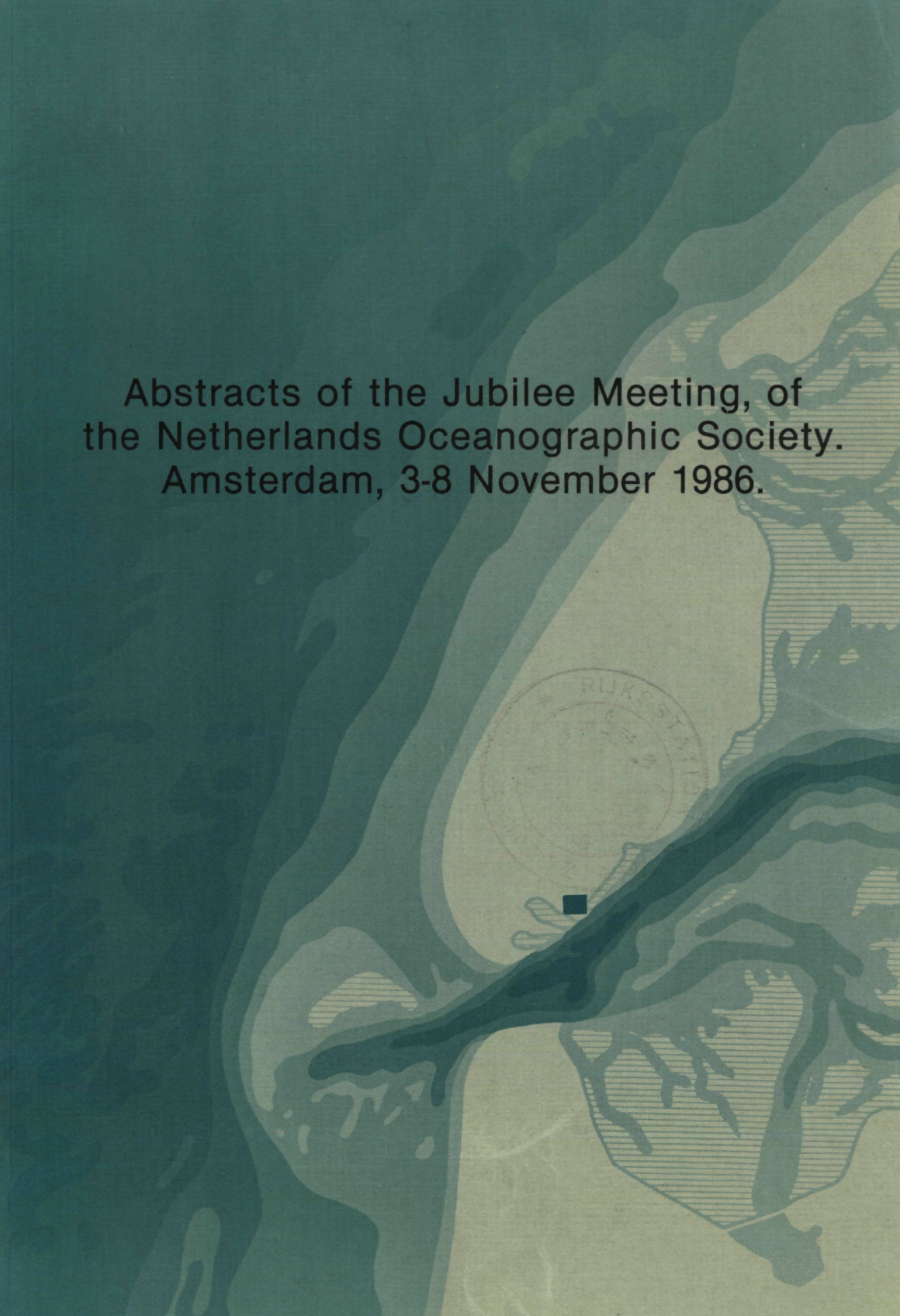
Abstracts of the Jubilee Meeting, of the Netherlands Oceanographic Society. Amsterdam, 3-8 November 1986.



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A B S T R A C T S

of the

POSTERS presented at the

Jubilee Meeting of the

Netherlands Oceanographic Society

Amsterdam 3 - 9 November 1986

PREFACE

15 YEARS DUTCH OCEANOGRAPHIC SOCIETY

When not many decades ago the science of management was invented, and teached at universities, the result was quickly that at various levels in our society science started to be managed. Nearly all scientifically 'developped' countries suffer from the blessings of sometimes a complete reorganisation of the traditional structures, in all cases intended to do better for the same or a smaller budget.

Indeed, many traditional structures of universities and scientific institutions were illogic. Their existance was due to initially private initiatives and using the budgets and possibilities for expansion present at that time.

Whether or not reorganisation excercises are good or bad, in this whole development it remains essential what happens on the working platform . The strength of inofficial circuits at this level and linking scientists over all thresholds of organisations and disciplines is most important for any country trying to improve its scientific capacity.

This publication is a result of such a working-platform spirit. The Dutch Oceanographic Society was born out of this idea to know each other better and to find out where contacts between marine scientist, or scientists having interest in oceanography and from possibly different disciplines , would be fruitful.

The presented abstracts concern the first overall poster presentation of a large variety of Dutch oceanographers from various organizations, including universities and institutions, of fundamental and applied research. The participants are all members of the Society, which was set up 15 years ago on the

initiative of the physical oceanographers Prof. P. Groen and Dr. L. Otto. The number of Society members is at present more than hundred and on an annual basis meetings are organized by scientists of each time a different organization.

The sixty seven abstracts, here presented, concern posters from 5 major groups of oceanography, being Estuarine Research, Biological Oceanography, Physical Oceanography, Chemical Oceanography and Geological Oceanography. These posters certainly do not represent all Dutch activities in marine research, but they present at least a cross-section of the older and more recently set up research units in the Netherlands. Interesting is in particular the participation from research groups of the recently created 'DGW' (Direction Tidal Waters) of the Rijkswaterstaat.

The spectrum of presented abstracts represents a random number of present-day studies, some of them being part of a larger multidisciplinary programme. They reflect the SNELLIUS-II expedition, jointly organized by Indonesia and the Netherlands, the research required for policy strategies in the North Sea, and research of young fellows carrying out Ph-D studies for 4 years in oceanography.

Science and management of water- , bottom- and ecosystem quality are in the near future more and more linked, and are of particular importance for near-coastal seas and estuaries that fall under the responsibility of national authorities. Integral water-, bottom- and ecosystem strategy plans have to be developped. For fundamental sciences there are equal responsibilities for the open oceans for which in particular joint international operations are foreseen.

The connections between scientists at the working platform

of the Dutch Oceanographic Society certainly contributes to this goal, and the publication here presented is a witness of this intention.

Let it be a start for another 15 years of fruitful inter-disciplinary exchange in marine science.

Dr. E. K. Duursma
Chairman Netherlands
Council of Oceanic Research

INTRODUCTION

Without the help of rules and convenance the Netherlands Oceanographic Society flourished for 15 years. For the first time in this period, oceanographers and oceanographic research groups of all disciplines presented results of their recent research activities at a poster exhibition held from 3-9 November 1986 in Amsterdam, to celebrate this jubilee.

The present abstract volume gives an almost complete picture of the posters presented; at the same time it gives an overview of the variety of oceanographic research presently carried out in the Netherlands.

The board of the Netherlands Oceanographic Society is indebted to the Institute for Taxonomic Zoology of the University of Amsterdam for hosting the poster exhibition and to the Netherlands Institute for Sea Research for assistance during the organisation and printing of this abstract volume.

The enthusiasm and input of the participants forms an invitation to our Society to organize some other year a follow up of this effort.

S. van der Spoel - H.W. Riepma - M. de Ligny - Tj.C.E. van Weering
Board of the Netherlands Oceanographic Society.

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ESTUARINE RESEARCH

CAN ADSORPTION PROCESSES REGULATE PHOSPHATE DYNAMICS IN AN ESTUARY?

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Field observations on the fosfate distribution in the Ems estuary showed a non-conservative concentration gradient with high summer values in the middle reaches. These high values could not be explained by biological processes. Therefore, attention was focused on physico-chemical processes related to phosphate and sediments as well as supended material. Experiments were carried out with material collected from different localities and the effects of salinity and pH on the phosphate concentrations were studied.
The results indicate the exxistence of two antagonistic mechanisms that regulate the phosphorus cycle. Carbonates (mainly calcite) and clay minerals presumably play a dominant role. Calcite is formed at sea and transported in coastal direction and to upper reaches of the estuary just as other suspended matter. During this transport phosphates adsorps onto calcite. Due to a decrease of pH in the upper reaches of the estuary calcite is partly dissolved and consequently part of the phosphate is desorbed. Other suspended matter components such as clay minerals, are also able to adsorb phosphate. Especially in the upper reaches of the estuary decreased salinities and pH-values create conditions that favour the adsorbtion of phosphate wich is available there due to the calcite dissolution. Thus, during the transport in upstream direction part of the calcite-bound phosphate changes position to the clay mineral fraction of the suspended matter.
It is postulated that the non-conservative concentration gradient in phosphate is caused mainly by the relatively fast phosphate desorption from dissolving calcite at decreasing pH. This process can be stimulated by the diurnal changes in pH-values due to biological activity. The processes of sediment transport and phosphate adsorption favour the accumulation of marine phosphates in the estuary and favour the retention of fluviatile phosphates in the estuary.

