beukema (NIOZ): (The highly variable reproductive success of bivalves on tidal flats of the Wadden Sea) R. Dekker (NIOZ): (Effects of predation by crustaceans on the reproductive success of bivalves in the Wadden Sea)
10 February	H. von Westernhagen (Biologische Anstalt Helgoland, Hamburg, FRG): Effects of anthropogenic contaminants on reproduction and egg development in marine North Sea fish species
17 February	L. Pihl (Kristineberg Marine Laboratory, Sweden): Eutrophication along the Swedish west coast and its effects G.C. Cadée (NIOZ): Positive and negative effects of eutrophication in Dutch coastal waters
24 February	G. Marees (NIOZ): (The use of optical remote sensing in oceanographic research)
3 March	J.M.J. Hoppema (NIOZ): (Distribution of alkalinity in Wadden Sea and North Sea) W. Kierskamp (NIOZ): (The interaction of the phosphorus and nitrogen cycles at N ₂ O level)
10 March	Tj.C.E. van Weering (NIOZ): (The effects of Norwegian Sea overflow on sedimentation of the Feni Ridge, NE Atlantic Ocean; an introduction) S. de Rijk (NIOZ): (Feni Ridge pistoncores 25 and 26, foraminiferal response to climatic change over the last 180 000 years) C. Brussaard (NIOZ): (A diatom study of surface and downcore sediment samples of the NE Atlantic Ocean) M. van Leeuwe (NIOZ): (Diatoms in cores from the Feni Ridge and the Norwegian Sea)
17 March	M.J.W. Veldhuis (NIOZ): (The application of flow-cytometry in marine algal research)
7 April	Long-term changes in the Wadden Sea M. de Boer and H.D. Rakhorst (RWS, directorate North Holland): Erosion and sedimentation in the western Wadden Sea and adjacent sea areas K. Dijkema (RIN, Texel): Sedimentation and succession of vegetation in relation to rising high-water levels in salt marshes in reclamation areas R. Berghahn (Univ. Hamburg, FRG): Impact of human activities on the ecology of the German Wadden Sea
21 April	A. Buma (NIOZ): (Distribution of phytoplankton pigments in Antarctic waters)
28 April	Mesocosm research G.W.N.M. van Moorsel (NIOZ): (Effects of harbour-sludge dumping on the macrozoobenthos) P.A.W.J. de Wilde (NIOZ): (The North Sea mesocosms: set-up and aims)

12 May	WINDOW-expedition H.J. Lindeboom (NIOZ): (Introduction) W. van Raaphorst (NIOZ): (Nutrient dynamics) R. Riegman (NIOZ): (Primary producers) B.R. Kuipers (NIOZ): (Macrozooplankton and conclusions)
10 November	M.J.W. Veldhuis (NIOZ): (The application of flow-cytometry in ocean research) P.T. Visscher (Biologisch Centrum Haren): (The sulphur cycle in layered-sediment ecosystem microbial mats in the Slufter)
17 November	T. Piersma (NIOZ): (Orientation problems of migrating waders in West Africa) L. Zwarts (RWS/Directie Flevoland): (Predation of whimbrels (<i>Numenius phaeopus</i>) on fiddler crabs (<i>Uca tangeri</i>))
22 November	K. Cochran (State University of New York): Scavenging and mass balance of ²¹⁰Pb in the North Atlantic and North Pacific Oceans H. Heijnis (CIO/RUG): The use of uranium series nuclides in late Pleistocene peat deposits: the correlation of the terrestrial and the oceanic record
15 December	R.L.J. Kwint: Coral reefs in the Red Sea: a fragile beauty
EPOS Workshops	From 13-15 September 15 EPOS participants met at NIOZ for a Silica workshop, organized by Johan van Bennekom and Anita Buma. The silica cycle was one of the key themes during leg 2 of the EPOS expedition, but during the workshop also other themes were discussed, notably: -Intercalibration of nutrient data from leg 1 and leg 2 -Water-mass distribution -Identification of phytoplankton species A postcruise workshop was held at NIOZ from 27 November to 1 December. The main purpose was the discussion of the first results of legs 1 and 2 of the EPOS cruises in the area of the Weddell-Scotia confluence in Antarctic waters with RV 'Polarstern'. The workshop was organized by NIOZ (C. Veth, A. Buma, J. Hart and J. Schröder) and was attended by 77 scientists of 14 countries. The subjects of study were for instance, the hydrography of the Weddell-Scotia confluence, the influence of the retreating ice on the plankton bloom, the role of the krill in controlling the plankton community, the modelling of the Antarctic ecosystem, etc. Many appointments have been made for cooperative and multidisciplinary papers. During the meeting the EPOS Managing Group had a regular meeting.
Callianassa workshop	This workshop was held on 26 September. Participants were from the University of Kiel, FRG and the University of Groningen; organizers G.C.A. Duineveld and P.A.W.J. de Wilde.

2.2.2. Lectures and posters

2.2.2.1. Lectures by NIOZ scientists (titles translated)

- Aken, H.M. van: The vertical hydrographic structure of the South Banda Basin. Geophysisches Seminar, Universität Hamburg, 29 June.
- Arkel, M.A. van: (Macrobenthos research around mining installations on the Dutch continental shelf). Benthos workshop of North Sea Directorate, Rijswijk, The Netherlands, 22 June.
- Baar, H.J.W. de: (Lectures and practicals series at the Free University,) Amsterdam, February.
- : First reliable observations of Rare Earth Elements in the Black Sea. AGU/ASLO Conference, Baltimore, USA, 10 May.
- : (Rare Earth Elements and other obscure metals in the oceans.) NWO Isotope Laboratory, 19 May; Free University lecture series, Amsterdam.
- : (Storage of carbon dioxide in the oceans.) Jaarbeurs, Utrecht, 27 September.
- : (The role of the oceans in the carbon dioxide 'greenhouse' effect.) Voorschoten, 10 October.
- : (Storage of carbon dioxide in the deep oceans.) Utrechtse Geologen Vereniging, University of Utrecht, 20 October.
- : Rare Earth Element distributions in the Black Sea. NATO Conference Black Sea Oceanography, Cesme, Turkey, 24 October.
- : (The role of the oceans with respect to carbon dioxide and the 'greenhouse' effect.) Nederlandse Oceanografen Club, The Hague, 22 November.
- : On the iron limitation hypothesis for phytoplankton from the Southern Ocean. EPOS Workshop, NIOZ, Texel, 28 November.
- Bak, R.P.M.: (Coral reef research in the Netherlands Antilles). Symposium Tropisch Marine Onderzoek, Werkgemeenschap Biologisch Aardwetenschappelijk Onderzoek in de Tropen (BAOT), Amsterdam, 3 April.
- : (Gradients in pelagic and benthic Protozoa). Workshop Banc d'Arguin, NWO, The Hague, 17 November.
- : Bioerosion of echinoids in two reef lagoons, French Polynesia. Annual Meeting Int. Soc. for Reef Studies, Marseille, France, 15 December.
- Bennekom, A.J. van: The marine silica cycle. University of Göteborg, Sweden, 28 April.
- Berger, G.W.: The behaviour of radionuclides in the estuary of the Nieuwe Waterweg. University of South Carolina, USA, 21 September.
- : Radioactive waste as released by the non-nuclear industry in the Netherlands. University of North Carolina, USA, 26 September.
- Beukema, J.J.: (Long-term changes in the bottom fauna of tidal flats: the influences of severe winters and eutrophication). Jaarvergadering NDV, Amsterdam, 15 February.
- : (Food limitation and predation on tidal flats). BION werkgemeenschap Aquatische Oecologie, Amsterdam, 2 March.
- : (Possible effects of climatic changes on coastal ecosystems). Najaarsvergadering Nederlandse Oceanografen Club, The Hague, 22 November.
- Boon, J.P.: (QSAR approach to the role of biotransformation in the accumulation of PCBs in marine organisms). University of Wageningen, 29 March.
- : (SAR approach to the role of biotransformation in the accumulation of PCBs in marine organisms). Course ecotoxicology PAON (Post Academisch Onderwijs Natuurwetenschappen), NIOZ, 11 April.
- : Residues of selected chlorinated biphenyl congeners and organochlorine pesticides in brain and liver of the Oystercatcher (*Haematopus ostralegus*) in relation to age and sex. International symposium on the responses of marine organisms to pollutants, Plymouth, UK, 13 April.

- Buma, A.G.J.: (A comparison of the pigment composition of two ecotypes of *Phaeocystis cf. pouchetii* in batch cultures). Jaarvergadering Werkgemeenschap Aquatische Oecologie, BION, Dalfsen, 25 April.
- Cadée, G.C.: (Biocoenose/thanatocoenose, the fossilization potential of recent marine biota). Course in marine geology of the Free University, Amsterdam, held at NIOZ, Texel, 18 April.
- Cramer, A.: Seasonal variation in benthic metabolic activity at the Frisian Front. 24th EMBS Symposium, Oban, Scotland, 3-10 October.
- Daan, R.: (On food limitation and predation in marine copepods.) BION Werkgemeenschap Aquatische Oecologie, Amsterdam, 2 March.
- Duineveld, G.C.A.: Results from studies on larval settlement. RENORA meeting, State University of Ghent, 15 February.
- : (The benthic fauna in the North Sea). Overleggroep Bodem, RSW, The Hague, 23 March.
- : (Results from ICES North Sea Benthos Survey). MILZON workshop, The Hague, 23 June.
- : (Callianassa research at NIOZ). Callianassa workshop, NIOZ, Texel, 26 September.
- : (Offshore benthos: abundance and biomass). Workshop Banc d'Arguin, NWO, The Hague, 17 November.
- Duyf, F.C. van: Bacterial production and biomass in intertidal sediments (Northwestern Europe). 5th Int. Symposium on Microbial Ecology, Kyoto, Japan, 28 August.
- Eisma, D.: Lecture series. Sedimentology Department, University of Utrecht, February.
- : Quaternary history of the North Sea. Geologisches Institut, University of Bonn, FRG, 3 February.
- : Flocculation of suspended matter in the sea. Annual meeting of the Dutch Zoological Society, Amsterdam, 15 February.
- : Deposition rates in the Golfe du Lion. (Also on behalf of Z. Zuo and G.W. Berger.) EROS-2000 Symposium, Paris, 8 March.
- : Sedimentation in the Wadden Sea. Use of ^{210}Pb for studying transport and deposition processes. Sektion Geol. Wiss. Ernst-Moritz-Arndt University, Greifswald, DDR, 20 April.
- : Flocculation of suspended matter. Sektion Geol. Wiss. Ernst-Moritz-Arndt University, Greifswald, DDR, 21 April.
- : Late Quaternary and recent sedimentation in the North Sea. Sektion Geol. Wiss. Ernst-Moritz-Arndt University, Greifswald, DDR, 25 April, and Sektion Geol. Humboldt University, Berlin, DDR, 27 April.
- : (Supply dispersal of suspended matter from the Zaire river). Management Course, TU Delft, 19 June.
- : Fluxes of particulate matter in the water column. Lecture series European Institute for Advanced Studies in Oceanography, Villefranche, France, 6-13 September.
- Everaarts, J.M.: A structure-activity relationship (SAR) approach towards metabolism of PCBs in marine animals from different trophic levels. Annual meeting of the Dutch Zoological Society, Amsterdam, 15 February.
- : (Pollution in marine benthic organisms). Workshop Banc d'Arguin, NWO, The Hague, 17 November.
- Fransz, H.G.: (Density regulation through food limitation and predation in theory and model). BION Werkgemeenschap Aquatische Oecologie, Amsterdam, 2 March.
- : Polar life cycles in marine zooplankton. Europe Today Symposium on international cooperation in Arctic research, European Cultural Foundation, Helsinki, 19 October.
- Gaast, S.J., van der: (X-ray diffraction and its applications in geology). Department of Earth Sciences, Free University, Amsterdam, 21 April.

- Helder, W.: Early diagenesis and sediment-water exchange in the Golfe du Lion. EROS-2000 workshop, Paris, 8 March.
- : (Mineralization of organic carbon compounds in marine sediments). Course in marine geology of the Free University, Amsterdam, held at NIOZ, Texel, 27 April.
- : The role of oxygen as electron acceptor in organic carbon degradation in coastal marine sediments. Department of Marine Biology, University of Oldenburg, FRG, 3 May.
- : Vertical distribution of oxygen and oxygen flux measurements in estuarine and coastal marine systems. Symposium 'Elemental fluxes in the coastal area', Primosten, Yugoslavia, 22 May.
- Jansen, J.H.F.: (Ocean sediments and terrestrial climate). Conference Ocean Sediment and Terrestrial Climate, AWON Community (Stratigraphy, Sedimentology, Palaeontology), NIOZ, Texel, 14 January.
- Kamermans, P.: (Food limitation and food competition of bivalve molluscs living in the Wadden Sea). Verwey-dagen, NIOZ, Texel, 28 February.
- : Food limitation and food competition of bivalve molluscs living in the Wadden Sea. 24th EMBS Symposium, Oban, Scotland, 9 October.
- : (Food limitation and food competition of bivalve molluscs). Delta Institute for Hydrobiological Research, Yerseke, The Netherlands, 21 December.
- Kuipers, B.R.: (Marine ecology. Course in aquatic conservancy). Middelbare Landbouwschool, Boskoop, 2 March.
- Lavaleye, M.S.S.: (General impression of the benthos). Workshop Banc d'Arguin, NWO, The Hague, 17 November.
- Leopold, M.: (Seabirds and hydrography in the North Sea). Meeting Dutch Ornithological Union, Groningen, 23 September.
- : (Seabird counts off Mauritania). Workshop Banc d'Arguin, NWO, The Hague, 17 November.
- Lindeboom, H.J.: Ecological modelling: a bridge between science and management? International seminar on Bangladesh. Foods: Regional and global environmental perspectives. Dacca, Bangladesh, 6 March.
- : (Introduction on eutrophication). Beleidspresentatie BEON, The Hague, 23 June.
- Marees, G.: (Interpretation of optical remote sensing data over coastal waters). Meeting of the research group Optical Remote Sensing Water (ORWA), NIOZ, Texel, 19 January.
- : (Remote sensing in the Netherlands). Ocean 2000 meeting, NIOZ, Texel, 14 March.
- Maas, L.R.M.: A new conservation law in hydrodynamics. Scripps Institute for Oceanography, La Jolla, USA, 5 April.
- : (A new conservation law for the shallow water equations on a rotating plane and its generalization). Workshop on applying nonlinear dynamics and chaos in fluid mechanics, Zeist, The Netherlands, 5-9 June.
- Moorsel, G.W.N.M. van: (The use of mesocosms to study marine oil pollution). Professor H.C. van Hall Instituut, Groningen, 17 April.
- : (Effects of harbour sludge on macrozoobenthos in estuarine mesocosms). Lecture to Provinciale Waterstaat Groningen, NIOZ, Texel, 16 June.
- Nolting, R.F.: Results on dissolved and particulate trace metals in sediments of the Gulf of Lions. EROS-2000 workshop, Paris, 8 March.
- Piersma, T.: (Top predators of the Wadden Sea benthos). Verwey-dagen, NIOZ, Texel, 28 February.
- : (How to arrive at the tundra in time? Knots and Bar-tailed Godwits are dependent on food and wind for a correct timing of their breeding season). Special day on the Banc d'Arguin, the Netherlands Ornithological Union, Amsterdam, 4 March.
- : (Waders of the Wadden Sea). Thematic day on life in the Wadden Sea organized by the KNNV, Drachten, The Netherlands, 11 March.
- : Energetics of migration as a component in the reproductive effort of tundra birds. Satellite meeting on costs of reproduction of the International Ethological Conference, Haren, The Netherlands, 17-18 August.

