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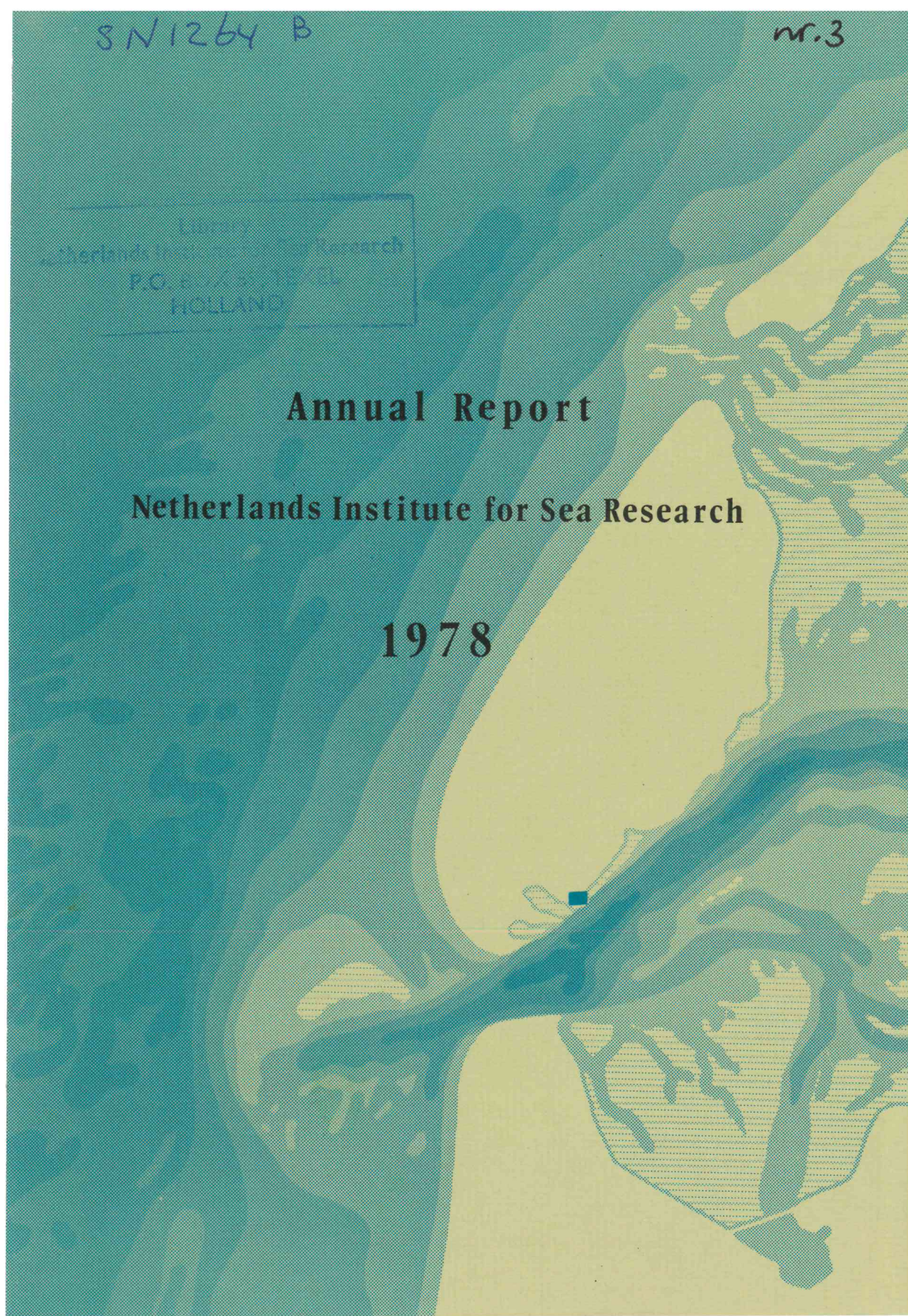
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1978



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ANNUAL REPORT

NETHERLANDS INSTITUTE FOR SEA RESEARCH

1978

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The "Griend", a wooden flat, served the Wadden Sea research from 1963 to 1978.

1. INTRODUCTION

1.1. GENERAL

The new building could for the first time be used for the whole year. A number of shortcomings still had to be repaired. Much trouble, for instance, gave the sea water supply system, but all things together the inhabitants were quite satisfied with their new environment. In December an official farewell was taken of Mr J.D. Doets, the building coordinator, and his collaborators.

Also completed was a new housing for the department for (biological) study requisites in Den Helder. The motor sloop Griend was replaced by a small iron boat with a length of 10 m that will carry the same name. It will be refurbished by our own workshops. The latter also built a number of climate rooms for biological research.

The number of personell again showed no increase, on the contrary, three vacancies could not be refilled because of economizing measures of the government. As a result the increase of personell that should have proceeded parallel with the increase in space, could not be realized. Obviously a continued stagnation also means a retardation of research development, since the optimum strength of the scientific department will be reached in later years than originally planned.

Consequently, the Institute has no lack of working space for some time to come. As in previous years, room was provided for the group studying the Eems-Dollard estuary (BOEDE) and the Department for economic ecology of the State Institute for Nature Management (RIN). At the end of the year this Department moved to the neighbouring building of the State Institute for Fishery Research (RIVO).

A report on the environmental aspects of an artificial North Sea island was completed (4.3.1.3). An investigation was started on the biological consequences of sand dredging in the Wadden Sea, supported by the Ministry of Traffic and Waterways (Rijkswaterstaat) (3.3.1).

1.2. RESEARCH

A full review of the investigations, divided in projects, which have been carried out in 1978 is given in Chapter 2. In this part only a few striking subjects will be mentioned.

Regarding physical oceanography new insights have been obtained on the relation between irregularities in tidal streams

(residual circulation patterns) and in bottom topography (2.01.1) which are of great importance for a new understanding of water movement and -mixing in the southern North Sea and the Wadden Sea. In the central and northern North Sea, where tidal currents are weaker, stratification develops in spring and summer. The location of the front between the unstratified and stratified region northwest of the island of Ameland is a subject with, besides physical, important biological and sedimentological aspects. The transition zone, of which the position depends on the northward decrease of tidal current velocity, is also reflected in a strong boundary from sandy to silty sediments at about $50^{\circ}30' N$. The relation between silt deposition and current velocities was verified in laboratory experiments (2.13.1; 4.2.17).

The turbulent southern North Sea itself has no or only temporary resting sites for fine-grained matter. This material escapes to the north, to areas as described above, or moves into adjacent estuaries such as the Wadden Sea. A good idea of transport paths, among others, of importance for problems of marine pollution, since so many polluting substances are contained in suspended matter (2.18.1; 2.18.2).

The investigation of chemical and sedimentological processes in river mouths was continued with vigour. In the mouth of the Rhine formation of gypsum particles was observed (2.02.1), a phenomenon that also seems to occur in comparable areas such as the entrance of the Zaire river (2.02.4). A better knowledge was also obtained of the behaviour of metals in the Rhine and Scheldt estuaries regarding precipitation and remobilization (2.18.2). In this connection it is also worth mentioning that in the Southern Bight the water masses of the above two rivers can be distinguished in winter by means of a different content of dissolved silica (2.06.4).

Attention was given, in the Wadden Sea as well as in the North Sea, to exchange processes between the sea floor and the overlying water. In the first area the magnitude of mineralization in the bottom is much larger than in the second (2.03.1); relatively but not absolutely, bacterial activity in the water column is in the North Sea more important than in the Wadden Sea (2.08.2). The determination of exchange rates between bottom and water turned out to be a tricky problem. This exchange is hardly ever determined mainly by molecular diffusion, but much more by bioturbation and water movement (2.05.1); moreover on a tidal flat transport through the bottom towards an adjacent creek seems possible at low tide. In cases where the salinity of the overlying water changes more or less periodically

cally, it seemed possible to measure exchange rates by means of corresponding but lagging salinity changes in the interstitial water (2.06.1).

The "ecosystem" of the Wadden Sea depends for a large part on supply of particulate organic matter from the North Sea. Supply during the spring bloom of phytoplankton appears to be of great importance (2.08.1). However, the increase of North Sea supply in recent years is not or hardly reflected in a larger secondary productivity. This indicates that food is no limiting factor for secondary producers or that the type of organic matter supplied is not suitable for this group. In this connection the observation is interesting that *Macoma*, which can take up suspended organic matter as well as bottom material, prefers the former (2.11.5). Recently, special attention is given to the chemical identification of organic matter (2.12.5).

Much research was devoted to *Arenicola*. Surprisingly, specific "nursery tidal flats" could be identified for this worm (2.12.4). At present so many observations on this animal have been collected in the field (see also 2.11.2), in the laboratory (2.16.3; 2.16.5) and in an indoor tidal flat (2.12.4), that a special number of the Journal will be devoted to this animal.

Also in the North Sea attention was given to the benthic fauna (2.11.3; 2.13.1). The most conspicuous aspect is a large spatial heterogeneity and a low density of the macrobenthos. The greatest population density is found near the coast and in the silt area north of 53°30' N mentioned above. Also zooplankton is in summer more abundant nearshore (2.09.1). The relative richness of the coastal zone may be correlated with a greater food supply by on-shore transport of organic matter, but it is also possible that this richness is promoted by better shelter.

Regarding fishes, the investigation of the role of the Wadden Sea as a "nursery" for young fish was continued. The suggested parallel with the human condition is valid as far as food and shelter is concerned, but new insights in predation and density-dependent mortality (2.14.3) cause the parallel to be less convincing. Regarding the food of flatfish, it is remarkable that it consists partly of regenerating parts of macrobenthic species, protruding out of the bottom (2.11.2).

Further, the observation is important that plaice larvae are capable to reach tidal inlets from far out of the North Sea, perpendicular to the main currents. It must also be noted that the flounder, which in the larval stage mainly enters the Wadden Sea through its westernmost inlet, subsequently moves

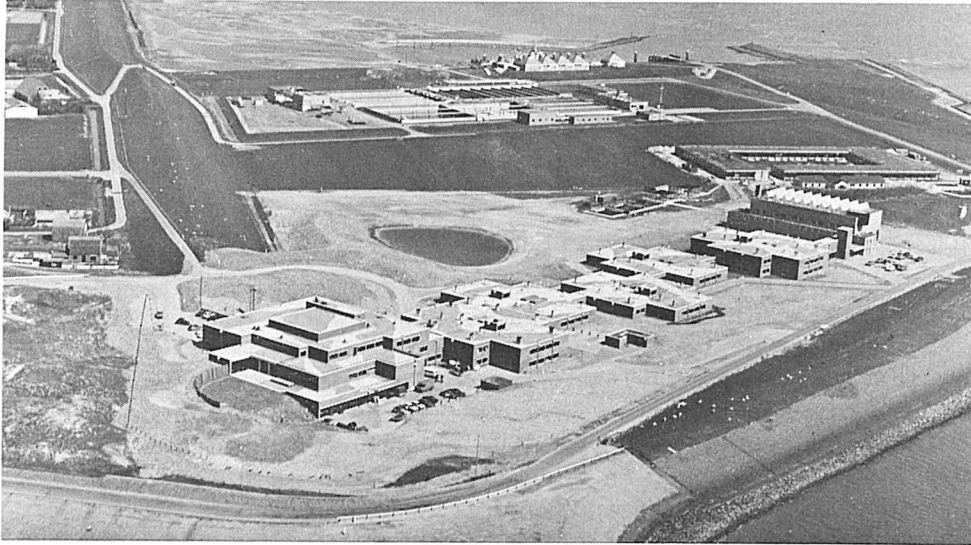
over the water sheds to tidal flat areas more to the east (2.14.5).

Regarding birds, it appeared that food shortage definitely plays a part in the small success of the growing up of eider duck chickens on the tidal flats. Experiments proved that adult guillemots catch prey fish even in dark nights, possibly by locating them in another manner than by sight (2.17.3).

Pelagic ecosystems were investigated in the North Sea (SIMPEL-SEASIM, 2.09.2) and in the Atlantic Ocean (NECTAR, 2.09.3), *i.e.* in an eutrophic and an oligotrophic region. Details are discussed in the relevant chapters of this report. From the NECTAR results an investigation on the deep chlorophyll maximum has been published (4.2.1.38). An important conclusion is that chlorophyll in higher water layers is decomposed by photo-oxidation. The same also appears to be the case for the fluorescing fractions of dissolved organic matter. The question now is whether photo-oxidation also plays a part in the North Sea and adjacent areas.

Finally, the considerations about the composition of sea water in the pre-Cambrium should be mentioned; these led to proposals for improvement of the classical RINGER physiological salt solution (2.16.3).





Following the dike of the projecting little polder 't Horntje: Ferry harbour, the new NIOZ building, the now abandoned (rectangular) "provisorium", the complex of the Mussel Experimental Station of RIVO (now RIN) and NIOZ harbour and harbour building.

2. PROJECT RESEARCH

2.01. CIRCULATION AND HEAT BALANCE OF THE SEA

2.01.1. Circulation and mixing in the North Sea and Wadden Sea

Theoretical research on nonlinear dynamics of mesoscale processes in tidal areas was continued (in cooperation with the Mathematical Centre in Amsterdam). New results give insight in the physics of vorticity transfer in quasi-two dimensional flow in tidal areas having an irregular topography. Besides residual circulation also results for the higher harmonics in the tidal frequency spectrum (the so called "shallow water tides") were obtained. As to the production mechanisms of residual circulation it appeared that its strength increases with decreasing bottom friction both for production by the Coriolis and bottom frictional torques. Not only topographic scales of the order of the tidal displacement amplitude produce a "resonance" in the vorticity transfer function but also higher harmonics of the basic topographic wavelength. The results have a connection both with shallow water tidal theory and with topographic turbulence theory. It is the latter connection which will be explored more extensively in the near future.

An investigation of three dimensional turbulence both in stratified and unstratified tidal waters by means of a laser doppler velocity meter was prepared. The instrument is now in a stage to be tested in a laboratory flume. First experiments in the sea will start in 1979. Moreover a survey of the seasonally stratified central North Sea was carried out. It appeared that fluctuations in building and breakdown of the thermocline over synoptic periods of some days to a week are more important than is generally assumed for this area.

By a further analysis of water exchange at the Balgzand tidal flat, using reactive silicate as a tracer, it was estimated that the flushing time of this area is of the order of 1 to 2 days. Flushing seems to be strongly promoted by a residual circulation over the tidal flat.

Finally, at the request of UNESCO, an estimation of seasonal fluctuations in the flushing of tidal basins was produced. A preliminary analysis shows that long waves, like storm surges, superposed upon the tide can appreciably decrease the flushing time scale of the basin. The intensity of surges is, of course, seasonally varying.

2.01.2. Heat balance of the Wadden Sea

A first test of an acoustic turbulent wind velocity meter (financed by Z.W.O.) was performed at the island of Schiermonnikoog. Results agree pretty well with those obtained by other techniques of measurement.

A start was made to develop a statistical climate model of a tidal flat sea, incorporating stochastic fluctuations due to variable weather conditions. Such a model is particularly relevant for estimating the signal to noise ratio of typical tide-radiation interaction signals in the tidal flat environments.

2.02. SEDIMENTS AND SEDIMENT TRANSPORT

2.02.1. Sediment transport in the North Sea

From particle size determinations in the southern North Sea and the Channel in 1976-1977 it appeared that especially in coastal waters particles of 0.5 to 2.0 μm are relatively numerous. Also in the Rhine estuary (Waterweg) many of such particles were found. Therefore, mixing experiments were carried out, mixing river water with aliquots of sea water, filtered over a 0.2 μm Nuclepore filter. After mixing with only a small amount of sea water a large number of particles of 1 to 2 μm already appeared to be present. After separating the size fraction $> 5 \mu\text{m}$ of river water and of the mixtures off with a centrifuge, the particles of 1 to 2 μm were examined under an electronmicroscope and with an EDAX microprobe. The newly formed particles were found to contain high concentrations of Ca and S and presumably are a form of gypsum. The experiments will be repeated in January 1979.

In July a number of boxcore samples were collected in the Skagerrak and the Kattegat for determination of sedimentation rate with C-14 and Pb-210. Also total suspended matter content and suspended particle size were measured along three profiles and the results compared with those obtained between Shetland and Norway, in the Southern Bight and in the Channel. In September a sampling cruise was made in the southern North Sea in collaboration with the State Water Board and the State Geological Survey, but the weather was very rough and only a few samples could be taken. The determination of sedimentation rate is being carried out in collaboration with E.D. Goldberg (Scripps), H. Erlenkeuser (Kiel) and W. Salomons (Haren, Groningen).

The results of the work carried out on a centrifuge method for the separation of clayminerals are being summarized in a paper. The results on mollusc faunas in the Southern Bight are to be published in two papers together with W.G. Mook and G. Spaijk.

2.02.2. Sedimentology northern North Sea

Because of the Angola Basin project (2.02.4) no work was carried out on this project in 1978.

2.02.3. Sedimentology Norwegian Channel and Skagerrak

In July a number of 6 m long piston cores were taken in the Skagerrak. Further north no cores could be taken because of bad weather circumstances. The samples taken previously as well as the surface samples obtained in 1978 were studied and analysed for grain size and other granulometric parameters, as well as content of organic carbon and carbonate. Mineralogical analysis of part of the material was done also. Based on the available seismic sections a map was prepared of the thickness of the Quaternary sediments in the Skagerrak and also partly of the Norwegian Channel. This map was compared with data known from acoustical reflector profiles in order to investigate the transport pattern of post-glacial and recent sediments. The combined results of seismic, acoustic and sample analysis investigations were presented at a number of meetings in Scotland and Norway.

2.02.4. Sedimentology Central Atlantic Ocean (Angola Basin)

In April-May a second cruise was carried out in the Zaire estuary and the Angola Basin, this time with the M.V. TYRO, fitted out with containers and winches. Scientists from the United States, Norway, Zaire and France participated in this cruise.

For an investigation of sedimentological and paleo-oceanographic processes in the Zaire submarine canyon and fan and in the Angola Basin 26 pistoncores of up to 11 m length were collected. A number of cores were opened on board, described and X-rayed with a Faxitron apparatus. Also a series of smear slides was made. After a first sedimentological investigation a number of specialists from outside the NIOZ will collaborate in this projects: with the State University of Utrecht for the

study of the calcareous fauna, with the Geological Institute of Bergen University (Norway) and the Danish Geological Survey (Kopenhagen) for radiolarians and diatoms, with the Royal Institute for Central Africa in Tervuren (Belgium) for pollen, with the Institute for Soil Fertility (Haren, Groningen) for trace metals, with the Marine Geological Laboratory of Göteborg University (Sweden) for C-14 dating and the stable oxygen and carbon isotopes, and with the Paleomagnetic Laboratory of Utrecht University for paleomagnetism.