EXTRAXTION OF DEPOSITS IN THE DUTCH WADDEN SEA: A POSSIBLE CAUSE OF INCREASED TURBIDITY

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The mean annual concentration of suspended matter in the Ems estuary increased by a factor ranging from 1.3 to 2.1 between 1954 and the period 1970 to 1979. The fluctuation in these concentrations showed a statistically significant correlation with the distance dredged annualy and not with the volume dredged annually. It was postulated that the fluctuations in concentrations of suspended matter were caused by the intensified erosion and the sedimentation cycle that is initiated after the local natural equilibrium between channel morphology and current pattern is disturbed. This explanation is supported by the morphological changes that occurred in part of the study area between 1975 and 1979 and the change in the tidal amplitude in the estuary. The available data further indicate that dredging in the lower reaches of the estuary has a stronger effect on the suspended matter concentrations than the same effort carried out in the upper reaches. The observed changes in suspended matter have ecological significance because there is close relationship between suspended matter and light regime(K_e) wich regulates potential primary production of phytoplankton. An increase in suspended matter also negatively influences vital functions of bivalves (e.g. the mussel Mytilus edulis). Dredging is not restricted to the Ems estuary alone. It also occurs in the Wadden Sea just as some related activities as the extractions of sand, clay and shells. Measurements done in the Wadden Sea indicate that also there changes occurred in suspended matter and consequently turbidity. The changes in this area are different, not only between but even within tidal basins and seem to be related with dredging and mining activities. An attempt will be made to support this relation and to give an explanation for the responsible mechanism in order to interest physicists for the ecological problems in estuarine

INVESTIGATIONS OF SALINITY AND FRESH WATER CHARACTERISTICS IN THE EASTERN SCHELDT DURING THE CLOSURE OF THE COMPARTMENT DAMS

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P.A.J. Perrels, Delft Hydraulics Laboratory
A. van der Wekken, Rijkswaterstaat, Tidal Waters Division

In the rear of the Eastern Scheldt estuary the compartment dams (Philipsdam and Oesterdam (fig. 1)) are presently under construction. With the closure of these dams the Deltaworks will be completed. (Oesterdam in October 1986 and Philipsdam in April 1987). Closing of the dams by a sand-fill technique will save many millions of guilders. However, such a technique can only be applied when the storm surge barrier in the mouth of the Eastern Scheldt is operated to prolong the tidal period and reduce the amplitudes, within the estuary or even eliminate it for short periods. Without such measures being taken velocities could run up too high, making sand-fill closure totally impossible.

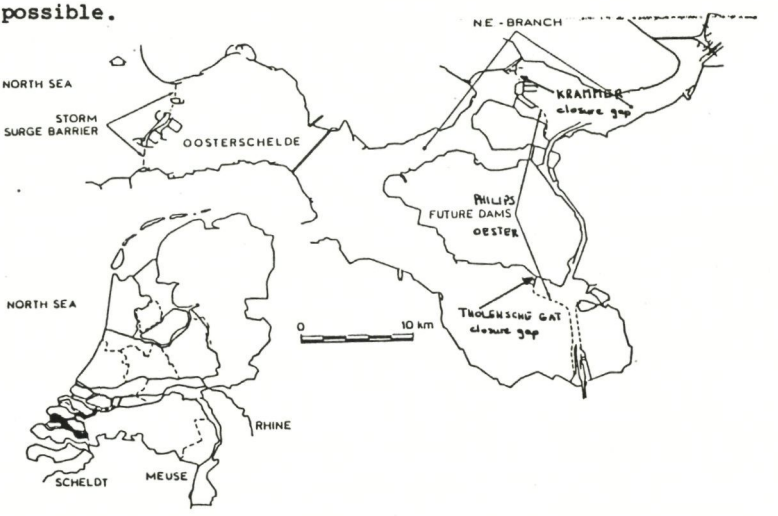
In the eastern part the fresh water enters the estuary from the river Dintel and the Volkerak locks, causing a salinity gradient from west to east. Mixing in the estuary is predominantly due to tidal action. The decreased mixing resulting from the operation of the storm surge barrier leads to a gravitational circulation. As a consequence the fresh water is dispersed over a large part of the Eastern Scheldt. Low salinities on certain locations and, associated large vertical density gradients may cause damage to the environment by the limitation of oxygen transport to the bottom layer.

To get a better insight in these problems computations have been made

using different mathematical models. These models are a stationary one-dimensional model (SYSAN), the non-stationary 1D models IMPLIC and ZWENDL and the non-stationary two dimensional vertical model DISTRO. Although the latter 2D model seems to be the most appropriate one to use, only part of the estuary was modelled for reasons of economy and the impossibility of calibration since not sufficient field data are available.

The computations have shown that measures have to be taken to prevent the above mentioned damage to the ecosystem.

Different compensating measures have been examined. The investigation has shown that reducing the fresh water discharge at the Volkerak locks is sufficient to reduce the change on norm crossings during both closures to a few percent. During the completion of the works field measurements are being carried out making a check of the model results possible.



THE INFLUENCE OF THE STORM SURGE BARRIER ON THE SUBLITTORAL HARD SUBSTRATE COMMUNITIES OF THE OOSTERSCHELDE ESTUARY (SW NETHERLANDS).

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In order to investigate the influence of the erection of the storm surge barrier on the sublittoral hard substrate communities of the Oosterschelde estuary, before the completion of the barrier a quantitative survey of the sublittoral communities and the regulating abiotic parameters has been carried out. In total 75 stations at 20 different locations were sampled. This abstract only deals with the first 33 stations at 16 locations (figure 1). At each station 4 quadrats of 1024 cm^2 were sampled. The sampled area of 4 quadrats (4096 cm^2) is sufficient for reaching the minimal area (figure 2). The percentage cover of the vertical projection on the substrate of every organism was estimated. Before cluster analysis all data were logarithmically transformed. Cluster analysis was carried out using the 'Average Linkage method' combined with the Bray-Curtis coefficient. The dendrogram resulting from this cluster analysis is shown in figure 3. After the normal analysis an inverse analysis was performed. This analysis procures information about the composition of the communities.

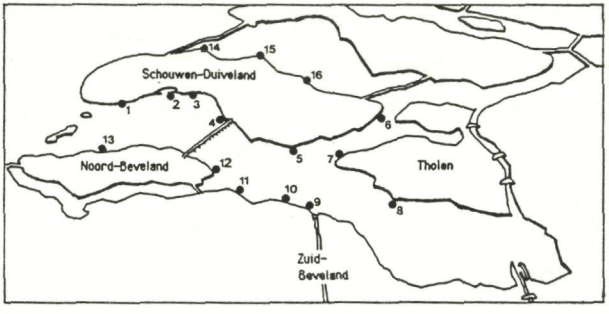

Figure 1. Situation of the locations

Schouwen-Duiveland:	1-Burghsluis	Zuid-Beveland:	9-Wemeldinge
	2-Schelphoek		10-Nieuwe Sluis
	3-Flauwers-West		11-Sas van Goes
	4-Zierikzee	Noord-Beveland:	12-Katshoek
	5-Ouwerkerk		13-Wissenkerke
	6-Zijpe	Schouwen-Duiveland:	14-Scharendijke
Tholen:	7-Stavenisse		15-Den Osse
	8-Gorishoek		16-Dreischor

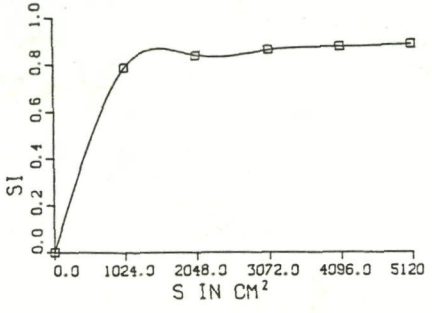

Figure 2. Bray-Curtis coefficient (SI) as a function of the sampled surface (S) for location 9 (8 meter MWL).

In the southern Delta area 9 sublittoral communities are defined using characteristic and dominant species. Two communities (F and G) are found in lake Grevelingen. This lake, a former estuary of the rivers Maas en Rijn, was formed in 1971 after completion of two enclosing dams. The community (F) between 3 and 6 meters is characterised by algae. Underneath, between 8 and 15 meters, a community (G) is found dominated by cirripedia and the tunicates Ciona intestinalis and Styela clava.

The remaining 7 communities are found in the Oosterschelde estuary. Three communities (E) are characterised by algae and are found to a depth of 4 meters. The other 4 communities are found at greater depths in their own abiotic environment. The factor that primarily causes the differences in composition between these sublittoral communities seems to be the exposure to water movement. This important ecological parameter was measured by relating the erosion of gypsum blocks to the rate of exposure. The erosion value is expressed as the weight loss of the gypsum blocks (g.hour^{-1}) during a lunar day (24.45 h). Community A, characterised by the anthozoan Metridium senile and most exposed to the water movement, is restricted to the mouth of the estuary. In the eastern section of the Oosterschelde, protected against the water movement by it's geographical position, a community (C) is found dominated by the anthozoan Diadumene cincta en the tunicate Styela clava. The community at Zierikzee (B), moderately exposed to the water movement, is dominated by the bryozoan Electra pilosa and the hydrozoan Halecium halecinum. The last community (D), found at very sheltered locations, is dominated by the tunicate Ciona intestinalis.

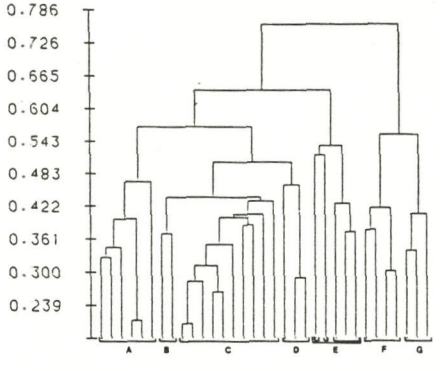

Figure 3. Dendrogram resulting from the clustering of the data. The clusters distinguished are marked with letters.

Modelling of a benthic-pelagic interaction
Application of an ecosystemmodel

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The ecosystem model discussed here has been constructed for the Ems estuary by the BOEDE-EON group in the period 1981-1985. It describes all important biological processes and those chemical and physical processes which are relevant to the biology.

The model can be used in 3 fundamentally different ways:

- As a research tool. The model is used to trace the consequences of certain hypotheses on the functioning of the modelled system. It will show up gaps in our knowledge and thus indicate new area's of research. After validation it may be used as a tool to calculate or estimate carbonfluxes through the ecosystem. A number of ecologically interesting calculations such as establishing productivities, efficiencies and system-wide carbon-budgets can be made easily with the model.
- As a management tool. The model can be used to predict changes in the ecosystem caused by management decisions. The results of such predictions need very careful interpretation by ecologists.