- Piersma, T.: Review of the migration of Siberian Knots *Calidris canutus*. Recent advances in understanding Knot migrations. Ribe, Denmark, 21 September.
- : (Migration strategies of Bar-tailed Godwits and Knots: energetic consequences of long-distance flights). RIN, Leersum, The Netherlands, 20 December.
- Piersma, T. & Prof. Dr. R.H. Drent: (What it is like to be a migrant bird). Nationale Wetenschapsweek, Groningen, 11 October.
- Raaphorst, W. van: Nutrient regeneration and bacterial production in the sandy sediments of the Dogger Bank area, North Sea. 9th International Symposium on Environmental Biogeochemistry (ISEB), Moscow, Sowjet Union, 5 September.
- Riegman, R.: (Effects of limited food resources and predation on phytoplankton.) BION Werkgemeenschap Aquatische Oecologie, Amsterdam, 2 March.
- Spaargaren, D.H.: Chemical interactions between shore crabs and their environment. Biol. Anstalt Helgoland, Hamburg, 12 January.
- Swennen, C.: (The Wadden Sea and its birds). Ver. Behoud Natuurmonumenten, Den Helder, The Netherlands, 21 February.
- : Oystercatchers feeding on giant bloody cockles in Mauritania. NOU, University of Amsterdam, 4 March.
- : Wader feeding ecology. Prince Songhla University, Had Yai, Thailand, 16 March.
- : Wader migration systems. Prince Songhla University, Had Yai, Thailand, 17 March.
- : Macrobenthic fauna in intertidal flats in the tropics. University of Malaya, Kuala Lumpur, Malaysia, 7 April.
- : How the Wadden Sea became not reclaimed but protected. Kyung Hee University, Seoul, Korea, 18 September.
- : Relation between wader migration and macrobenthic fauna in intertidal areas. Institute of Ornithology, Seoul, Korea, 19 September.
- Veer, H.W. van der: Seasonal occurrence of coelenterates in the western Wadden Sea. 5th International Conference on Coelenterate Biology, Southampton, UK, 13 July.
- : Recruitment mechanisms in plaice, *Pleuronectes platessa* L. Fish Population Biology Symposium, Aberdeen, Scotland, 18 July.
- : Interactions between benthos and epibenthic predators in the western Dutch Wadden Sea. 24th European Marine Biological Symposium, Oban, Scotland, 7 October.
- : The impact of eutrophication in the North Sea. University of Zürich, Switzerland, 24 November.
- : Regulation in flatfish populations. Belle W. Baruch Institute, University of South Carolina, Columbia, USA, 5 December.
- : Eutrophication of the Dutch coastal zone. Belle W. Baruch Institute, University of South Carolina, Columbia, USA, 5 December.
- : Recruitment mechanisms in flatfish species. University of Georgia, Marine Institute, Sapelo Island, USA, 11 December.
- : Eutrophication of the North Sea environment. University of Georgia, Marine Institute, Sapelo Island, USA, 15 December.
- Veldhuis, M.J.W.: (First application of flow-cytometry in marine phytoplankton research). Hydrobiologische Vereniging, Amsterdam, 10 March.
- : (Water bloom and phytoplankton). Wetenschapsdagen Hortus Haren, Haren, The Netherlands, 15 October.
- Vosjan, J.H.: (Microbiological processes in the sea.) Course in marine geology of the Free University, Amsterdam, held at NIOZ, Texel, 27 April.
- : Microbial activities in tropical and Antarctic waters. Institute of Botany, University of Frankfurt, FRG, 2 November.
- : Marine microbial ecology. Lecture series at the Free University of Brussels, Belgium, November-December.

- Weering, Tj.C.E. van: Structural and sedimentary aspects of the Lombok and Savu fore-arc basins. National Institute of Oceanography, Karachi, Pakistan, 27 February.
- : (Sediments and sedimentation on Feni Ridge, NE Atlantic Ocean). Sed. Kring, Utrecht, 23 March.
- : Sediments and sedimentation on Feni Ridge; palaeoceanographic implications. EUG V congress, Strassbourg, France, 31 March.
- : Sedimentation on Feni drift as an indicator of palaeo-bottom-current activity. Geol. Inst. Kiel, FRG, 26 June.
- : Sedimentary structures and ^{210}Pb datings as markers for tidal flat development in southern Hangzhou Bay. (Presented by Li Yan.) Workshop Muddy Tidal Flat Research, Shanghai, China, 19 October.
- Wilde, P.A.W.J. de: (The use of mesocosms in oceanographic research). Annual Meeting of the Dutch Zoological Society, Amsterdam, 15 February.
- : (The benthic system of the North Sea). Hydrobiol. Soc., Amsterdam, 10 March.
- : Distribution of metabolic activity in the southern North Sea from ETS. ICES Benthos Ecol. Working Group, Vigo, Spain, 20 April.
- : (Hydrography of the coastal waters off the Banc d'Arguin, Mauritania, 1988). Workshop Banc d'Arguin, NWO, The Hague, 17 November.
- : Ecosystem research in the Wadden Sea and the North Sea. Third Inst. of Oceanography, Xiamen, P.R. China, 11 December.
- : Mesocosm research in the Netherlands. Third Inst. of Oceanography, Xiamen, P.R. China, 11 December.
- : Research in experimental ecosystems (Review of results from soft bottom systems, conclusions and outlook). Third Inst. of Oceanography, Xiamen, P.R. China, 12 December.
- Witte, H.J.: (Densities and biomass of the zooplankton). Workshop Banc d'Arguin, NWO, The Hague, 17 November.
- Zimmerman, J.T.F.: (Dynamical oceanography). Lecture series, University of Utrecht, January-June.
- : (The symmetry properties of ocean circulation). Colloq. KNMI, De Bilt, The Netherlands, 16 February.
- : β plane renormalization and the symmetry properties of nonlinear wind driven ocean circulation. 7th Conf. Atmospheric and Oceanic waves and stability, San Francisco, USA, 11 April.
- : (Physical oceanography). Lecture series, Int. Inst. Hydr. Env. Eng. Delft, June.

2.2.2.2. Posters

- Baar, H.J.W. de. Distribution of Rare Earths and other transition metals in the hypersaline, anoxic Bannock Basin. NATO Conference Black Sea Oceanography, Cesme, Turkey, 25 October.
- Bak, R.P.M. Damage and regeneration essential in the ecology of reef-building organisms? Symposium Tropisch Marine Onderzoek, Werkgemeenschap Biologisch Aardwetenschappelijk Onderzoek in de Tropen (BAOT), Amsterdam, 3 April.
- Cadée, G.C. *Phaeocystis* increase in the Marsdiep. 4th International Conference on Toxic Marine Phytoplankton, Lund, Sweden, 26-30 June.
- : Carapaces of *Carcinus maenas* as a substrate for epizoa. 8th International Conference of the International Bryozoology Association, Paris, 16-22 July.
- Everaarts, J.M., A. de Buck & J.P. Boon. Residues of selected chlorinated biphenyl congeners and organochlorine pesticides in brain and liver of the Oystercatcher (*Haematopus ostralegus*) in relation to age and sex. 5th International Symposium in responses of marine organisms to pollutants, Plymouth, UK, 12-14 April.
- Jansen, J.H.F. Aridity in West Central Africa, a record from deep-sea sediments in the NE Angola Basin. Third International Conference on Paleo-Oceanography, Cambridge, UK, 13-15 September.

- Leopold, M. Wintering Little gulls (*Larus minutus*) in the North Sea. Meeting of the Dutch Ornithological Union, Groningen, 23 September.
- . NIOZ research on Stormpetrels at sea. Meeting of the Dutch Ornithological Union, Groningen, 23 September.
- Maas, L.R.M. A Renormalized Green's function for nonlinear circulation on the β -plane. 7th conference on atmospheric and oceanic waves and stability of the Am. Meteorological Soc., San Francisco USA, 10-14 April.
- Marees, G. & M.R. Wernand. Optical remote sensing in oceanographic research. Airborne remote sensing meeting, Amsterdam, 24 January.
- Sabri Wahyudin, R.A. Kühnel & S.J. van der Gaast. Characteristics of bentonite from Karangnunggal deposit, West Java, Indonesia. 9th International Clay Conference, Strassbourg, France, 28 August - 2 September.
- Veldhuis, M.J.W. Nutrient limitation as a factor controlling *Phaeocystis* blooms in the western Wadden Sea and coastal zone of the North Sea (The Netherlands). 4th International Conference on Toxic Marine Phytoplankton, Lund, Sweden, 26-30 June.
- Vosjan, J.H. & E. Pauptit. Metabolism in East Indonesian deep-sea basins. 9th International Symposium on Environmental Biochemistry, Moscow, USSR, 4-8 September.
- Weering, Tj.C.E. van, G. Klaver & C. Beets. Ce-anomalies in Zaire Fan deep sea sediment. EUG V Congress, Strassbourg, France, 20-23 March.
- Weering, Tj.C.E. van, L. Labeyrie, G. Klaver, S. de Rijk & S.R. Troelstra. Sedimentation on Feni Ridge, NE Atlantic Ocean. 3rd International Conference Paleoceanography, Cambridge, UK, 10-16 September.
- Weering, Tj.C.E. van & W. van der Werff. Seismic facies distribution on Feni Ridge. 3rd International Conference Paleoceanography, Cambridge, UK, 10-16 September.
- Zevenboom, W., M. Mulder, M.A. van Arkel & H. van het Groenewoud. Adverse effects of discharged offshore mining drilling waste on the Dutch continental shelf. 3rd North Sea Seminar, The Hague, 31 May - 2 June.

2.2.3. Advice offered

- Within The framework of the project 'Application of processed NOAA-AVHRR images in ecological studies (BEON)', M.R. Wernand developed a data sampling programme and did the interfacing on a PC system on board Rijkswaterstaat RV 'Holland'. Also two single-band (530 nm) irradiance meters were designed for this project (RWS/DGW).
- L. Otto has acted as 'Gutachter' for the 'Deutsche Forschungsgemeinschaft' to referee the German WOCE programme.
- Advice on seabird distribution and concentrations was offered to the Ministry of Agriculture and Fisheries, which is compiling an atlas of the North Sea.
- J.W. Baretta and P. Ruurdij visited the Instituto Superior Technico of the University of Lisbon to give information on estuarine ecosystem modelling. The model developed by BEWON proved to be suited for the modelling effort of this university. During a second visit, P. Ruurdij installed the BAHBOE-packet on their VAX.
- The Institute of the History of Natural Sciences (Drs. R. Roell) received advice in matters concerning the development of ethology in the Netherlands. The role of NIOZ and its former directors J. Verwey and G.P. Baerends was traced from various archives (General archive Napels/Roscoff archive (KNAW), NDV library).
- Advice and information were given to Dr. J.L. Lozan, the Institut für Hydrobiologie und Fischereiwissenschaft der Universität Hamburg, on the estimation of food intake of dab (*Limanda limanda*) in the North Sea.

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
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
DSDP	Deep Sea Drilling Project
EC	European Community
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
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
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)
NWO	(Nederlandse Organisatie voor Wetenschappelijk Onderzoek) Netherlands Organization for the Advancement of Scientific Research
OPEX	Oil Pollution Experiment
PCB	Polychlorinatedbiphenyls
POM	Particulate Organic Matter
RCG	(Rijks-commissie voor Geodesie) State commission for Geodesy
REE	Rare Earth Elements
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
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
WOCE	World Ocean Circulation Experiment
WOTRO	(Wetenschappelijk Onderzoek Tropen) Netherlands Foundation for the Advancement of Tropical Research
XRD	X-Ray Diffraction

3. Nederlandse samenvatting van de wetenschappelijke resultaten en andere activiteiten

3.1. SAMENVATTING VAN DE WETENSCHAPPELIJKE RESULTATEN

3.1.1. Inleiding

Ondanks de andere opzet van ons jaarverslag hebben we getracht de Nederlandse samenvatting net als vorige jaren per onderzoeksgebied te geven (Estuariene gebieden, Noordzee, Oceaan en Speciale projecten).

3.1.2. Estuaria (w.o. de Waddenzee)

Onderzoek van de N-cylus in de Waddenzee toonde aan dat, na de daling van het nitraatgehalte in het water door de voorjaarsalgenbloei, de denitrificatiesnelheden afnemen. Hierdoor is er een flux van N_2O naar het Waddenzee sediment gedurende de zomer en herfst. Ook de chemische reductie van nitriet door ferro-ionen, de remming van denitrificatie door sulfide-ionen en de effecten van gereduceerde S-verbindingen op micro-organismen van de N-cyclus werden bestudeerd.

Van de algenmatten in de Slufter werden elke zes weken cores genomen en de verticale verdeling van een twaalfstal zwavelverbindingen en de verdeling van diverse fysiologische groepen van bacteriën beschreven.

Uitwisseling, transport en verdeling van organische verontreinigingen en metalen in de sediment-water-laag werden bestudeerd. Het bleek o.a. dat organische verontreinigingen van kustsedimenten zo langzaam uit het sediment naar de waterfase diffunderen dat dit proces meerdere eeuwen in beslag zal nemen.

Het onderzoek naar flocculatie van gesuspendeerd materiaal gevolgd door afzetting en erosie werd in verschillende gebieden voortgezet. Een begin werd gemaakt met het meten van de grootteverdeling van gesuspendeerde deeltjes in West-Europese estuaria met behulp van het beeld-analyse-systeem en de benthos-plankton camera. In de Gironde werden deeltjes waargenomen van meerdere honderden micrometer diameter. In de Dollard werden sedimentatiesnelheden gemeten waaruit bleek dat dit gebied beschouwd kan worden als een ophopingsgebied voor fijn sediment. Een speciale expeditie onderzocht flocculatie/deflocculatie in het Zaire estuarium. In samenwerking met Chinese geologen werd onderzoek verricht in getijdegebieden langs de Chinese kust. Een Chinese geoloog verrichtte promotieonderzoek naar de vorming van getijdedelta's en geulen in en bij de Waddenzee. Verdeling van radionucliden in estuaria, zoals de Nieuwe Waterweg, toonde aan dat ^{210}Pb in

gesuspenseerd materiaal 50 maal boven het 'natuurlijke' niveau ligt. Ook werden monsters uit andere gebieden zoals uit de Sabaki rivier (Kenia), uit de Adriatische zee en uit Hangzhou baai (China) geanalyseerd.

In de Waddenzee werd onderzoek verricht aan structuur en functioneren van het benthische ecosysteem met nadruk op de kwantificering van de voedselketens en productieprocessen. Het bleek dat in het fytoplankton in 1989 minder *Phaeocystis* aanwezig was dan in 1988, maar meer diatomeeën, welke beter geschikt zijn als voedsel voor 'suspension feeders'. Er zijn dan ook aanwijzingen dat de groei van mossels en andere tweekleppigen beter was dan in 1988.

De rol van bioturbatie door vogels voor de verticale verdeling van benthische diatomeeën werd in de Mokbaai, Texel, bestudeerd. Jaarlijks wordt 2,5 cm van het sediment omgeploegd door vogels; dit is ongeveer 1/10 van wat enkele soorten 'deposit feeders' presteren, namelijk 35 cm per jaar.

Lange-termijn waarnemingen, gestart in 1969, van het macro-benthos in de westelijke Waddenzee werden voortgezet. De milde winter 1988/1989 veroorzaakte een hoge overleving van garnalen, welke zeer vroeg in het voorjaar talrijk op de platen verschenen. Ook de strandkrab verscheen enkele weken eerder dan normaal in grotere aantallen op de platen. Deze hoge dichtheid van predatoren veroorzaakte een slechte rekrutering bij de tweekleppigen. Experimenten omtrent deze predatie met behulp van kooitjes op het wad bevestigen dit.

Waarschijnlijk door de toenemende eutrofiëring in de westelijke Waddenzee ontstond er in de zomer plaatselijk gebrek aan zuurstof op de platen waardoor mogelijk de massasterfte van de kokkel kan worden verklaard. Ook als consequentie van de eutrofiëring, is de primaire produktie hoger en hierdoor is de groeisnelheid van de tweekleppigen de laatste 20 jaar toegenomen. In het veld en in 'mesocosms' wordt de competitie om voedsel bij tweekleppigen bestudeerd. Door het experimenteel wijzigen van dichtheden van organismen werd hun ontwikkeling en die van andere organismen gedurende de zomer en herfst gevolgd. Duidelijk was de negatieve invloed van de wadpier op zijn eigen broed en op de talrijkheid van de slijkgarnaal.

Voedselopname en de omzetting van voedsel in groei bij verschillende temperaturen werd voor de verschillende benthische predatoren, zoals de puitaal, knorhaan en de zeester, bestudeerd. De groei van de zeester blijkt in de Waddenzee niet voedselgelimiteerd, maar in de Noordzee wel.