The shallow seismic profiling that preceded the coring program was only partly successful due to a not optimal functioning of the apparatus and a defect in the towing fish. The conclusion is that adapting shallow-water apparatus to deep water conditions is not the right approach and that for deep ocean work well-established deep-water systems should be used.

As part of this project, research was carried out during one week, in collaboration with the Geological Department of the University of Brazzaville, on the continental shelf of the Congo People's Republic and on the southern part of the continental shelf of Gabon. For this purpose seismic profiling apparatus and cores as well as three people were transferred to the R.V. NIZÉRY, belonging to the ORSTOM at Pointe Noire.

Samples for total suspended matter and particle size were collected in the Zaire river and estuary and the Angola Basin down to more than 5000 m in combination with nephelometer profiles. For electronmicroscopy of the suspended particles a series of samples was prepared. Also mixing experiments were carried out with river water and filtered seawater to investigate whether in the Zaire estuary particles were formed, as has been found in the Rhine estuary (2.02.1).

For the research on nutrients in the Zaire river and estuary and in the adjacent ocean, see project 2.06.5.

The material and data collected in 1976 as well as the results, are being prepared for publication in the Netherlands Journal of Sea Research, together with part of the results of 1978 (see at 4.2.1 the numbers 2, 3, 11, 26 and 28).

The Zaire research program led the CNEXO (Paris) to ask the collaboration of the NIOZ for a future research project in the Ganges river mouth and the Bay of Bengal. With the same background D. Eisma visited India for two weeks at the invitation of the Physical Research Laboratory at Ahmedabad to carry out a research program in the Godavari river mouth.

2.02.5. Sedimentation on the Cape Verde Rise

The investigation of cores collected on the Cape Verde Rise was concluded and a publication on sedimentation rates has meanwhile been published (4.2.1.29). The determination of the Th-isotopic ratios is not yet completed.

2.02.6. Paleomagnetic dating

The results of a study of the litterature have been summarized in a report. On the basis of the report and in collaboration with the Paleomagnetic Laboratory of Utrecht University an application for a research grant was submitted to the Netherlands Organization for Pure Research (ZWO) for paleomagnetic research on deepsea cores from the Angola Basin, in combination with some fundamental research on the magnetization processes in deepsea deposits.

2.03. MINERALIZATION IN THE SEDIMENT, SULPHUR CYCLE

2.03.1. Energetical and ecological aspects of microbial activities in sediment

By way of measurements of electron transport system (ETS) activities in different sediments from a large indoor artificial tidal system (2.12.4), from the Dutch Wadden Sea and from the North Sea, an impression is obtained of the relative mineralization velocities. As was expected the activity of the sediment of the Dutch Wadden Sea is higher than the activity of North Sea sediment. ETS-activity was correlated with ATP (biomass); a high correlation was found. Energy charge calculations could not be made because of difficulties in the measurements of AMP in the sediment.

In a cooperation with Dr Billen (Brussels) was shown that nitrate had an effect on a continuous culture of *Desulfovibrio*, but nitrate was not reduced. A trial to isolate a nitrate reducing sulphate reducing bacterium was not successful.

In the artificial tidal system (2.12.5) the effect of bioturbation on mineralization is studied.

2.03.2. Sulphide oxidation, ecological and metabolic aspects

Between *Thiobacillus denitrificans* and *Thiomicrospira denitrificans* a number of competition experiments were performed

by adding various energy sources or by limiting different factors. Up till now it appeared that *Thiobacillus denitrificans* was always the winning species. Further research has to be done to determine the conditions under which *Thiomicrospira* will be successful in this competition.

2.04. MINERALIZATION IN THE WATER COLUMN

2.04.1. Ecological aspects of heterotrophic bacteria

During the NECTAR expedition of 1977 it appeared that mineralization measured by the ETS method showed a good correlation with primary production in the open ocean. Highest activity was found on the μ -filters. By using more selective polycarbonate filters, bacterial C could be measured by CPS determinations and by fluorescence techniques.

2.04.2. Redox-reactions of inorganic nitrogen compounds

In 1978 the experiments with continuous culture systems of NH_4^+ -oxidizing chemoautotrophic bacteria (*Notrosomonas*) was continued. Also a chemoautotrophic NO_2^- oxidizer (*Nitrobacter*) was isolated from water and sediment of the Eems-Dollard estuary. From both species the Michaelis-Menten kinetics were studied. The effects of abiotic factors like salinity, temperature and oxygen on growth were studied in chemostats as well as in batch cultures.

A start was made with field activity measurements of nitrifying bacteria by means of N^{15} -addition techniques.

In cooperation with projects 2.05.1 and 2.03.2 the number of nitrifying bacteria, as well as the number of denitrifying bacteria, as a function of depth in estuarine sediments, was studied. Discussions about the project with microbiologists of the University of Groningen took place regularly.

2.05. EXCHANGE OF NUTRIENTS BETWEEN BOTTOM AND OVERLYING WATER

2.05.1. Exchange of nitrogen and phosphorus between sediment and water in the southern North Sea

This project was set up to determine to what extent the nutrient budget of the Southern Bight of the North Sea is influenced by mineralization of organic matter in the sea bottom.

For practical reasons, the fieldwork this year was done in

a shallow subtidal region of the Wadden Sea that resembled the situation at the bottom of the southern North Sea as closely as possible. Changes with time of pore water nutrient concentrations were recorded. From concentration increases in sediment cores in which the exchange with overlying water had been minimized, mineralization rates could be estimated.

In cooperation with projects 2.03.2 and 2.04.2 the numbers of nitrifying and of denitrifying bacteria in the sediment were determined. This resulted in the following picture: In the topmost 10 cm bacterial activity is high. Nevertheless, the nutrient concentrations in this layer are very low due as a result of an intensive exchange with the overlying water. Between 10 and 20 cm depth, bacterial activity is lower. Nutrient concentrations are highly variable which may in part be caused by the varying wave action. Below 20 cm depth, the situation is rather stable. Turnover rates are low, as is the influence of currents and wave action.

The methods and concepts that have been developed in the Wadden Sea area, will now have to be applied in the North Sea.

In cooperation with project 2.15.5 the mineralization in the bottom of photosynthetically formed organic material is studied in an indoor tidal mud-flat ecosystem.

2.06. DISTRIBUTION OF NUTRIENTS IN THE SEA

2.06.1. Wadden Sea chemistry

The investigation of chemical components in the Wadden Sea aimed at the study of concentration changes by organic production and mineralization. Work on fluorescence and salinity of interstitial water of the Balgzand and other intertidal areas was continued. Parts of this study carried out by students were published as internal reports, who partly appeared in 1978 (4.3.1.14).

A cooperative investigation with Rijkswaterstaat, Hoorn, of the Balgzand (2.06.4) was also published as an internal report (4.3.1.2).

2.06.2. Nitrogen compounds in the Dutch Wadden Sea

No cruises took place; results are studied.

2.06.3. Nutrients in the southern North Sea

In cooperation with 2.06.4 another winter picture of nutrient

concentrations in the Southern Bight and the Scheldt, Rhine and Meuse estuaries was obtained. The aim of the winter cruises in this region are twofold. They contribute to a year around nutrient distribution in the Straits of Dover and to a winter long-term trend in Dutch coastal waters to be related in the future with the ever increasing eutrophication of our large rivers.

2.06.4. The marine silica cycle

Dissolved silica was used as a tracer to discern between waters from the Scheldt and the Rhine in the region where the river plumes overlap. The dissolved silica concentration in the Scheldt is twice as high as in the Rhine, but only in January the effect of diatom growth is sufficiently small to use the differences in a quantitative way up to the high salinities in the offshore overlap region. Comparison of winter cruises from 6 different years shows that the fresh water fraction of the sea water in the mouth of the western Scheldt contains from 10 to 50% water from the Rhine, the variation being mainly determined by the wind direction. Processing of all dissolved silica data obtained in the North Sea will be continued in 1979.

The tidal cycle of dissolved silica is quite stationary within the measuring period of the "project Balgzand" (see 2.06.1. and the figure on page 57). Other nutrients gave, to a slightly lesser extent, also a stationary picture. A preliminary summary of the results was published (4.3.1.2). Comparison with other data (mainly from student courses) showed that the Balgzand tidal flats are a very important source of dissolved silica for the diatom population of the western Wadden Sea.

In the upwelling region near Cap Blanc (Mauretania) a negative correlation between diatoms and dissolved aluminium was found. Diatoms collected from this region were examined by Dr Sawatzky with the ESCA apparatus at Groningen University and appeared to contain appreciable amounts of Al in the surface layers. These results, giving some weight to the possible part Al plays in the formation of the diatom frustules, were posterred during the "5th International Symposium on living and fossil diatoms" at Antwerp.

In the Zaire estuary, dissolved Al was produced during estuarine mixing; this contrasts with observations in other estuaries (4.2.1.3).

2.06.5. Nutrients and primary production in the Gulf of Guinee and the influence of the rivers Niger and Zaire

During the second "Zaire cruise" (2.02.4) investigations into the hydrographic, chemical and biological phenomena were carried out in the Zaire estuary. The situation was—in a different season—largely the same as during the 1976 cruise: Initial rapid mixing of river water and ocean water from around 30 m depth increased the nutrient concentrations in the plume waters relative to river water. Moreover phosphate was desorbed or dissolved from river-borne particulate material. In 1978 also coastal upwelling contributed to this increase. Effects of phytoplankton growth on the concentrations of nutrients (especially nitrate) were only detected far offshore.

The deeper layers of the inner Zaire canyon were again anoxic. In this zone oxidation of organic matter to nitrate is inhibited and nitrite accumulates, in 1978 only faint indications for reduction of nitrate were found. Phosphate is precipitated, possibly onto iron-coated quartz grains, while reactive silicate and especially ammonia increased markedly. Results for the 1976 and 1978 cruises were published simultaneously in one paper (4.2.1.11).

2.06.6. Nutrient distributions, stratification and biomass in the North Equatorial Current

Analysis of the vertical sections at 20° N, from the NECTAR 77 expedition, showed the region to be an encounter for North and South Atlantic Waters. Some sort of open ocean upwelling was found at 23° W, possibly at the western edge of the Canary Counter Current. This was mainly South Atlantic Water, containing high nutrient- and low oxygen concentrations.

Determinations of carbon, nitrogen and phosphorus in plankton samples have been completed. Oxygen concentrations are above 100% of the saturation value, showing an important flux to the atmosphere.

After much experimentation a high precision Winkler titrator with optical endpoint determination was built and calibrations performed. Precisions better than 0.1% were routinely obtained. A motor-microburet with digital volume reading was built for this titrator.

2.07. MARINE OPTICS

Measurements of photosynthetically available radiation (PAR) and daily irradiation as functions of depths performed in 1977 in tropical North Atlantic (NECTAR 2.09.3) were repeated in 1978 by means of the improved photon scalar irradiance meter. Also, measurements of the spectral irradiance were performed during NECTAR 1978 by means of a newly developed instrument. This instrument enables direct determination of the spectral scalar and vector irradiance at different depths. Hence the absorption spectra *in situ* can be computed. Investigations on the relationship between the underwater irradiance and absorption spectra and primary productivity, composition and concentration of suspended particles, and other oceanographic parameters are in progress. Preliminary results indicate differences in the composition of the suspended algal particles particularly in the stations in the Atlantic Ocean where vertical stratification of the water column appeared. To a possible chromatic adaptation of the photoplankton populations was concluded.

Preparations for a research program on "optics of the Dutch coastal waters" were made. In contrast with the open ocean, the light propagation in the turbid coastal waters is mainly determined by the distribution of organic and inorganic particles. Because of the substantial variations of the particulate content of the sea water in space and time, variations in the underwater light field can be expected as well as a relation between both effects.

2.08. PHYTOPLANKTON AND PRIMARY PRODUCTION

2.08.1. Production and input of organic matter in the Wadden Sea

Primary production of microphytobenthos on a tidal flat near the Institute amounted this year to $160 \text{ g C} \cdot \text{m}^{-2} \cdot \text{yr}^{-1}$ *i.e.* about 1.5 times the ten years average value for this locality. The phytoplankton and chlorophyll sampling program in the Marsdiep tidal inlet area was extended to include organic carbon measurements (particulate, dissolved and total organic). The Total Carbon System we have in use works satisfactory: POC plus DOC values are generally the same as TOC values measured independently. However variation between duplicates remains high, which makes sampling at least in quadruplo necessary.

During the phytoplankton spring bloom POC increased from 1 to 6 mg C·l⁻¹ and DOC from 1.5 to 4.5 mg C·l⁻¹. POC increased from about 3% of suspended matter to 24%.

The phytoplankton spring bloom coincided with the period of increase of organic carbon content of tidal flat sediments observed earlier. This suggests that import of organic matter from the North Sea might show a seasonal variation with a peak during the phytoplankton spring bloom. The phytoplankton spring bloom varies in length and height from year to year, this may influence the annual amount of organic matter imported from the North Sea to the Wadden Sea.

2.08.2. Primary production in the southern North Sea

In the Southern Bight of the North Sea primary production may occasionally be very high, especially in the eastern part. Not all of this newly-produced algal matter is grazed away by copepods: the diversity of breakdown products of phytoplankton pigments signifies that other heterotrophs, such as bacteria and protozoa, may be major consumers of the algal crop.

The large number of chlorophyll surveys in the southern North Sea made during the last decade justified the production of an animated film showing the changes in phytoplankton distribution in the course of a year. The wax and wane of large patches is visualized very well in this film.

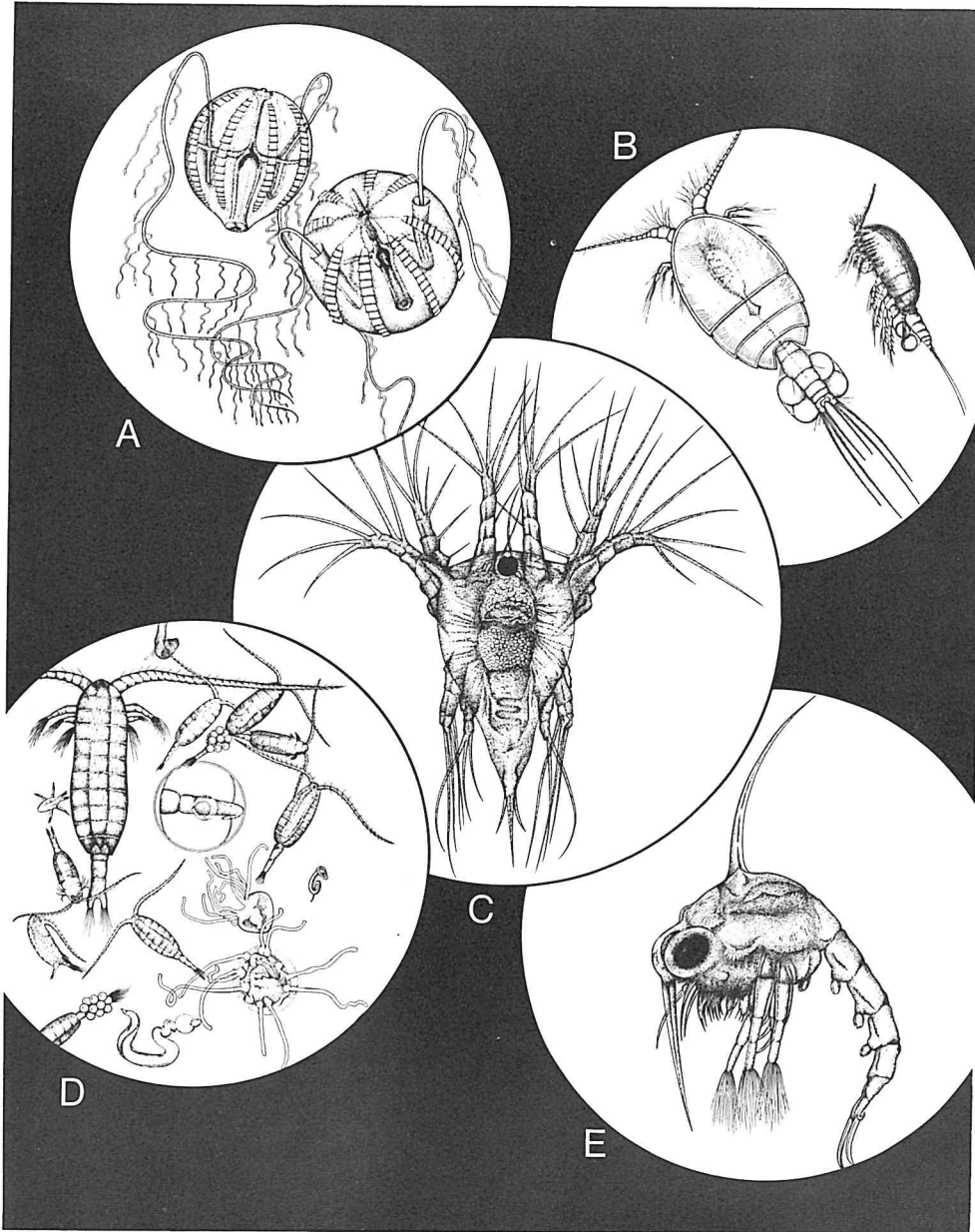
2.08.3. Primary production in the ocean

The chapter "Primary production in the aquatic environment" in the review "The global carbon cycle" was finished. The book will appear in the spring of 1979.

2.09. ZOOPLANKTON AND SECONDARY PRODUCTION

2.09.1. Population dynamics and production of zooplankton in the Wadden Sea and the North Sea

As in 1973, during June-July 1977 the 4 dominant herbivorous copepods (about 70% of the total herbivore biomass) were 6× more abundant in a 30 km wide zone along the Dutch North Sea shore than in more offshore waters. However, a summer decline of the copepod populations was not observed. Neither a near-shore peak density of fish larvae occurred. These larvae, mainly of sprat, were found in low densities (up to 2·m⁻³) in the entire area between the 35‰ salinity isopleth and the



Zooplankton of the North Sea (2.09.1): A *Pleurobrachia pileus*, B *Pseudocalanus elongatus*, C nauplius larva of *Balanus*, D a.o. *Calanus finmarchicus*, E zoea larva of *Carcinus maenas*.

coast. Relatively high densities of the hydromedusa *Phialidium hemisphaericum* (up to $154 \cdot \text{m}^{-3}$), the ctenophore *Beroe gracilis* (up to $6 \cdot \text{m}^{-3}$) and the scyphomedusae *Aurelia aurita* and *Cyanea lamarckii* (up to $2 \cdot 1000 \text{ m}^{-3}$) were found. The dialy copepod production was estimated to be $9133 \mu\text{g} \cdot \text{m}^{-3}$ near-shore and $1367 \mu\text{g} \cdot \text{m}^{-3}$ offshore. The dialy consumption by predators was about 2500 and $1250 \mu\text{g} \cdot \text{m}^{-3}$ respectively which appeared to be too low to cause a summer decline of the copepod populations. Food relationships between medusae, fish larvae, copepods and phytoplankton determine the productivity of the coastal area. Because the food web shows important annual quantitative fluctuations, it will be investigated again during 6 weeks in the summer of 1979.