The model contains 32 state variables or constituents: 3 categories of primary producers, 8 categories of consumers, 3 categories of bacteria, 10 detrital constituents and 8 abiotic variables. Each constituent is modelled in 5 spatial compartments. Between the compartments transport processes take place, which modify the distribution of the transported constituents over the five compartments.

The model has been validated for some of the state variables, but for most of the state variables there were no independent sets of field-data which had not been used in constructing the model.

To illustrate the use of the model as a research tool we pose the following question: What are the consequences to the functioning of the ecosystem if we include/exclude suspended benthic diatoms as a food source for zooplankton? In the standard model these (benthic) diatoms are ignored as a potential food source, since only recently information on the extent to which these benthic organisms enter the watercolumn has become available.

To answer this question, a model run has been made, which includes the suspended benthic diatoms into the zooplankton diet.

The results show that especially in the Dollard (compartment 2 in the model), where tidal flats cover a large percentage of the total area and thus contribute much to the biomass of primary producers in the pelagic, the zooplankton now is able to maintain a higher biomass all through the winter (when true phytoplankton is scarce). These higher standing stocks then manage to shift the occurence of the phytoplankton spring bloom in time, at the same time reducing the peak density of the spring bloom.

The seasonal dynamics of the zooplankton and the phytoplankton both are strongly modified by the inclusion of suspended diatoms in the zooplankton diet, whereas the benthic diatoms themselves are nearly completely unaffected. The similarity between model results and field-data increases when we include suspended benthic diatoms in the zooplankton diet. Examining zooplankton faecal pellets from the Ems estuary for benthic diatom frustules may resolve this question fully.

SUSPENDED SEDIMENT FLUCTUATIONS IN THE TAGUS ESTUARY ON SEMI-DIURNAL AND FORTNIGHTLY TIME SCALES

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ABSTRACT - Nine multi-ship synoptic surveys of the distribution of suspended sediment, each survey including the conditions at both low and high tide, were carried out over a 12 month period in the meso-tidal Tagus estuary in Portugal. Additional measurements of the semi-diurnal fluctuations of suspended sediment concentrations and current strengths were made at fixed stations during a neap and a spring tide. During the study period, the river discharge of water and suspended sediment remained below the mean annual discharge and did not show a pronounced seasonal fluctuation.

A turbidity maximum, defined as an area with suspended sediment concentrations greater than 50 mg l^{-1}, was absent during neap tides (1.3 m amplitude) but appeared and grew in both extent and turbidity as the tidal amplitude increased, and was fully developed with concentrations greater than 50 mg l^{-1} throughout the entire estuary during spring tides (>3 m amplitude). Maximum concentrations, reaching as much as 1000 mg l^{-1} during spring tides, were always found in the inner shallow bay region of the estuary. In contrast to the salinity distribution, which fluctuated from partly stratified during neap tides to well mixed during spring tides, the vertical distribution of suspended matter in the turbidity maximum zone was always stratified with highest concentrations near the bottom. The fluctuation in suspended matter concentration is interpreted as a fortnightly erosion-sedimentation cycle, caused by a cyclic variation in the strength of the bottom currents. Superimposed on this is a semi-diurnal cycle. The semi-diurnal fluctuation of the suspended sediment concentration was negligible during neap tides, but attained magnitudes during spring tides that was comparable to the fortnightly fluctuation. The amount of material involved in these cycles is equivalent to the input of suspended sediment by the Tagus river during a year of normal discharge conditions. The suspended sediment regime in the Tagus estuary is related to the considerable fluctuation in the wet cross section of the estuary over the spring-neap cycle and the frictional dissipation of tidal energy as the water spreads laterally over an extensive intertidal mud flat area.

THE BEHAVIOUR OF PCBs IN THE SCHELDT ESTUARY

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Introduction.

The Scheldt estuary is well-mixed with water residence times up to three months and it shows a strong longitudinal oxygen gradient.[1] The occurrence and fate of selected PolyChloroBiphenyl (PCB) congeners has been investigated to provide more precise answers of the effects of future major changes in the estuary on the behaviour of organic microcontaminants.

Sampling and analysis.

Four sampling cruises were made from March to June 1986. During each cruise, 9-11 water samples of 25-100 L each were taken (at 3 metres depth) and filtered (pore size 1 µm) directly on board. The entire procedure took place in a closed system to prevent sample contamination. Extraction of water and suspended matter was executed in the laboratory.[2] The following 15 PCB congeners, given by their systematic IUPAC numbers[3], were determined: 15(dichlorobiphenyl, di-CB); 18, 26,28,31(tri-CBs); 44,49,51(tetra-CBs); 82,101,118(penta-CBs); 153, 138(hexa-CBs); 170 and 180(hepta-CBs).

Results and discussion.

Dissolved PCBs.

The dissolved PCB concentrations are comparable with concentrations previously found in the Scheldt[4] and in other Westeuropean estuaries (Elbe[5], Weser[6], Rhine[7]). The sum concentrations of the congeners 52,101,118,153 and 180, as a function of salinity, for the four cruises together, are given in figure 1. The data of figure 1 have been processed statistically. The results of tests determining autocorrelation and normal distribution of residuals indicate that the linear regression model, implicating conservative mixing, cannot be rejected. The deviations at low salinities cannot be explained at this moment. The conservative behaviour is surprising, because dissolved organic carbon (DOC) behaves non-conservatively in the Scheldt estuary.

Particulate PCBs.

The concentrations of particulate PCBs, normalized to organic carbon, show the highest values in the turbidity maximum (see as an example figure 2). We explain this phenomenon by the resuspension

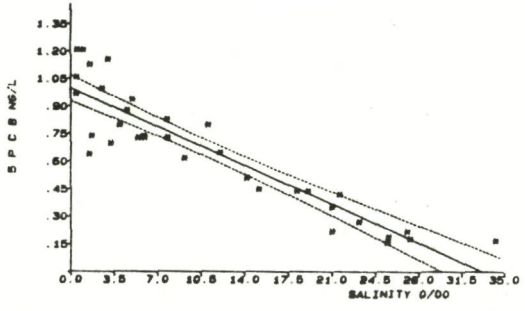

Figure 1. The sum of five dissolved PCBs (in $ng.L^{-1}$) as a function of salinity. The linear regression equation is: $y = (0.030 \pm 0.002)x + (1.00 \pm 0.07)$ $ng.L^{-1}$; $r = 0.92$, $n = 34$.

of bottom sediments of which the organic matter is already partially broken down, while PCBs have been readsorbed onto the remaining organic matter. This results in higher PCB concentrations.

Relationships between dissolved and particulate PCBs.

Some average distribution coefficients Kd and Koc (=Kd/foc, the particulate organic carbon fraction) are presented in table 1. Our Kd values agree with literature values. From table 1, it follows that the

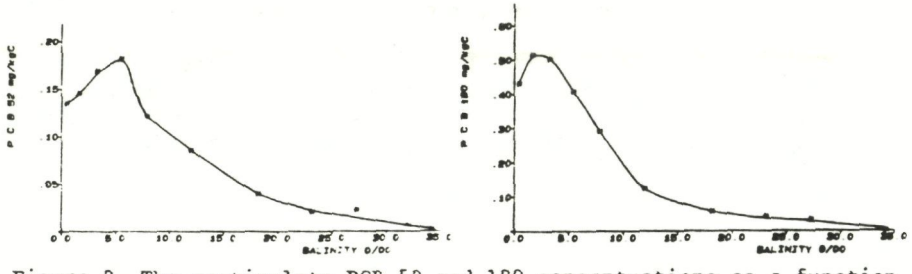

Figure 2. The particulate PCB 52 and 180 concentrations as a function of salinity for the June cruise (in $mg.kgC^{-1}$).

higher chlorinated congeners are relatively more present in the particulate phase than the lower chlorinated congeners, because of their stronger hydrophobicity. For example, the average dissolved PCB 52 and 180 concentrations at S=0.5 °/oo, are respectively 0.51 and 0.07 $ng.L^{-1}$, which amount to 52% of total (dissolved and particulate) PCB 52 and 5% of total PCB 180.

Table 1. Some average distribution coefficients in the Scheldt and some other Westeuropean rivers.

	$Kdx10^4(L.g^{-1})$ this study	$Kocx10^5(L.gC^{-1})$ this study	$Kdx10^4(L.g^{-1})$ Scheldt[4]	$Kdx10^4(L_4gC^{-1})$ 4 rivers
PCB 52	2.9	2.1	4.0	5.5
PCB101	14.0	10.1	8.0	9.0
PCB180	56.0	42.7	10.0	105.0

We found, like others[8], a strong relationship between log Koc and log Kow (data from literature[9,10]). The relations are respectively:

$$\log Koc = 0.77 \log Kow + 0.70 \quad (r = 0.99, n = 8)$$

and $$\log Koc = 0.66 \log Kow + 1.57 \quad (r = 0.85, n = 12).$$

The annual total PCB load (sum of 15 PCBs) to the Scheldt estuary is estimated at 50 kg, which is 20-30 times less than the annual PCB load transported by the river Rhine across the Dutch border[11].

Conclusions.

Dissolved PCBs behave conservatively in the Scheldt estuary. Particulate PCB concentrations (normalized to organic carbon) are highest in the turbidity maximum. The observed distribution coefficients agree with values reported in literature.

Literature.

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BIOLOGICAL OCEANOGRAPHY

BENTHOS RESPONSES TO EUTROPHICATION OF THE DUTCH WADDEN SEA

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During the last decades nutrient concentrations in the Dutch coastal waters have increased significantly. Rates of primary production as well as concentrations of chlorophyll and particulate organic matter have been higher during recent years as compared to estimates from earlier periods (see abstract by G.C. Cadée). Thus more food will have been available for herbivorous benthos during recent years. What is the evidence for a positive response by benthic herbivorous animals, expressed in such parameters as biomass, growth rate and rate of secondary production?

During a 15-year study (1970-1984) of the macrobenthos living at 15 fixed sampling stations in a tidal flat area in the westernmost part of the Wadden Sea, annual records of numerical densities and biomass were obtained in 27 common species. During this period nearly half of these species increased in numbers and biomass, whereas only 1 species showed a declining trend. In the remaining species fluctuations were irregular, affected primarily by the incidence of severe winters. Total biomass in the early eighties was roughly twice as high as during the early seventies. Increases were observed both in suspension and deposit feeders.