Populatiodynamica van de 0-groep platvis leerde dat predatie door crustaceeën de belangrijkste factor voor de rekrutering is. Onderzocht wordt of deze predatie door crustaceeën wereldwijd de platvispopulatie reguleert. Hieromtrent is ook in Japan onderzoek verricht.

De eidereendpopulatie in de Waddenzee vertoonde in 1989 een hoge mortaliteit ten gevolge van infectie met darmparasieten. In de Gele Zee bij Korea werd op getijplaten het voedselzoekgedrag van enkele vogelsoorten bestudeerd. Jaarlijkse energiebehoefte van de over grote afstanden migrerende kanoetstrandloper werd bestudeerd. Met behulp van modellen werden de energiekosten van thermoregulatie onder verschillende klimatologische omstandigheden gemeten.

Fysiologische experimenten bewezen dat silicium niet alleen een functie heeft om de stevigheid van het exoskelet van de garnaal te verhogen maar ook dat het een essentieel element is met een metabolische functie.

3.1.3. Noordzee

Optisch onderzoek stond geheel in het teken van Remote Sensing met nadruk op de troebele kustwaterzone. Satellietbeelden werden vergeleken met de zee-waarnemingen, terwijl tijdens een van de tochten een vliegtuig kon worden ingeschakeld voor RS-werk (in het kader van het nationale Remote Sensing programma).

Stromingen bij het Friese Front (~ 60 km N van de Waddeneilanden), blijken in geostrofisch evenwicht te zijn. Ze worden voornamelijk opgewekt door lokale windschuifspanning evenwijdig aan de dieptelijnen.

Dag- en nachtritmes in zuurstof en soms ook anorganische stikstofverbindingen blijken in ditzelfde gebied als gevolg van fytoplanktonactiviteit duidelijk aanwezig in de bovenste 15 m, maar zij kunnen verstoord worden door instabiele hydrografische omstandigheden.

Uit ²¹⁰Pb-metingen van kernen uit hetzelfde gebied blijkt dat slib sedimentatie beperkt is tot een nauwe zone die ongeveer samenvalt met het Friese Front. Hier sedimenteert jaarlijks naar schatting 2 miljoen ton slib (van de totale Noordzee-slibsedimentatie van 45 miljoen ton). Studies in een ander belangrijk sedimentatiegebied in de Noordzee, de Noorse Geul, toonden aan dat sedimentatie daar het grootst is in het centrale en westelijke deel.

Dit jaar werd een begin gemaakt met onderzoek naar vorming en omwerking (vooral tijdens stormen) van zandbanken voor de kust van IJmuiden.

Het maandelijks verzamelen van zoöplankton in de gehele zuidelijke Noordzee met de 'Challenger' (de Nederlandse bijdrage aan het British North Sea Project) werd voortgezet tot Augustus 1989. Na 1 à 2 jaar uitwerken zal dit een compleet jaarbeeld geven zoals tot nog toe niet beschikbaar was.

Onderzoek naar voedselcondities van haringlarven op de verschillende paaipplaatsen in de Noordzee (in samenwerking met RIVO) toonde aan dat haringlarven een dagelijks ritme vertonen in voedselopname met pieken tussen 10 - 12 uur en 20 - 22 uur.

Uit een vergelijking van de RNA/DNA-verhouding in pelagische schollarven (een maat voor de toename in proteïnen) en de dikte van dagelijkse groeiringen in de otolieten bleek dat dagelijkse groei goed in de otolieten gedocumenteerd wordt. Drie jaar waarnemingen aan de Waddenzee binnentrekkende schollarven toonde aan dat hun groei positief gecorreleerd was met de zeewatertemperatuur.

Temora longicornis en *Pseudocalanus elongatus*, 2 algemene Noordzee copepoden, zijn eind dit jaar respectievelijk 118 en 70 generaties aan één stuk in cultuur gehouden, dit om vragen uit het veld experimenteel te benaderen. De groei blijkt voornamelijk door voedselkwaliteit bepaald te worden. Adulte *Temora*'s bleken in langdurige cultuur steeds kleiner te worden. Introductie van vers in de Noordzee verzamelde mannetjes (verrijking genenmateriaal) bracht de adulten weer op normale grootte.

Analyse van benthosmonsters verzameld tijdens het ICES Synoptic Mapping Programme is dit jaar voltooid en een synthese van door alle deelnemende landen verzamelde gegevens zal in 1990 volgen. Rond de Doggersbank werd aan de zuidzijde wel, aan de noordzijde geen verrijkte macrobenthoszone gevonden vergelijkbaar met die bij het Friese Front. De groei van de hartegel *Echinocardium cordatum*, die algemeen voorkomt in het Doggersbankgebied, blijkt de afgelopen 6 jaar op de ondiepe zandige delen van de Doggersbank continu te zijn toegenomen.

De relatief hoge respiratie van het benthos bij het Friese Front kan verklaard worden door een hogere aanvoer van organisch materiaal. Duidelijke fluctuaties werden gevonden in de dikte van groeiringen van de schelp van de meer dan 100 jaar wordende noordkromp (*Arctica islandica*) uit de Fladengronden. Dit moet een goede documentatie geven van historische fluctuaties in de groei; ^{14}C determinaties worden uitgevoerd om te bewijzen dat de groeiringen inderdaad jaarringen zijn.

Met succes kunnen sinds 1988 grote ongestoord genomen bodemonsters in het aquariumgebouw verder gekweekt worden. In zogenaamde mesocosmos experimenten zijn nu $2 \times 3 \text{ m}^2$ Noordzeebodem (van Breeveertien en het Friese Front). Hierin wordt speciaal het effect van (extra) toevoeging van organisch materiaal bekeken. Graaactiviteit (bioturbatie) van de kreeft *Callinassa subterranea* dient als monitor voor de activiteit van macrobenthos. Duidelijke verschillen werden gevonden in de protozoa in de Breeveertien en Friese Front mesocosmos.

Zeevogeltellingen werden verricht over de hele Noordzee. Concentraties van alken, zeekoeten en Noorse stormvogels werden gevonden bij de Bruine Bank van januari tot april (samenhangend met fytoplankton voorjaarsbloei?). In september werden grote concentraties zeevogels waargenomen in het paaigebied van de haring langs de Engelse kust, praktisch alle alk-achtigen uit het Noordzeegebied komen hier dan samen. Bij het Friese Front blijken jonge alk-achtigen die zich hier eind zomer concentreren sprot te eten. Uit echo-waarnemingen was al gebleken dat sprot hier dan veelvuldig voorkomt.

Verheugend lijkt het dat dit jaar meer walvisachtigen werden waargenomen in de Noordzee (speciaal langs de Engelse kust) dan in de twee vorige jaren.

3.1.4. Oceaanonderzoek

In 1989 is een begin gemaakt met de Nederlandse bijdrage aan JGOFS, een internationaal gecoördineerd programma voor de studie van bio-geochemische fluxen in de oceaan, in het bijzonder de flux van koolstof. Gedurende twee maanden zijn met de 'Tyro' waarnemingen gedaan en monsters verzameld in de N.O. Atlantische Oceaan rond de 20°W meridiaan. Deze waarnemingen hebben betrekking op de hydrografie, primaire productie, bacteriële en secundaire productie, opgeloste organische en anorganische koolstof, gesuspenderd materiaal en de omzetting van organisch materiaal in het sediment.

Door NIOZ-technici is een vrijvallende benthische lander ontwikkeld die is uitgerust met een meetsysteem om *in situ* het zuurstofprofiel in het sediment te bepalen. Deze lander is met succes gebruikt tijdens de JGOFS-tocht bij een waterdiepte van 4640 m. De verkregen gegevens tonen het belang aan van het zeer actieve oppervlakesediment (0-6 mm) voor de mineralisatie van organische koolstof.

Een totaal van 112 CTD-profielen is geregistreerd gedurende het JGOFS-programma. Deze profielen zijn alle verwerkt tot 1 m-waarden, beschikbaar voor gegevensuitwisseling. Ter voorbereiding van de Nederlandse WOCE-bijdrage in 1990 is in het IJslandbekken een systeem met 4 zelfregistrerende stroommeters verankerd.

Fytoplankton is bestudeerd met behulp van een flow-cytometer, HPLC-technieken, ^{14}C - en O_2 -incubatie-experimenten. In samenhang met de fysische en chemische noord-zuid-variatie is ook een aanmerkelijke variatie in

sommige biologische eigenschappen waargenomen. Terwijl op 60°N niet-groene algensoorten de fytoplanktonsamenstelling overheersten, domineerden op 47°N de cyanofyten en op 33°N de prochlorofyten. De primaire productie op 60°N was hoger dan op 33°N, hoewel daar het zonlicht veel dieper doordringt.

Tijdens de door de European Science Foundation georganiseerde EPOS-tochten aan boord van de Duitse 'Polarstern' is door verschillende NIOZ-afdelingen onderzoek verricht.

CTD-profielen gemeten in de frontale zone bij de Weddell-Scotia-confluentie tonen grote horizontale gradiënten in temperatuur en saliniteit. Zuid van het front zijn meso-schaal-watervmassa's en -wervels in verschillende stadia van ontwikkeling waargenomen.

Van watermonsters verkregen op de EPOS-tochten zijn concentraties van koper, zink, cadmium en ijzer bepaald. De verdeling van deze metalen in de Weddellzee verschilt van die in de Scotiazee. Processen die hierbij een rol spelen zijn het smelten van ijs, bio-geochemische kringlopen en —voor ijzer— sediment-water-interactie rond eilanden.

Met ^{32}Si -isotopen is de groeisnelheid van diatomeeën in cultures bepaald. Extrapolatie van hiermee verkregen resultaten toont aan dat de bijdrage van Antarctica aan het Si-budget van de wereldzeeën kleiner is dan tot nu toe is aangenomen. Incubatie-experimenten zijn uitgevoerd waarbij de invloed van de toevoeging van aluminium op de silicacyclus is bepaald. Ook is opgelost silica gebruikt als indicator voor de oceaancirculatie. De variaties in de silicaconcentratie vertonen een duidelijke samenhang met de aanwezigheid van meso-schaal wervels.

Extreem hoge dichtheden van protozoën zijn waargenomen, overwegend kleiner dan 5 μm . Verscheidene kenmerken vertonen duidelijke verschillen voor de Weddellzee en de Scotiazee.

Fytoplankton is bestudeerd met HPLC-technieken en microscooptellingen. De aanvankelijk dominerende diatomeeën werden bijna volledig weggegraasd door zoöplankton. Hierdoor verschoof de fytoplankton-gemeenschap naar een overheersing door flagellaten.

Zowel de biomassa als de diversiteit van het meso-zoöplankton bleek zuidwaarts, van de Weddellzee naar de Scotiazee, af te nemen. In de hoeveelheid zoöplankton werd noch een seizoenstrend, noch een systematische dagelijkse gang waargenomen.

Gegevens van verschillende metalen in het sediment, verkregen tijdens het Europese EROS-2000-programma in de Golfe du Lion, zijn nader geanalyseerd. Deze tonen aan dat het materiaal afkomstig uit de Rhône beperkt blijft tot een klein gebied rond de riviermonding. In de diepere gedeelten van de Golfe du Lion speelt atmosferische depositie van metalen een voorname rol voor de verspreiding van metalen.

De geologische kernen verzameld in de Golfe du Lion zijn geanalyseerd op ^{210}Pb en ^{132}Cs . De horizontale variatie van de hieruit afgeleide sedimentatiesnelheden suggereert dat het meeste sediment afkomstig is uit de Rhône.

De samenwerking met de Universiteit van Hamburg is voortgezet tijdens een tocht van de 'Valdivia' in de Groenlandzee. Een CTD-sectie door het Arctische front heeft het bestaan van tenminste 4 verschillende fronten binnen de Arctische frontale zone aangetoond. De 12 stroommeters van het NIOZ —in 1988 verankerd tussen Jan Mayen en Groenland— zijn in september 1989 opgehaald door de IJslandse 'Bjarni Saemundson'.

Seismische en acoustische profielen van de Fenirug tonen grote sedimentgolven en erosie van de zuidelijke helling van het Rockallplateau. De ontwikkeling van de sedimentgolven is begonnen in het zuidwesten van de rug en heeft zich noordwaarts verspreid. Sedimentkernen tonen de aanwezigheid van ijsstijdcycli door variaties in de concentratie van calciumcarbonaat en organische koolstof.

Als vervolg op de Snellius-II expeditie is geologisch veldwerk uitgevoerd op het Indonesische eiland Sumba. Het doel hiervan is het op land bestuderen van sedimenten die in het Savubekken en Lombokbekken seismische reflectoren vormen.

Een methode is ontwikkeld om de stabiliteit van basalt bij verweeringsprocessen te bepalen. Met Röntgendiffractie en electronenmicroscopie wordt de structuur bestudeerd van klei-mineralen, die bij dergelijke verwerking ontstaan.

De monsters verkregen bij Mauretanië met trawlnet en 'box-corer' vertonen een rijke benthische fauna, zowel bij de kust als in diep water. Op de meeste stations overtreft de biomassa de niveaus die in de Noordzee worden gevonden.

Voor verschillende zeegebieden is de relatieve microbiële biomassa en de potentiële zuurstofconsumptie bepaald met behulp van microbiologische methoden. De kringloop van organisch materiaal blijkt in polaire gebieden ongeveer tien maal langzamer te gaan dan in tropische wateren. Fysiologische experimenten tonen een sterke invloed van ultraviolette straling op mariene bacteriën.

Tijdens een paleo-oceanografische expeditie in het Angolabekken zijn sedimentkernen verzameld met een totale lengte van 350 m. Al aan boord van de 'Tyro' is de chemische samenstelling van deze kernen globaal bepaald met een op het NIOZ ontwikkeld Röntgenfluorescentie-instrument.

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 de vervaardiging van ecosysteemmodellen voor Waddenzee en Noordzee.

Met het hydrodynamisch model voor de westelijke Waddenzee kon aangetoond worden dat de uitwisseling Noordzee/Waddenzee door het Eierlandsegat groter is dan door de andere gaten, en dat dit samenhangt met de bathymetrie van de zeegaten.

Analyse van de fosfaatgegevens voor de westelijke Waddenzee suggereert dat het IJsselmeer de belangrijkste P-bron is en niet de Noordzee zoals vroeger gedacht.

Samen met Duitse en Deense instituten is bij de EG een voorstel ingediend om een model voor de hele Waddenzee te maken. Binnen Nederland wordt nu nauw met RIN en de DGW samengewerkt.

Veel aandacht werd besteed aan het verzamelen van bouwstenen voor een Noordzee ecosysteemmodel.

Uitwerking van de in 1988 gehouden expeditie naar het Doggersbank-gebied (WINDOW) geeft aan dat 60-75% van de organische stikstof en 20-30% van de organische fosfor die door mineralisatie uit de bodem vrijkomt in de waterkolom weer door plankton wordt gebruikt. Tijdens de expeditie (juli-augustus) leverde de bodem <15% van de Si, 2% van de N en <1% van de P die het fytoplankton verbruikte.

Mineralisatie in de bodem werd ook bestudeerd op 2 kuststations en in de Noordzee 'mesocosms' van Breeveertien en het Friese Front. C-toevoer naar de bodem lijkt de bacteriële activiteit direct te beïnvloeden: *in situ* en in 'mesocosms' met extra C-aanvoer werd een verhoging van de bacteriële produktie gemeten die zonder deze C-aanvoer achterwege bleef. Nitrificatie- en denitrificatieactiviteit bleek laag evenals het NO₃ gehalte van het poriënwater.

In de waterkolom blijken de hoogste aantallen bacteriën voor te komen in de Noordzeekustzone. In fronten werden hoge aantallen heterotrofe nanoflagellaten aangetroffen die waarschijnlijk de oorzaak zijn van relatief lage aantallen bacteriën daar.

Modelsimulatie van fytoplanktongroei over het jaar werkt thans naar wens. Veel aandacht is besteed aan het ontwikkelen en inrichten van continu-cultures voor fytoplankton.