At the Fladen Grounds in the northern North Sea, the copepod *Calanus finmarchicus* is predominant (up to 90% of the total zooplankton biomass). During the phytoplankton spring bloom in April-May 1976 the species was present in the upper 40 m, where it produced many eggs and faecal pellets. In June, after the bloom, the *Calanus* population had increased in biomass but it had descended to depths below the euphotic zone from 50 m to the bottom at 120 to 150 m. Eggs and excrements were much less abundant than during the spring bloom. The estimated daily secondary production during the bloom was $20 \text{ mg C} \cdot \text{m}^{-2}$. The grazing level seemed much too low to cause the termination of phytoplankton bloom.

2.09.2. Analysis of the pelagic system of the southern North Sea

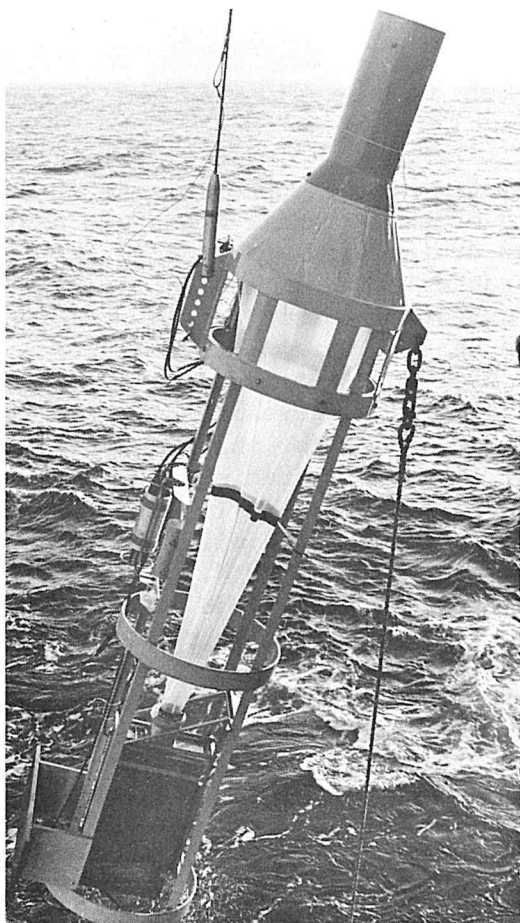
The model SIMPEL for simulation of the dynamics in a vertically mixed coastal area was defined in the language CSMP. It is now ready for use at the Agricultural University Computer Centre at Wageningen. The plankton and predator submodels are revised in virtue of newly available information and other models recently published. It is intended to extend the model from a mere concept to a mechanistic representation of the real system, which is based on factual knowledge. The model, renamed SEASIM (season simulator) will be used to schematize the system behaviour, to pinpoint the properties of the communities of living organisms responsible for stability and continuity, and to define the essential differences between the investigated ecosystems.

2.09.3. Plankton research in the stratified ocean (NECTAR)

Investigation on the ecosystem of the euphotic zone in a permanently stratified region of the Atlantic Ocean was continued during a second NECTAR cruise with HMS Tydeman in November-December 1978. The characteristics of the photic zone along a transect in the North Equatorial Current at 20° N between 18° and 40° W as determined in 1977 were confirmed during NECTAR 1978: (a) relatively high nutrient concentrations near Cap Blanc resulting from upwelling, decrease westwards to practically zero in the mixed layer, (b) sharp decline in biomass from east to west, (c) at all stations highest biological activities occur in the mixed layer, (d) a deep chlorophyll maximum at depths of 40 to 60 m 200 miles from the coast, gradually deepens till 110 to 150 m at 40° W.

More ship time as compared with 1977 made it possible to extend the sampling at the 6 stations (drift stations) to 2 days each. As a result more attention could be paid to 24 h cycles in biological, chemical and physical parameters and potentially from this rates of biological process may be estimated. To avoid the horizontal heterogeneity in the field additional 24 h observations were performed in deck enclosures (1 m^3), comprising O_2 , POC, chlorophyll, ETS and ATP measurements, among others. The *in situ* experiments, with bottles of different sizes at platforms under drift buoys at different depths, were greatly extended, involving determinations of primary production, photo-oxidation of chlorophyll, bacterioplankton and particle dynamics. An enlarged Dutch Gulf III, equipped with a main $50 \mu\text{m}$ net, was used for bulk sampling of zooplankton for both taxonomical examinations and chemical analysis, while detailed vertical profiles were obtained with a Gulf V supplied with a deck-controlled Longhurst-Hardy Plankton Recorder. Filtration over $8 \mu\text{m}$ gauze of 30 l water samples from the rosette sampler produced microzooplankton profiles in addition. Larger nekton samples were obtained with a coarser Isaacs-Kidd net (IKMT).

Higher swells as compared with 1977 and a changed ship behaviour after rebuilding of the stern confronted the NECTAR 1978 expedition with a lot of technical misfortunes, but most of the programme could be executed due to the presence of enough spare equipment. It can already be stated that important results are achieved with measurements concerning spectral irradiance and absorption (*cf.* 2.07). Experiments concerning photo-oxidation of chlorophyll seem to confirm the



NECTAR (2.09.3). Plankton recorder, macro-plankton catch and inspection of the spectral irradiance meter.

hypothesis developed from preliminary thin-layer chromatography in 1977, that, at least in this region of the Atlantic, the occurrence of the deep chlorophyll maximum can mainly be attributed to non-bleaching at low light levels. The layer does not display a detectable primary production and consists for a great part of derivatives of chlorophyll and, therefore can better be called a deep pigment layer as was done in a publication concerning this topic (4.2.1.38). No indications for higher concentrations of micro- and macrozooplankton in this layer seem to strengthen this opinion.

Oxygen determinations, carried out on board with a new titration technique (*cf.* 2.06.6), reached sufficient accuracy to detect minor concentration changes in these oligotrophic waters due to biological day-night rhythms. The observations in the deck containers reached different developments in a number of parameters as compared with the field, this already after the first 12 hours, which make the use of far smaller volumes for ^{14}C incubations very questionable. Moreover, larger bottles (4 l) and shorter (successive) incubation periods (2 l) as usually recommended, generated primary production values one order of magnitude higher as current figures for oligotrophic areas.

The research concerning concentrations of heavy metals in the open ocean was extended to chromium due to the participation of Dr C.H. van der Weyden (Geochemical Laboratory, Utrecht). Perfection of sample technique did lower the values found for lead and zinc as compared with NECTAR 1977 (*cf.* 2.18.2).

2.10. ZOOPLANKTON, INTERACTIONS AND BEHAVIOUR

2.10.1. Experimental investigation on zooplankton

This project aims to explain variations in development, growth and mortality of quantitatively important copepod species (project 2.09.1) by experiments in the laboratory.

It appears from the literature that rearing of marine copepods is not easy. Most experimental work with copepods is done under circumstances far from optimal for the individuals and fatal for the population. The investigation started with a search for rearing conditions good enough to raise copepods from one generation to the next and so continued for many generations. Thereafter it will be tried to evaluate the effects of variations in temperature, salinity, food *etc.* on development, growth, survival and reproduction.

According to this scheme successful experiments have been performed with *Acartia clausi* during one year. Ten successive generations were reared, and the growth and generation time were studied under constant conditions.

Two species of algae are cultured in continuous cultures as food for the copepods. Still attention has to be paid to the infection with several species of dinoflagellates in the experimental tanks. The role of these organisms as food for the copepods and as "grazer" of the other algae is not yet clear.

Automation of the food supply of the copepods with a turbidostat has been planned. Application of quantitative techniques for counting and measuring both algae and copepods will also be necessary in the future.

2.11. BENTHOS, DISTRIBUTION AND SECONDARY PRODUCTION

2.11.1. Secondary production and population dynamics of macrobenthic animals living in the Dutch Wadden Sea and adjacent parts of the North Sea

Annual sampling of bivalves and other macrobenthic species was continued on the tidal flats of Balgzand and subtidally in the North Sea near the islands of Texel and Terschelling. Both changes in numerical densities and in growth rates are being measured for a number of species that contribute significantly to zoobenthic biomass in order to estimate their production (both in organic matter and shell lime) and to explain annual and local variability.

Evaluating the past 10 years period of intensive sampling the benthos on Balgzand, the fruitfulness of the chosen long-term design is emerging. Two examples are presented as an explanation.

a. Results of the uninterrupted series of frequently repeated samplings on Balgzand proved to be essential for an explanation of some changes observed in the composition of the macrobenthic fauna on tidal flats in other parts of the Wadden Sea, surveyed with much longer intervals (publication: 4.2.1.6).

b. Working up the data on numerical densities of *Macoma balthica* obtained at 15 sampling stations during 10 years, yielded significant differences in annual survival both from place to place as from year to year. Survival on the tidal flats increased with increasing distance from the coast (going together with increasing daily periods of immersion). Conse-

quently, the annual migration of almost 1 year old *Macoma* from the coastal breeding areas to areas situated more offshore favours their longevity. Annual differences in survival appear to be related positively to the highly variable densities of cockles (*Cerastoderma edule*). An explanation may be that the numerous oyster-catchers (*Haematopus ostralegus*) switch to *Macoma* when *Cerastoderma* (their favorite prey) are scarce.

Participation is planned in a long-lasting European research Project on benthic coastal ecology. Such cooperative research is needed to determine the effects of broad-scale operating climatic and hydrographic factors in order to separate such effects from those of short term and local phenomena like pollution.

2.11.2. Secondary production by macrobenthic animals in the Wadden Sea by means of regeneration

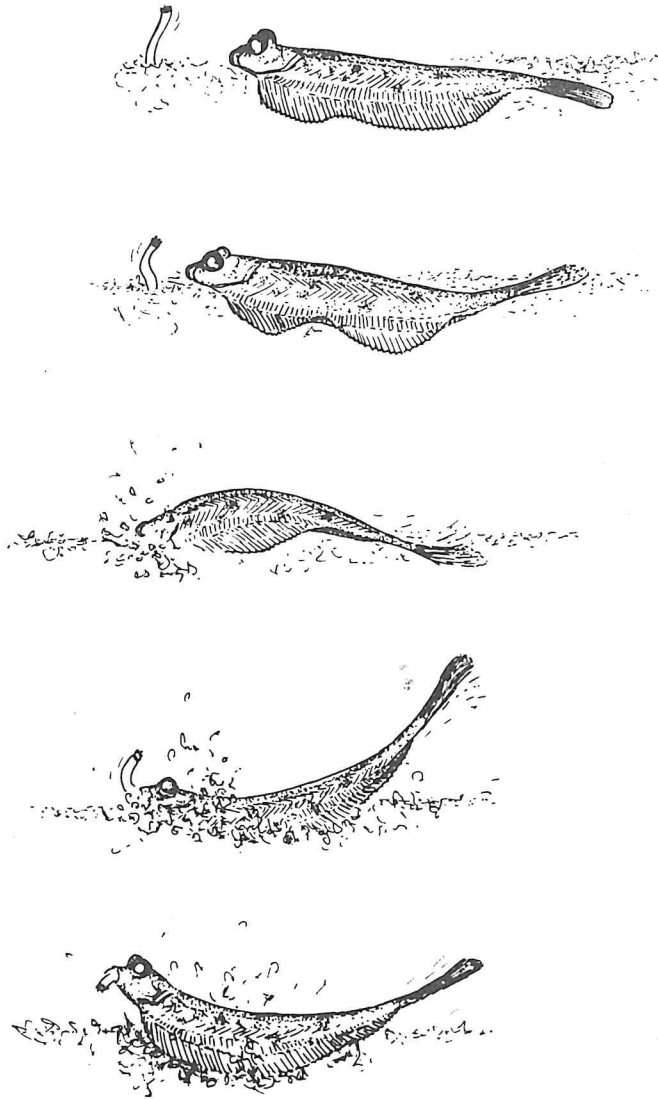
This project started in 1975 and was concluded in 1978. The investigations were supported by the Foundation for Fundamental Biological Research (BION), which is subsidized by the Netherlands Organization of Pure Research (ZWO).

In 1978, the stomach contents of the flatfishes caught at Balgzand in 1975 and 1976 have been analysed, and other results of the preceding years have been worked out.

Both in 1975 and in 1976 the annual consumption by flatfish in the whole area investigated was about $6 \text{ g} \cdot \text{m}^{-2}$ (ash-free dry weight). In 1976, about $2.1 \text{ g} \cdot \text{m}^{-2}$ of this food intake was found to consist of regenerating parts of benthic animals: siphons of *Cerastoderma edule*, *Macoma balthica*, *Mya aerenaria* and *Scrobicularia plana*, tail tips of *Arenicola marina* and *Heteromastus filiformis*, heads and tentacles of spionid Polychaetes.

Of these parts, tail tips of *Arenicola* alone represented about $1.3 \text{ g} \cdot \text{m}^{-2}$. This equals an annual cropping on average of about 240 tail segments per m^2 , 12 segments per worm and 10 to 15% of the weight of the *Arenicola* population. There was a good agreement with the independent results of the sampling programme of the *Arenicola* population and experiments with *Arenicola* on Balgzand as well as with laboratory experiments on the effects of this cropping on weight and number of tail segments. Within some weeks after amputation of 3 to 5 tail segments, *Arenicola* restores the balance between the weights of body and tail. During this period the growth of the body is retarded.

Siphon tips of *Macoma* were cropped by O- and I-group plaice,



Predation of young plaice on regenerating parts of benthic animals (2.11.2). When a juvenile plaice discovers a siphon, it (1) swims nearer by short jerks, (2) rushes forward, (3) makes a dart for the siphon under the sand, (4) tears it off, and (5) swallows the end bitten off.

and to a lesser extend by I-group flounder. Siphon nibbling took place mainly during April, May and June. During this period siphons of *Macoma* were the main food of the just settled O-group plaice. Among the diet of I-group plaice siphon tips played a moderate role. As, however, total food intake of the I-group is much more than in O-group, both age groups consumed about the same quantities of siphon tips. The total annual consumption of *Macoma* siphons amounted to $105 \text{ mg} \cdot \text{m}^{-2}$. This is only 3% of the weight of the soft parts of the *Macoma* population. In laboratory studies, *Macoma* restored its siphon weight after amputation within a few days. This accounts for the observed absence of clear effects on weights of *Macoma* and their siphons in the field populations.

The results of this study will be published in 1979 (4.2. 1.56) and 1980.

2.11.3. Bottom fauna of the southern North Sea

Both surveys (performed in 1976 and 1977) of the bottom fauna of the Southern Bight between Hoek van Holland and Den Helder agree very well in results. Numerical densities were lower in winter than in the preceding autumn. Striking is the high heterogeneity in distributions at a low average standing stock. Bivalves predominate the biomass, followed by the polychaetes.

Growth rates and fluctuations in density are measured for species high in biomass and not too difficult for age determination. This is done on a few fixed stations. Acceptable results were obtained in *Spisula subtruncata* and *Macoma balthica* and specially in the short-living species *Abra alba* and *Pectinaria koreni* that in the summers of 1976 and 1978 showed large waves in the presence of brood at the coastal station, possibly correlated with high silt contents in the upper sediment layer in this area.

As the growth rates did not differ so much from year to year production was largely determined by the success of spat-fall.

The extensive material is worked out now after the field work was closed off.

2.11.4. Meiofauna

Linking on the sampling of meiofauna on the Balgzand tidal flat in 1976 and 1977, a new sampling schedule is started in April 1978 for one year. Since a difference in quantities of nematods could not be proved in the previous year, a more frequent sam-

pling schedule on only one station was performed. An easily recognizable nematod, *Theristus setosus*, was chosen to follow the fluctuations of one species in time. Beyond this numbers per sample per species or per group of animals was determined, just as was done for the biomass of the nematods.

2.11.5. Food uptake and growth rate of *Macoma balthica* in the Wadden Sea

To unravel relationships between primary and secondary production it is necessary to know how much and what kind of food is consumed by secondary producers. In the Wadden Sea, the potential food consists of algae, micro-organisms and organic debris. Specimens of the bivalve *Macoma balthica* obtain their food either from the overlying water by suspension feeding or from the bottom surface by means of deposit feeding.

The chlorophyll a quantity in the stomach is taken as a measure of the food quantity consumed. At the same time chlorophyll a was measured hourly during a whole tidal cycle by means of a Turner fluorometer. These measurements have been made during all seasons on several places with different depths within the tidal zone.

Macoma ingested food during the periods of submersion. By preventing food intake in part of the animals, it was shown that digestion too reached its maximum rate during the submersion periods.

The chlorophyll a content of the stomach was observed to be positively correlated with the chlorophyll a concentration of the overlying water, but not with that on the bottom.

These results suggest that *Macoma* is primarily filtering its food from the water column. Also the qualitative composition of the stomach content, which generally resembles the composition of the water better than that of the bottom deposit, points to the same conclusion.

The investigations were supported by the Foundation for Fundamental Biological Research (BION) which is subsidized by the Netherlands Organization for the Advancement of Pure Research (ZWO).

2.12. EXPERIMENTAL WORK IN RELATION TO THE SECONDARY PRODUCTION OF THE BENTHOS

2.12.1. Feeding mechanism of Lamellibranchiates

No work was done on this subject in 1978.

2.12.2. Bioenergetics in benthic organisms

In mature females of the lugworm, *Arenicola marina*, spawning could be induced in the laboratory and egg masses quantitatively collected. Males were dissected to collect the coelomic fluid containing the spermadisci. In this way the amount of energy loss by liberation of sexual products in both males and females was estimated; this loss represented about 20 to 30% of the body weight.

In the brown shrimp, *Crangon crangon*, oxygen consumption was measured in a wide temperature range and in relation to body size. Moreover, attention was paid to diurnal activity rhythms.

2.12.3. *In situ* oxygen consumption by benthic communities

Measurements were carried out in a transparent bell-jar in which the enclosed water was recirculated. In this way the oxygen content drops during the night but raises again during the day by primary production. Hence long measuring series could be obtained. In the indoor tidal mud-flat ecosystems (2.12.4) lower organisms, bacteria and probably also meiofauna, account for the larger part of the oxygen consumption.