Growth rates could be studied only in a few species of bivalves showing clear year marks. In the cockle, *Cerastoderma edule*, a species with high biomass values (upto half of the total biomass), growth rates were found to be negatively related to density and density showed an increasing trend during the period of observation. In the low-biomass species *Macoma balthica*, growth rates increased during the 15-year

period as did numbers, biomass and production.
A preliminary estimate of total macrobenthic secondary production shows an increasing trend.
Though causal relationships cannot be proven from parallel time series, the accumulated evidence favours the view that the macrobenthos living in the sediment of the tidal flats responded positively to the eutrophication process in the Wadden Sea.

QUANTITATIVE-AND COMPARATIVE ANALYSIS OF MICROBIAL POPULATIONS IN SUSPENDED MATTER WITH THE AID OF A S.E.M. (NORTH SEA,WADDENSEA,INDONESIA)

H.R. BOS

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The scanning electron microscope(S.E.M.) was used to compare the number of bacteria in the suspended matter fraction of surface-watersamples,taken in the Dollard- and Jade -estuaria(Waddensea), along the Dutch Westcoast and Indian Ocean (Lombok-and N. Australian Basin) during the Snellius -II expedition in Indonesia. Watersamples(15/150 ml.) were filtered over 0.45 um nucleopore filters,fixated with alcohol,dried and cold-coated for S.E.M.-analysis. Various forms of bacteria were visible and were often seen binding sediment and debris particles. The ratio R=number of bacteria/number of suspended matter particles was determined in the Dollard-estuary during daylight at HW(Fig.1). A landward increase of R was found at the east side of the estuary (station 5,3,2,1)in January 1984 ,and in August 1983 at the west side (stat.4,6,7),which is in contrast to a decrease at resp. the west-and east-side during these month's . In the Jade-estuary a decrease of R was found towards the inner part of the estuary in October 1984 (Fig.2). Between the Jade entrance and Eems entrance ,R increased from 0.1/0.7 towards 0.7/3.79, probably because of the higher organic-and nutrient-input in the Eems-Dollard. Along the Dutch Westcoast bacteria-ratio's were high at Westschouwen(stat.2) and the Maasvlakte(stat.3), due to the nutrient input of the rivers Rhine and Meuse (Fig.3). As a tropical contrast bacteria-ratio's were also determined in the Indonesian waters (Fig.4). An increase of bacterial concentrations was found near the coast of Lombok,possibly caused by the nutrient-input from the Banda Sea. Generally spoken bacterial counts are very low compared to the North Sea.

Conclusions: The method proved to be well suitable for in situ comparison of bacterial populations . However bacterial counts are lower compared to previous used techniques (e.g. two phase method).This could have been caused by slight leakage during the filtration and by the absence of the smallest fraction of micro-organisms. The use of a more accurate filtration-apparatus and nucleopore-filters with a smaller pore-size could improve this.

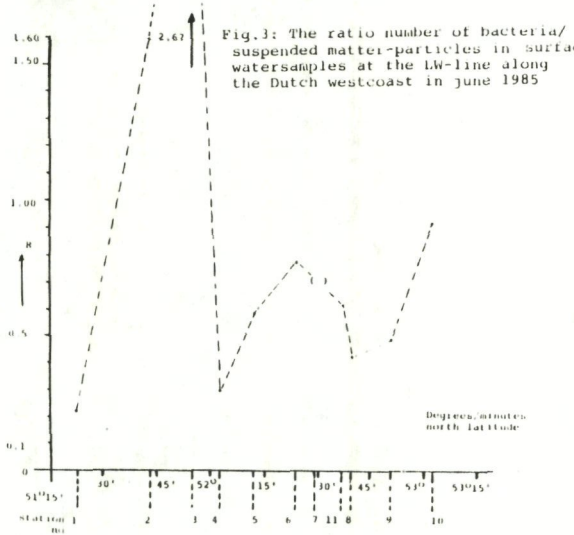

Fig.3: The ratio number of bacteria/ suspended matter-particles in surface-watersamples at the LW-line along the Dutch westcoast in june 1985

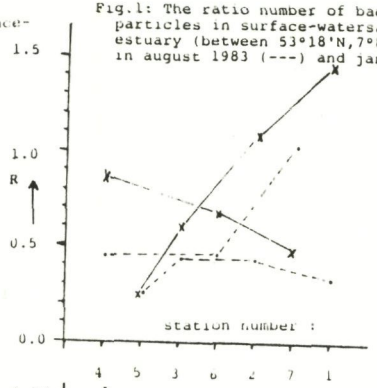

Fig.1: The ratio number of bacteria/suspended matter-particles in surface-watersamples in the Dollard-estuary (between 53°18'N,7°8'E and 53°14'N,7°13'E) in august 1983 (---) and january 1984(——) .

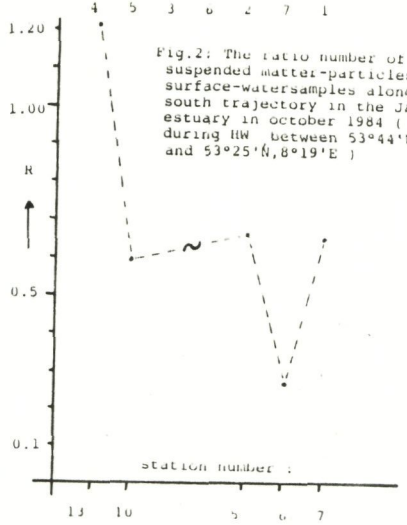

Fig.2: The ratio number of bacteria suspended matter-particles in surface-watersamples along a north-south trajectory in the Jade-estuary in october 1984 (daylight, during HW between 53°44'N,8°7'E and 53°25'N,8°19'E)

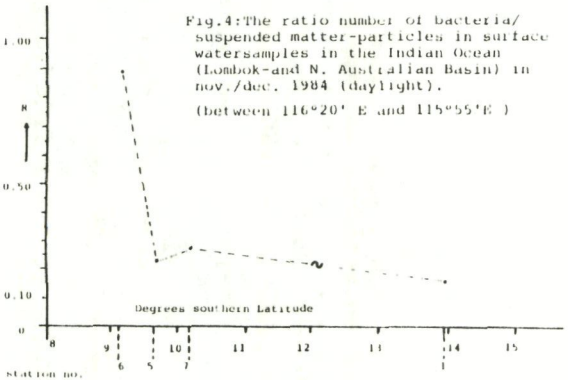

Fig.4:The ratio number of bacteria/ suspended matter-particles in surface watersamples in the Indian Ocean (Lombok-and N. Australian Basin) in nov./dec. 1984 (daylight).

(between 116°20' E and 115°55'E)

BIOLOGICAL AND SEDIMENTOLOGICAL INVESTIGATION OF DUTCH BEACHES (BISONS): A MULTIDISCIPLINARY STUDY.

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The BISONS-project is carried out by unemployed scientists under the supervision of the Foundation for the Advancement of Oceanography in The Netherlands (SBNO). The main purpose of this investigation is to get a better understanding of the role of the surf- and intertidal zones in the Nort Sea ecosystem. A comparative study is being carried out on micro- and meiofauna, macrozooplankton, chlorophyll-a content and sedimentary structures.
Surfacewater-samples and boxcores have been taken at the low-water line in June 1985.
- Chlorophyll-a contents in watersamples vary between 7.4 mg/m^3 (Callantsoog) and 89.9 mg/m^3 (Bloemendaal), and are relatively high in the coastal zone between Katwijk a. Zee and Bergen a. Zee. This is in contrast with the relatively low bacterial concentration in this area (with a minimal concentration of 23.9 bact./ml in Bloemendaal). Extremely high bacterial concentrations have been found at the Maasvlakte (1240 bact./ml) located near the outflow of the Nieuwe Waterweg (a heavily industrialized area). The content of phaeopigments has been determined, and varied between 0.5 mg/m^3 at Westschouwen and 26.9 mg/m^3 at Bergen a. Zee. Bacteria may play a role in the degradation of chlorophyll-a to phaeopigments. However, in this study no relationship has been found.
- Cross-sections made from boxcores show that sedimentary structures can be well preserved even in the turbulent surfzone. Shell fragments are mainly sedimentated in the coastal zone between Monster and Bloemendaal, and in the area near Wijk a. Zee.

MACROZOOPLANKTON: So far, little research has been carried out in the surfzone of the Dutch coast. This area is the nursery for many commercially fished species (fishes, shrimps), and therefore of great economic importance. Recent investigations (Vethaak, 1986) suggest that cancers, found in adult demersal fish, may be caused by damaging effects of PCB's in juvenile specimens.
The intertidal zone of the North Sea ecosystem, a highly dynamic environment with high turnover rates, is most strongly influenced by river input (runoff) and therefore the area most likely to be affected by contamination. In case of calamities at sea (oil-spills), the effect of river-derived pollution may be added to, or even enhanced by sea-derived pollution.
An inventory of zooplankton is being made at a number of stations along the Dutch coast. A study is made on relations between abundance, species composition and pollution, which may lead to recognition of planktonic species that are biological indicators of different stages of pollution. So far, juvenile demersal and other fish, Crustacea, Chaetognatha, Polychaeta, Gastropoda, and adult Crustacea, Hydrozoa,Polychaeta, Chaetognatha and Ctenophora have been found.

MEIOFAUNA RESEARCH: Micro- and macromeiofauna are responsible for the purification of large volumes of seawater, flushed through the sandy beaches by waves and tides. This interstitial fauna is an important part of the mineralisation complex of the coastal zone.
Aim of this meiofauna research is to investigate the influence of pollution of the purifying capacity of the interstitial system, and an attempt is made to point out indicator species of different stages of pollution. A new method for processing micro- and macromeiofauna samples is being developped.
Macrozooplankton, micro-and macromeiofauna samples have been taken from August 1986 until present.