Onderzoek van de hogere trofische niveau's in de Noordzee concentreert zich op het effect van eutrofiëring op het voedsel voor benthische predatoren. Speciale aandacht werd besteed aan groei en aantallen van de jonge schol. Groei van de 0-groep schol blijkt positief gecorreleerd met de macrobenthos biomassa. Groei was niet dichtheidsafhankelijk: hogere dichtheden bleken zelfs samen te gaan met een sterkere groei. Dit betekent dat 0-klasse scholletjes een relatief groter deel van het macrobenthos zullen consumeren bij een toename van de macrobenthos biomassa.

De normale procedure voor het bepalen van PCB's maakt het niet mogelijk juist enkele van de meest giftige congenen te scheiden. Aansluitend bij gepubliceerde wijzigingen werd een nieuwe scheidingsmethode opgezet en met succes gebruikt voor onder andere monsters van vogels en zeehonden. De meest giftige congenen zijn tot nog toe niet opgenomen in internationale monitoring-programma's.

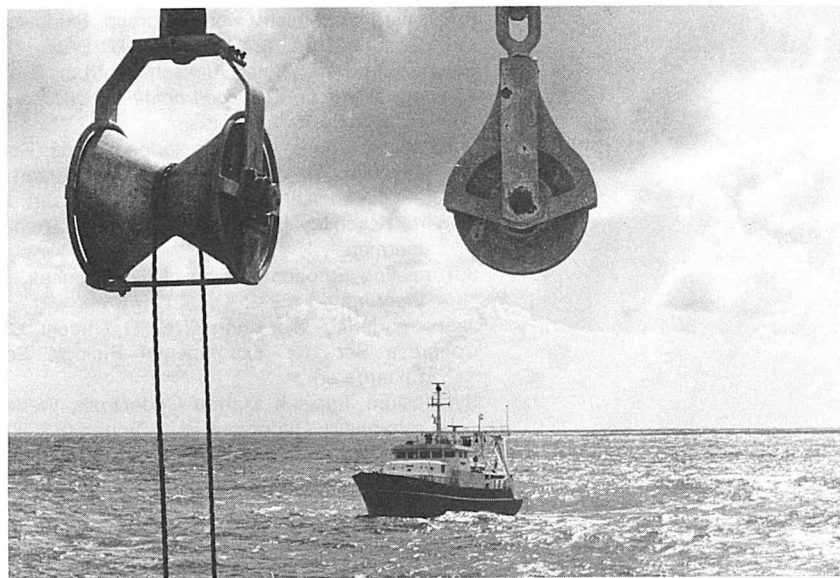
Sublethale effecten van PCB-mengsels werden bestudeerd bij de schol, met nadruk op effecten op enzymsystemen zoals het 'Mixed-Function Oxygenase' (MFO) systeem.

Biologisch onderzoek rond boorplatforms bevestigde eerdere resultaten: effecten van lozen van boorspoeling op oliebasis geeft veranderingen in de bodemfauna in een straal van enige honderden meters; deze zijn ook na enige jaren nog merkbaar. Voor dit onderzoek werden in 1989 ook 'boxcosms' in het aquarium gebruikt. Vooral *Echinocardium cordatum* blijkt hierin sterk te reageren op verontreiniging met boorspoeling.

In 1989 werd in samenwerking met RIVO en RWS/DNZ een uitgebreide studie naar de effecten van de trawlvisserij op bodemorganismen gestart. Bodemfauna werd bemonsterd voor en na bevissing van een gebied met een grote bodemtrawl en diverse overlevingsproeven werden uitgevoerd; de resultaten worden thans uitgewerkt.

In het kader van het NAZORG-project werd wederom de NEA stortplaats voor radioactief afval (Atlantische Oceaan, 46°N, 17°W) bemonsterd om eventuele effecten van deze thans gestopte stortingen na te gaan. Nadruk ligt op vergelijking van dichtheden van macro- en meiofauna in en buiten de stortplaats.

De hogere aantallen Copepoda die nu gevonden werden zijn gedeeltelijk het gevolg van andere monsterapparatuur: de 'multiple-corer' blijkt beter dan de eerder gebruikte 'Scripps-boxcorer', die een grotere boeggolf opwekt. Foraminifera (vroeger niet meegeteld) bleken in hoge aantallen voor te komen (max. 1.85 miljoen per m²). Duidelijke verschillen werden niet gevonden tussen monsters in en buiten het stortgebied, of tussen deze en eerder genomen monsters. Met 2 trawltrekken verzamelde grotere organismen zullen geanalyseerd worden op mogelijke contaminatie.



(Photo: NIOZ)

3.2. BEZOCHTE CONGRESSEN

EUROMAR models, Copenhagen, 12-13 januari: H.J. Lindeboom.
International workshop Seal Disease Epidemic, RIN, Texel, 17-19 januari: J.P. Boon.
ICES marine chemistry working group, Skidaway Oceanographic Institute, Savannah, Georgia, USA, 12-19 februari: J.P. Boon.
Symposium Polar Winter, Arctisch Centrum, Groningen, 23 februari: H.G. Fransz.
ICES workshop on *Chrysochromulina polyilepis*, Bergen, Noorwegen, 28 februari - 3 maart: M.J.W. Veldhuis.
International Seminar on Bangladesh Foods: Regional and Global Environmental Perspectives, Dhakar, Bangladesh, 4-11 maart: H.J. Lindeboom.
EROS-2000 workshop, EEG, Parijs, 6-10 maart: D. Eisma, W. Helder, R.F. Nolting.
General Assembly European Geophysical Union, Barcelona, 13-17 maart: J.T.F. Zimmerman.
5th meeting European Union of Geosciences, Straatsburg, 20-23 maart: Tj.C.E. van Weering.
Jaarvergadering Sed. Kring KNGMG, Utrecht, 23 maart: Tj.C.E. van Weering.
Congress Soc. for Experimental Biology, Edinburgh, Scotland, 2-7 april: D.H. Spaargaren.
Symposium Tropisch Marine Onderzoek, Werkgemeenschap Biologisch Aardwetenschappelijk Onderzoek in de Tropen (BAOT), Amsterdam, 3 april: R.P.M. Bak, F.C. van Duyl.
ICES Working Group on Shelf Seas Oceanography, Bidston, Engeland, 4-6 april: L. Otto.
The 7th conference on atmospheric and oceanic waves and stability of the Am. Meteorological Soc., San Francisco, USA, 10-14 april: L.R.M. Maas, J.T.F. Zimmerman.
5th International Symposium on the Responses of Marine organisms to Pollutants, Plymouth, Engeland, 12-14 april: J.P. Boon, J.M. Everaarts.
ICES Benthos Ecology Working Group, Vigo, Spanje, 18-21 april: G.C.A. Duineveld, P.A.W.J. de Wilde.
Meeting ICES Working Group on Oceanic Hydrography, Göteborg 25-26 april: H.M. van Aken, A.J. van Bennekom.
Jaarvergadering WGM Aquatische Oecologie, Dalfsen, 25-26 april: F.C. van Duyl, R. Riegman, H.G. Fransz, G.C. Cadée.
Symposium Elemental Fluxes in the Coastal Area, Primosten, Joegoslavië, 22 mei: W. Helder.
Workshop British Seabirds at Sea Team, St. Kilda, Schotland, 1 juni: M. Leopold.
Workshop on 'Applying nonlinear dynamics and chaos in Fluid Mechanics', Zeist, 4-6 juni 1989: L.R.M. Maas, C. Veth, H. Ridderinkhof.
SCOR WG 85 Mesocosms, Rhode Island, USA, 6-9 juni: P.A.W.J. de Wilde.
Workshop Project Ecologische Inpasbaarheid Stoffen, Rijks Instituut voor Volksgezondheid en Milieuhygiëne, Bilthoven, 15 juni: J.M. Everaarts.
5e Vergadering en bijeenkomst van de Nederlandse Protozoëncub, NIOZ, Texel, 23 juni: R.P.M. Bak, F.C. van Duyl.
4th International Conference on Toxic Marine Phytoplankton, Lund, Zweden, 26-30 juni: A.G.J. Buma, G.C. Cadée, R. Riegman, M.J.W. Veldhuis.
IOC Assembly, Parijs, 6-12 juli: L. Otto.

5th International Conference on Coelenterate Biology, Southampton, Engeland, 11-16 juli: H.W. van der Veer.

ICES Meeting of the working group on larval fish ecology, Aberdeen, Schotland, 12-14 juli: F. Hovenkamp.

8th International Conference of the International Bryozoology Association, Parijs, 16-22 juli: G.C. Cadée.

Fish Population Biology Symposium, Aberdeen, Schotland, 16-22 juli: H.W. van der Veer.

23rd Annual General Meeting of the Caribbean Conservation Association, Curaçao, 31 juli - 4 augustus: R.P.M. Bak.

4th International Symposium on Earth Tides, Helsinki, 31 juli - 4 augustus: J.T.F. Zimmerman.

5th International Symposium on Microbial Ecology, Kyoto, Japan, 27 augustus - 1 september: F.C. van Duyl.

9th International Clay Conference, Straatsburg, 28 augustus - 2 september: S.J. van der Gaast.

9th International Symposium on Environmental Biogeochemistry, Moskou: 4-8 september: W. van Raaphorst, J.H. Vosjan.

Workshop on processing and modelling of the first results of the North Sea Project, Liverpool, Engeland, 5-6 september: J.W. Baretta.

4th AVHRR data users' meeting. Rothenburg ob der Tauber, BRD, 5-8 september: G. Marees, M.R. Wernand.

3rd International Conference on Paleoceanography, Cambridge, 10-16 september: J.H.F. Jansen, Tj.C.E. van Weering.

IWRB Ecology Symposium and Wader Study Group Annual Conference, Ribe, Denemarken, 17-25 september: T. Piersma.

Workshop Seabird Diets and Energetics, Schiermonnikoog, 24-25 september: M. Leopold.

Workshop International Arctic Polynya Program (Arctic Ocean Sciences Board), Bremerhaven, 26-27 september: H.G. Fransz.

Climate and Energy, Jaarbeurs Utrecht, 27 september: H.J.W. de Baar, M.H.C. Stoll.

24th European Symposium on Marine Biology, Oban, Schotland, 4-10 oktober: A. Cramer, M. Fonds, P. Kamermans, S.S. Oosterhuis, H.W. van der Veer.

77th Statutory Meeting ICES, 's Gravenhage, 5-13 oktober: H.M. van Aken, M.A. Baars, J.J.M. van Haren, B.R. Kuipers, L.R.M. Maas, G. Marees, L. Otto, M.J.W. Veldhuis.

Meeting on the reference materials for the analysis of seawater. EEG, Brussel, 18 oktober: R.F. Nolting.

Europe Today Lecture and symposium, Helsinki, 19-22 oktober: H.G. Fransz.

Black Sea Oceanography, NATO Conference, Cesme, Turkije, 21-29 oktober: H.J.W. de Baar.

Euromar, Bottom Systems and Mesocosms, La Spezia, Italië, 24-25 oktober: P.A.W.J. de Wilde.

Workshop Banc d'Arguin 1988, Den Haag, 16-17 november: R.P.M. Bak, E.M. Berghuis, G.C.A. Duineveld, J.M. Everaarts, S.R. Gonzalez, A. Kok, M.S.S. Lavaleye, M. Leopold, G. Nieuwland, G. van Noort, P.A.W.J. de Wilde, H.J. Witte.

Polar research workshop, Polish Academy of Sciences, Warsaw (Madralin), 4-9 december: J.H. Vosjan.

Advanced Training Course on Mesocosms, Xiamen, P.R. China, 11-14 december: P.A.W.J. de Wilde.

Annual Meeting of the International Society for Reef Studies: Biology and Geology of Modern and Tertiary Coral Reefs, Marseille, 14-16 december: R.P.M. Bak.

EPOS-workshop NIOZ Texel, 27 november - 1 december: H.J.W. de Baar, R.P.M. Bak, A.G.J. Buma, A.J. van Bennekom, G.C. Cadée, H.G. Fransz, S.R. Gonzalez, G.W. Kraay, G. Nieuwland, R.F. Nolting, S. Ober, C. Veth, J.H. Vosjan.

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 Mijnbouwinstallaties
- 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
- H.J.W. de Baar
- voorzitter Wetenschappelijke Commissie voor Chemische Oceanografie NWO/SOZ
 - voorzitter Werkgroep voor Joint Global Ocean Flux Study NWO/SOZ
 - lid International Committee for Joint Global Ocean Flux Study ICSU/SCOR
 - docent Chemische Oceanografie, Instituut voor Aardwetenschappen, Vrije Universiteit, Amsterdam
 - docent cursus milieubiologie, RU Groningen
 - lid NWO werkgroep Veranderingen Aardsystemen
 - lid programmeringscommissie Nationaal Onderzoeks Programma Mondiale Biosfeer
 - lid Scientific Program Committee JGOFS Symposium to be held in Washington DC, September 1990

M.A. Baars

- coördinator BION-discussiegroep zoöplankton-FRIENDS
- lid redactie Snellius II proceedings voor thema 3

R.P.M. Bak

- bijzonder hoogleraar Tropische Mariene Biologie, Universiteit van Amsterdam
- treasurer International Society for Reef Studies
- 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

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 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
- G.C. Cadée
- lid commissie voor buitenlandse marien-biologische stations KNAW
 - lid DORA commissie (diepzee opberging radioactief afval)
 - lid redactie NIOZ encyclopedie
 - lid redactie Snellius II proceedings voor thema 3
 - advisor Hydrobiological Bulletin
 - associate editor Ichnos
 - lid advisory council International Bryozoology Association
- G.C.A. Duineveld
- lid ICES Benthos Ecology Working Group
- E.K. Duursma
- hoogleraar Algemene Oceanologie, Rijksuniversiteit Groningen
 - voorzitter Nederlandse Raad voor Zeeonderzoek/Stichting Onderzoek der Zee (SOZ)
 - voorzitter SOZ commissie Antarctica
 - voorzitter EUROMAR Board
 - redactielid Oceanologica Acta, Marine Chemistry, Thethys en Journal of Environmental Radioactivity
 - lid redactie NIOZ encyclopedie
- D. Eisma
- lid working group on marine sediments in relation to pollution ICES
 - lid adviesgroep marien aardwetenschappelijk onderzoek KNAW
 - lid projectgroep slibeigenschappen en coördinatiecommissie slib, Raad van Overleg fysisch oceanografisch onderzoek Noordzee
 - lid commissie geologische wetenschappen, KNAW
 - lid beheerscommissie NWO laboratorium Isotopengeologie
 - lid commissie Afvalgips en Vliegass Gezondheidsraad
 - lid gebruikerscommissie Laser-korrelgrootte bepalingen
 - lid Steering Committee EROS 2000 Program
 - adviserend hoogleraar East China Normal University, Shanghai
 - docent oceanografie Rijksuniversiteit Utrecht
- 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 werkgemeenschap mariene monitoring (SOZ)
 - lid redactie Snellius II proceedings voor thema 5
 - lid redactie NIOZ encyclopedie
 - lid Working Group on biological effects of contaminants ICES
- M. Fonds
- lid Mariculture Committee ICES
- H.G. Fransz
- lid commissie mariene biologie SOZ
 - lid begeleidingscommissie STW-project voor optische analyse van algen door flowcytometrie
 - lid stuurgroep Joint Global Ocean Flux Study Nederland
 - voorzitter werkgemeenschap Aquatische Oecologie BION
 - lid SCOR/JGOFS werkgroep Modelling
 - secretaris Klimaat-onderzoeksgroep NIOZ