The effect of bioturbation by *Arenicola* and other endofauna elements on oxygen production and consumption in the benthic community could not yet be evaluated properly. Sometimes elevated demands or a lowered production were found, but also the reverse occurred. Probably the initial phytobiomass and the physiological status of the algae are important in this respect. The investigations will be continued.

2.12.4. Indoor tidal mud-flat ecosystems

In this project members from various other NIOZ working groups participated. The aim is research on long term process, chemical and biological as well. In one of two largely controlled indoor (meso) systems the development of the ecosystem is followed continuously, now for a period of 3½ years. Notwithstanding large variations occurring in the wax and wane of microniches, it was found that the system as a whole shows a remarkable stability. Characterization of the organic matter by means of pyrolyses mass spectrometry showed in the deeper sediment layers absence of easily metabolisable compounds and thus the whole system is thought to be in direct equilibrium with the *in situ* primary production. The lugworm population has decreased now to a density of about 20 animals per m². The benthic community respiration amounts to about 2000 µgat O₂



The effect of bioturbation is one of the aspects studied in the indoor mud-flat ecosystems (2.12.4). In absence of larger bottom evertebrates a very abnormal situation develops whereby all primary production accumulates above the sediment's surface and the sediment itself remains almost free from organic matter. After 4 months a dense *Enteromorpha* vegetation is present.

per m².

In the other indoor system, lodged in a twin tank, a new set-up with 8 equal compartments filled with clean beach sand poor in organic matter was made. The intensity of the light irradiance was somewhat lowered. After an initial period of some months, in which stable nutrient profiles in the sediment were reached, all compartments were inoculated with a natural mixture of benthic algae. In direct relation with the available nutrients in the overlying water, this resulted in a rapidly increasing, later on stabilizing primary production, mainly of *Enteromorpha* spec. By adding more nutrients the total phytobiomass was raised to a level of about 2500 g ash-free dry weight. A next step will be now the introduction of macrofauna organisms (lugworms) to the system and the study of the effect of bioturbation caused by the worms on the algal mat structures and the fate of the organic matter (see also 2.12.5, bio-geochemic research in the experimental systems).

Dr Hubert Farke (Kiel) finished his research on spawning, early larval development and migration of post-larval and juveniles of *Arenicola*. The complete larval cycle and important parts of the life history of the lugworm could be described. We may acknowledge here the Beyerinck Popping Foundation for its financial support by which the observations obtained in the laboratory could be verified in the field. Around the island of Texel a census of the so-called nursery flats was undertaken, and the densities of juveniles and adults were estimated.

In 1979 or early 1980 a special issue of the Netherlands Journal of Sea Research will be devoted to the recent *Arenicola* research of the Institute.

2.12.5. Biogeochemistry of experimental tidal flat ecosystems

The quality of organic matter used as energy source by the lugworm *Arenicola marina* was investigated by flash pyrolysis mass spectrometry of suspended matter fractions of sediment collected in the tidal mud-flat ecosystem (2.12.5, first mentioned tank), in smaller experimental microecosystems, and on natural tidal flats.

Surface sediments rich in organic matter from the tidal mud-flat ecosystem were decomposed under various decomposition conditions with the object to compare the pyrolysis mass spectra with those found in the microhabitats. The mass pyrograms give detailed information on the structure and composition of

bio- and geo-polymer mixtures in sediment samples investigated. We greatly acknowledge the FOM Institute for Atomic and Molecular Physics, Amsterdam for the possibility to use their flash pyrolysis mass spectrometer.

Investigations on algal mats from a hypersaline lagoon in the Baffin Bay (Texas, U.S.A.) provided understanding about the organic matter composition in areas without bioturbation by deposit feeding worms. This research is carried out in co-operation with the organic geochemistry units of Delft University of Technology (J.W. de Leeuw) and the Bristol School of Chemistry (G. Eglinton), and the Space Sciences Laboratory of the University of California, Berkeley.

2.13. PRODUCTION AND DISTRIBUTION OF PREDATORS: MACROBENTHOS

2.13.1. Distribution of macrobenthos in the southern North Sea

In the course of the years a clear picture was obtained of the distribution patterns of the macrobenthic fauna in the area of research between 52°20' N and 54°30' N and between 2°30' E and 4°50' E. Especially in the eastern part a sandy area in the south and a silty area in the north can sharply be distinguished. This must be related to the decreasing velocity of the tidal streams in the north. The relation was confirmed by means of an experiment in a circular current tank containing a large mud sample from the northern area (4.2.1.17). Also decreasing effects on the bottom of wave action with increasing depths in the north may contribute to the distribution of silt. In terms of communities of infauna a *Venus gallina* community in the south and an *Amphiura filiformis* community in the north may be recognized (PETERSEN, 1918; THORSON, 1957). The transition is found at a latitude of about 53°30' N. Probably the northern area, which is inhabited by a richer fauna, not only receives energy from primary production in the overlying water mass but also from nearby sandy areas where water turbulence prevents deposition of detritus.

A comparative study between the northern and southern area is initiated by investigating the composition and biomass of the infauna (mostly secondary producers) by the group Benthic Systems (2.11.3) and the composition, biomass and food composition of tertiary producers (carnivores) by the group Autecology. With 24 hours beam-trawl surveys at a fixed station in the sandy area and in the silty area an attempt will be made to find some periodicity in feeding enabling a quantitative estimation of the food intake by carnivores.

2.14. PRODUCTION AND DISTRIBUTION OF PREDATORS: FISHES

2.14.1. Annual and seasonal fluctuations of the fish species in the western part of the Wadden Sea

The fykenet fishery near 't Horntje on Texel, started in 1959, was continued up to 1978.

Remarkable catches by fisherman landing their fish in Den Helder, were booked in the files of the Institute. From these files material of some fish species was sent on request to Dr H. Nijssen of the Institute of Taxonomical Zoology in Amsterdam.

2.14.2. Pelagic fish populations in the Wadden Sea

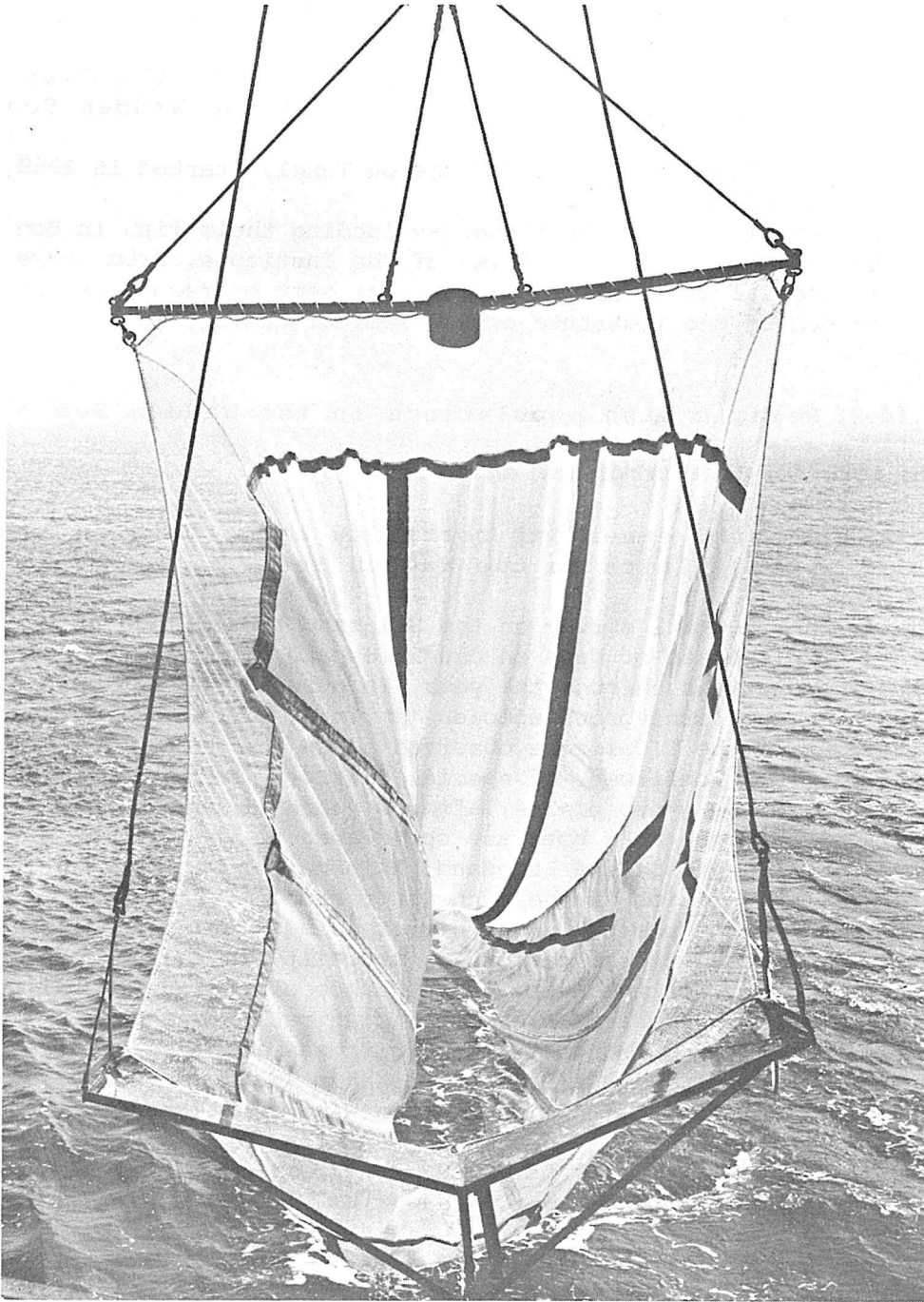
The work for this programme ended in 1978.

2.14.3. Density dependant mortality and growth in young plaice in the Wadden Sea

The 1978 beam-trawl survey on the Balgzand tidal flats provided a complete set of data on densities and biomasses of predator populations through the year. In general the seasonal trends in the carnivorous species (shrimps, crabs, gobies and flatfish) of the tidal zone observed since the surveys started in 1973, were confirmed. Of special interest are mortality and growth in O-group plaice; after 6 years of observation there is evidence that both are correlated to the initial population-strength on the Balgzand. This may be an important step in the solution of the much wider problem of numbers regulation of the plaice in its nursery, and further studies will be directed to the causes of mortality in the O-group. An explanation for the density dependance of O-group mortality may be found in predator-prey relationships between O-group plaice and *Crangon crangon*. This shrimp was found to predate on the plaice's youngest bottom stages in 1976 and 1977. Special field studies of this phenomenon will be started in 1979.

2.14.4. Migration and food consumption of predators in the tidal zone of the Wadden Sea

During 1978 on the Balgzand tidal flats a two-weekly sampling programme was carried out from March to November, just as in the preceding years. Apart from the seasonal patterns in density and growth of juvenile plaice (*Pleuronectes platessa*),



The Isaacs-Kidd midwater trawl in use for the study to selective tidal transport in juvenile plaice and flounder (2.14.5).

shrimps (*Crangon crangon*), shorecrabs (*Carcinus maenas*) and gobies (*Potamoschistus minutus* and *microps*), distribution patterns of successive stages of these organisms over the Balgzand tidal flats were studied. Densities of young plaice and shrimps were several times as high in 1978 as they were in preceding years while growth was normal. A study on larval immigration (Annual Report 1977: 2.14.5) suggested already that the importance of the flounder population on the Balgzand had been underestimated. One of the possible causes might be that the Balgzand stations did not cover the flounder habitat adequately. This was excluded in 1978 by adding 4 new stations in muddy zones near the dykes, to the usual 36 stations. This, however, did not raise the catch of flounders significantly. Two other possibilities are a very high larval mortality, and early settling of flounders elsewhere. Along the Wadden Sea coast between Den Helder and Den Oever samples with a push-net were taken in search for newly settled flounders, but results were not promising.

2.14.5. Tidal transport of young flatfish

After having established that plaice larvae migrate into the Wadden Sea through the tidal inlets by means of selective tidal transport the question arises how plaice larvae move from open sea, 35 to 70 km off the coast, to the shore and to the tidal inlets. As in 1977 a survey is carried out in early spring on the distribution of different stage plaice larvae in transects perpendicular to the coast line. The samples were taken in oblique plankton hauls with an Isaacs-Kidd midwater trawl.

The youngest larval stages were mainly found some 50 km from the shore whereas the older larval and postlarval stages were found concentrated close to the coast. A possible selective transport through onshore and offshore water movements will be studied experimentally.

2.15. EXPERIMENTAL WORK ON PREDATORS: FISHES (AND SHRIMPS)

2.15.1. Influence of environmental factors on development of fish eggs

In 1978 no research on this topic took place.

2.15.2. Influence of environmental factors on activity, metabolism and growth of fish and shrimps

Measurements of daily food intake and growth of gobies and young soles were finished in 1977. Publication of the results is in preparation. In 1978 the same measurements were started with plaice, flounder and brown shrimp. The fishes are kept in large tanks at constant temperatures, which are changed in steps during the year following the seasonal change of the temperature in the North Sea. Daily food intake, respiration and growth or decrease in weight of starving fish are measured over periods of about 14 days. The measured parameters (y) are correlated with the weight of the animals (W) according to the exponential growth formula ($y = aW^b$), and the influence of the water temperature (T) on a and b is calculated. This leads to simple empirical models; like:

$$\text{daily food intake} = a \times e^{bT} \times W^{c-dT}$$

where a, b, c and d are constants, e the base of the natural logarithm, T temperature and W wet weight. With such models we hope to be able to estimate the food consumption of populations in the sea. The measurements of daily food intake of plaice and flounder, research stated by two students, will be continued in 1979 to complete the seasonal cycle.

It is planned to start measurements of food intake, growth and metabolism of some other common North Sea animals like echinoderms (*Asterias*), crabs (*Portunus*) and fish (dab, whiting, etc.).

2.16. EXPERIMENTAL RESEARCH ON ADAPTATION TO ABIOTIC MARINE ENVIRONMENTAL FACTORS

2.16.1. Respiratory functions and ontogeny of haemoglobin of the herring *Clupea harengus*

The research has been finished and resulted in the publication of a thesis (4.2.1.31), that also appeared in the Netherlands Journal of Sea Research (4.2.1.30).

2.16.2. Vision of Odontocetes

The study of the ocular anatomy of the Amazon dolphin was postponed, awaiting the results of refractometrical and ophthalmo-

scopical observations on the eyes of living animals. The species is present in the Zoo of Duisburg; we expect to carry out the measurements there in due time.

A technique was developed which greatly facilitates the determination of ganglion cells in the dolphin's retina. A comparative research, including a number of cetacean species, is in progress.

Two students (R.V., Utrecht) are carrying out behavioural experiments at the Dolphinarium at Harderwijk with the aim to learn more about the way of functioning of the cones, which have been found in the dolphin's retina in small numbers.

2.16.3. Eco-physiological research on marine organisms

The work on the structure and function of the gills of *Carcinus* was continued. Some new experiments, regarding the electrical properties of the gills, were carried out, using other electrode configurations. Various difficulties in the interpretation of the results made that, up till now, no final conclusions could be reached.

Research, considering the volume regulation of *Arenicola*, showed that between the coelomic fluid and the medium of lugworms a perfect Donnan-equilibrium is present. At salinity changes in the environment a new equilibrium is established very rapidly (within 3 hours) despite the fact that the concurrent change in body volume (water content) takes much more time to disappear. The (average) molecular weight of the organic compounds in the coelomic fluid remains low (at the level of free amino acids and dipeptides), independent of the salinity. A synthesis-degradation mechanism as described in Crustacea is lacking. A detailed paper is prepared and will give a complete description of the results.

In a study on the hydrodynamic properties of (semi-benthic) Crustacea, data were collected on the specific gravity and drag coefficients for a number of species. These two qualities are important for the sinking rate when an animal stops its locomotory movements. Their significance for the energy requirements for swimming and for the distribution of a species under the influence of tidal currents are discussed in an interspecific comparison of the results obtained.

Finally, research took place considering the use of ancient (pre-cambrium) sea water as a physiological saline. Additional to previous studies (4.2.1.73) it appeared to be possible to derive the ionic composition of the primitive environment—in which the basic biochemical processes were fixed—in

more detail. Deviations from normal sea water are the same as that found in most physiological salines commonly in use, quantitative differences exist. Tests, using ancient sea water as a physiological saline, showed that this fluid offers a much more favourable environment to living tissues than for instance the often used Ringer solution.

2.16.4. Comparative physiological research into a number of selected polychaete species from tidal mud-flat areas

Investigations into the haemoglobin and oxygen binding of the sedentary polychaete *Heteromastus filiformis* were finished. An internal report (4.3.1.6) is available.

Dr Hubert Farke (Kiel) worked on spawning, spawning mechanisms, larval development and migration of larvae and juveniles of the lugworm *Arenicola marina*.

2.16.5. Investigation on the influence of sulphide on the physiology of the lugworm

The investigation (started in 1977) to the quantitative distribution of sulphide, in free form as well as FeS, in the mud-flat near the NIOZ harbour, was finished. In relation to this, some abiotic (particle size distribution and water content of the sediment, dissolved organic carbon in the interstitial water) and biotic (population density of *Arenicola marina*) parameters were studied. The distribution of the free sulphide appeared to be very constant, apart from some seasonal variation, but to vary from place to place. The burrows of *Arenicola* on this flat are not much deeper than 20 cm which makes that a level with higher concentrations of free sulphide is not reached in most cases.

In comparative LD₅₀ experiments with several species of polychaetes from the open North Sea, animals were incubated in sulphide solutions under different conditions. It was found that factors as pH, buffering capacity and presence of antibiotics have much influence.

Sulphide can easily penetrate into the body of the lugworms; within short time high concentrations in blood and coelomic fluid could be demonstrated and soon an equilibrium is reached with almost equal external and internal concentrations. The animals appear to be not injured by this. Also the influence of sulphide on the oxygen-binding capacity of *Arenicola* blood was examined; no harmful effects were observed.

(2.16.6. This research is inserted in project 2.14.5)

2.17. PRODUCTION AND DISTRIBUTION OF PREDATORS: SEABIRDS

2.17.1. Population research in seabirds

During earlier experimental research in the field to the causes of a usual high mortality among the chicks of the eider-duck it appeared that shortage of food was the reason of the low success in recruitment. This conclusion could be confirmed in the field observations in 1978. In contrast to many preceding years, this year many chicks grew up concurrent to a supply with small prey animals that was many times as large as in earlier years. This opportunity was used to organize a special catching expedition during which a great number of fledglings could be sexed and ringed. It appeared in contrast to what was known from literature—that the sex ratio at birth is 1 : 1, but that in the first weeks there is an unequal mortality causing an excess in males. Such an excess in males was also found in the winter population of adults.