EXPERIMENTAL BIOGEOGRAPHY OF SEAWEEDS

A.M. Breeman, W.T. Stam, H. Rietema, C. Yarish, P.V.M. Bot, M.L. Cambridge, A.M.T. Joosten and C. van den Hoek

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The goal of this interdisciplinary and international research program is to test hypotheses explaining large scale distribution patterns of benthic seaweeds. The program encompasses three different approaches:

I. World-wide distribution patterns

We investigated world-wide distribution patterns of seaweeds using various clustering and ordination techniques. The resulting patterns can be explained partly by present day climatic conditions of the oceans, partly by conditions and configurations of the oceans (and continents) in the geologic past (plate tectonics). For instance, the great similarity between the genetic red algal floras of the Caribbean and the Indo W Pacific (which are at present separated by 2 oceans and 2 continents) can be explained by interpreting both floras as two disjunct portions of a formerly (up to c. 15.10^{-6} yr) continuous Tethys flora.

II. Genome relationships

The historical hypotheses generated by approach I are difficult to test because of the absence of fossil records for most seaweed-groups. However, recently, one does no longer entirely depend on fossil "archives", because using molecular biological methods one also has access to the species "genomic archives". Using these methods it is possible to estimate the degree of genetic divergence, and the divergence times between disjunct populations of species with a highly disjunct distribution. These populations are often separated from one another by wide oceans, continents or adverse climatic belts. In one green algal species (Cladophora albida) divergence times between

Australian and W European populations were estimated at c. 35.10^6 yr but Japanese and Australian populations diverged much more recently (less than 5.10^6 yr). This evidence suggests a Tethyan origin of the distribution pattern of C. albida.

III. Distribution in relation to limiting environmental conditions

This approach centers on the question why seaweed species do not spread beyond their geographic limits when there are no apparent obstructions to their dispersal. Temperature, sometimes in combination with photoperiod or nutrient-levels, seems to be responsible. Critical temperature ranges for growth, reproduction and survival have been determined in experimental laboratory cultures under defined conditions. For several endemic red algal species of W European-African coasts narrower latitudinal ranges corresponded with narrower experimental temperature ranges. These W Eurafrican endemics cannot grow along NE American coasts because the seasonal temperature fluctuations (> $20^{\circ}C$) at any point along these coasts exceeds their temperature tolerance. Three NE American endemics have a completely different temperature tolerance. These species tolerate very wide temperature ranges (< $0^{\circ}C$ - $30^{\circ}/35^{\circ}C$) and occur from the tropical margins up into New England, where they profit by the high summer temperatures in shallow inshore waters (> $20^{\circ}C$) to reach sufficient growth and reproduction. These species would not be capable to disperse to Europe along the stepping stones in the N Atlantic Ocean (Greenland, Iceland) because of too low temperatures for growth in summer. Along the coasts of Europe summer temperatures would be too low for growth and reproduction as far south as Portugal.

EUTROPHICATION OF THE DUTCH WADDEN SEA

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The role of phytoplankton and microphytobenthos in the Dutch Wadden Sea has been studied since the late sixties. From these studies an increase in biomass and primary production became apparent.

Microphytobenthos living on a tidal flat in the western part of the Wadden Sea doubled in biomass and primary production from 1967 to 1981.

Phytoplankton biomass (based on chlorophyll measurements) increased since 1978. Primary production data for phytoplankton are less complete, but they also show a doubling in the early eighties as compared with the 1964 to 1976 period. Cell counts of phytoplankton indicate a spring peak of diatoms followed 2 to 3 weeks later by a peak in the colonial flagellate *Phaeocystis pouchetii*. Cell numbers of *P. pouchetii* as well as the duration of its spring bloom increased since the late seventies.

It seems logical to relate the observed increases in primary production and biomass to the increased nutrient concentrations in the Dutch coastal waters. However, it remains obscure why this affected phytoplankton only since the late seventies. Macrobenthos in the Dutch Wadden Sea responded to the increase in food by an increase in biomass and secondary production (see abstract Beukema).

DECLINING ZOOPLANKTON DENSITIES IN SUMMER
PREDATION OR FOOD LIMITATION ?

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Copepod populations in the Southern North Sea increase steadily during spring and culminate in June or July. In July this development breaks down and the populations dwindle within short time. "Predation" and "food limitation" are keyfactors suggested to explain this phenomenon.

Field studies carried out on the "REM-eiland" (an artificial platform near the Dutch coast) in 1984 and 1985, revealed that the decline in population densities manifested itself first in a precipitous fall in numbers of nauplii (copepod larvae). This information raised questions about the significance of:

a) diminished recruitment of nauplii as a consequence of increased predation on copepod eggs by planktonic carnivores
b) diminished recruitment as a consequence of diminished egg production by adult copepods at deteriorating food conditions
c) inter- and intraspecific predation (cannibalism) by adult copepods on nauplii.

Predation on copepod eggs was observed in the Hydromedusa Phialidium and the Zooflagellate Noctiluca. The latter appeared of particular interest, because of its maximum abundance coincided with the rapid decline in the numbers of naupii. Often a high percentage of the total amount of copepod eggs present in the system (up to 75 %) was found inside Noctiluca cells. However, the digestion of the eggs appeared very slow, so that estimates of total egg production never exceeded 50% of the egg production (c.q the potential recruitment of nauplii).

Individual egg production by adult copepods (determined in experiments and estimated from field

densities) was extremely low at the time of the nauplii decline (10 to 15 % of the previous productivity), which pointed at food shortage for the adults. The simultaneously observed low chlorofyll-a values in situ and a changing phytoplankton composition do conform to this idea.

Predation on nauplii by adult copepods may increase, when the adults experience shortage of food. In the observed situation, in which recruitment of nauplii was severely reduced but adults were still abundant, cannibalism could give the final blow to densities of nauplii. In this way food limitation is also indirectly responsible for the decline of nauplii.

DISPERSAL OF THE AMERICAN JACKKNIFE CLAM ENSIS DIRECTUS (Conrad, 1843) IN N.W. EUROPEAN WATERS.

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The American jackknife clam, wich lives along the east coast of North America, turned up in the German Bight in June 1979. Within a few years the species had spread out towards the Danish as well as Dutch waters. Dispersal towards Dutch waters occurred against the anti-clockwise residual current along the Dutch and German coasts of the North Sea.

The dispersal against current can be explained by:

1. Long lasting pelagic occurrence of larvae and post-larvae of Ensis Directus.

2. Counter currents in shallow coastal waters due to deformation of rotational tidal currents.

3. Temporary inversion of residual currents due to north-easterly winds.

SEDIMENTATION FIELDS IN THE WADDEN SEA
A POTENTIAL NURSERY FOR MACROZOOBENTHOS?

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In the Dutch Wadden sea there are ca. 7900 ha of sedimentation fields: a network of brushwood groynes and ditches, providing good conditions for sedimentation of supended matter. These fields have been managed for landreclamation purposes. Nowadays conservation and improvement of natural values prevail.

In the ditches ca. 10 macrobenthic invertebrate species occur. Dominant species are Nereis diversicolor, Macoma balthica and Corophium volutator.

Preliminary results indicate that the ditches in the sedimentation fields may be a nursery wich significantly contributes to the populations in the tidal flats of the Wadden Sea.

THE DISTRIBUTION OF SERPULIDAE (ANNELIDA, POLYCHAETA) ON THE WARM-TEMPERATE AND TROPICAL EASTERN ATLANTIC SHELF

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INTRODUCTION

Since 1976 seven expeditions have been held to Macaronesia (E.Atlantic, 40°-10°N). They are part of a long-term programme of biogeographically oriented marine research, the CANCAP project, organised by the National Museum for Natural History, Leiden, with participation of various other institutes.

So far we have identified the serpulid material of the first six expeditions, covering Morocco, Mauretania and the Archipelago's of Madeira, Selvagems, Canary and Cape Verde Islands; more material from the last area is still being studied.

The serpulid distribution, based on this material and an exhaustive survey of the literature, is compared with the zoogeographical divisions as given by Briggs (1974). The hypothesis that his Lusitanian Province can be divided in a) a warm-temperate "Lusitanian s.str." Subprovince (N. of Cape Finisterre, Spain), b) a Mediterranean Subprovince and c) a Mauretanian Subprovince (S.of the Strait of Gibraltar) has been checked.

RESULTS

In the Lusitanian Province 46 taxa of Serpulidae occur, including "world-wide" species. Depending upon the place where the southern border is drawn, 18-22 (39-48%) are endemic.

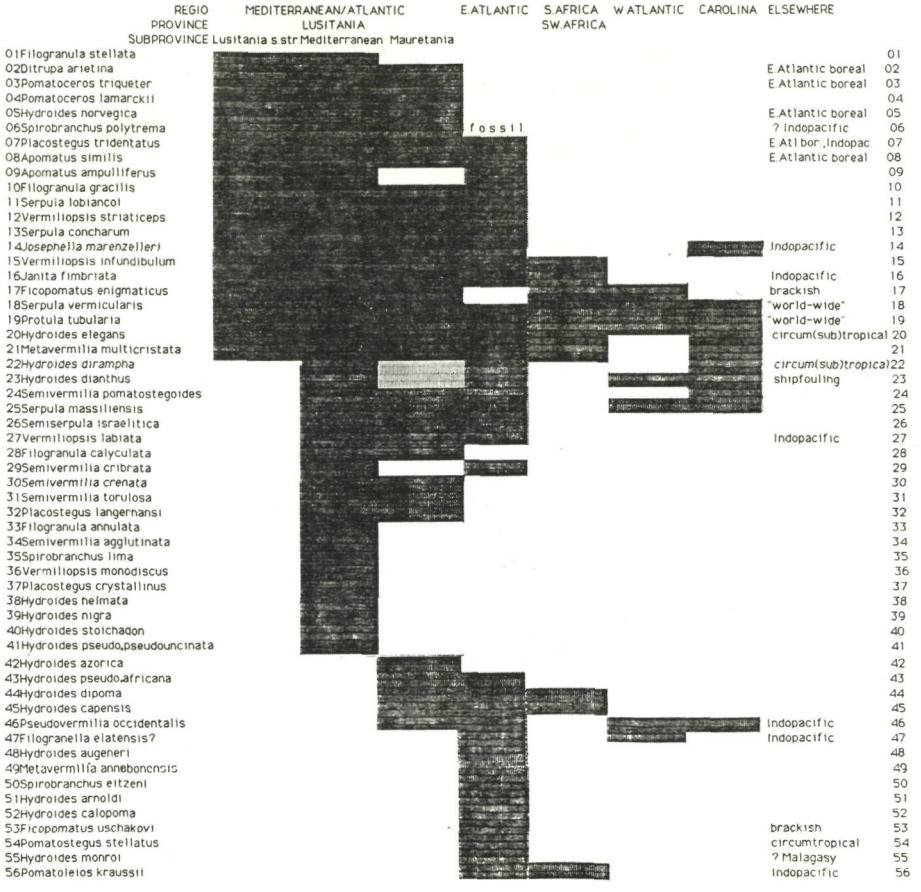
a) "Lusitania s.str." shows 21 species, all occurring in the Mediterranean too; 5 species are of boreal origin, endemic species are absent. A zoogeographical distinction is not justified.

b) The Mediterranean yields 41 taxa (Lessepsian migrants excluded), 89% of all Lusitanian forms, of which 9 (22%) are endemic. According to Briggs' hypothesis distinction upon Province level is justified.

c) The Mauretanian area shows 32 taxa, of which 27 (84%) are found in the Mediterranean too, and 18 (56%) even range into Lusitania s.str. Three of the species have a southern distribution. A zoogeographical distinction is not justified.