- 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
- lid Commissie Milieuhygienische Aspecten van de Gezondheidsraad
- voorzitter Nederlandse Oceanografen Club
- expeditieleider JGOFS benthische leg
- ad-hoc expert Belgische Ministerie van Wetenschappen
- 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
- lid redactie NIOZ encyclopedie
- W.C.M. Klein Breteler
- voorzitter/secretaris BION-discussiegroep Zoöplankton-FRIENDS
- B.R. Kuipers
- lid redactie NIOZ encyclopedie
- M. Leopold
- bestuurslid Nederlandse Zeevogelgroep
- H.J. Lindeboom
- lid Commissie voor Milieueffectrapportage
- lid stuurgroep SEDEX
- lid coördinatiegroep ecologie Noordzee en Waddenzee
- Nederlands afgevaardigde EUROMAR Working group on models
- lid commissie mariene biologie SOZ
- geëncijmteerde Hogeschool 'Noorderhaaks' studierichting milieu
- L.R.M. Maas
- lid redactie NIOZ encyclopedie
- lid computer commissie NIOZ
- G. Marees
- lid werkgroep Optische Remote Sensing Water (ORWA)
- 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 (World Ocean Circulation Experiment)
- lid Bestuur Stichting Onderzoek der Zee (SOZ)
- Voorzitter Commissie voor Oceanografische Informatieuitwisseling SOZ
- lid Commissie voor Fysische Oceanografie SOZ
- lid Programmaraad Werkgemeenschap MFO-NWO
- nominated member SCOR
- lid redactie NIOZ encyclopedie
- 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
- 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 International Association of Geochemistry and Cosmochemistry; working group on natural waters, protection from pollution, Rostov-on-Don, USSR
- C. Swennen
 - lid werkgroep bijlage VEG-vogelrichtlijn
 - lid Nederlandse sectie International Council of Bird Preservation (ICBP)
 - nationaal kontaktpersoon sea duck branch, International Waterfowl Research Bureau (IWRB)
- H.W. van der Veer
 - 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
- J.H. Vosjan
 - lid redactie NIOZ encyclopedie
- docent Vrije Universiteit Brussel, België
- T.C.E. van Weering
 - 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
 - adviseur wetenschappelijke studiekring Nederlandse Antillen
 - 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 ICES, Biological Oceanography Committee

- 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 kerngroep Voorbereiding Nederlandse Raad voor de Aardwetenschappen, KNAW
- J.J. Zijlstra †
- bijzonder hoogleraar Mariene Zoölogie, Rijksuniversiteit Groningen
 - lid bestuur Stichting Onderzoek der Zee
 - voorzitter commissie mariene biologie van de Stichting Onderzoek der Zee
 - lid redactie Snellius-II proceedings voor thema 3
 - lid commissie antarctisch onderzoek SOZ
 - lid Koninklijke Nederlandse Akademie van Wetenschappen
 - secretaris sectie Biologie, KNAW
 - vice-voorzitter van de Biologische Raad
 - voorzitter bestuur Beijerinck-Popping fonds
 - lid Directeuren Overleg Chemie/Biologie Noordzee
 - lid NWO-adviescommissie gebiedsraad-in- oprichting Biologie
 - lid wetenschappelijke commissie van het Rijksinstituut voor Natuurbeheer (RIN)
 - lid biological oceanography committee ICES
 - voorzitter Publication Committee ICES
 - lid European Polar Study-group (ESF)
 - lid Wissenschaftliche Beirat Alfred-Wegener-Institut für Polar- und Meeresforschung, Bremerhaven, B.R.D.
 - lid van de Arbeitsgruppe Meeresforschung des Wissenschaftsrates Bundesrepublik Deutschland

3.4. STUDENTENONDERZOEK

E. van Arnhem	Hogeschool Alkmaar	BEWON
J. Belger	Int. Agrarische Hogeschool 'Lazenstein', Wageningen	B1-11
R. de Boer	RU Groningen	B2-03
L.H. Bravo Rebolledo	LU Wageningen	B2-03
C. Brussaard	RU Groningen	H3-09
H. Corstjens	Nautisch College, Den Helder	BEWON
A. Dekinga	v. Hall Inst., Groningen	B3-08b
G.W. Doeglas	v. Hall Inst., Groningen	B3-03
N. Fokma	RU Utrecht	BEWON
J.G.M. Gelinck	Hogeschool Oost Nederland	BEWON
G. Gerds	Universiteit Hamburg, BDR	B1-02
D.A. Gutter	Bakhuis Roozeboom Inst., Beverwijk	B3-03
R. Heesters	Bakhuis Roozeboom Inst., Beverwijk	H1-08/H1-09
R. Hoekstra	RU Groningen	B3-08b
B. Hondeveld	GU Amsterdam	B1-06
H.J. Huitema	RU Groningen	B3-03
M. Hup	v.d. Broek Instituut, Amsterdam	B3-07
S. Hulscher	RU Utrecht	H2-09
E. de Jong	RU Groningen	B2-01
R. Lanfers	LU Wageningen	B3-05
M.A. van Leeuwe	RU Groningen	H3-09
J.P. Ouweltjes	Hogeschool Alkmaar	BEWON
E. van de Pol	Hogere School voor Gas en Petroleum Technologie, Den Helder	BEWON
W.L. Rozemeyer	GU Amsterdam	B3-10
J. Samuels	Moller Instituut, Tilburg	B3-08b
R.A.A. Schillemans	TU, Eindhoven	BEWON
J. Stapel	KUN Nijmegen	B1-11
M.H.C. Stoll	RU Groningen	B2-02
T.M. Tahey	KUN Nijmegen	B1-11
J.P. Uit Oude Groeneveld	RU Groningen	SEDEX
W. v.d. Werff	VU Amsterdam	H3-09
P. Wiersma	RU Groningen	B3-08b
R.A.H. Woertman	Hogeschool Oost Nederland	BEWON

3.5. CURSUSSEN, VERGADERINGEN EN EXCURSIES

3.5.1. NIOZ cursussen

De cursus 'Inleiding in de Oceanologie' werd gegeven van 6 februari tot 3 maart. Er waren 21 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 6 tot 10 februari gegeven werd en het praktische gedeelte van 13 tot 24 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 gehele cursus 'Mariene Oecosystemen' besloeg in 1989 de periode van 5 juni tot 1 juli; gedurende de eerste week daarvan werden de colleges, in Groningen, verzorgd door Dr. J. Videler aan de hand van de Syllabus van vorig jaar. Daarna, van 12 tot 24 juni, werd het praktische gedeelte op het NIOZ gegeven onder leiding van Dr. B.R. Kuipers. Dit jaar meldden zich slechts 12 cursisten. Het geplande werk, vooral het uitzoekwerk aan benthische fauna, vissen en plankton, bleek wat te veel voor zo'n kleine groep. Daartegenover stond, dat de begeleiding door NIOZ-ers zeer uitvoerig kon zijn. De collegestof werd aangevuld met enkele voordrachten, in de Potvis en op het NIOZ.

Op 13 november 1989 vond de jaarlijkse bijeenkomst 'Onderwijs Mariene Biologie' plaats, waar vrij uitvoerig is gesproken over de NIOZ cursus, en vooral over de colleges. Het NIOZ zal in 1990 met een klein aantal biologen deze colleges in Groningen geven. De collegestof zal, in overleg met de RUG, worden afgestemd op de andere studieonderdelen en op de NIOZ cursus zelf.

3.5.2. Andere cursussen gehouden op het NIOZ

14-15 januari	Conference on: Global change and stasis in the geological past. Koninklijk Nederlands Geologisch en Mijnbouwkundig Genootschap
17-19 januari	International Workshop Seal Disease Epidemic
19 januari	Meeting Optical Remote Sensing Water (ORWA)
27 en 28 februari	Verwey-dagen: eerste landelijke AIO-bijeenkomst Mariene Biologie
14 maart	Ocean 2000 Meeting
10-22 april	Cursus Mariene Biologie voor geologen van de Vrije Universiteit, Amsterdam
24-29 april	Cursus mariene oecosystemen
30 april	Wadden info dag
23 juni	Bijeenkomst Protozoëncub
4 oktober	Werkbijeenkomst samenwerkingsverband radaraltimetrie

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

8 maart	Ontwerp-en-Vormgevingsbureau Van Raalte
16 maart	Bewoners Jellinekcentrum, Texel
5 april	Stichting Opleiding Leraren, Utrecht
17 april	Prof. H.C. van Hall Instituut, Groningen
27 april	Duitse geologen
3 mei	Rijnlands Lyceum
5 mei	Groninger Biologen Duikvereniging
12 mei	Ambassadeur Pakistan
19 mei	Nederlandse Ingenieurs Vereniging, Afd. Alkmaar
23 mei	Texelse Vrouwengilde
24 mei	Stichting Opleiding Leraren, Utrecht
2 juni	Veterinaire Hoofdinspectie
16 juni	Rijkswaterstaat Groningen, Afd. Milieu
21 juni	Bestuur Gemeente Heerden
3 juli	Bad Sachsa Pädagogium
7 juli	Leerkrachten Scholengemeenschap Wieringermeer
31 augustus	Prof. H. Adam: Natuurw. Fakultät, Salzburg, Oostenrijk
13 september	Kottenparkcollege, Enschede
13 september	Besturen Texelse Landbouworganisaties
25 september	Energie Centrum Nederland, Petten
10 oktober	Pedagogische Academie, Sittard
12 oktober	Rijksnormaalschool, Luik, België

3.6. INTERNATIONALE ORGANISATIES EN PROGRAMMA'S

Het NIOZ kent zeer vele vormen van bilaterale en multilaterale samenwerking op het niveau van instituten en wetenschappelijke organisaties over de gehele wereld.

Hieronder een opgave van de geformaliseerde overkoepelende organisaties die Europese en/of mondiale wetenschappelijke samenwerking beogen en de belangrijkste internationale programma's waarin het NIOZ participeert.

ICSU - International Council of Scientific Unions

Een non-gouvernementele internationale organisatie met als doelstelling de stimulering van internationale wetenschappelijke activiteiten. De ICSU doet dit 1) door het initiëren, coördineren en opstellen van internationale interdisciplinaire onderzoekprogramma's, zoals bijvoorbeeld het Global Change programma; 2) door voor multidisciplinair of transdisciplinair onderzoek (zoals zeeonderzoek, Antarctisch onderzoek, milieu-onderzoek) wetenschappelijke commissie in te stellen (SCOR, SCAR, SCOPE). ICSU onderhoudt nauwe contacten met UNESCO.

SCOR - Scientific Committee on Oceanic Research

Doelstelling: het bevorderen van internationale wetenschappelijke activiteit in alle takken van oceaanonderzoek. SCOR organiseert wetenschappelijke congressen, ontwikkelt plannen, zet werkgroepen op etc.

SCAR - Scientific Committee on Antarctic Research

Doelstelling: het bevorderen en coördineren van wetenschappelijk onderzoek in Antarctica, vrije uitwisseling van informatie. Onder SCAR functioneren verschillende werkgroepen o.a. op het gebied van biologie en geologie. SCAR besteedt speciale aandacht aan de oplossing van logistieke problemen (veldstations, schepen). Het kent een beperkt lidmaatschap verbonden aan de mate van onderzoekactiviteit, maar heeft geen formele banden met de Antarctic Treaty.

SCOPE - Scientific Committee on Problems of the Environment

Doelstelling: o.a. het verzamelen en toegankelijk maken van wetenschappelijke informatie over de antropogene invloeden op het natuurlijke milieu en de effecten daarvan. SCOPE heeft verschillende werkgroepen, o.a. Ecotoxicologie, Continental Wetlands, Coastal Chemistry. SCOPE werkt nauw samen met UNEP (United Nations Environmental Programme) in het programma over biogeochemische cycli.

IUGG - International Union of Geodesy and Geophysics

Doelstelling: bevorderen en coördineren van fysische, chemische en mathematische studies van de aarde en zijn omgeving, met inbegrip van de gravitatie- en magneetvelden, de dynamiek en de vorm van de aarde, haar interne structuur, tectoniek, magma's, vulkanisme e.d., hydrologische cyclus, sneeuw en ijs, alle aspecten van de oceanen, atmosfeer, ionosfeer, magnetosfeer en zon-aarde relaties. Onder de IUGG functioneren 7 associaties waarvan de IAPSO (International Association for the Physical Sciences of the Ocean) voor NIOZ van belang is. De IAPSO kent 3 commissies (Mariene Chemie, Fysische Oceanografie en Mariene Geofysica).

IUBS - International Union of Biological Sciences

Doelstelling: bevordering van de biologische wetenschappen, coördinatie en facilitaire ondersteuning van onderzoek dat internationale samenwerking vereist, organisatie van conferenties en publicaties, uitgave van een magazine. De IUBS wetenschappelijke programma's zijn interdisciplinair van aard en worden uitgevoerd in samenwerking met nationale en internationale organisaties. Tot deze programma's behoort ook de biologische oceanografie, gecoördineerd door de IABO (International Association of Biological Oceanography) lid van IUBS.

UNITED NATIONS (UN)

UNESCO - United Nations Education, Scientific and Cultural Organization - Division of Marine Sciences + Regional Offices

Doelstelling: bevordering van mariene wetenschappen door onderzoek en ontwikkeling van 'human resources' en infrastructuur. De wetenschappelijke activiteiten worden uitgevoerd door de Divisie voor mariene wetenschappen in samenwerking met de Regionale kantoren en de IOC. Bij de ontwikkeling van eigen programma's ligt de nadruk op kustnabije systemen, opleiding en training in ontwikkelingsgebieden, samenwerkingsprojecten met internationale organisaties, verspreiding van gegevens. UNESCO werkt veel samen met SCOR, IABO (International Association for Biological Oceanography), IAPSO (International Association for the Physical Sciences of the Ocean), ICES (International Council for the Exploration of the Sea) e.a.

IOC - Intergovernmental Oceanographic Commission

Doelstelling: bevordering van wetenschappelijk onderzoek om meer kennis te verwerven over de aard en de rijkdommen van de oceanen door samenwerking van de leden. Het heeft binnen UNESCO een zekere autonomie. De IOC definieert problemen in zee-onderzoek die internationale samenwerking vereisen en ontwikkelt, doet aanbevelingen over en coördineert internationale programma's. Van de vijf hoofdthema's is Ocean Dynamics and Climate (ODC) voor NIOZ belangrijk. ODC omvat delen van het ICSU-WMO World Climate Research Programme (WCRP), dat door IOC in samenwerking met SCOR wordt gecoördineerd. Twee belangrijke projecten zijn WOCE en TOGA.

WMO - World Meteorological Organization

Doelstelling: o.a. wereldwijde samenwerking ten behoeve van netwerken van meteorologische stations; snelle uitwisseling van meteorologische gegevens; standaardisering, toepassing van meteorologie, operationele hydrologie en bevordering en internationale coördinatie van onderzoek en opleiding.

ICES - International Council for the Exploration of the Sea

Intergouvernementele organisatie ten behoeve van de uitvoering van internationale onderzoekprogramma's op het gebied van de visserij, de verontreiniging en de hydrografie van de Noordatlantische Oceaan en zijn aangrenzende zeeën. Leden zijn de betrokken landen (België, Canada, Denemarken, Finland, Frankrijk, BRD, DDR, IJsland, Ierland, Nederland, Noorwegen, Polen, Portugal, Spanje, Zweden, UK, USA, USSR). ICES heeft een piramidale structuur met aan de top de Council. In de Werkgroepen worden de activiteiten en projecten voorbereid. Hierover wordt aan de Committee's gerapporteerd. Besluitvorming vindt plaats in de Council. NIOZ neemt deel aan verschillende Werkgroepen en Committee's, onder andere Marine Environmental Quality Com., Hydrographic Com., Biological Oceanographic Com., Mariculture Com., Marine Chemistry WG., Biological effects of Contaminants, Shelf Seas Hydrography WG, Marine Sediments in relation to pollution.

ODP - Ocean Drilling Programme

Internationaal samenwerkingsverband van wetenschappers en onderzoeksinstituten voor het onderzoek naar de structuur en geschiedenis van de zeebodem door middel van boorprofielen. ODP wordt gefinancierd door de US National Science Foundation en enkele partners zoals Canada, Frankrijk, BRD, Japan, UK en het ESF Consortium for Ocean Drilling (ECOD), waarin ook Nederland participeert.

ESF - European Science Foundation

ECOD (zie boven)

Netwerk voor Polaire Wetenschap

Doelstelling: beter gebruik van de faciliteiten binnen Europa om de polaire wetenschap te stimuleren, Europese samenwerking te versterken en zodoende een meer gelijkwaardige partner t.o.v. de USA, Canada en USSR te worden. Uit dit netwerk is het EPOS (European Polarstern Study) programma voortgekomen.

ECOPS - European Committee on Ocean and Polar Sciences.