In the years coming recaptured, ringed birds will result in a picture about—among others—the dispersion of the eiders when adult.

2.17.2. Parasitical relations

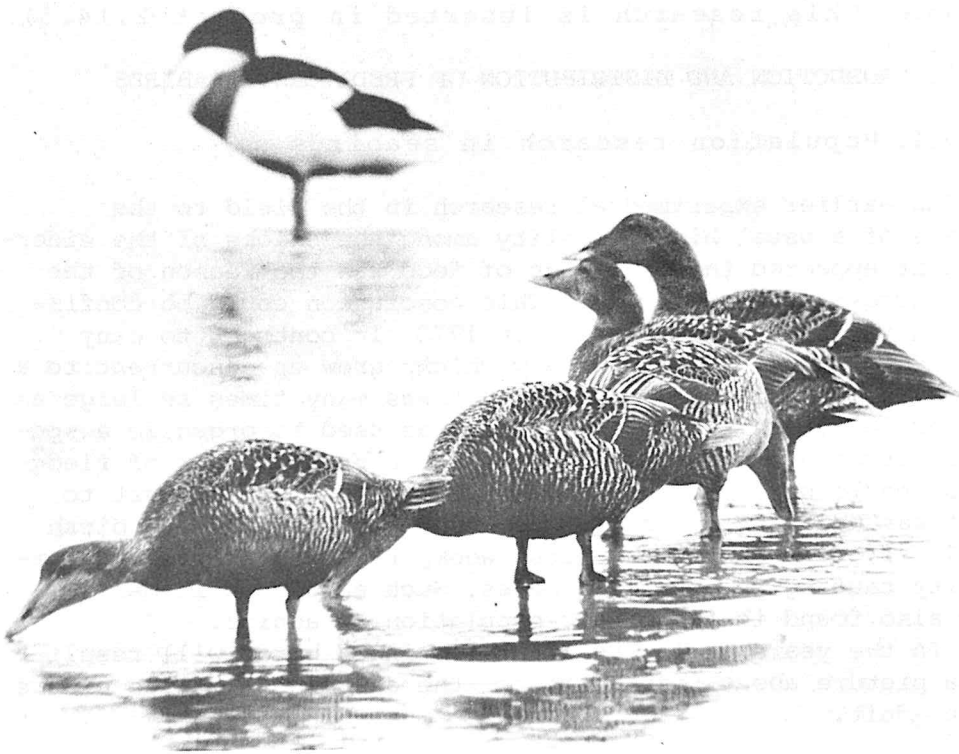
Research was continued to immuno-suppressive characteristics of PCB's on chicks of the eider in their influence on the effects of infestations with the intestinal parasite *Polymorphus botulus* (see 2.19.1).

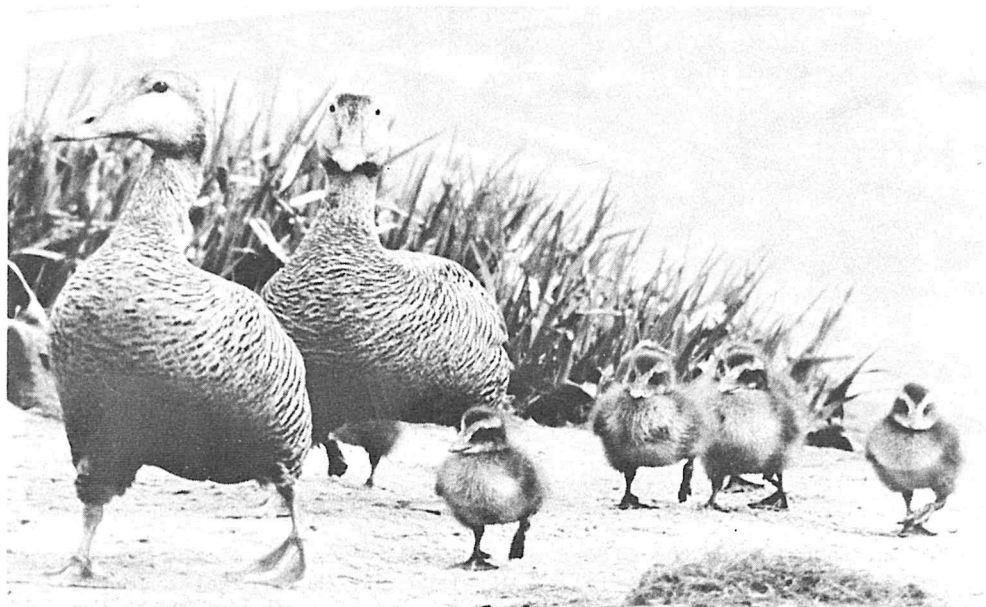
Part of the parasites material gathered from aquatic birds in foregoing years was put at the disposal of Dr F.H.M. Borgsteede, C.D.I., Lelystad for determination. For virological research material of eider chicks was afforded to Dr T. Smit, C.D.I., Doorn.

2.17.3. Laboratory research in seabirds

It appeared that moulting time in guillemots shifts to later in the season with age. Now the experimental animals had reached an age of 6 years, this shift has gradually come to an end.

Observations to partner-binding in guillemots were continued by students. Before breeding time the birds often bring a prey to the colony where they offer it exclusively to the







Population research in the eiderduck (2.17.1). Pictures of the breeding population at the Wadden island Vlieland and (this page) a couple of chickens that for research purposes is accompanied by a mobile artificial breeder (heating and shelter at any moment needed) and cage experiments at the edge of the tidal flat (various food rations)
 (photography Th. Mulder, Wieringen).

fixed partner. As soon as a couple has its first egg, this behaviour ends. Birds without partner continue to bring fishes to the breeding ridge for the whole breeding season.

In training experiments it turned out that guillemots are able to localize and catch prey animals (fishes hung up in the water) at very low light intensities, *viz.* during overcast winter nights without moon. The coming winter it will be tried out if the animals indeed use their eyes in such cases or have other means to detect prey.

2.18. CHEMICAL POLLUTANTS: DISTRIBUTION, CHEMISTRY

2.18.1. Organochlorines

A method was developed for obtaining sufficiently low blanks in the accurate determination of organochlorines in sea water solution. This method has been applied in the analysis of a large series of samples from the entire Wadden Sea, including its rivers.

Samples taken in the Rhine-Meuse estuary in the same period contain several components that have not yet been identified. The distribution of several components over dissolved and particulate forms has been determined in the whole region of estuarine mixing.

Samples of stranded seals were analyzed for organochlorines.

2.18.2. Metals

Dissolved fractions of zinc, cadmium, lead and copper in samples obtained during NECTAR 1977 (compare 2.09.3) were analyzed by electrochemical techniques. Also, the complexing capacity of these samples for copper was studied. The results will be compared with those of the 1978 cruise in the same area.

Samples of organs of Cetacea were analyzed for metals.

The analysis of samples collected in the Danish, German and Dutch Wadden Sea during the 1976 cruise was completed. The research on dissolved and particulate metals in sea water, in close cooperation with the Energy Research Centre (Petten) was continued: some results are ready for publication. A model was developed for the behaviour of trace metals in the Rhine estuary, containing the relative importance of mixing, precipitation and remobilization in the bottom. A special study was devoted to manganese. The results of the research on this element, that has been done by two institutes independently in

the two estuaries for a couple of years, have been combined into a model for estuarine behaviour (cooperation between Laboratoire d'Océanographie, Université de Bruxelles and our group). An extensive sampling programme was performed in the Scheldt estuary, in cooperation with Institute for Soil Fertility, Delft Hydraulics Laboratory, Energy Research Centre and Laboratoire d'Océanographie. A chapter was written in "Biogeochemistry of estuaries" (OLAUSSEN & CATO) on sorption processes of metals in estuaries.

A start was made with the study of a relation between metals and organic matter.

2.19. CHEMICAL POLLUTANTS: BIOLOGICAL EFFECTS

2.19.1. Sublethal effects of chemical pollutants on marine organisms

The climate-room for the experimental set-up to perform chronic tests with toxic substances at low concentrations was put into use. The sea water system provides a continuous supply of constant quality sea water free of suspended matter. A continuous flow-through of toxic substances will prevent the concentration of the toxics in the water-phase to decrease, as observed in static systems. Besides this, the system guarantees the animals good constancy of physico-chemical conditions (pH, PO₂, salinity) during the experiments.

The results of the experiment on immuno-suppression of PCB has been worked out. The relative concentrations of the separate chlorobiphenyl components have been measured in different organs (liver, kidney, brain, mesenteric fat and pectoral muscle) of the eiderduck (*Somateria mollissima*) and related to some haematological parameters and the numbers of the parasite *Polymorphus botulis* which is specific for the eiderduck and lives attached to the intestine wall. Notably, an increase in the concentration of hexa- and heptachlorobiphenyl causes some decrease of the haemoglobin concentration and the haematocrit. At the same time there is a change in the liver somatic index; the liver decreases in weight with respect to the total body. Possibly, a slight correlation exists between the concentration of hexachlorobiphenyl in the kidney and the number of parasites attached to the intestine wall. A second experiment has been performed.

2.20. BIOLOGICAL RESEARCH IN THE EEMS-DOLLARD ESTUARY (BOEDE)

The aim of this project is:

The indication and description of the factors which determine the structure and function of the ecosystem in the Eems-Dollard estuary. Therefore a qualitative and a quantitative description of the system in its present state have been made, which processes in the estuary are being studied (such as production, consumption, distribution, mineralization).

The study of changes, and the prediction of changes, in the estuarine ecosystem, as a result of changing environmental conditions due to chemical and physical or topographical disturbances, if possible with the help of mathematical model(s) of (parts of) the estuary.

The study and supply of data for control and management of the estuary, and, possibly, for other similar areas.

Personnel, publications and reports are listed in this report; a full Annual Report is published separately.

2.30. RIN AND COBW-RESEARCH:NATURE MANAGEMENT OF NETHERLANDS COASTAL WATERS

The Research Institute for Nature Management (RIN) carries out applied scientific research and gives management advices to several governmental bodies that are responsible for nature conservation. Also environmental impact statements are written. The Department of Estuarine Ecology is located on Texel as for a well-founded advice intensive discussions with NIOZ-scientists are necessary, and as a wealth of information concerning Dutch coastal waters is available at the NIOZ.

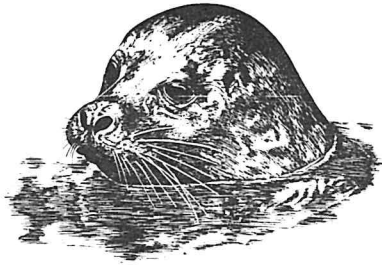
At present, the most important project of the RIN group is the compilation of all available information on the natural history of the Wadden Sea between Den Helder and Esbjerg. This will afford a solid base to start further research and to fill in gaps in the available information. Examples are the study of the effects of disturbance on populations of wading birds and seals, the study of processes which govern the transport of organic and inorganic matter in saltmarshes, and an investigation to the accuracy of bird counts in the area.

Personnel, publications and reports are listed in this report; a full Annual Report is published by RIN.

2.40. STEERINGGROUP STUDY NORTH SEA ISLANDS AND TERMINAL
(STUNET)

A study of litterature has been made on the biotic and abiotic environment of the southern North Sea. This study has been made in relation to the consequences of the possible construction of an artificial island in the Southern Bight.

A report has been published (4.3.1.3).



3. ACCIDENTAL RESEARCH

3.1. RESEARCH BY VISITING SCIENTISTS

Dr Hubert Farke did research on the lugworm *Arenicola marina* (see 2.12.4 and 2.16.4).

Dr G. Hallegraeff (C.S.I.R.O., Cronulla, Australia) assisted with the determination of algal pigments with thin-layer chromatographic methods.

Adi Hanafi (Indonesia) followed a one-month training at the pollution working group.

M. Pettine (Institute of Water Research, Rome) followed a training at the pollution working group (15 September - 15 October).

R. Theeg (Institut für Hydrobiologie und Fischereiwissenschaft, Hamburg) stayed for some weeks at the Institute to study the ETS method. It appeared that this method is also very useful to be applied for higher evertbrates.

Dr R.F. Uglow (Zoological department University of Hull, U.K.) visited the NIOZ from April 11th to 29th. He carried out experiments concerning the heart stroke variability in *Carcinus*.

Dr C.G.N. de Vooy stayed at the Stazione Zoologica, Naples (Italy) for five months. He carried out an investigation on the anaerobic metabolism of *Mytilus galloprovincialis* in relation with the sublittoral existence of this species in the Mediterranean. A comparison was made with published work on the anaerobic metabolism of *Mytilus edulis* from tidal regions (Wadden Sea and North Sea). This investigation was made possible by a grant from the Royal Dutch Academy of Sciences.

Dr R.E. Weber (Zoophysiological Laboratory University of Aarhus, Denmark) visited the NIOZ from January 15th to 27th. He participated in experiments concerning the suitability of ancient sea water as a physiological saline (see 2.16.3).

3.2. PARTICIPATION IN NATIONAL AND INTERNATIONAL PROGRAMS

3.2.1. Cooperation was promised to an ICES-program concerning an egg-patch study of plaice in the southern North Sea, in 1980 the cooperation will be in the biological and oceanographical field.

3.2.2. In Hamburg lectures were given about the NIOZ contribution in FLEX-76 (Fladen Grounds project to study the spring bloom in the northern North Sea). Two publications will appear

in 1979 in Meteor Forschungsergebnisse. All data were sent in "Format" to the Data Centre in Germany.

3.2.3. The results of an intercalibration programme for the determination of organochlorines, together with the Institut für Meeresforschung (Bremerhaven), were studied and prepared for publication.

3.2.4. The pollution group participated in the fourth round of the ICES intercalibration of trace metals in sea water solution.

3.2.5. Measurements of chlorophyll and organic carbon and counts of phytoplankton in the Marsdiep tidal inlet area (2.08.1) proved to be useful for research on *Mytilus edulis* in the western Wadden Sea by Mr H. Pieters (RIVO). Therefore, sampling programs were interrelated, chlorophyll methods intercalibrated, and a series of chlorophyll samples of Mr H. Pieters measured.

3.2.6. The investigations concerning spatial variability of residual circulation in the southern North Sea (2.01.1) (STROVAR) is a joint exercise by KNMI, Rijkswaterstaat, Royal Marine and NIOZ.

3.2.7. A program of sedimentological research in the Angola Basin was carried out in collaboration with a number of institutes in the Netherlands and abroad (see 2.02.4).

3.3. RESEARCH ON BEHALF OF THIRD PARTIES

3.3.1. In commission of the State Waterworks Friesland Drs E. T. van Ierland and Ir H.W. van der Veer investigated biological effects of dredging for the winning of sand in the Wadden Sea. Besides literature research Miss van Ierland did research to the effect of dredging on the turbidity of the water and Mr van der Veer on the time the bottom fauna needs to re-establish and on the effects of influenced water quality on a number of biological parameters, mainly the settlement and growth of mussel spat. In cooperation with NIOZ and RIZA scientists they also studied influences on the chemical composition of the water.

3.3.2. Chlorinated hydrocarbon concentrations in macrophyte samples from the Delta area were analysed on behalf of the

Delta Institute for Hydrobiological Research.

3.3.3. TNO at Den Helder was assisted in analysis of variance and computations of copepod development and production in plastic bag enclosures used to study the influence of heavy metal pollution.

3.3.4. ETS activities were measured in samples collected by the Limnological Laboratory (G.U. Amsterdam) from the water column of a fresh water lake (Maarseveenseplas).

3.4. ADVICES ISSUED

- Advice to the State Waterworks Friesland with regard to effects of sand dredging in the Wadden Sea.
- Advice to Steeringgroup Study North Sea Islands and Terminal (*cf.* 2.40).
- Advice to Delta-dienst State Waterworks with regard to the effects of a permeable dam in the Oosterschelde for the physico-chemico-biological regime in the sea-arm.
- Advice with regard to the storage of mud dredged from the Rotterdam harbours.
- Advice to Research Institute for Nature Management with respect to a biological report about the Balgzand (*cf.* 2.30).
- Advice to Research Institute for Nature Management with respect to German plans for a new harbour in the Eems at Emden.
- Advice to Shell with regard to fouling on offshore oil plants.

4. PUBLICATION

4.1. NIOZ PUBLICATIONS

4.1.1. Netherlands Journal of Sea Research

The Netherlands Journal of Sea Research is published by NIOZ and contains papers of Dutch and foreign institutes dealing with the various fields of marine science. Since 1973 the frequency is one volume, comprising 4 issues, per year. The last years, however, there is delay in publishing of about half a year.

Of volume 12 the issues are dated July (114 pages), November (138 pages) and December 1978 (issues 3 and 4 combined 168 pages). The volume comprises 26 papers of which 12 (251 pages) from the NIOZ, 2 (26 pages) from cooperating NIOZ and foreign authors, 1 (15 pages) from the Delta Institute, Yerseke, 1 (33 pages) from Netherlands Institute for Fishery Investigations (RIVO), IJmuiden and 10 (93 pages) from foreign authors.

The combined 3rd and 4th issue contain 14 articles about the Zaire estuary and plume as a special theme. As to subject the following division of the contents of the volume can be made: 1 paper (8 pages) on animal taxonomy, 3 (49 pages) on production biology, 1 (16 pages) on population dynamics, 2 (29 pages) on migration, 1 (57 pages) on animal physiology, 2 (31 pages) on degradation and mineralisation, 12 (126 pages) on chemical oceanography of estuaries and 4 (88 pages) on sedimentology.