The Tropical Eastern Atlantic Region shows 35 taxa, of which 21 (60%) occur in the Mediterranean too. Five species (14%) are endemic, 11 (31%) have a temperate distribution as well.

Alltogether 56 taxa are known from the entire warm-temperate and tropical E.Atlantic. 31 (55%) are endemic to the area. 71% (22 species) of the endemics occur in the Mediterranean, 29% (9 species) even exclusively. An amphi-atlantic distribution is shown by 4(-6) species only (excluding "world-wide" ship-fouling species). An estimate of the number of W.Atlantic (boreal temperate and tropical) serpulids gives 60+ species. Thus the percentage of amphi-atlantic species is 3(-5).



CONCLUSION

The strong Mediterranean element in the Tropical Eastern Atlantic lends support to the hypothesis that the Mediterranean developed into a centre of dispersal after the Miocene salinity crisis. The low number of endemics in the tropics might reflect heavy extinction during the cooling of the Ice Ages, followed by a recolonization from neighbouring areas.

EXPERIMENTS ON EFFECTS OF ALGAE AND INVERTEBRATES ON THE STABILITY OF THE BENTHIC BOUNDARY LAYER.

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Altough Holland et al.,(1974) suggest that benthic diatoms stabilize sediments, significant numbers of benthic diatoms in the field occur concomitantly in the water, indicating that both stabilizing and destabilizing processes occur in the benthic boundary layer.
Under experimental conditions the presence of the diatom species Navicula salinarum in the sediment clearly decreased the resuspension of the 55 µm sediment fraction. The dramatic start of the sediment resuspension corresponds very well with the start of the tubulent conditions measured as an increase in small-scale current velocity (method: laser Doppler velocimetry) occurring simultaneously with a decrease in gross current velocity (method: float). The strongest reduction of resuspension was 50%, clearly demonstrating the stabilizing effect of the diatoms.
Also, the destabilizing effect of the invertebrates Crangon crangon, Corophium volutator, Cerastoderma edule and Macoma balthica was studied using an experimental system filled with sediment containing Navicula salinarum. The numbers of invertebrates used per square meter corresponded with natural densities. As a reference, sediment with diatoms only was used. Destabilization was measured by assessing the amount of resuspended diatoms in the watermass.
All animals increased the entrainment of diatoms in the water. At low current velocities this is due to the animal activity and at higher current velocities the resuspension was caused by a complex of animal activity, altered bottem roughness, and organisms protruding above the sediment surface.

Clearly, the diatom Navicula salinarum can stabilize surface sediments significantly and invertebrates can destabilize it. The changing interaction between stablization and destabilzation may be the reason why microphytobenthos is patchily distributed in the benthic boundary layer under field conditions.

NANNOPLANKTON FROM INDIAN OCEAN AND RED SEA SURFACE WATERS, SNELLIUS II EXPEDITION

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In June-July 1985 nannoplankton samples were taken during Cruise Gx, the home voyage of M.S. "Tyro", Dutch-Indonesian Snellius II Expedition. The obtained calcareous nannoplankton will be used to

- recognize floral assemblages and study their relation to water masses
- compare the distribution zones with those of other planktonic groups, especially the Foraminifera
- study geographic intraspecific variation.

Samples from the upper five meters of the watercolumn were obtained with a seawater pump. The water was filtered through Nuclepore filters with a pore size of 1.0 um. Then parts of the filters were examined with a Scanning Electron Microscope to determine species composition and standing crop.

More than 100 species, of which detailed SEM-micrographs have been made, could be determined. Some new species have been discovered.
After examination of the samples from the Indian Ocean and the Red Sea, 6 assemblages could be recognized and be related to different water masses.

A REMARKABLE FRONTAL ZONE IN THE SOUTHERN NORTH SEA

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Because of the shallow depth, the strong tidal currents and the influence of the wind, most of the Southern Bight water is vertically mixed all the year round. Due to this turbulence, particulate organic material (mainly generated during severe spring plankton blooms) and fine particulate inorganic matter (of which the British coast is an important source) remain in suspension. Hence, the seabed in the area consists of clean sand, with a poor infauna.

Along the continental coast of the Southern North Sea, a residual current moves in north-easterly direction towards the German Bight, carrying its load of suspended matter. This watermass flows along the southern edge of the Oyster-grounds, where the sea widens, and depth increases slowly. Here, along the 30-m depth line, the turbulent water moves along a more stagnant and in summer temperatur-stratified northern sea area.

Over at least 100 miles along this tidally induced front - i.e. where both water masses meet - the seabed shows a several miles wide zone of freshly sedimentated mud with a high content of organic carbon. This local enrichment has strong effects on the benthic and pelagic system:

- There is a local change in the character of the benthic invertebrate fauna, especially with regard to feeding types. Most invertebrates outside the frontal zone are suspension feeders, whereas in the mud deposit feeders dominate.
- Benthic biomass and total community respiration in the muddy zone are very high, and comparable with those in e.g. the rich tidal area of the Wadden Sea.

- The high release of dissolved nutrients from the seabed in the muddy zone leads to a persistent chlorophyll-a maximum in the overlying water; the high primary productivity in the water reinforces the productivity of the seabed.
- Concentrations of zooplankton and macroplankton (mainly fish-larvae) are high in the zone. The effects are strongest in late summer and autumnwhen the pelagic system in the surrounding sea is poor due to depletion of nutrients.
- In autumn and winter, echo-soundings and midwater-trawl catches over the enriched zone show high concentrations of sprat and whiting, which explains clearly the distribution of seabirds in the area with their maximum occurence in the frontal zone.

Conclusion: In the Southern Bight of the North Sea redistribution mechanisms concentrate the primarily produced material in restricted areas. In this way, the productivity in higher trophic levels of the ecosystem is aggregated in particular small parts of the sea.

SEABIRD CONCENTRATIONS AT A TIDALLY INDUCED FRONT IN THE SOUTHERN NORTH SEA

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In the southern North Sea a gradual increase in depth is found from south to north, accompanied by gradually dropping tidal current velocities (Creutzberg 1985). At a certain latitude (ca. 50 km north of Texel) a critical velocity is reached, inducing stratification of the water in summer and deposition of mud and detritus particles. This boundary, or front, is characterized by a highly enriched benthic fauna, higher chlorophyl-a and zooplankton concentrations, and also relatively high fish-stocks, as compared to the sea on both sides.

We have started to study whether certain fish-eating seabirds, as the top-carnivores in the system, are able to benefit from the relatively high biomass at lower trophic levels. If this would be so, higher densities and probably higher "qualities" of the birds involved would be expected in the area of the front, as compared to the areas on either side. Seabirds were counted from the R.V. "Aurelia" in the period February-November 1983 in an area extending on both sides of the frontal zone. Individual counts lasted for 10 minutes at ship speeds ranging from 7.5 to 9.5 knots. All birds seen in each count were identified, and if possible their age and state of moult was noted.

Among the non ship-followers, enhanced numbers were found for the Guillemot Uria aalge in the periods February-April, and October-November. Guillemots from the frontal zone and to the north of this area were of a better quality (older or in better condition) after the winter than birds occurring south of the front. A higher percentage of birds still in winter plumage was found in the south, whereas from the frontal zone northward relatively many summer-plumage birds were found in the early spring. Guillemots that had regained their summer plumage appeared to leave the area before conspecifics that were still in winter plumage, so wintering south of the front is linked to a late departure to the breeding colonies. Razorbills Alca torda were also found at relatively high numbers in the frontal zone at the end of the winter. In summer, Razorbills were not found within the area studied, but Guillemots, being always the more common species of the two, were seen in every month of the counting period.

Trawler-scavenging seabirds are all highly mobile and their distribution at sea is for a great part determined by the fishing activities of man, bringing otherwise inexplorable food sources within reach of the birds. Fishery seems particularly intense in the frontal area (MAFF 1981; own obs.), making this enriched area even more profitable for scavengers. Several species were found to occur in relatively high numbers in the frontal zone for at least part of the year: Fulmar Fulmaris glacialis in July (mainly moulting birds); Lesser Black-backed Gull Larus fuscus in summer; Greater Black-backed Gull L. marinus in autumn and Kittiwake Rissa tridactyla in Februari and from September to November (NB: no counts are available for mid-winter). The general conclusion that can be drawn from these first results is that pursuit divers as well as scavenging seabirds profit from the locally enriched zone of the tidal front in the southern North Sea.

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Effects of drill cuttings with adhering oil on the macrobenthic fauna in the North Sea.

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Since 1985 a tentative research programme has been carried out in order to detect possible effects on the macrobenthic fauna and in sediments, due to the spilling of oil-based drilling muds, adhered to the cuttings.