AOSB - Arctic Oceans Sciences Board

Een non-gouvernementele organisatie ter bevordering van internationale en nationale wetenschappelijke activiteiten in de Arctische Oceaan en de aangrenzende zeeën. De AOSB brengt de mensen en middelen tezamen in samenwerkingsprogramma's om zijn doelstelling te bereiken. Deze programma's zijn ondermeer het Greenland Sea Project (GSP) en het International Arctic Polynya Project (IAPP).

ICBP - International Council of Bird Preservation

ICBP is actief op het gebied van de bescherming van vogels, waar het gaat om de internationale aspecten daarvan. ICBP stimuleert en coördineert fundamenteel onderzoek en bevordert internationale samenwerkingsprogramma's op het gebied van wilde vogels.

EG DG XII (Science, Research and Development)

MAST - Marine Science and Technology Programme (50 M ECU)

Een 3-jarig programma (1989-1992) voor onderzoek en ontwikkeling voor wetenschap en technologie op zee, te vatten onder punt 7.1 van het EG Kaderprogramma. Doelstellingen zijn onder meer: Bijdrage leveren aan een betere kennis van de zee, in het bijzonder de Europese kustwateren en regionale zeeën, om beheer en de bescherming ervan te verbeteren en veranderingen te kunnen voorspellen. Ontwikkelen van nieuwe technologieën, verbetering van coördinatie en samenwerking, het verlenen van hulp bij Europese deelneming in oceaanprogramma's over de gehele wereld.

STEP - Science and Technology for Environmental Protection (175 M ECU)

Onder het Kaderprogramma vallend speciaal onderzoekprogramma.

Doelstelling: Wetenschappelijke en technische steun voor het milieubeleid van de EG, verbetering van de onderzoekinspanning, coördinatie van de nationale programma's, bevordering van de wetenschappelijke en technische kwaliteit van het milieu-onderzoek. Van de negen onderzoekgebieden die onder STEP vallen is Ecosystem Research van belang voor het NIOZ.

EPOCH - European Programme On Climatology and Natural Hazards (40 M ECU)

Een onder het Kaderprogramma vallend 3-jarig onderzoekprogramma in verband met klimaatsverandering.

COST - European Cooperation in the field of Scientific and Technological Research.

EUREKA - Europese samenwerking op het gebied van industriële ontwikkeling en toegepast onderzoek.

EUROMAR - Samenwerking in EUREKA-kader op het gebied van het ontwikkelen van technologieën voor het onderzoek en het beheer van ecologische systemen in de zee. Er zijn negen internationaal samengestelde werkgroepen ter voorbereiding van concrete projecten, die rapporteren aan de EUROMAR Board. NIOZ is lid van de Werkgroepen Bottom instrumentation and mesocosms en Modelling.

Raad van Europa

EAMST - European Association of Marine Sciences and Techniques
Een non-gouvernementele organisatie ter bevordering van de coördinatie en samenwerking in onderzoek en opleiding op het gebied van mariene wetenschap en technologie.

GROTE INTERNATIONALE PROGRAMMA'S

JGOFS - Joint Global Ocean Flux Study

Internationaal oceaanonderzoek programma in het kader van het IGBP (International Geosphere-Biosphere Programme) van ICSU (de 'Global Change' programma's.) Op initiatief van SCOR en in samenwerking met IOC opgezet. Looptijd voorzien van 10 jaar. Doelstelling: het verwerven van basiskennis op wereldschaal en de bepaling van de in de tijd variabele fluxen van koolstof en andere biologisch belangrijke elementen in de oceaan en de evaluatie van de daarmee verband houdende uitwisseling met de atmosfeer, de zeebodem en de continentale grenzen. NIOZ neemt sinds 1989 deel aan de North Atlantic Pilot Study. Expedities zijn gehouden in 1989 (JGOFS I en II) met R.V. 'Tyro' en zijn goedgekeurd voor 1990 (JGOFS III en IV). NIOZ is vertegenwoordigd in de International JGOFS Committee. Ook zijn er voorstellen voor deelname in 1991, 1993, 1995 en 1997. Voor 1992 wordt gewerkt aan een voorstel JGOFS/EPOS Antarctic Study waarvoor de R.V. 'Polarstern' van het Alfred-Wegener-Institut (AWI), Bremerhaven, beschikbaar is. Aan JGOFS nemen circa 9 landen deel.

WOCE - World Ocean Circulation Experiment

Het WOCE programma is een initiatief van SCOR (ICSU) samen met IOC (UNESCO). Het is onderdeel van het World Climate Research Programme (WCRP) dat door ICSU en WMO gezamenlijk is opgezet. Het WCRP heeft tot doel het bepalen van de mate waarin klimaatsveranderingen kunnen worden voorspeld en in hoeverre menselijke activiteiten van invloed zijn. WOCE richt zich op de verwerving van basiskennis van het mondiale klimaatsysteem door onderzoek naar de interrelatie van het klimaat met fysische processen in de oceanen. WOCE is gestart in 1989 en heeft een beoogde looptijd van 10 jaar. NIOZ levert een bijdrage in het WOCE Hydrografische Programma (WHP) met DUTCH-WARP (Deep and Upper Transport Circulation and Hydrography WOCE Atlantic Research Programme). Hiervoor is in 1989 binnen de JGOFS-vaartijd enige tijd ingeruimd en wordt in 1990 een expeditie van 1 maand uitgevoerd met R.V. Tyro. Er ligt een aanvraag voor 1991. Voor 1993-1999 zijn aanvragen in voorbereiding. Aan WOCE nemen circa 20 landen deel.

EPOS - European Polarstern Study

Een door ESF gecoördineerd Antarctisch Onderzoek programma ter ontrafeling van de productiecycli en voedselketens in de Zuidelijke Oceaan, in het bijzonder in het pakijsg gebied. In 1988/1989 is EPOS-I uitgevoerd met uitgebreide participatie van NIOZ. NIOZ beraadt zich over deelname aan vervolgexpedities van EPOS.

ECOD - NIOZ levert een bescheiden bijdrage aan het onderzoek in ECOD kader.

GSP - Greenland Sea Project

Een onder de AOSB gecoördineerd langjarig internationaal onderzoekprogramma met als hoofddoel het onderzoek naar oceaancirculatie en vorming van watermassa's, de diepe convectorie in de Groenland Zee. Er wordt gebruik gemaakt van veldwaarnemingen door de inzet van verschillende onderzoekschepen en remote sensing technieken. NIOZ is betrokken bij circulatie, frontenonderzoek en mesoschaalexperimenten. Er zijn duidelijke verbanden tussen GSP en JGOFS/WOCE. In ICES kader vindt de archivering van gegevens plaats.

IAPP - International Arctic Polynya Project (IAPP)

Dit is een onder de AOSB in voorbereiding verkerend internationaal onderzoekprogramma naar de polynya's in de Arctische wateren. Het onderzoek concentreert zich op de ecologie, met ondersteuning van fysisch en zee-ijs onderzoek. Polynya's zijn specifieke gebieden die een veel hogere biologische productiviteit hebben dan de rest van de Arctische wateren. Vanuit het NIOZ zijn 3 voorstellen bij IAPP ingediend.

EG-PROJECTEN

MAST - NIOZ heeft als hoofdaanvrager drie aanvragen onder MAST die reeds de onderhandelingsronde zijn ingegaan, o.a. ERSEM (European Regional Seas Ecosystem Model), looptijd 2 jaar en EROS-2000 (II) (European River-Ocean System-2000 II) looptijd 3 jaar.

STEP/EPOCH - In het kader van STEP en EPOCH zijn vanuit NIOZ als hoofdaanvrager voor elk twee aanvragen gedaan.

COST - Een deel van het NIOZ-macrobenthos onderzoek is ondergebracht in het COST-647 project. COST-647 (Intertidal Soft Bottoms) is een langjarig internationaal programma met als doel de numerieke dichtheid van geselecteerde soorten benthische dieren in de Europese kustzones vast te stellen en de fluctuaties te correleren.

4. Hulpafdelingen

4.1. ALGEMEEN

1989 werd gekenmerkt door een aantal grootschalige innovatieprojecten, waarvan enkele nog over meerdere jaren doorlopen. De druk op de afdelingen was ook dit jaar weer bijzonder groot. Dit werd mede veroorzaakt door een vrij omvangrijk oceaanprogramma dat in een relatief korte tijd moest worden afgevoerd. De vindingrijkheid van de technische begeleiders van de tochten is weer danig op de proef gesteld. De communicatie met het onderzoeksschip 'Tyro' is dankzij het geïnstalleerde satellietcommunicatiesysteem sterk verbeterd.

Het nieuwe Noordzee-onderzoeksschip is in oktober besteld.

4.2. TECHNISCHE HULPAFDELINGEN

Ontwikkelingen.—Voor de werkgroep Chemische Oceanografie is door de afdelingen Instrumentmakerij en Electronica een instrumentenframe (tripode-bodemlander) ontwikkeld, vervaardigd en getest, waarmee *in situ* temperatuur- en zuurstofmetingen in het sediment van de oceaانبodem worden verricht.

Het valgedrag en het acoustisch releasemechanisme van het frame zijn in de Grevelingen getest. Hiervan zijn video-opnames gemaakt.

Het besturingsmechanisme van de meetprobes en de electronica zijn middels een proefopstelling in het instituut getest.

Op 21 september is het frame, inmiddels TROL gedoopt (Temperature Resistivity Oxygen Lander), voor de eerste maal vanaf de 'Tyro' nabij Madeira gelanceerd en heeft op een diepte van 4680 meter met succes metingen verricht. Op 22 september werd zij weer geborgen.

Voor de werkgroep Bentische Systemen is een groot instrumentenframe in ontwikkeling. Dit frame is eveneens in de Grevelingen getest. De bentische meetklokken waarmee dit frame ondermeer wordt uitgerust worden ook door bovengenoemde afdelingen ontwikkeld en vervaardigd. Met dit frame zullen tijdens een verblijf van een dag op de zeebodem ondermeer foto's van de te bemeten bodem worden genomen voor en nadat de meetklok in de bodem wordt gedrukt en afgesloten. Hierna worden diverse biologische parameters gemeten en worden watermonsters genomen.

Voor de werkgroep Geologie zal een groot instrumentenframe worden vervaardigd voor lange-termijnonderzoek aan erosie en (her)sedimentatie van de oceaانبodem als functie van de waterstroming ter plaatse. De instrumentatie voor deze erosie-monitor bestaat vooral uit kant en klare apparatuur. De componenten om de afzonderlijke instrumenten tot een interactief systeem te maken, worden op het NIOZ ontwikkeld.

Samenwerking.—In samenwerking met de RUU en RWS is een instrumenten-frame van RWS aangepast om stroomsnelheidsmetingen bij de bodem uit te voeren en om veranderingen in bodemligging en suspensiegehalte te registreren. Ook werd een onderwaterbehuizing voor de bijbehorende electronica vervaardigd. In mei is dit frame met de 'Navicula' weggezet voor de Nederlandse kust en later weer geborgen.

Veel tijd is besteed aan sedimentvallen (VUA) vanwege een elektrische en mechanische modificatie van een aantal vallen van Duits fabrikaat, die tot dan toe uitermate slecht functioneerden. In juni zijn onder NIOZ-leiding de Duitse en vier nieuw aangeschafte Franse sedimentvallen vanaf Hr. Ms. 'Tydeman' weggezet. Hiervoor heeft een personeelslid van de Koninklijke Marine vier weken stage gelopen op het NIOZ. De samenwerking met de Koninklijke Marine verliep uitstekend.

In samenwerking met de Universiteit van Toulon is door de instrumentmakers een apparaat ontwikkeld waarmee snel de organische stikstofconcentratie in zeewater kan worden bepaald. Er is langdurig geëxperimenteerd met diverse materiaalsoorten en vormen van het reactievat, waarin, bij zo'n 500°C, een voor het materiaal zeer agressieve reactie plaatsvindt.

Oceaanprogramma.—Voor de dit jaar gevaren expedities met de 'Tyro' zijn door alle afdelingen de nodige voorbereidingen getroffen. De tractieler is van een nieuwe, 10 km lange, draaivrije kabel van superaramide kunststofvezel voorzien, waarvan veel wordt verwacht. Tevens is deze lier van een nieuwe hydraulische aandrijfmotor voorzien en is de beschadigde tandwielkast gereviseerd.

Nieuwe, van sleepringen voorziene, draaibare tow-links zijn op het NIOZ vervaardigd en aan de uiteinden van draag- en signaalkabels van de lieren bevestigd. Moderne uitleeskasten voor de lieren, die behalve kabelgegevens ook boodschappen vanuit de meetcontainers kunnen laten zien zijn geïnstalleerd.

Door de eigen technici is op de 'Tyro' een nieuw windstation met data-uitlezing geïnstalleerd. Ook is door hen een gedeelte verschansing aangepast, waardoor een beter en veiliger werksituatie is ontstaan.

Er is een nieuwe trap naar het ondertussendek gemaakt, waardoor de op- en afgang naar dit dek sterk is verbeterd.

De flow-cytometer van de werkgroep Pelagische Systemen is in een nieuwe container geplaatst, waardoor dit instrument aan boord kon worden gebruikt.

In de clean-labcontainer is een nieuwe waterzuiveringsinstallatie geïnstalleerd.

Een tiental technici voeren dit jaar om toerbeurt van eind juli tot half januari op de 'Tyro' mee om technische assistentie tijdens de diverse expedities te verlenen.

Eind augustus zijn de Franse sedimentvallen, in juni weggezet met Hr. Ms. 'Tydeman', door de 'Tyro' geborgen met 100% resultaat. Kort daarop zijn de vallen weer weggezet tot voorjaar 1990. Daar het bar slecht weer was, was het niet mogelijk de Duitse sedimentvallen te bergen. In november verzocht SOZ het NIOZ een viertal technici ter beschikking te stellen om tijdens de terugtocht van de 'Tyro' naar Den Helder na Kerstmis op de Azoren op te stappen om de Duitse vallen alsnog te bergen.

Voor de werkgroep Geologie is een röntgencore-scanner ontwikkeld en geproduceerd die daarna in een container werd geplaatst. Geplaagd door lever-tijdproblemen is het instrument nagezonden naar Madeira waar het op de 'Tyro' aan boord is genomen. Het instrument overleefde het transport echter niet,

waardoor een technicus met enige vitale onderdelen onder de arm naar Pointe Noir afreisde. Deze werd verzocht aan boord te blijven daar de bedienaar van het instrument wegens een sterfgeval in zijn familie naar Nederland was afge-reisd. Enkele weken later konden zij elkaar aflossen in Walvisbaai.

Haven en vaartuigen.—De 'Aurelia' heeft 170 vaardagen gemaakt met 226 opstappers. Tijdens de dokweek is de huiddikte gemeten, BB ankerketting vernieuwd en het ondiep-water echolood vervangen.

De 'Navicula' heeft 154 vaardagen gemaakt met 460 opstappers. In de winter is de SB hoofdmotor gerevideerd en zijn de schroefasafdichtingen vernieuwd.

De 'Griend' heeft 110 vaardagen gemaakt.

De motor van de vlet is gerevideerd en er is een nieuwe schroef aangehangen.

De fuikvisserij, die al sinds 1960 plaatsvindt, werd ook dit jaar weer voortgezet. Eind maart werd de vangopstelling bij de Stuifdijk geplaatst en de komfuik geïnstalleerd. Het sinds enige jaren verplichte antizeehondennet werd in de fuikopening bevestigd, hetgeen misschien de vangst beïnvloed heeft, maar een plezierige bijkomstigheid is dat het aantal kwallen in de fuik is gereduceerd. Dagelijks is de fuik gelegeerd en de 24-uurs vangst bemeten. Op verzoek van het RIVO werden van de bot de zichtbare ziektes genoteerd en werd de zeeforel voor een onderzoek in het kader van het Rijn-actieplan bewaard en opgestuurd. Een aardige waarneming was een in Duitsland gemerkte zeeforel, die in de fuik werd teruggevangen. Een probleem vormde dit jaar de grote hoeveelheden zeesla, waardoor in juni het schutwant scheurde en enkele palen deed afbreken, waardoor de vangst tijdelijk moest worden gestaakt. Bijzonderheden dit jaar waren de geringe palingvangsten en de relatief grote aantallen gevangen broed van enkele pelagische vissoorten zoals flint, horsmakreel en zeebaars.