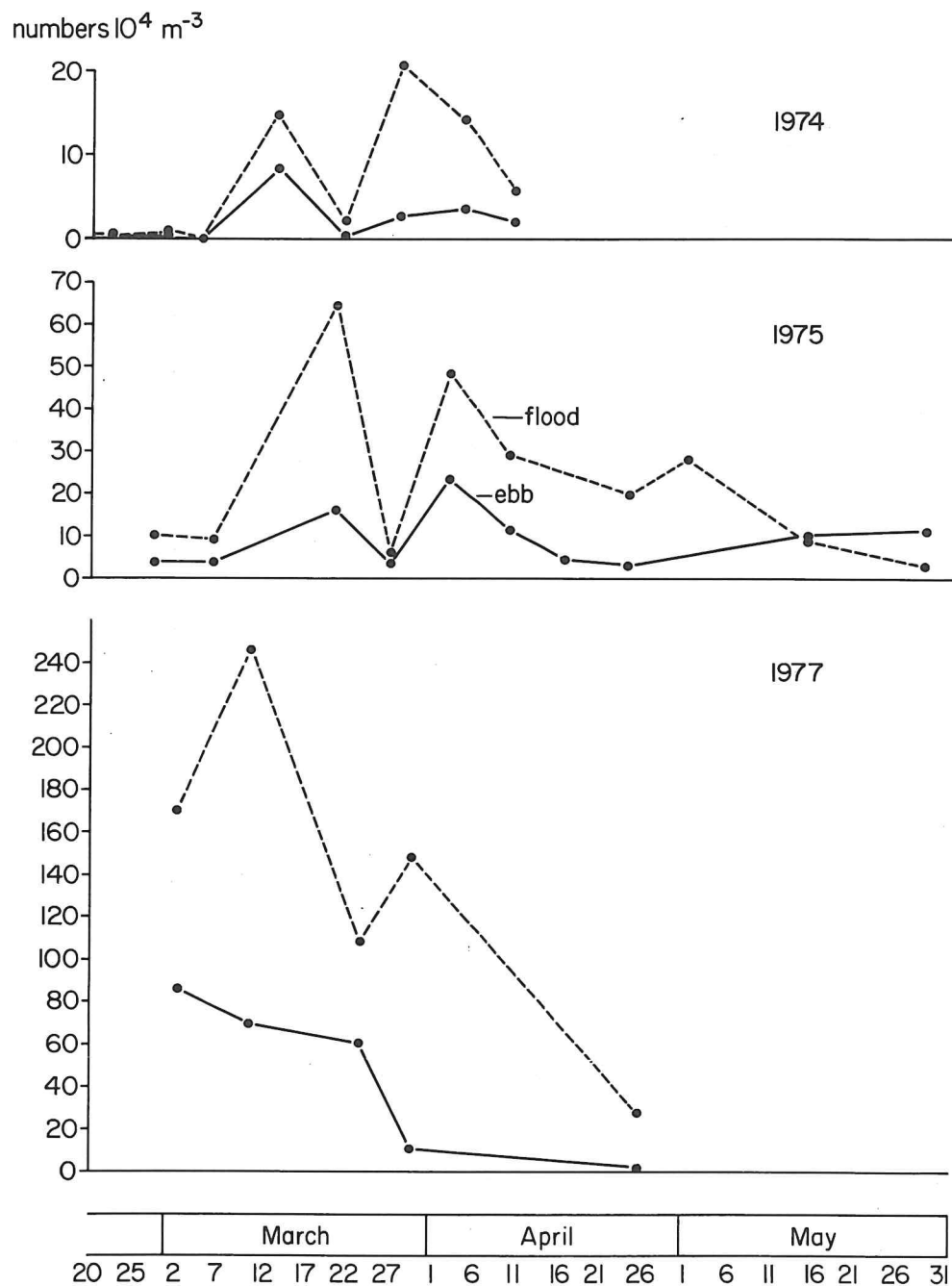
In 1978 50 manuscripts have been submitted for publication (to 25 in 1977 and 25 in 1976) to which must be added 4 manuscripts standing over from 1977. Of these 54 manuscripts 26 have been published in 1978, 9 have been accepted for publication in 1979, 11 are still being considered and 8 have been refused.

One article (4.2.1.31) was published also as a thesis.

4.1.2. Netherlands Institute for Sea Research Publication Series

This series is supplementary to the Neth. J. Sea Res., has the same board of editors, but will appear irregularly, as the occasion requires. It is printed in offset by the reprographic department of the Institute. In 1978 did appear:

- No. 1. K. Essink. Effects of pollution by organic waste



Differences in caught number of plaice larvae in the Marsdiep, showing net tidal transport of the larvae into the Wadden Sea during spring (after Creutzberg, Eltink & van Noort, 1978).

on macrofauna in the eastern Dutch Wadden Sea.

- No. 2. (Annual Report Netherlands Institute for Sea Research 1977) (did only appear in Dutch).

4.1.3. Internal Reports Netherlands Institute for Sea Research

These reports fix data or results of NIOZ research for internal use, they are not considered as publications. BOEDE (2.20) produces and RIN-COBW (2.30) produce the same type of reports (For these Internal Reports issued in 1978 see 4.3).

4.1.4. Separate publication

One thesis (4.2.1.43) was published separately.

4.2. PUBLICATIONS 1978

4.2.1. Publications NIOZ 1978

Note that part of the publications arranged in this 1978 Report (numbers 5, 17, 22, 37, 40, 47, 49, 56) in reality were published in 1977 or 1979 (they are not repeated in the Annual Reports of these years).

1. BENNEKOM, A.J. VAN. The Balgzand (Dutch Wadden Sea) tidal flats as a source of soluble silicate.—Hydrobiol. Bull. 12 (2): 143-144 (abstract).
2. BENNEKOM, A.J. VAN, G.W. BERGER, W. HELDER & R.T.P. DE VRIES. Nutrient distribution in the Zaire estuary and river plume.—Neth. J. Sea Res. 12 (3/4): 296-323.
3. BENNEKOM, A.J. VAN & J.E. JAGER. Dissolved aluminium in the Zaire river plume.—Neth. J. Sea Res. 12 (3/4): 358-367.
4. BEUKEMA, J.J. The trophic function of marine zoobenthos.—Neth. J. Zool. 28: 273-274.
5. BEUKEMA, J.J. & W. DE BRUIN (1979). Calorific values of the soft parts of the tellinid bivalve *Macoma balthica* (L.) as determined by two methods.—J. exp. mar. Biol. Ecol. 37: 19-30.
6. BEUKEMA, J.J., W. DE BRUIN & J.J.M. JANSEN. Biomass and species richness of the macrobenthos animals living on the tidal flats of the Dutch Wadden Sea: longterm changes during a period with mild winters.—Neth. J. Sea Res. 12: 58-77.

7. BOON, J.J. Molecular biogeochemistry of lipids in four natural environments. Delft: 1-215 (thesis).
8. BOON, J.J. & J.W. DE LEEUW. The analysis of wax esters, very long mid-chain ketones and sterol ethers isolated from Walvis Bay diatomaceous ooze.—*Mar. Chem.* 7 (2): 117-132.
9. BOON, J.J., J.W. DE LEEUW & A.L. BURLINGAME. Organic geochemistry of Walvis Bay diatomaceous ooze. II. Structural analysis of the monoenoic and polycyclic fatty acids.—*Geochim. cosmochim. Acta* 42: 631-644.
10. BOON, J.J., W. LIEFKENS, W. IRENE, C. RIJPSTRA, M. BAAS & J.W. DE LEEUW. Fatty acids of *Desulfovibrio desulfuricans* as marker molecules in sedimentary environments. In: W.E. KRUMBEIN. Environmental biogeochemistry and geomicrobiology. Ann Arbor Science 1: 355-372.
11. CADEE, G.C. Primary production and chlorophyll in the Zaire river, estuary and plume.—*Neth. J. Sea Res.* 12 (3/4): 368-381.
12. ———. Sediment-omwerking door depositfeeders.—*Meded. Werkgr. Tert. Kwart. Geol.* 15 (3): 85-100.
13. ———. Voedselproductie in de Waddenzee.—*Natuur Techn.* 46 (11): 730-749.
14. ———. On the origin of organic matter accumulating on tidal flats of Balgzand, Dutch Wadden Sea.—*Hydrobiol. Bull.* 12 (2): 145-150.
15. CREUTZBERG, F. Transport of marine organisms by tidal currents. In: N. DANKERS, W.J. WOLFF & J.J. ZIJLSTRA. Fishes and fisheries of the Wadden Sea. Final report of the section Fishes and Fisheries of the Wadden Sea Working Group. Stichting Veth tot steun aan Waddenonderzoek, Leiden. Report 5: 26-32.
16. CREUTZBERG, F., A.T.G.W. ELTINK & G.J. VAN NOORT. The migration of plaice larvae *Pleuronectes platessa* into the western Wadden Sea. In: D.S. McLUSKY & A.J. BERRY. Physiology and behaviour of marine organisms. Pergamon Press, Oxford: 243-251.
17. CREUTZBERG, F. & H. POSTMA (1979). An experimental approach to the distribution of mud in the southern North Sea.—*Neth. J. Sea Res.* 13 (1): 99-116.
18. DUINKER, J.C. Verontreinigende stoffen. In: J. ABRAHAMSE, P. HENDRIKS, P. LAKO & H. WOUTERS. Eemsmond grenzenloos. Assen: 129-135.
19. DUINKER, J.C. & M.T.J. HILLEBRAND. Minimizing blank values in chlorinated hydrocarbon analyses.—*J. Chromatogr.* 150: 195-199.

20. DUINKER, J.C. & J.H. KOEMAN. Summary report on the distribution and effects of toxic pollutants (metals and chlorinated hydrocarbons) in the Wadden Sea. In: K. ESSINK & W.J. WOLFF. Pollution of the Wadden Sea area. Final report of the section Pollution of the Wadden Sea Working Group. Stichting Veth tot steun aan Waddenonderzoek, Leiden. Report 8: 45-54.
21. DUINKER, J.C. & R.F. NOLTING. Mixing, removal and mobilization of trace metals in the Rhine estuary.—Neth. J. Sea Res. 12 (2): 205-223.
22. DUINKER, J.C., R.F. NOLTING & H.A. VAN DER SLOOT (1979). The determination of particulate and dissolved metals in coastal waters by different sampling and processing techniques.—Neth. J. Sea Res. 13 (2).
23. DUINKER, J.C. & H. POSTMA. Wat gebeurt er met verontreinigende stoffen die in zee terechtkomen?—TNO Project 6 (5): 187-191.
24. EISMA, D. Stream deposition and erosion by the eastern shore of the Aegean. In: W.C. BRICE. The environmental history of the Near and Middle East. Academic Press: 67-81.
25. ———. Bijdragen "Coastal morphology of Eastern Asia", "Shelf sedimentation", "Intertidal sand habitat", "Nearshore water characteristics" en "Polders". In: R. FAIRBRIDGE & M.L. SCHWARTZ. Encyclopedia of Beaches and Coastal Environments.
26. EISMA, D. & A.J. VAN BENNEKOM. The Zaire river and estuary and the Zaire outflow in the Atlantic Ocean.—Neth. J. Sea Res. 12 (3/4): 273-292.
27. EISMA, D., S.J. VAN DER GAAST, J.M. MARTIN & A.J. THOMAS. Suspended matter and bottom deposits of the Orinoco delta: turbidity, mineralogy and elementary composition.—Neth. J. Sea Res. 12 (2): 224-251.
28. EISMA, D., J. KALF & S.J. VAN DER GAAST. Suspended matter in the Zaire estuary and the adjacent Atlantic Ocean.—Neth. J. Sea Res. 12 (3/4): 382-406.
29. EISMA, D. & C.A. PASSCHIER. Rates of sedimentation on the Cape Verde Rise.—Neth. J. Sea Res. 12 (1): 107-114.
30. EVERAARTS, J.M. The haemoglobin of the herring, *Clupea harengus*.—Neth. J. Sea Res. 12 (1): 1-57.
31. ———. The haemoglobin of the herring, *Clupea harengus*. Rijksuniversiteit Groningen: 1-57 (thesis).
32. FONDS, M. The seasonal distribution of some fish species in the eastern Dutch Wadden Sea. In: N. DANKERS, W.J. WOLFF & J.J. ZIJLSTRA. Fishes and fisheries of the

Wadden Sea. Final report of the section Fishes and Fisheries of the Wadden Sea Working Group. Stichting Veth tot steun aan Waddenonderzoek. Leiden. Report 5: 42-76.

33. FONDS, M. & V.P. SAKSENA. The influence of temperature on the daily food intake of young soles. In: N. DANKERS, W.J. WOLFF & J.J. ZIJLSTRA. Fishes and fisheries of the Wadden Sea. Final report of the section Fishes and Fisheries of the Wadden Sea Working Group. Stichting Veth tot steun aan Waddenonderzoek. Leiden. Report 5: 132-138.
34. FRANSZ, H.G., M. OTTEMA & P.A. SEIP. Abundance and growth of fish larvae during the summer decline of copepod populations in Dutch coastal waters of the North Sea and possible interactions with jellyfish and ctenophores. ICES C.M. 1978/L:19 (mimeo).
35. FRANSZ, H.G. & P.J.H. REIJNDERS. Estimation of birth rate and juvenile mortality from observed numbers of juveniles in a seal population with normally dispersed reproduction. ICES C.M. 1978/N:7 (mimeo).
36. GIESKES, W.W.C. Phytoplankton, primary production and eutrophication in the southern North Sea.—Acta Bot. Neerl. 27 (1): 93-94.
37. GIEKES, W.W.C. & G.W. KRAAY (1977). Continuous Plankton Records: changes in the plankton of the North Sea and its eutrophic Southern Bight from 1948 to 1975.—Neth. J. Sea Res. 11 (3/4): 334-364.
38. GIESKES, W.W.C., G.W. KRAAY & S.B. TIJSSSEN. Chlorophylls and their degradation products in the deep pigment maximum layer of the tropical North Atlantic.—Neth. J. Sea Res. 12 (2): 195-204.
39. HELDER, W. De Waddenzee. Voedingsstoffen en algengroei.—Natuur Techn. 46 (9): 594-617.
40. HELDER, W. & R.T.P. DE VRIES (1979). An automated phenol-hypochlorite method for the determination of ammonia in sea- and brackish waters.—Neth. J. Sea Res. 13 (1): 154-160.
41. HUMMEL, H. & J.J. ZIJLSTRA. Some notes on the production of the North Sea. ICES 1978, Gen. 11 (mimeo).
42. KÜHL, H. & B.R. KUIPERS. Qualitative food relationships of Wadden Sea fishes. In: N. DANKERS, W.J. WOLFF & J.J. ZIJLSTRA. Fishes and fisheries of the Wadden Sea. Final report of the section Fishes and Fisheries of the Wadden Sea Working Group. Stichting Veth tot steun aan Waddenonderzoek. Leiden. Report 5: 112.

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44. KUIPERS, B.R. & M. FONDS. Consumption and utilization of food by juvenile plaice in the Wadden Sea. In: D.S. McLUSKY & A.J. BERRY. Physiology and behaviour of marine organisms. Pergamon Press, Oxford: 47 (abstract).
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46. POSTMA, H. The nutrient contents of North Sea water: changes in recent years, particularly in the Southern Bight.—Rapp. P.-v. Réun. Cons. int. Explor. Mer 172: 350-357.
47. POSTMA, H. & J.W. ROMMETS (1979). Dissolved and particulate organic carbon in the North Equatorial Current of the Atlantic Ocean.—Neth. J. Sea Res. 13 (1): 85-98.
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49. SPAARGAREN, D.H. (1979). Waddieren en hun milieu.—Natuur Techn. 47 (6): 356-371.
50. SPAARGAREN, D.H. & J. VERWEY. Zoutgehalte en osmoregulatie. In: J. VERWEY. De eenheid van milieu en organismen in de Waddenzee; een overzicht. Stichting Veth tot steun aan Waddenonderzoek, Leiden, Med. 4 Werkgroep Waddengebied: 73-85.
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56. VLAS, J. DE (1979). Consumption of regenerating parts of polychaetes and molluscs by plaice and flounder on a tidal flat.—Neth. J. Sea Res. 13 (1): 117-153.
57. VOSJAN, J.H. Mineralization in the sea.—Acta Bot. Neerl. 27: 95-96.
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67. ZIJLSTRA, J.J. On the navigation of herring (*Clupea harengus*) in the central and southern North Sea.—Neth. J. Sea Res. 12 (2): 148-163.
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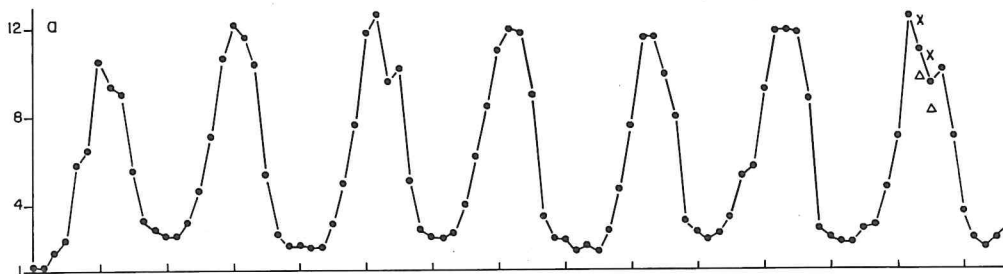
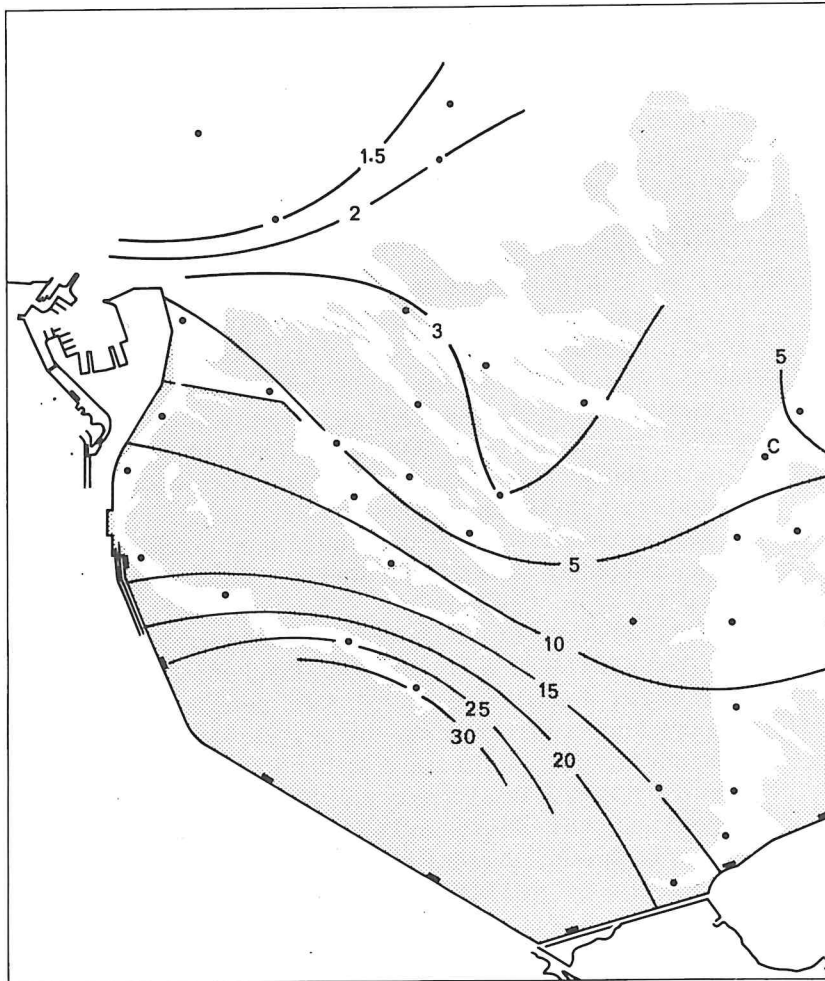
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4.2.2. Publications BOEDE

1. ADMIRAAL, W. Experiments with mixed populations of benthic estuarine diatoms in laboratory micro ecosystems. —Botanica Marina 20: 479-485.