This programme was initiated by Rijkswaterstaat North Sea Directorate, to develop a monitoring programme suitable for the Dutch sector of the Continental Shelf. The aim was to improve and select methods to detect the distribution and effects of dumped cuttings with adhering oil-based mud.

The Netherlands Institute for Sea Research, dept. EON was requested to carry out investigations on the macrobenthic fauna, while the Netherlands Organization for Applied Scientific Research TNO investigated the hydrocarbon concentrations in sediments and organisms and grain-size distribution. They used also active biological monitoring with mussels.

Three locations were chosen in the Dutch sector in different sediment zones:platforms K12a, P6b and P15a, all in use as a production platform. Two transects were laid near each platform: a transect of 5 km long in the direction of the residual current and another one perpendicular to the first one with a length of 3 km. On the residual current transect sampling was done at 250-500-750-1000-1500-2000-3000-5000 m from the platform. The other transect was sampled at 250-500-750-1000-2000 and 3000 meter. The survey near platform K12a was carried out one year and a half after the last well was drilled.

The fauna of K12a consisted of approx. 100 species, inhabiting fine sediment mixed with silt. The number of species at each sampling station was approx. 70. The preliminary results show that in the vicinity of the platform (0-250 m residual current transect) the fauna consits for a greater part of young animals (small body size), indicating a serious mortality of the fauna during drilling and recolonization afterwards. This fact was not observed at the other stations of this transect. A few opportunist species were abundant near the platform. This means a shift in faunal composition near K12a.

Platform P6b with sandy sediments mixed with shell fragments appeared to have approx. 100 species. The samples from the residual current transect show a decrease in species number towards the platform.

The preliminary results justify continuing of the investigations. The 1986 programme provides surveys near platform L4a before, during and after drilling with OBM. The first survey will be used as a baseline and the other one to see whether there are short and long term effects of the used OBM on the fauna.

Platform K12a will be visited again. The sampling will be carried out

nearly three years after the last well was drilled. The last part of the prgramme of 1986 is an investigation of the fauna around platform F18/8, where water-based mud is used for drilling.
The results will be published in 1987.

PRELIMINARY REPORT ON THE CHAETOGNATHA OF THE AMSTERDAM MID NORTH ATLANTIC PLANKTON EXPEDITION (AMNAPE) 1980.

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The AMNAPE cruise 1980 was made in the period April 11 - May 2, 1980 in the Mid North Atlantic between 55°N and 24°N, roughly along 30°W (Fig. 1). Discrete depth samples were made between 30m and 1200m depth with a Rectangular Midwater Trawl: RMT 1+8. Open net hauls were made with an open RMT1 and an open 1 m diameter ringnet in the upper 150m. For further details on the cruise one is referred to Van der Spoel (1981).

The chaetognaths of this cruise showed that for 55°N to about 42°N the fauna consists of 7 species (*Sagitta maxima, S. planctonis* f. *zetesios, S.macrocephala, S.lyra, Eukrohnia bathyantarctica, E.hamata, E.fowleri*). *Sagitta hexaptera* did not occur north of 49°N, its vertical distribution ranged from 30-400m. *S.lyra, S.maxima, E.bathyantarctica* and *E.hamata* were found throughout the watercolumn from 0-1200m. *S.planctonis* f. *zetesios* occurred below 150m and *S.macrocephala* and *E.fowleri* below 500m only.

South of about 42°N 15 taxa were found. At about 42°N was the northern boundary of several taxa e.g. *Sagitta minima, S.planctonis* f. *planctonis, S.enflata, S.tasmanica, S.decipiens, Pterosagitta draco* and *Krohnitta subtilis*. *Sagitta hexaptera* and *S.lyra* became more abundant in the samples south of 42°N. *S.maxima, S.macrocephala, S.planctonis* f. *zetesios, Eukrohnia bathyantarctica* and *E.fowleri* occurred deeper than 500m only. *E.hamata* was found deeper than 200m.

South of 38°N *Sagitta bipunctata* was found and south of 34°N two more taxa occurred e.g. *S.serratodentata* and *S.sibogae*, characterizing more subtropical water.

There is a clear faunal boundary in the Mid North Atlantic for Chaetognatha at about 42°N where the number of taxa reduces from 15 in the south to 8 in the north. Also at this boundary the vertical distribution of several taxa, *Sagitta maxima*, *S.planctonis* f. *zetesios*, *Eukrohnia bathyantarctica* and *E.hamata* changes from mesopelagic south of this boundary to epi- and mesopelagic in the north, the so called tropical submergence.

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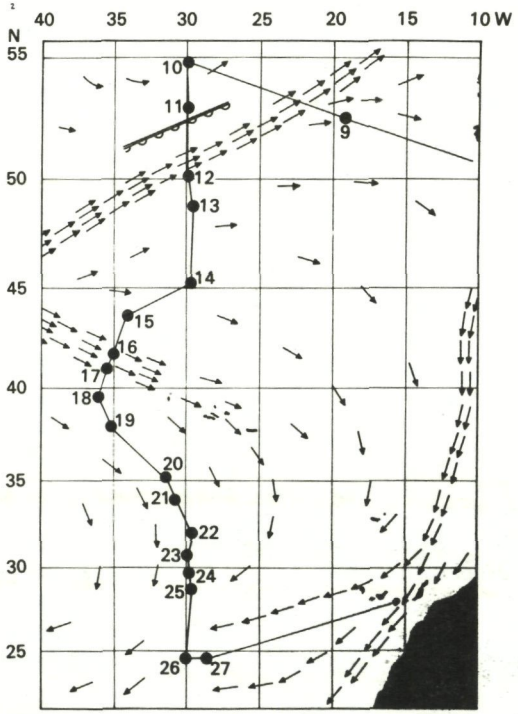

Fig. 1a - Position of the stations with a diagrammatic representation of surface currents (arrows) and the polar front (double line).

POPULATION DYNAMICS OF MACROALGAE IN CORAL REEFS

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The availability of free substratum is generally a limiting factor in coral reefs, which are characterised by multispecific assemblages of scleractinian corals and crustose corallines (main reef-building organisms) and sponges, gorgonians etc. Fleshy and filamentous algae seem to form only a minor constituent, but, on closer inspection, reef substrata appear to be covered by a great abundance of algae. However, these algal vegetations are reduced to inconspicuous algal turfs by large populations of herbivorous fishes and sea urchins. Larger macroalgae, characteristic in temperate regions, are restricted to areas with reduced herbivory in tropical reefs. This general picture disregards specific properties of single algal species to cope with the severe grazing pressure characteristic of coral reefs.

Thus, the Dept. of Marine Biology, University of Groningen, continued its project on coral-reef-algae at Curaçao with extensive research on temporal and spatial distribution patterns of some macroalgae. One of these species, *Lobophora variegata*, a brown foliose alga, which is encountered at depths greater than c. 20m, has a spatial distribution pattern, which suggests a negative correlation of algal abundance and abundance of herbivores. Detailed studies on population dynamics revealed no seasonal changes in cover, blade sizes, growth rates and turn-over rates. However, we discovered that turn-over rates of *Lobophora*-blades were very high and that the apparently constant cover of *Lobophora* is, in fact, the result of a dynamic process of growth and losses. Cage experiments confirmed that grazing by fishes and sea urchins was responsible for these high turn-over rates, which, in turn, determine mean blade size (Fig. 1).

Mass mortalities in the herbivorous sea urchin *Diadema antillarum*, which reduced populations at Curaçao to less than 5% of their former values, confirmed this conclusion: *Lobophora* cover and blade size increased at locations where pre-mortality *Diadema*-densities had been high until a new equilibrium in algal cover was reached (Fig. 2). A comparable trend was observed in the cover of algal turfs. These new equilibrium levels are now maintained by the remaining herbivores (fish), but the initial expansion of algae following *Diadema* mortality demonstrates that reduced herbivory will result in increased algal cover and this must be considered as a strong warning against overfishing in coral reefs. Although we demonstrated that corals are able to defend themselves, to some extent, against overgrowth by algae, by reducing algal growth rates (Fig. 3), crustose corallines are easily overgrown and this will have an adverse effect on the reef structure.

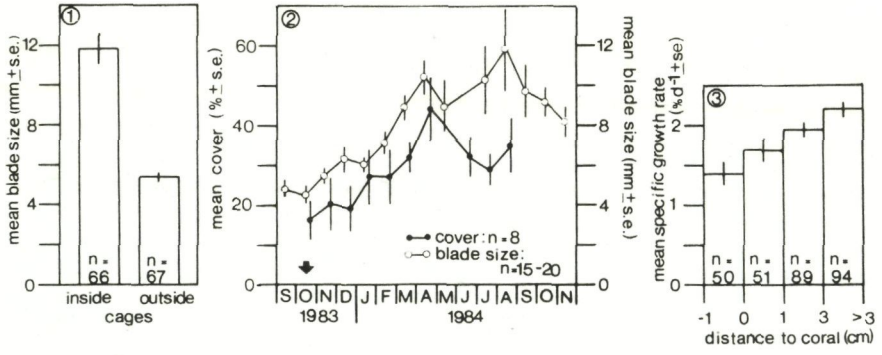

Fig.1. Effect of grazing on blade size of *L. variegata*; mean blade size inside (no grazers) and outside cages.

Fig.2. Increase in cover and blade size of *L. variegata* following mass mortality (arrow) of herbivorous sea urchin *D. antillarum*.

Fig.3. Reduction in growth rates of *L. variegata*-blades growing close to coral colonies.

MONSOON RELATED CHANGES IN ZOOPLANKTON AND MICRONEKTON POPULATIONS IN THE EASTERN BANDA SEA AND WESTERN ARAFURA SEA.

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The SE-monsoon affects upwelling conditions in the Banda Sea area, resulting in an eutrophic situation, whereas the NW-monsoon affects downwelling conditions, resulting in an oligotrophic situation (Wyrtki, 1957; Baars and Zijlstra, 1987). Zooplankton and micronekton have been sampled with the RMT 1+8 during two identical cruises in August 1984 (SE-monsoon) and February 1985 (NW-monsoon).