Scheepsnieuwbouw.—Dit jaar is ondermeer besteed aan de uitwerking van het voorlopig ontwerp van het nieuw te bouwen Noordzee-onderzoekschip ter vervanging van de 'Aurelia'.

In gemeen overleg met de NIOZ-bouwcommissie, het ontwerp bureau MSC en de afdeling Rijksvaartuigen van DGSM is het technische bestek gereed gekomen. Door allen is daarnaast veel aandacht geschonken aan de indeling van het schip en het overzicht vanuit en de inrichting van het stuurhuis. Door MSC zijn bewegingsanalyses gemaakt waarbij de scheepsvorm is geoptimaliseerd, waarna naar tevredenheid van allen een modelproef in de sleeptank bij het Maritime Research Institute Netherlands MARIN te Wageningen zijn uitgevoerd.

In juli zijn vijf Nederlandse scheepsbouwers uitgenodigd offerte te maken. Na onderhandeling over prijs en leveringsomvang is op 18 oktober de bouw gegund aan Verolme Shipyard Heusden (VSH) te Heusden. Het schip zal in maart 1991 opgeleverd worden.

Voor die tijd dient de NIOZ-haven aangepast te worden om het schip te kunnen ontvangen. Aan Rijkswaterstaat is gevraagd een nieuw havenontwerp te maken.

Gebouwen en installaties.—Naast de dagelijkse beslommeringen zijn de afdelingen werktuigbouw, electro, houtbewerking en aquariumtechniek betrokken geweest bij diverse verbouwingen, aanpassingen en reparaties aan de gebouwen en de installaties. Een greep uit deze werkzaamheden.

Voor de werkgroep Geologie is de bestaande röntgendiffractiekamer geheel verbouwd en heringericht zodat er twee machines kunnen worden geplaatst.

Ten behoeve van de werkgroep Speciale Projecten zijn op de werkvloer van het experimenteeraquarium twee klimaatkamers gebouwd en ingericht. De bedoeling is dat in de klimaatkamers, in separaat staande kasten, algenkweekcultures worden opgesteld waarin door middel van lucht- en waterkoeling een bepaald temperatuurniveau en door middel van om de cultures geplaatste TL buizen een bepaald licht-regime kan worden gehandhaafd.

Het overdekt terras naast de kantine is bij de kantine getrokken waardoor er 24 extra zitplaatsen beschikbaar kwamen.

Voor de werkgroep Chemische Oceanografie is een 'clean room' gebouwd waarvoor de nodige water-, gas-, lucht- en electra voorzieningen door ons zijn verzorgd.

Na de dakrenovatie van het aquariumgebouw vorig jaar kon een begin gemaakt worden met de renovatie van de diverse proefopstellingen op de werkvloer. De verlichtingsornamenten zijn gewijzigd en aangebracht.

Een nieuwe dimregeling voor de TL verlichting in het auditorium is geïnstalleerd die naar tevredenheid functioneert.

Een oude schuld is ingelost door de afdeling electronica met de bouw van een 'particle control system' voor het constant houden van voedercondities voor algen in een 16-tal meetbakken.

Magazijnbeheer.—In vorige jaren zijn pogingen ondernomen om de inventarisatie, registratie en tracerings van NIOZ en SOZ apparatuur in beheer bij het instituut, van de grond te krijgen. Door allerlei oorzaken lukte dit slechts ten dele. Dit jaar is een begin gemaakt om deze zaak op een serieuze manier aan te pakken. De dringende noodzaak hiervoor wordt ingegeven door de groeiende hoeveelheid apparatuur en door de aanwas van douaneactiviteiten, veroorzaakt door het toegenomen grensoverschrijdend verkeer, en de complexiteit van deze activiteiten mede veroorzaakt doordat bepaalde apparatuur alleen buiten de EEG te verkrijgen is. De bedoeling is om naast een goed inzicht, op termijn tot kostenbesparing te komen, waarbij de mogelijkheid van het opzetten van een fictief douane entrepôt op het instituut niet wordt uitgesloten.

Het bestand aan verbruiksgoederen in het centraal magazijn van het instituut omvat 1445 artikelen. De omzet bedroeg dit jaar ca. f 200.000,— waarvan ca. f 145.000,— voor laboratoriumbenodigdheden en chemicaliën.

Vorig jaar zijn ca. 1300 artikelen in het bestand opgenomen die bestemd zijn voor de gecontaineriseerde werkplaats in gebruik tijdens de oceaanexpedities. Hierdoor was het dit jaar mogelijk om met behulp van het geautomatiseerde systeem de aanvullende bestellingen te doen.

Transport.—Dit jaar werd de Ford Transit bestelwagen vervangen door een Volkswagen bestelbusje.

Naast de dagelijks transporten zijn dit jaar 13 vrachtwagencombinaties met containers en materiaal naar de 'Tyro' gebracht voor de diverse oceaanexpedities.

4.3. ADMINISTRATIEVE HULPAFDELINGEN

Algemeen.—De overgang van het NIOZ naar de Nederlandse organisatie voor Wetenschappelijk Onderzoek heeft ook op de administratieve hulpafdelingen zijn uitwerking gehad.

Onderzocht werd in hoeverre de administratieve organisatie van het NIOZ aangepast moest worden aan de eisen en voorwaarden die NWO zou gaan stellen. Deze aanpassing had ondermeer betrekking op het inventarisbeheer, het inkoopbeleid, de inrichting van de begroting en het financieel jaarverslag. Een extern adviesbureau werd ingeschakeld om dit onderzoek te verrichten en hieruit aanbevelingen te doen.

Bibliotheek.—In 1989 werden 139 boeken aangeschaft. Het tijdschriftenbestand is per 1 januari 1989 uitgebreid met de volgende tijdschriften:

Antarctic Science 1(1),-
C.W.I. Quarterly 1,-
FEMS Microbiology Ecology 62(1),-
Kwantitatieve Methoden 10(31),-
Oceanography 1(1) 1988,-
Science total Environment 80(1),-
Statistica Neerlandica 43(1),-

Ruil:

Bulletin Central Geological Survey, Taipei 3(1984),-
Directorate Marine Science Korea 3(1989),-
Kobie, Revista de B. Artes y Ciencias 15(1985-86),-
Proceedings Sherkin Island Marine Station, 1985,-
Publicaties en Rapporten 'Ecologisch Herstel Rijn', 1989,-

Redactie.—zie 2.1.1.

Reprografische afdeling.—In 1989 is een ACAD-tekensysteem aangeschaft. Hierdoor kunnen basistekeningen in het computer-geheugen opgeslagen worden en voor diverse doelen gebruikt worden. Bij volledige installatie en operationalisering van het systeem zullen bepaalde onderdelen van het tekenwerk makkelijker en efficiënter verwerkt kunnen worden.

Veel werk werd verricht voor de Snellius Proceedings, voor de uitgaven van het Netherlands Journal of Sea Research en voor een Noordzee-boek dat in 1990 wordt uitgebracht. Het aantal publicaties en interne verslagen nam aanzienlijk toe. De afdeling verleende haar medewerking bij de totstandkoming van een aantal dissertaties en bij de inrichting van exposities. In december werden ± 250 exemplaren gemaakt van de Arbeidsvoorwaardenregeling van de Stichting NIOZ.

Administratie.—Per 1 mei heeft het hoofd van de administratie, de heer G. Goslinga, gebruik gemaakt van de VUT-regeling. De werkzaamheden van de heer Goslinga werden overgenomen door en verdeeld over de medewerkers van de afdeling. Mevrouw I. Wernand-Godee werd benoemd tot plaatsvervangend hoofd en de salarisadministratie werd overgedragen aan de heer D.J. Bruin. De werktijden van de dames M. Spel en A. Keijzer werden uitgebreid.

In verband met de op handen zijnde overgang naar NWO, werd in de loop van 1989 onderzocht of de administratieve organisatie van de afdeling eventueel aangepast zou moeten worden en of de functie-inhoud van het hoofd administratie eveneens veranderd zou moeten worden. Verwacht wordt dat hierover in 1990 een beslissing wordt genomen.

Huishoudelijke dienst/Logeergebouw 'In den Potvis'.—In 1989 is de kantine uitgebreid door het overkapte terras bij de kantine te betrekken. De verbouwing van de counter is tot nader order uitgesteld.

De bezetting van de éénpersoonskamers is, evenals in 1988, volledig geweest. Het aantal losse overnachtingen bleef op hetzelfde niveau als in 1988. De huisjes zijn vrijwel het gehele jaar bewoond geweest. De volkwagenbus vloog spontaan in brand, overigens zonder persoonlijk letsel van de chauffeur, de heer G. Steenhuizen.

Biologisch studiemateriaal.—In 1989 was het door de quoterings en door de verscherpte AID-maatregelen in sommige gevallen moeilijk om aan bepaalde zeedieren te komen. Zo bleef in het najaar de aankoop van doornhaai erg achter. De rest van de voorraad is overigens wel op peil gebleven.

De totale verkoopopbrengst was hoger dan in 1988 terwijl de kosten van inkoop minder waren zodat het bruto overschot steeg.

Het aantal bestellingen uit het buitenland nam iets af, maar in volume waren deze groter. De binnenlandse zendingen bleven ten opzichte van 1988 nagenoeg gelijk. De afvoerinstallatie werd aangesloten op het Helderse rioolnet. Gepleit wordt voor een grotere aanvoer vanuit de fuikenvisserij van het NIOZ.

4.4. REKENCENTRUM

In maart 1989 is de mini-computer van Norsk Data ND-530 vervangen door zijn snellere broertje ND-5400, die meer opslagcapaciteit heeft. Gebleken is dat het knelpunt van de afgelopen tijd nu grotendeels verholpen is.

Per 1 oktober 1989 heeft het NIOZ een full-time statisticus in dienst genomen, van wie verwacht wordt, dat hij samen met de onderzoekers onder andere het onderzoek meer statistisch verantwoord gaat opzetten.

Gedurende het gehele jaar is er een discussie geweest over een aantal taakwijzigingen met betrekking tot het rekencentrum. Er is een duidelijkere afbakening gekomen tussen mini-computer en PC's. In dit kader moet men ook denken aan de verwachte komst van een netwerk. Het realiseren van een complex netwerk met 80 aansluitingen voor PC's zal veel inzet, veel geduld en veel overleg met de toekomstige gebruikers vragen.

5. Sociaal jaarverslag

5.1. ALGEMEEN

In veel opzichten is 1989 een bewogen jaar geweest. Twee tragische gebeurtenissen dienen allereerst vermeld te worden: het onverwachte overlijden van Arie Boon, 1e machinist op het O.V. 'Aurelia', op 4 maart en het toch nog plotse-linge overlijden, na zijn vertrek per 1 mei, van Jenne Zijlstra, voormalig algemeen directeur van het NIOZ, op 2 augustus.

Veel werk werd verricht om de overgang van het NIOZ naar de Nederlandse organisatie voor Wetenschappelijk Onderzoek (NWO) voor te bereiden. Vertegenwoordigers van het Ministerie van O&W, van de NWO en van het NIOZ participeerden in een werkgroep ingesteld om deze overgang te formaliseren. Daar de Nederlandse Dierkundige Vereniging per 1 januari 1990 niet langer als werkgever zou fungeren, werd op 29 september de Stichting NIOZ opgericht die per 1 januari 1990 als nieuwe werkgever in de plaats zou treden. Hiertoe dienden er nieuwe statuten gemaakt te worden. Bij het Ministerie van Binnenlandse Zaken werd een verzoek ingediend om de zogenaamde 'B3-status' in het kader van de Algemene Burgerlijke Pensioenwet te verkrijgen. Tot stand kwam de Arbeidsvoorwaardenregeling van de Stichting NIOZ bestaande uit het Arbeidsreglement en een aantal Uitvoeringsregelingen. Alle personeelsleden kregen een nieuwe arbeidsovereenkomst aangeboden en ontvingen een exemplaar van de bovengenoemde regeling. Het NIOZ nam in het laatste half jaar informeel al deel aan het Werkgeversoverleg met de stichting Fundamenteel Onderzoek der Materie (FOM), de Stichting Mathematisch Centrum (SMC) en met NWO en aan het Georganiseerde Overleg (overleg tussen werkgevers en vertegenwoordigers van werknemers).

5.2. BEHEER

Zoals hierboven is aangegeven, was 1989 het laatste jaar waarin de Nederlandse Dierkundige Vereniging het beheer voerde over het NIOZ. De N.D.V. blijft als vereniging voortbestaan met een eigen doel en statuten, zonder enige relatie met het instituut. De overdracht van de onroerende en roerende goederen naar de Stichting NIOZ is in 1989 voorbereid en zal in het voorjaar van 1990 worden geëffectueerd.

Bestuur (per 1-12-1989)

Commissaris: Prof. Dr. W. Scharloo
 Commissie van toezicht: Prof. Dr. W. Scharloo
 Dr. W.F. Jansen (penningmeester NDV)
 Prof. Dr. J. Lever
 Prof. Dr. W.G. Mook
 Prof. Dr. Ir. J.A. Battjes

Wetenschappelijke commissie

Prof. Dr. Ir. J.A. Battjes	Faculteit der Civiele Techniek, Technische Universiteit Delft.
Prof. Dr. N. Daan	Rijksinstituut voor Visserij- onderzoek, IJmuiden
Dr. H. van Gemerden	Laboratorium voor Microbiolo- gie, Rijksuniversiteit Groningen
Prof. Dr. C.H.R. Heip	Delta Instituut voor Hydrobiolo- gisch Onderzoek, Yerseke
Prof. Dr. J.E. van Hinte	Instituut voor Aardwetenschap- pen, Vrije Universiteit, Amsterdam
Prof. Dr. C. van den Hoek	Vakgroep Mariene Biologie, Rijksuniversiteit Groningen
Dr. J. van der Land	Rijksmuseum van Natuurlijke Historie, Leiden
Prof. Dr. J. Lever	Amsterdam
Mw. Drs. W. de Ligny	Shell Int. Petr. Mij., Den Haag
Dr. G.M. Lokhorst (secretaris)	Rijksherbarium, Rijks- universiteit Leiden
Prof. Dr. W.G. Mook (voorzitter)	Centrum voor Isotopen Onder- zoek, Rijksuniversiteit Groningen
Prof. Dr. R.A. Prins	Laboratorium voor Microbiolo- gie, Rijksuniversiteit Groningen
Prof. Dr. W.P.M. de Ruyter	Vakgroep Meteorologie en Fysi- sche Oceanografie, Rijks- universiteit Utrecht
Dr. W. Salomons	Instituut voor Bodemvrucht- baarheid, Haren (Gr)
Prof. Dr. W. Scharloo	Vakgroep Populatie- en Evolu- tiebiologie, Rijksuniversiteit Utrecht
Prof. Drs. P.A. Schenck	Afd. Scheikundige Technologie, Technische Universiteit Delft
Prof. Dr. C. Schuurmans	Koninklijk Nederlands Meteoro- logisch Instituut, de Bilt
Prof. Dr. W.J. Wolff	Rijksinstituut voor Natuurbe- heer, Leersum

Stichting Nederlands Instituut voor Onderzoek der Zee (opgericht 29 september 1989):

Bestuur: (met ingang van 1 januari 1990)

Voorzitter	Prof. Dr. W. Scharloo
Vice-voorzitter	Prof. Dr. W.G. Mook
Secretaris/penningmeester	Prof. Dr. Ir. J.A. Battjes

5.3. WERKOVERLEG

In 1989 is 8 keer overleg gevoerd met de Ondernemingsraad. Belangrijke aandachtspunten waren de overgang van het NIOZ naar NWO, de hiermee in verband staande statutaire wijzigingen, de benoemingsprocedure van 2 nieuwe directieleden en de nieuwe Arbeidsvoorwaardenregeling van de op te richten Stichting NIOZ. Eén lid van de OR was vertegenwoordigd in de werkgroep die de overgang voorbereidde van het NIOZ naar NWO en nam deel aan het overleg tussen werkgevers en vertegenwoordigers van werknemers (Georganiseerd Overleg).