4.2.3. Publications RIN (COBW)

1. BERGMAN, M., N.M.J.A. DANKERS & C.J. SMIT. De ecologische consequenties van het omleggen van de Eems door de Dollard. Rapport Rijksinstituut voor Natuurbeheer, October 1978: 1-128.
2. DANKERS, N.M.J.A. Het Nederlands Instituut voor Onderzoek der Zee, zijn gastafdelingen en het onderzoek gericht op de levering van informatie aan beleidsinstanties. WLO-Mededelingen 5 (1978): 22-23.
3. ———. De ecologische gevolgen van havenaanleg op het Balgzand. In: Een haven op het Balgzand? Rapport Nederlands Economisch Instituut en Rijksinstituut voor Natuurbeheer: 1-98.
4. ESSINK, K. & W.J. WOLFF. Sources of Pollution. Sources within the Wadden Sea. In: K. ESSINK & W.J. WOLFF.



Distribution of dissolved silicate in the waters of the Balgzand tidal area on 25 May 1977 and the tidal cycle in dissolved silica as measured at station C from 23 to 27 May showing minima during high water slack and maxima during low water slack. The small asymmetry of these tidal curves indicates a substantial export of dissolved silicate from the tidal flats (see 2.06.4 and 4.3.1.2).

- Pollution of the Wadden Sea area. Final report of the section Pollution of the Wadden Sea Working Group, Leiden: 11-13.
5. FRANSZ, H.G. & P.J.H. REIJNDERS. Estimation of birth rate and juvenile mortality from observed numbers of juveniles in a mammal population with normally dispersed reproduction. ICES, Marine Mammal Committee, C.M. 1978/N:7.
 6. HEUKELS, P. & K.S. DIJKEMA. Vegetation. In: J. ABRAHAMSE e.a. Eemsmund Grenzeloos. Stichting Werkgroep Eemsmund, Groningen: 61-74.
 7. REIJNDERS, P.J.H. Zeehonden. In: Eemsmund Grenzeloos. Uitgave Stichting Werkgroep Eemsmund, Groningen.
 8. ———. The Texel Museum: its functioning in relation to the harbour seal population in the Dutch Wadden Sea. —Aquatic Mammals 6 (2).
 9. ———. Recruitment in the harbour seal (*Phoca vitulina*) population in the Dutch Wadden Sea.—Neth. J. Sea Res. 12 (2): 164-179.
 10. WOLFF, W.J. Effect of pollution. Radioactive pollution. In: K. ESSINK & W.J. WOLFF. Pollution of the Wadden Sea area. Final report of the section Pollution of the Wadden Sea Working Group, Leiden: 61.
 11. ———. Effects of pollution. Introduction. In: K. ESSINK & W.J. WOLFF. Pollution of the Wadden Sea area. Final report of the section Pollution of the Wadden Sea Working Group, Leiden: 39.
 12. ———. Sources of pollution. Radioactive pollution. In: K. ESSINK & W.J. WOLFF. Pollution of the Wadden Sea area. Final report of the section Pollution of the Wadden Sea Working Group, Leiden: 37.
 13. ———. Sources of pollution. The North Sea as a source of pollution of the Wadden Sea. In: K. ESSINK & W.J. WOLFF. Pollution of the Wadden Sea area. Final report of the section Pollution of the Wadden Sea Working Group, Leiden: 13-15.
 14. ———. The pollution of the Wadden Sea area: introduction. In: K. ESSINK & W.J. WOLFF. Pollution of the Wadden Sea area. Final report of the section Pollution of the Wadden Sea Working Group, Leiden: 8-10.
 15. ———. Inleiding. In: J. ABRAHAMSE, P. HEUKELS, P. LAKO & H. WOUTERS. Eemsmund Grenzeloos: 15. Groningen, Werkgroep Eemsmund.
 16. ———. The degradation of ecosystems in the Rhine. In: M.W. HOLDGATE & M.J. WOODMAN. The breakdown and restoration of ecosystems. Plenum Publ. Corp. 169-188.

4.3. INTERNAL REPORTS

4.3.1. Internal Reports NIOZ 1978

- ZONDERVAN, K. De natuurlijke fluorescentie en de chloriniteit van het interstitiële water in de wadbodem in het westelijk deel van de Waddenzee in de winter. No. 1978-1.
- MANUELS, M.W. Water-, stof- en warmtehuishouding van het Balgzand. No. 1978-2.
- LANGE, G.J. DE & H. HUMMEL. Beschrijving van het abiotisch en biotisch milieu van het Nederlands Continentaal Plat. No. 1978-3.
- MURRIS, H.R. Pelagische Polychaeta en larven van Polychaeta in de Zuidelijke Bocht van de Noordzee in 1973. No. 1978-4.
- SWENNEN, C. Report on a visit to France on account of the Amoco Cadiz oil disaster. No. 1978-5.
- PALS, G. De intracellulaire coeloom haemoglobine van de annelide *Heteromastus filiformis*. No. 1978-6.
- GLAZENBURG, A.G. & D. BRAND. Paarvorming bij zeekoeten (*Uria aalge*). No. 1978-7.
- TIJJSSEN, S.B. Salinity intercalibration JONSDAP 76. No. 1978-8.
- VEEN, W. VAN DER. Bepaling van het opaalgehalte in de as van bentische diatomeeën. No. 1978-9.
- VERWEY, J. Krabben van de Zuidelijke Noordzee I. No. 1978-10.
- DAPPER, R. Aantallen, biomassa en verspreiding van garnalen (*Crangon crangon*) op het Balgzand in 1977. No. 1978-11.
- . De Balgzand scholgegevens 1975, 1976, 1977. No. 1978-12.
- EISMA, D. & J. KALF. Suspended matter between Norway and Shetland and in the Sognefjord. No. 1978-13.

4.3.2. Internal Reports BOEDE

- COLIJN, F. Primary production measurements in the Eems Dollard estuary during 1975 and 1976. 1-1978.
- ES, F.B. VAN, H.G.J. SCHRÖDER & A.J. KOP. Belasting van het Eems Dollard estuarium met organische stof door de persleiding Veenkoloniaal Afvalwater in 1977: Effecten op het sediment en bacteriepopulaties: 1-33. 2-1978.
- HYLKEMA, H. & F. ROORDA. Oriënterend onderzoek naar de invloed van olieverontreiniging op groei en fotosynthese van bentische diatomeeëncultures, geïsoleerd uit het Eems Dollard estuarium: 1-48. 3-1978.
- FORMSMA, J.J. Lengte-gewicht relaties, groeisnelheid en productiviteit van *Eurytemora affinis*: 1-26. 4-1978.

RUYTER VAN STEVENINCK, E. DE. Begrazing van benthische diatomeeën door *Oligochaeten* in het Eems Dollard estuarium: 1-28. 5-1978.

VRINS, A. De groei en populatiedichtheid van kokkels op enkele plaatsen in de Eems Dollard: 1-72. 6-1978.

5. LECTURES

5.1. SEMINARS AND LECTURES AT THE INSTITUTE (titles translated)

13 January

C. Winkelman (NIOZ): The bottom of the North Sea: benthos.

M. Rutgers van der Loeff (NIOZ): Mineralization in the bottom of the North Sea.

27 January

L.J. Bouchez (Utrecht University): The law of the sea conferences.

J.J. Zijlstra (NIOZ): Scientific aspects of the conferences on the Law of the Sea.

17 February

H.G. Fransz (NIOZ): Recruitment in a population with disperse reproduction.

P.H.J. Reijnders (State Institute of Nature Conservancy): Population dynamics of the seal in the Wadden Sea.

3 March

R.T.E. Schüttenhelm (Dutch Geological Survey): Geologic development of the southern North Sea.

T.C.E. van Weering (NIOZ): Geologic development of the northern North Sea.

10 March

S.B. Tijssen, A.J. van Bennekom, J.T.F. Zimmerman (NIOZ) and H. Vugts (University of Amsterdam): Water exchange and nutrient production of the Balgzand area.

23 March - Research in the North Equatorial Current (NECTAR-77).

J.J. Zijlstra (NIOZ): Introduction.

S.B. Tijssen (NIOZ): Nutrient profiles.

D. Spitzer (NIOZ): Optical measurements.

A. Timmer - ten Hoor (NIOZ): Mineralization.

W.W.C. Gieskes (NIOZ): Chlorophylls and primary production.

M. Baars (NIOZ): Grazing experiments.

J.W. Rommets (NIOZ): Carbon profiles

C.J.M. Kramer (NIOZ): heavy metals.

7 April

H. Hummel and G.J. de Lange (STUNET): Description of the abiotic and biotic environment of the Dutch Shelf.

28 April

J. Kuiper and J. van de Eikhoff (Applied Research): Simulation of phytoplankton development in model systems.

H.G. Fransz (NIOZ): SIMPEL, a model for simulation of the dynamics of the ecosystem in the southern North Sea.

12 May

D. Riepma (Dutch Meteorological Office), J.T.F. Zimmerman and C. Veth (NIOZ): Current measurements in tidal areas.

26 May

C.G.N. de Vooy (NIOZ): The SCOPE project: primary production in the oceans.

R. Eisler (Environmental Research Lab Naragansett): Biological effects of metals and oil in the sea.

2 June

Postersession: Wadden Sea, North Sea, and Ocean Research of NIOZ staff.

29 September - Research in the Angola Basin, April-May 1978.

D. Eisma (NIOZ): Introduction.

T.C.E. van Weering (NIOZ): Deep sea fan sedimentation.

J.H.F. Jansen (NIOZ): Preliminary results of the geological sampling programme.

D. Eisma (NIOZ): Transport of suspended matter to the deep sea.

A.J. van Bennekom, G. Berger, W. Helder and R.T.P. de Vries (NIOZ): Chemistry and hydrography of the Zaire estuary, a comparison with results of 1976.

13 October

H. Farke (University Kiel): Reproduction and cycle of larval development of *Arenicola marina*.

J. de Vlas (NIOZ): Decrease of growth rate and unmeasured production of *Arenicola marina* caused by flatfish predation.

20 October

K.A. Bouwman (Research Eems-Dollard Estuary): Nematodes of the Eems-Dollard region.

J.J. Zijlstra (NIOZ): Meiofauna of the Balgzand.

10 November

J. Dronkers (State Waterworks Agency): Mixing processes in the Oosterschelde.

A.J. van Bennekom (NIOZ): Influence of wind on distribution of Rhine and Scheldt water in the North Sea.

24 November

W. Salomons (Groningen University): Physical and chemical behaviour of heavy metals in lakes and estuaries.

J.C. Duinker (NIOZ): Geochemical and thermodynamic behaviour of manganese in the estuaries of Rhine and Scheldt.

6. VISITORS FROM ABROAD

- Prof Dr Cj. Aempel, Institut für Meeresforschung, Kiel, West Germany.
- Dr G. Allen, CNEXO, Paris, France.
- Mr J. Baars, Botanisches Institut, Technische Hochschule Aachen, West Germany.
- Dr K. Bjørrellund, Geologisk Institutt, Bergen, Norway.
- Dr M. Debyser, CNEXO, Paris, France.
- Dr F. Duncombe, Ligue Française pour la protection des oiseaux, Caen, France.
- Dr R. Eisler, E.P.A., Narragansett, Rhode Island, U.S.A.
- Prof Dr S. Gerlach, Institut für Meeresforschung, Bremerhaven, West Germany.
- Dr R. van Grieken, Departement Scheikunde, Universitaire Instellingen, Antwerpen, Belgium.
- Dr G. Hallegraeff, C.S.I.R.O., Division of Fisheries and Oceanography, Cromella, Australia.
- Dr J. Hylleberg, Institute of Ecology and Genetics, University of Aarhus, Denmark.
- Dr M.I. Jennes, Davis & Elkins College, U.S.A.
- Dr S. Krishnaswami, Physical Research Laboratory, Ahmadabad, India.
- Dr H. Kühl, Institut für Küsten und Binnenfischerei Laboratorium Cuxhaven, West Germany.
- Dr J.-M. Martin, Laboratoire de Géologie, École Normale Supérieure, Paris, France.
- Dr G. Maus, Seeland Aquarium GmbH, Pulheim, West Germany.
- Dr M. Meybeck, Laboratoire de Géologie, École Normale Supérieure, Paris, France.
- Prof Dr W. Nellen, Institut für Meeresforschung, Kiel, West Germany.
- Dr D.B. Peakall, Canadian Wildlife Service, Ottawa, Canada.
- M. Pejrup, University Copenhagen, Denmark.
- D. Quaghebeur, Instituut Hygiëne en Epidemiologie, Ministerie van Volksgezondheid, Brussels, Belgium.
- Prof Dr L. Schmekel and Dr B. Sanders-Esser, Zoologisches Institut der Westfälischen Wilhelms-Universität, Munster, West Germany.
- Mr M. Smart, International Waterfowl Research Bureau, Slimbridge, U.K.
- Dr A. Takemura, Faculty of fisheries, Nagasaki University, Japan.
- R. Theeg, Institut für Hydrobiologie und Fischereiwissenschaft, Hamburg, West Germany.

- Dr A. Thomas, Laboratoire de Géologie, École Normale Supérieure, Paris, France.
- R.F. Uglow, Zoological Laboratory, University of Hull, U.K.
- R. Vogler, Planungsgemeinschaft, Schlosy Holyfeld, West Germany.
- Dr R.E. Weber, Zoophysiological Laboratory, Aarhus, Denmark.
- E. de Wulf, Instituut Hygiëne en Epidemologie, Ministerie van Volksgezondheid, Brussels, Belgium.
- Dr Young Joo Park, Korea Research Institute of Geoscience and Mineral Resources, Seoul, Korea.

7. EDUCATION

7.1. STUDENTS' RESEARCH SUBJECTS

As a subject for their final examination the following students took part in the research:

C. van der Brink	R.U. Utrecht	(2.17.3)
L.W.F. Claessen	Biol., R.U. Nijmegen	(2.09.1)
R. Cronie	Biol., Univ. Amsterdam	(2.15.2)
R. Dekker	R.U. Groningen	(2.11.1)
Miss E. van Donk	Biol., Univ. Amsterdam	(2.12.2)
J. van Esch	R.U. Utrecht	(2.01.1)
A. Faber	Biol., R.U. Leiden	(2.14.4)
G.W.N.M. van Moorsel	R.U. Groningen	(2.11.1)
R. Mulder	R.U. Groningen	(2.07)
Miss M. Ottema	Biol., R.U. Leiden	(2.09.1)
P. Oudshoorn	R.U. Utrecht	(2.17.3)
E.W.F. Pauwe	Univ. Amsterdam	(2.02.1)
P.A. Seip	Biol., R.U. Leiden	(2.09.1)
M. Streefkerk	Biol., V.U. Amsterdam	(2.03.1)
J.P. van der Velde	Biol., R.U. Leiden	(2.12.3)
D. Vethaak	Biol., Univ. Amsterdam	(2.15.2)
R. van der Weijden	R.U. Utrecht	(2.01.1)

7.2. NIOZ COURSES

7.2.1. Course on Marine Biology. From the different universities in the Netherlands 44 students participated in the course which was held from June 12 to 23. During the course the participants were introduced to a variety of subjects such as hydrography, primary production, zooplankton research, sampling of tidal flats, fisheries, marine pollution, physiology and microbiology.

7.2.2. Oceanography course. The course was held from August 28 to September 1. Due to a large number (38) of participants two parallel courses were given. Field work was conducted successfully at the Balgzand tidal flats and in the harbour of the Institute. The World Data Center A in Washington provided a large number of physical and chemical station data from the Atlantic. Nice north to south vertical sections west of the Mid Atlantic Ridge, were constructed from these data.

7.2.3. In May a 4-day course was organized for technicians of the Amsterdam School for Technicians, Department of Ecology. The course consisted of lectures, films, excursions and practical work. A ship was rented for a short cruise to show aspects of activities in the field.

7.2.4. On the 14th and 15th of December a group of students of the University of Amsterdam were taught by the NIOZ staff in the framework of a project "Biology and Society".

7.3. COURSES ACCOMODATED AT THE NIOZ

22-26 January:	Biological students of the Laboratory for Ecology and Systematics, Free University Brussels.
28 April-1 May:	Biological students of the Zoological Institute, University of Cologne.
5-11 May:	Students ecology of the Amsterdam School for Analists.
28 Aug.-1 Sept.:	Students of the Department Aquatic Ecology of the University of Nijmegen.
4-8 September:	Students ecology of the Amsterdam School for Analists.
8-11 September:	Students ecology of the Amsterdam School for Analists.

7.4. MEETINGS AND EXCURSIONS RECEIVED AT THE NIOZ

18-19 February:	Excursion students Zoologisches Institut Technische Universität Braunschweig.
22-23 February:	Scientific meeting "Watermovements and mixing in the southern North Sea", organized by the national project MLTP-4.
10 March:	Excursion Institute State Waterworks Hoorn.
15-16 March:	Meeting COBW and RIN
17 March:	Scientific meeting Hydrobiological Society and BION working group Aquatic Ecology.
28-29 March:	Excursion Institut für Meereskunde, Kiel.
13 April:	Excursion Laboratory of Organic Chemistry of the Groningen University.
15 April:	Excursion of the section Amsterdam of the Aquarists Society Biologia Maritima.
20-21 April:	Scientific meeting BION working group of metabolism microbiologists.

20-23 April:	Diving weekend of the Divers Society Groningen.
26-27 April:	Visit of scientists of the Institut für Meeresforschung Bremerhaven.
11 May:	Excursion Frisian Drainage Boards.
17, 23, 24, 25 May:	Excursions of the Provincial Services of the Province North Holland.
23 May:	Meeting of the group Fauna of the committee TNO-CNB, subgroup aquatic animals.
2-3 June:	Excursion and scientific meeting Netherlands Zoological Society.
2 June:	Excursion Physics Laboratory of the Groningen University.
25 August:	Excursion International Union for the Conservancy of Nature (congress at Texel).
15-17 October:	Visit of scientists of the Institute for Genetics and Ecology of the Aarhus University.
20-27 October:	Diving weekend of the Divers Society Groningen.
27-28 October:	Scientific meeting BION working group Aquatic Ecology.
17 November:	Excursion personnel drainage district Uitterwaterende Sluizen Kennemerland en Westfriesland, Edam.