5.4. PERSONEELSBELEID

Bevorderingen

In 1989 werden onderstaande personen bevorderd:

E. van Abs	directie
E.J. Adriaans	haven & vaartuigendienst
J.W. Schröder-ter Avest	directie
G.W. Berger	geologie
D.J. Bruin	administratie
R. Dapper	rekencentrum
J.M. Everaarts	chemische oceanografie & zeeverontr.
F. Eijgenraam	rekencentrum
H. Franken	electronica
H.G. Fransz	pelagische systemen
B. Bak-Gade	redactie
C. Gerssen	haven & vaartuigendienst
I. Wernand-Godee	administratie
S.R. Gonzalez	pelagische systemen
R. Groenewegen	electronica
W. Helder	chemische oceanografie & zeeverontr.
M.Th.J. Hillebrand	chemische oceanografie & zeeverontr.
J.M. van Iperen	
(met terugwerkende kracht tot 1-1-1988)	geologie
W. Lewis	BEWON
S. Oosterhuis	pelagische systemen
H.H. de Porto	werktuigbouw
J. Mulder-Starreveld	redactie
C. Veth	fysische oceanografie
M. Zonnenberg	receptie

Gratificatie

Voor een gratificatie kwamen in aanmerking de heren R.J.R. Anthonijsz (haven en vaartuigendienst), J.M. Nieuwenhuizen (studiemateriaal), S.W. de Porto en A. Ran (magazijn).

Functioneringstoelage

Aan de heren H.J.W. de Baar (chemische oceanografie en zeeverontreiniging), G.M. Manshanden (electronica), M.W. Manuels (fysische oceanografie) en F.J. Parlevliet (werktuigbouw) werd een functioneringstoelage toegekend.

Mutaties

In dienst:

J. Seepma	2 ^e S.W.K.	haven & vaartuigen	24-4
M.C. Bakker	SOZ technicus	energietechniek	15-05
K. Booi	wet. onderzoeker	chem. ocean. & zeeverontr.	01-07
M.J. Rietveld	directeur	directie	01-09
J. v.d. Meer	statisticus	algmene dienst	01-10

Uit dienst:

A. Boon	1 ^e machinist	haven & vaartuigen	04-03†
H. v. Veen	SOZ technicus	energietechniek	01-04
R. Schmidt	electronics	electronica	01-05
F.J. Wetsteijn	1 ^e lab. assistent	chem. ocean. & zeeverontr.	01-05
J.J. Zijlstra	hoofddirecteur	directie	01-05 (vut) 02-08†
R. Dekker	promotie-assistent	kustsystemen	01-06
G. Goslinga	hoofd administratie	administratie	01-06 (vut)
F. Hovenkamp	promotie-assistent	pelagische systemen	01-10
W.J. Kieskamp	promotie-assistent	chem. ocean. & zeeverontr.	01-11
E.K. Duursma	directeur	directie	01-12 (vut)
J.M.J. Hoppema	promotie-assistent	chem. ocean. & zeeverontr.	01-12
M.J.M. Reichert	promotie-assistent	pelagische systemen	01-12

5.5. PERSONEELSLIJST (per 31-12-1989)

Direktie:	Secretaresse:	Assistentie:
Wet. hfd. dir.: vakature	J.M.G. Hart-Stam	J.W. Rommets
Direkteur: Drs. M.J. Rietveld	J.W. Schröder- ter Avest	I.I.J. Witte

Techn.- Adm. dir.: Ing. E. van Abs

Statisticus: Ing. J. v.d. Meer

Onderzoekafdelingen

afd. chemische oceanografie en
onderzoek zeeverontreiniging

onderzoeker:	Assistentie:
Dr. W. Helder	K. Bakker
Dr. Ir. H.J.W. de Baar	M.Th.J. Hillebrand
Dr. K. Booi	S. Jansen
Dr. J.M. Everaarts	R.F. Nolting
Drs. L. Gerringa	R.T.P. de Vries
Drs. C. Westra	

afd. fysische oceanografie

Drs. C. Veth	M.W. Manuels
Dr. H.M. van Aken	S. Ober
Dr. L.R.M. Maas	M.R. Wernand
Prof. Dr. J.T.F. Zimmerman	

afd. mariene geologie en geochemie

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
Ir. T. Schuhmacher	E. Okkels
Dr. Tj.C.E. van Weering	J. Schilling
Drs. Z. Zuo	

afd. benthische systemen	Dr. P.A.W.J. de Wilde Prof. Dr. R.P.M. Bak Drs. A. Cramer Drs. G.C. Duineveld Drs. R. Heyman Dr. J.H. Vosjan	E.M. Berghuis A. Kok G. Nieuwland G. van Noort E. Pauptit
afd. pelagische systemen	Dr. Ir. H.G. Fransz Dr. M.A. Baars Dr. W.C.M. Klein Breteler Dr. B.R. Kuipers Dr. M.J.W. Veldhuis	S.R. Gonzalez G.W. Kraay S.S. Oosterhuis N. Schogt H.J. Witte
afd. kustsystemen	Dr. J.J. Beukema Dr. G.C. Cadée 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 Puyl 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 Drs. 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 Ing. H.Th. Kloosterhuis W. Lewis J.F.P. Malschaert M. Mulder
Rekencentrum	R. Dapper F. Eijgenraam	
Hulpafdelingen		
Hoofd administratieve hulpafdelingen tevens personeelschef: P.C. Vooyo		
redactie	Dr. J.J. Beukema	B. Bak-Gade J.P. Mulder-Starreveld
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 N. Krijgsman R. Nichols B. Verschuur
telefoon/receptie	M. Zonnenberg	J.M.M. Hin-Zoetelief
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 A.A. Balk J.C. Groot W.J.M. Koomen	C.J. Mozes J. Pieterse R. Rebel J. Seepma A.J. Souwer J.C. Tuntelder

5.6. TIJDELIJKE PERSONELE ONDERSTEUNING

E. van Arnhem	analist	BEWON	23-10 tot 31-12
K.M.J. Bakker	analist	chem. ocean. & zeeverontr.	01-01 tot 31-12
H. Ellermeijer	instr. maker	instrumentenmakerij	01-01 tot 01-03
Drs. C.V. Fisher	analist	BEWON	01-01 tot 15-02
Drs. E.C. Flach	redactie ass.	redactie	01-02 tot 01-12
A.J.M. Gieles	analist	geologie	01-10 tot 31-12
W. Hart	assistent	reprografie	01-04 tot 31-12
Drs. Th. Herkink	onderzoeker	t.b.v. encyclopedie	01-01 tot 16-02 en 15-03 tot 01-04
S.M. Jansen	analist	chem. ocean. & zeeverontr.	01-01 tot 31-12
B. Koster	electronicus	electronica	15-09 tot 31-12
Drs. M. Philippart	onderzoeker	t.b.v. encyclopedie	01-02 tot 15-02
Drs. E. Ufkes	onderzoeker	geologie	25-09 tot 20-11
A. Hillebrand-Kikkert	inval telefoniste	receptie	oproepbaar
C.A. Barten	inval typiste	redactie	16-05 tot 08-09 en 01-11 tot 31-12

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:

J.C.H. Ursen	01-01 tot 14-05	BRI	Kustsystemen
M. Hup	01-01 tot 01-04	v.d. Broek Instituut	Kustsystemen
E.M.C. van Arnhem	01-01 tot 01-06	HLO Alkmaar	Chem. ocean.
E. Blaauw	01-01 tot 14-01	NTC Noorderhaaks	Energietechniek
J.G.M. Gelinck	01-03 tot 15-06	HTS de Maere	BEWON
B. van Heerwaarden	01-01 tot 14-01	NTC Noorderhaaks	Electronica
J.G. Koning	01-01 tot 20-01	MTS A&O	Energietechniek
M.E. Lamers	01-01 tot 01-06	HLO Alkmaar	Geologie
H. Messemaker	27-02 tot 16-06	NTC Noorderhaaks	Werktuigbouw
C. Oderkerk	01-01 tot 25-02	NTC Noorderhaaks	Werktuigbouw
J.P. Ouweltjes	01-01 tot 01-06	HLO Alkmaar	BEWON
P. Parisius	16-01 tot 01-08	NTC Noorderhaaks	Electronica
C. Rapp	27-02 tot 16-06	NTC Noorderhaaks	Energietechniek
R.H.A. Woertman	01-03 tot 15-06	HTS de Maere	BEWON
C.H. Zandbergen	23-01 tot 17-06	MTS A&O	Energietechniek
W. Warmerdam	01-01 tot 01-06	HLO Alkmaar	Geologie
M. van Egmond	01-01 tot 01-02	MLO Alkmaar	Kustsystemen
B. Koster	01-01 tot 01-09	HTS Alkmaar	Electr./geologie
R. Heesters	01-02 tot 01-07	BRI	Cem. ocean.
E.G.M. v.d. Pol	01-02 tot 01-04	NTC Noorderhaaks	BEWON
H. van Osch	13-02 tot 23-03	Streekschool NHN	Instr. makerij
W.J. van Halm	01-02 tot 01-07	HTS Alkmaar	Geologie
D.A. Gutter	01-02 tot 01-07	BRI	Kustsystemen
A.W. Mahne	01-02 tot 01-07	HLO Alkmaar	Geologie
E.N. Bakker	28-08 tot 31-12	MTS A&O	Energietechniek
R. Klok	14-08 tot 31-12	MTS A&O	Electronica
T. Kater	04-12 tot 31-12	NTC Noorderhaaks	Werktuigbouw
D. Heerschap	14-08 tot 31-12	NTC Noorderhaaks	Energietechniek
N. van Heerwaarden	14-08 tot 31-12	NTC Noorderhaaks	Electronica
J.J.M. Belgers	25-09 tot 31-12		
H.P.A.F. Corstjens	01-08 tot 31-12	Hoge school Wag.	BEWON
J. Samuels	15-07 tot 31-12	NLO	Kustsystemen
A. Detringa	01-11 tot 31-12	HAS	Kustsystemen

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:

Antarctisch Onderzoek (SOZ) Drs. A. Buma	01-01 tot 31-12
Remote sensing (RWS - BCRS) Dr. G. Marees Drs. T.F. de Bruin	01-01 tot 31-12 01-10 tot 31-12
NAZORG (Verkeer en Waterstaat) Drs. M.S.S. Lavaleye S.E. Holtman	01-01 tot 01-12 01-01 tot 15-05
Boorspoeling IV + V (Verkeer en Waterstaat) Dr. R. Daan	01-01 tot 16-06 en 17-07 tot 31-12
A. Keijser I. Schweimler	01-10 tot 31-12 0-01 tot 16-08
SEDEX (Verkeer en Waterstaat) Drs. G.W.N.M. van Moorsel Drs. R. Dekker	01-08 tot 31-12
Phaeocystis (EEG) Drs. W. van Boekel	01-01 tot 31-12
RENA (EEG) Drs. C.V. Fischer	15-02 tot 31-12
EROS-2000 L. Lohse	01-10 tot 31-12
Visserijeffecten Drs. R. Witbaard	01-01 tot 16-01

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.

Onderzoekers met een NWO-beurs:

Drs. J.J.M. van Haren	Fysische oceanografie
Drs. C. de Boer	Fysische oceanografie
Drs. M.H.C. Stoll	Chemische oceanografie en zeeverontreiniging
Drs. H.G. Epping	Chemische oceanografie en zeeverontreiniging
Dr. R.W.J. Dirks (post-doc)	Fysische oceanografie

Samenwerkingsovereenkomst:

UVA/NIOZ Drs. W. van der Werff	Geologie
KNMI/NIOZ Dr. L. Otto	Fysische oceanografie
RUG/NIOZ Drs. Th. Piersma Drs. F. Schut	Kustsystemen Pelagische systemen

Gedetacheerd door TNO

Dr. P. de Wolf

A. Stam

A.J. Kop

Ten behoeve van het vaarprogramma van de Stichting Onderzoek der Zee (SOZ) zijn de volgende personen bij het NIOZ voor onbepaalde tijd aangesteld:

W. Polman	Werktuigbouw
P.R. Alkema	Werktuigbouw
J. Blom	Werktuigbouw
J. Nieuwenhuis	Electronica
R. Schmidt (tot 01-05)	Electronica
R. Witte	Houtbewerking
H. van Veen (tot 01-04)	Energietechniek
M.C. Bakker (vanaf 15-05)	Energietechniek

In het kader van de vervangende dienstplicht waren als erkend gewetensbezwaaarden geplaatst:

Drs. M.J.C. Rozemeijer	BEWON
M. Hup	BEWON

Met toestemming van de gemeente en/of de uitkerende instantie werkten als vrijwillig(st)er:

A. de Graaf (per 01-01-1990 in dienst)	via G.M.D. Alkmaar
S.H. Hashemi Saleh	via gemeente Texel/Alkmaar
W. Frankema	
O. Schilling	via gemeente Texel

5.8. DEELTIJD

Onderstaande personen vervulden in 1989 een part-time dienstverband:

J.W. Schröder-ter Avest	32 uur	directie-secretaresse
T.C. Steenhuizen-Borculo	19 uur	huishoudelijke dienst
A. Cramer	32 uur	promotie-assistente
R. Dekker	32 uur	promotie-assistent
J. van der Wal-Doornekamp	33.25 uur	bibliotheecaresse
E.K. Duursma (NIOZ/RUG)	27.5 uur	directeur
B. Bak-Gade	19 uur	redactie-assistente
L. Gerringa	32 uur	promotie-assistente
A.C. Bol-den Heijer	25.5 uur	secretaresse
R.P. Heyman	32 uur	promotie-assistent
J.M.M. Hin-Zoetelief	8 uur	telefoniste/receptioniste
J.M.J. Hoppema	32 uur	promotie-assistent (tot 01-12)
F. Hovenkamp	32 uur	promotie-assistent (tot 01-10)
J.M. van Iperen	8 uur	laboratorium-assistente
P. Kamermans	32 uur	promotie-assistente
W.M. Keskamp	32 uur	promotie-assistent (tot 01-11)
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	electronicus
L. Moodley	32 uur	promotie-assistent
E. Okkels	32 uur	analiste
M. Bruining-du Porto	33.25 uur	bibliotheek-assistente
M. Reichert	32 uur	promotie-assistent (tot 01-12)
T. Schuhmacher	32 uur	promotie-assistent
M.M. Spel	33.25	adm. medewerkster
J.P. Mulder-Starreveld	19 uur	redactie-assistente
H.W. van der Veer	30.4	wet. onderzoeker
C. Westra	32 uur	promotie-assistent
J.T.F. Zimmerman	26.6 uur	sen. wet. onderzoeker
M. Zonnenberg	35.15	telefoniste/receptioniste
Z. Zuo	32 uur	promotie-assistente

5.9. VERSLAG VAN DE PERSONEELSVERENIGING

Op vrijdag 2 maart werd het kinderpannekoekenfeest georganiseerd. De Noord-Hollandse goochelaar Jan van Woessik met assistente verzorgde het zaalgebeuren.

Vrijdag 14 april werd een toneelavond voor Texel verzorgd door de 'Comedia de la NIOZ' met de éénauteurs 'Niemand heeft meer pijn' en 'De bijsluiters' geschreven door M.R. Wernand.

Zaterdag 15 april was er een tweede optreden van de 'Comedia de la NIOZ' en het jaarlijkse PV. feest met Disco 83 uit Schagen.

Tijdens de 5% actie in mei, van het verplegend personeel, heeft de 'Comedia de la NIOZ' het toneelstuk 'Niemand heeft meer pijn' opgevoerd in het Amsterdams Medisch Centrum (AMC) voor personeel en patiënten.

Tweejaarlijks is er de alternatieve sportdag. Op vrijdag 6 oktober werden de fietsen uit het vet gehaald en ploegde men tegen een stevige noordwester op. De saté met brood en allerlei lekkere salades maakten aan het eind van de dag alles weer goed. Winnaar van de wisseltrofee werd Pelagische systemen.

Op 5 december is Sinterklaas het NIOZ voorbij gereden.

Subsidie voor volleybal en voetbal werd verleend.

Zieke PV-leden werden wederom verblijd met een fruitmand of notenbakje.



De dames van de administratie als vertegenwoordigsters van hun afdeling op de alternatieve sportdag.
(Photo: M.R. Wernand)