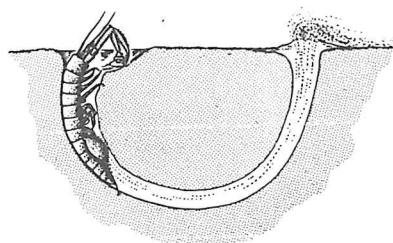
7.5. EDUCATION

7.5.1. The department of biological study material (compare 8.14) again supplied a substantial amount of living as well as preserved study material to universities, schools and educational institutes.

7.5.2. A series of contributions was written for the periodical *Natuur en Techniek* dealing with diverse aspects of oceanographic research in the Wadden Sea. In 1978 four articles were published (4.2.1, the numbers 13, 39, 64 and 65).

7.5.3. A short film was produced showing spatial distributions of chlorophyll in the Southern Bight of the North Sea (see 2.08.2).

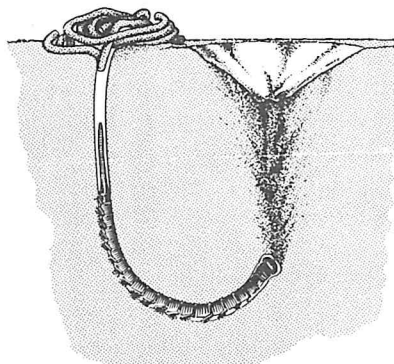
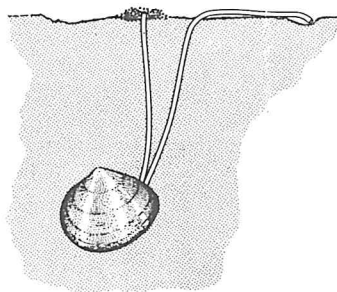
7.5.4. Parts of the film "Deposit Feeding" were used in educational TV productions of the Netherlands Education Television and the Netherlands Broadcasting Corporation (see also page 69).



DEPOSIT FEEDING:

The bottom animals pictured on this page appear in the 16 mm colour film "Deposit Feeding", produced by the NIOZ reprographic department. The peculiar feeding habits of these five important Wadden Sea species are shown. It are *Hydrobia ulvae*, *Corophium volutator*, *Pygospio elegans*, *Macoma balthica* and *Arenicola marina*, all feeding in a different way on bottom deposits. That the film is experienced as an instrumentive one is demonstrated by the fact that copies are kept at:

- Department of Geology and Geophysics, Yale University, U.S.A.
- Department of Oceanography, University of Washington, U.S.A.
- Department of Geophysical Sciences, University of Chicago, U.S.A.
- Audio-Visual Services, University of Washington, U.S.A.
- Media Center, University of North Carolina, U.S.A.
- Stichting Film en Wetenschap (Utrecht) took care of the distribution in the Netherlands (Cat. nr 1201B).



7.5.5. Cooperation was given to a programme of the Belgian TV, resulting also in a contribution in Weekblad TV Expres, nr 12, 1978.

7.5.6. Assistance was given to a film production about the Wadden Sea by J. van der Keuken "The flat jungle".

DE PLATTE JUNGLE

EEN FILM VAN JOHAN VAN DER KEUKEN



8. GENERAL PART

8.1. AUXILIARY DEPARTMENTS

8.1.1. Library

The library has been expanded by subscriptions to the following periodicals: *Oceanologica Acta* and *Earth and Planetary Science Letters* and by exchange with *Netherlands Journal of Sea Research* by the periodicals *Acta Phytogeographica Suecica*, *Uppsala*, *Bulletin de l'Office National des Pêches*, *la Goulette Port*, *Tunesia*, *Iowa Academy Proceedings*, *Memories Musea do Mar Serie Zool.*, *Cascais*, *Portugal*, *Oceanologica Limnologia Sinica*, *Publications of the Australian Institute of Marine Science*, *Townsville* and *Thalassographica*, *Athens*.

Via the RIN the NIOZ receives (starting 1978): *Acta Botanica Neerlandica*, *Biological Conservation*, *Botanica Marina*, *Environmental Conservation*, *Gorteria*, *Journal of applied Ecology* and *Journal of Ecology*.

J.H. Vosjan followed two courses for on-line literature research using the computer terminal of the Institute. For about twenty researchers he did literature documentation in this way.

8.1.2. Computer centre

A computer-terminal Tektronix 4051 with graphic display and a matrix printer were installed at the computer centre. Together with the hardware owned by BOEDE (a similar Tektronix 4051 with hard-copy unit and modem), a Tektronic 31 desktop calculator and a IBM 29 card punch, this forms the basic equipment for processing of data and information. Locally, both Tek 4051 computers with a capacity of 32K bytes are programmable in BASIC and can be used to construct data files and programmes for host computers on cassette tapes. By telephone cable and a device for modulation and transmission (modem) the computer can be connected to a large host computer and transformed into a terminal. Most external computing is executed at the Academic Computer Centre at Utrecht. Simulation programmes are submitted at the Agricultural University Computer Centre at Wageningen. The terminal is also used to scan external literature documentation files. This system is chosen because it combines optimal possibilities for low-cost local computing with the versatility of large computer centres.

8.1.3. Reprography

Now the machines for offset printing function more time was needed for reprographic photography which left less possibilities for scientific photographic and cinematographic products. Drawing and printing work was carried out and a film was produced about the activities of the Institute which was shown during the days that "Open House" was held. Preparative drawings were made to build a scale model of the North Sea.

8.1.4. Biological study material

Again this year the department provided living and preserved study material to universities, schools and comparable institutions.

The department was transferred this year to a substituting building at the outer harbour in Den Helder, because the old building of the former "Zoological Station" had to be demolished for a reconstruction of the sea defence works.

8.1.5. Workshops

Besides the normal maintenance and repairs of electronical and mechanical apparatus, diverse adaptations and new projects were carried out for the research, largely of own designs.

Much work had to be done for the ocean programmes, partly concerning the deck containers and oceanographic winches. Three technicians assisted during the ocean and North Sea cruises.

A small commercial vessel was conversed for research purposes; it will replace the disused wooden flat "Griend" and bears the same name.

For the department of biological study material and its new location a sea water circuit and cooling and deep-freeze cells were installed. Also two climate rooms for research purposes were built.

8.1.6. Harbour and ships

For the research the "Aurelia" made 140 navigation days, the "Ephyra" 149 for BOEDE and 11 for NIOZ, the "Eider" 138 and the "Griend" 40.

Of the "Aurelia", "Ephyra" and "Eider" ship's installations functioned without important repairs. The "Griend" came to disuse as leakage made its sailing dangerous. The "Ephyra"

after repairs was certificated again for a year by the shipping inspection.

8.1.7. Guest house

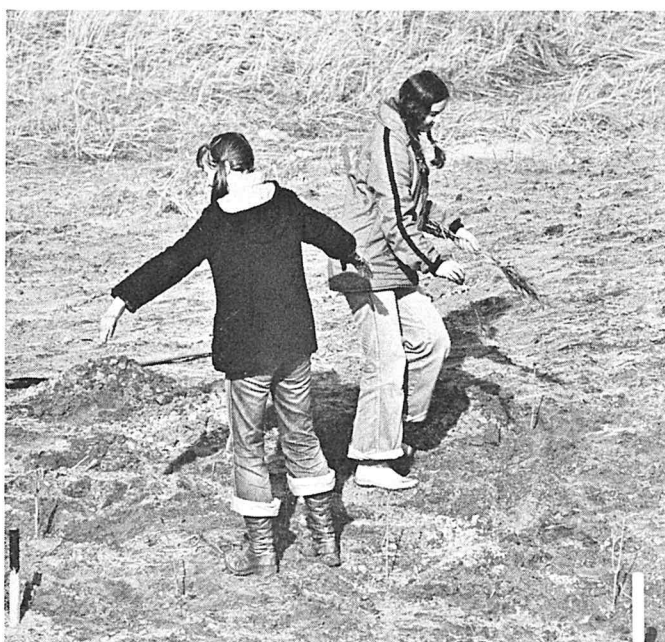
Accommodation was provided for course students and participants in meetings (1730 nights), for post-graduate students and guest researchers (6102 nights) and for visitors to the Institute (235 nights).

8.2. REVENUES AND EXPENDITURES

exploitation funds	f 8.873.000	
sale of study material	42.000	
rent of houses	22.000	
accommodation charges	18.000	
subscriptions Neth. J. Sea Res.	4.000	
assistance to third parties	182.000	
banking interest	1.000	
personnel costs		f 6.947.000
general service		372.250
domestic service		519.000
laboratory costs		300.750
auxiliary departments		520.500
publication Neth. J. Sea Res.		70.000
training students and researchers		15.000
assistance by third parties		48.500
accommodation students and guests		88.000
special projects		182.000
dredging of harbour		19.000
removal costs		30.000
symposium		30.000
	<u>f 9.142.000</u>	<u>f 9.142.000</u>

Long-term investments:

funds for scientific and general equipment	f 728.000
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A tree-planting day for the own staff members provided the grounds of the Institute with 10 000 young trees and shrubs.

9. MANAGEMENT AND PERSONNEL

9.1. MANAGEMENT

The Netherlands Institute for Sea Research (NIOZ) is an institute of the Netherlands Zoological Society. The research is almost fully paid for by the Dutch Government, mainly the Ministry of Education and Science. The directors of the Institute are appointed by the Minister and are for their management responsible to the Board of the Society.

The latter has delegated the regular supervision to one of its members, the Commissioner. Budgetary matters are handled by the Finance Committee, that consists of the Commissioner as chairman, the Treasurer of the Society, the Chairman of the Science Committee and an appointee of the Minister. Without the government official the Committee also acts as a Board of Supervisors.

Concerning the scientific activities of the NIOZ advice is asked from the above mentioned Science Committee, the members of which are appointed by the Minister. The Committee consists of representatives of the Dutch universities and of other institutions active in marine research.

The Science Committee met this year on 14 December at the Institute.

Constitution Board of Supervisors:

Prof Dr J. Lever	(Commissioner)
Dr A.C. van Bruggen	(Treasurer)
Prof Dr A.D.F. Addink	(Chairman Science Committee)

Constitution Science Committee:

Prof Dr A.D.F. Addink (Chairman)	(Zoological Laboratory, Leiden) for State University Leiden.
Prof Dr F.J. Verheyen (Vice-Chairman)	(Laboratory for Comparative Physiology, Utrecht) for State University Utrecht.
Dr A.G. Vlasblom (Secretary)	(Delta Institute for Hydrobiological Research, Yerseke) for Delta Institute, Yerseke.
Prof Dr C. den Hartog	(Laboratory of Aquatic Oecology) for Catholic University Nijmegen.
Prof Dr L.B. Holthuis	(State Museum for Natural History, Leiden) for State Museum for Natural History, Leiden.
Prof Dr J. Lever	(Biological Laboratory of the Free University Amsterdam) for the Netherlands Zoological Society.

Dr W.G. Mook (Physical Laboratory of the Groningen University) for State University Groningen.

Drs K.H. Postuma (Netherlands Institute for Fishery Investigations, IJmuiden) for Netherlands Institute for Fishery Investigations, IJmuiden.

Prof Dr R. Dorrestein (Head of the Department Scientific Research of the Meteorological Institute, De Bilt) for the Meteorological Institute, De Bilt.

Dr P.J. Roos (Zoological Laboratory Amsterdam) for University Amsterdam.

Dr H.J. Veenstra (Geological Institute, Groningen) for State University Groningen).

Dr E.H.Th. Verdurmen (Z.W.O. Laboratory for Isothopes Geology, Amsterdam) for Z.W.O. Laboratory for Isothopes Geology, Amsterdam.

Prof Dr A.J. Wiggers (Institute for Earth-Sciences of the Free University, Amsterdam) for the Free University Amsterdam.

9.2. PERSONNEL

9.2.1. Personnel employed in NIOZ research departments

The participants of research personnel in the research projects as listed in this Annual Report, is indicated by the numbers behind the names. For guest scientists see 3.1; for students taking part in the research see 7.1.

-) means: left service; +) entered service; 0) not in service of NIOZ.

Scientists:

Assistants:

Direction

H. Postma	M. Geel-)
	J. Hart-Stam+)
J.J. Zijlstra	L. Everhardus

Chemical Oceanography

H. Postma 2.06.1;2.18.1	J.W. Rommets 2.06.1;2.18.1
S.B. Tijssen 2.06.3;2.06.5	F.J. Wetsteyn 2.06.3;2.06.5
W. Helder 2.04.2;2.06.2;2.06.5	R.T.P. de Vries 2.04.2;2.06.2;
M. Rutgers v.d. Loeff 2.05.1	2.06.5
C.N.G. de Vooy 2.08.4	

Physical Oceanography

J.T.F. Zimmerman 2.01.1;2.01.2;	M.W. Manuels 2.01.1;2.06.5
2.06.5	
C. Veth 2.07;2.01.1	M. Wernand 2.07
D. Spitzer 2.07	

Marine Pollution Research

J.C. Duinker 2.18.1;2.18.2 M.Th.J. Hillebrand 2.18.1
C.J.M. Kramer 2.18.2 R.F. Nolting 2.18.2
J.M. Everaarts 2.19.1

Marine Geology and Geochemistry

D. Eisma 2.02.1;2.02.4;2.02.5	S.J. van der Gaast 2.02.1-4
J.H.F. Jansen 2.02.2;2.02.4	J. Kalf 2.02.1-5
T.C.E. van Weering 2.02.3;2.02.4	J. Schilling 2.02.1-4
A.J. van Bennekom 2.06.4;2.06.5	G.W. Berger 2.06.4;2.06.5
M. van Vreumingen ^{o)} 2.02.6	R. Gieles-Witte 2.02.1-4
	A. Visser-Hennese ^{y)} 2.02.1-4

Experimental Biology

Experimental Biology
P.A.W.J. de Wilde 2.12.2-4; 2.16.4 E. Berghuis 2.12.2-4; 2.16.4
J.H. Vosjan 2.03.1; 2.04.1 A. Kok[†]) 2.12.2-4
A. Timmer-ten Hoor 2.03.2; 2.09.3 F. Eijgenraam 2.03.2; 2.09.1;
2.09.3
M. Groenendaal 2.16.5 E. Pauptit 2.03.1; 2.16.4
J. Boon^o) 2.12.4; 2.12.5

Autoecology

F. Creutzberg 2.13.1;2.14.5	G. van Noort 2.13.1;2.14.3; 2.14.5
A.D.G. Dral 2.12.1;2.16.2	
M. Fonds 2.15.2	P. van der Puyt 2.15.2
B.R. Kuipers 2.12.4;2.14.3; 2.14.4	R. Dapper 2.13.1;2.14.3; 2.14.4
D.H. Spaargaren 2.16.3	G. Nieuwland ⁺) 2.16.3

Benthic systems

J.J. Beukema 2.11.1	W. de Bruin 2.11.1;2.11.5
J. de Vlas ^{o)} 2.11.2	J.J.M. Jansen ^{o)} 2.11.1;2.11.2
C. Swennen 2.17.1-3	P. Duiven 2.17.1-3
C. Winkelman 2.11.3	J. Zuidewind 2.11.3;2.17.3
G.C. Cadée 2.06.5;2.08.1	J. Hegeman 2.08.1
H. Hummel ^{o)} 2.11.5	

Pelagic systems

<u>Periode System</u>	
H.G. Franz 2.09.1;2.09.2	W.C. van Arkel 2.09.1;2.09.2
W.W.C. Gieskes 2.08.2;2.09.3	G.W. Kraay 2.08.2;2.09.3
M.A. Baars 2.09.3	S. Oosterhuis 2.09.3
W.C.M. Klein Breteler 2.10.1	J.M. Nieuwenhuizen
	N. Berger-Schoft ^o) 2.09.1; 2.09.3
	A. Witte ^o) 2.09.1;2.09.3

G. Swaan-Zonnenberg

Publication and Library

J.W. de Blok	D.E. Jourdan-Thomas	E.M. Swart-Nijssen ^o) G.E. de Schipper ⁺)
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J. v.d. Wal-Door- nekamp	M. Bruining-du Porto	
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Reprography

H. Hobbelink	B. Verschuur	R.P.D. Aggenbach
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Maintenance Department

T. Verveer	L. Heerschap	R.J.R. Anthonijsz
	F.J. Parlevliet	F.J. Schilling
	T. Buisman	R.M. Daalder
	A. Ran	S. Gieles
	J. Visser	

Workshop

M. Manshanden	N. Prins	A.J. Vaars
	J. van Heerwaarden	H.J. Boekel
J.J.A. van Weereld	G.M. Manshanden	R.L. Groenewegen ⁺)

Department of Biological Study Material

M. Buhre

Domestic service

S.W. de Porto	T. Agema-Lebbe
G.C. Weijdt-Eelman	J. de Vries
C. Bakker ^o)	

Harbour and ships

H.A. Beumkes	W.P. Jongejan	C. Snijders
	R. de Vries	
C. van Zwieten	C. Gerssen	A. Boon
	A. Schol	G.L. de Vries
	G.H. Steenhuizen	A.J. Souwer
	J.C. Groot	C.J. Mozes
J.H. Oversluizen	S. Dogger	
N. Muller	C. Wisse	

9.3. STAFF MATTERS

9.3.1. Training courses attended by staff members

J. Kalf	röntgen analysis
C. van Zwieten	merchant service officer G.H.V.
R. Dapper	algol, fortran
J. Kalf and	
S.J. van der Gaast	knowledge of materials CI-A

W.G. van Arkel statistician VVS
part of the personnel fire service
administration course IRIS

9.3.2. Works Council

During 1978 six meetings of the Works Council with the directors of the Institute took place. The following subjects have been points of discussion:

The payment of ocean cruise overtime: discussion led to agreement on this subject.

The regulations of the Works Council: juridical advice was sought on the provisional regulations that had served during 1 year. The discussions on a definite text have not yet been concluded.

Voluntary shorting of worktime. An inquiry conducted on this subject revealed that many employees were interested in a voluntary reduction of their working time, especially if this would result in the creation of new jobs.

The budget of personnel costs and the effect of the Government's economy programme on this budget.

The representatives of the personnel consider the discussions to have been usefull, though a greater spontaneity could improve the contact between representatives and directors.

9.3.3. Association of personnel

This year the association organized a newyear reception, a movies evening and a movies afternoon (with borecale meal).

In August a sporting day became a success by the enthusiasm of the participants, the nice weather and a copious barbecue.

Various sport activities were financially supported.