Zooplankton biomass, in wet weight, proved to be twice as much in August (20 gr.w.w./m^2) compared to February (9.5 gr.w.w./m^2) considering the upper 300m at night. A patchy horizontal distribution occurs in the former period, and a more homogenuous distribution in the latter. Diel vertical migration was found to be significantly enhanced in the poor NW-monsoon period, and the vertical distribution at night was distinctly shallower. Differences in biomasses at the various stations between the two cruises showed that largest influence of the monsoon occurred in the NE part and SW part of the area studied.

Micronekton, mainly crustaceans and mesopelagic fishes, showed a similar decrease from August (5.43 gr.w.w/m^2) to February (2.88 gr.w.w./m^2). Highest concentrations were found in the western part of the area in August and in the middle in February, showing a different distribution as the zooplankton, perhaps indicating that both cruises show only a momentary 'photograph' of an dynamic ecosystem. In numbers fishes and crustaceans showed about the same abundance in the two seasons, but the weight per specimen was much lower in August.

The biological activity, measured as ETS activity, of the zooplankton assemblages and some micronekton species, showed no differences in weight specific activity between the seasons, suggesting that the adaptation to the poorer NW-monsoon period was executed mainly by a decrease in biomass and not by lowered activities. The significantly increased diel vertical migratory activity of the zooplankton in the NW-monsoon period, bringing the organisms in deeper colder waterlayers during day time, yields a saving of 9 to 36% in ETS activity in

daytime, compared with the night values of a 500m watercolumn, suggesting that diel vertical migration is an energy saving adaptation to the poorer period.

Based on biogeography and meristic characters of pteropods, used as watermass indicators, an influx of Pacific waters in the eastern part of the area in August is suggested. In February a homogenuous pattern was found, and the populations bore a more typical equatorial character, possibly indicating Java Sea or Indian Ocean influx in the whole area.

Monsoonal winds prove to be of severe significance for the zooplankton and micronekton communities inhabiting the area. Large changes in biomass rather than in numbers and in (migratory) behaviour rather than in biological activity result from the alternating changes in hydrography, induced by the monsoonal winds. The heterogenity in biomass and species distributions in August point to a highly dynamic ecosystem during the SE-monsoon, in contrast with more homogenuous conditions and maybe a less dynamic system in the NW-monsoon. Alternating influxes of Pacific and Indian Ocean faunas seem to futher complicate this situation.

PARAMETER	SE-MONSOON	NW-MONSOON
SPECIES COMPOSITION	EQUATORIAL SPECIES	EQUATORIAL SPECIES
	'PACIFIC' SPECIES	NONE
	'UPWELLING SPECIES	NONE
NUMBERS EQ. SPEC.	DECREASE	INCREASE
NUMBERS PAC. SPEC.	INCREASE	NONE
NUMBERS UPW. SPEC.	INCREASE	NONE
HOR. DISTRIBUTION	PATCHY	HOMOGENUOUS
VERT. DISTR. AT NIGHT	DEEP	SHALLOW
BIOMASS PER M3	INCREASE	DECREASE
BIOMASS PER ANIMAL	INCREASE	DECREASE
DIEL VERT. MIGRATION	NONE OR REVERSED	ENHANCED
BIOL.ACT./UN.WEIGHT	NO CHANGE	NO CHANGE
BIOL.ACT./M3	INCREASED	DECREASED

Schematic presentation of effects of monsoons on the studied parameters of the zooplankton and micronekton populations.

COMBINED ETS-ACTIVITY AND RESPIRATION MEASUREMENTS ON SIZE-FRACTIONATED PLANKTON SAMPLES

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Microplankton (20 -200 µm ESD) contains a high number of fragile species which tend to desintegrate when mechanically or chemically stressed as occurs during handling of samples or adding fixatives. Quantitative microplankton counts are therefore unreliable.

To acquire information on the activity of microplankton in the Wadden Sea as compared to total pelagial respiration and on the effects of sampling, handling the samples and incubation, parallel measurements have been made of oxygen consumption by the Winkler technique and ETS-activity.

Samples have been fractionated into two size classes: < 20 µm, < 200 µm by reverse flow-filtration; unfiltered samples contained all size classes.

Respiration and ETS-activity, indicating the potential respiration capacity, are closely correlated.

The results from these experiments showed an increase in ETS-activity during 24-hours incubations in spring and summer which was absent during fall and winter. Identical increases in ETS-activity were found in roughly treated samples (vigorously shaken) and carefully handled samples, though the final ETS-activity in the shaken samples was lower than in carefully handeled samples.

These increases, irrespective of the treatment, suggest growth during incubation, masking any deleterious effects of handling, filtration and/or shaking.

The measured oxygen consumption during the incubations does not reflect these increases in ETS-activity in that the dissolved oxygen concentration does not decrease exponentially; at least the decrease in dissolved oxygen concentration is not significantly different from a straight line.

Using only the oxygen measurements during the experiments as an indication for the presence or absence of growth thus would fail.
The combined measurements on the other hand, give some insight into the rapid changes in the samples during incubation and offer the possibility of correcting for changes in the measured respiration rate due to growth in the samples.

LONG-TERM RECRUITMENT FAILURE IN EIDERDUCKS; AN OCEANOGRAPHIC MYSTERY

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The Eiderduck (Somateria mollissima) is a large seaduck, living in inshore waters. The birds spend the whole year at sea, except for the females which are on land for about four weeks during the nesting period. After the eggs have hatched, the young are led to the sea by the female. The ducklings are able to feed themselves. The role of the female is restricted to guiding the brood to good feeding and resting places, and to protect them against predators. For more effective protection against gull predation, broods are amalgated into creches, guarded by several females. Even so a high mortality often occurs in the first week of life due to predation by gulls (mainly Larus argentatus and L. marinus).

The numbers of ducklings that fledged in the 1963-1986 period show, besides large yearly variations, also a long-lasting recruitment failure between the years 1966 (or 1971) and 1977 (Figure 1). This failure was largely independent of the number of ducklings born or of the numbers of females or gulls present.

Observations showed that females usually are quite capable to intimidate and drive off attacking gulls. Only stray ducklings or ducklings that react too slowly to the alarm calls of the females fall victim to gull predation. In an extensive study it was shown that straying and slowly-reacting ducklings had lost all their energy reserves that they had at birth (c. 15% fat), because they had not found enough food (Swennen in prep.).

The fluctuations in the fledging success in each of the 5 large, Dutch Eider colonies are similar each year (Swennen 1983). This indicates that local factors are subordinate to one or more factors operating over a much larger area. Small invertebrates were scarce at the time the ducklings hatched in the period of recruitment failure. Either because Eider hatching was not well synchronized with the reproduction of most molluscs, crustaceans and worms, or because young of these animals were in general less numerous than normal in our coastal waters and in the Wadden Sea. There are indications that the latter factor was most important in that period. Why this happened is not clear, but there were some parallel changes in productivity in the North Sea. According to data on plankton from 1948 to 1975, blooms of the planktonic alga Phaeocystis pouchetii occurred regularly from 1948 up to 1964, but were less pronounced or even absent from 1969 onwards. In this stage probably other algae became dominant (Gieskes & Kraay 1977). In another study from 1973 to 1985, marked peaks of Phaeocystis were found again from 1977 onwards (Cadee & Hegeman 1986). The intermediate period corresponds perfectly with the period of recruitment failure in Dutch Eiders. It is possible that

the food chains based on these two primary producers are very different from each other. This is supported by the fact that the stock of Sprat (Sprattus sprattus) in the North Sea increased in 1971, and sharply declined after 1978. There was no evidence that this was related with changes in fishery practices. During the 1970s the larval production of herring (Clupea harengus) was extremely low but sharply increased from 1977 at the same time as the sprat decline (Corten 1986).

It can be concluded that the primairy cause of the large duckling mortality is food scarcity and not gull predation. The scarcity of duckling food coincides with some other long-term biological phenomenon in the North Sea, not being directly related to Eider food.

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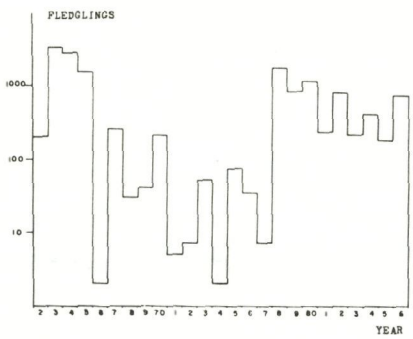

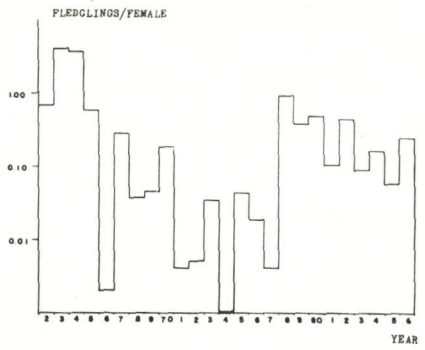

THE NECESSITY FOR A SOUND TAXONOMY OF MARINE CALANOID COPEPODS

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Free-living planktonic copepods (Crustacea: Copepoda: Calanoida) constitute 70% of total zooplankton biomass. They form a dominant factor both in numbers of species (over 4000) and individuals (1-2.000 x 10^3 per liter sea-water). It obvious that neither descriptions of plankton communities nor conclusions in marine biogeography can claim anything of comprehensiveness when excluding this group.

A basic requirement to explore in full the potentials of the Copepoda as a source of data in marine research is the availability of a sound classification. However, copepod systematics has hitherto failed to produce anything beyond a coarse inventory of primary units (species) and a rough sketch of the taxonomic structure of the group. Thus, detailed conclusions about species composition of zooplankton communities and about distribution patterns are generally not possible. But this can change.

For now we have got at our disposal the eight fundamental requirements to lift the taxonomy of copepods above the alpha-stage and into the bèta and gamma levels of taxonomic research:

1. Detailed knowledge of external morphology (Von Vaupel Klein, 1982).
2. Detailed knowledge of internal anatomy (Park, 1966; Boxshall, 1985).
3. The character complex of integumental perforation patterns, permitting resolution to infra-specific levels (Fleminger, 1973).
4. An operational procedure for phylogenetic analyses (Von Vaupel

Klein, 1984).

5. A compendium of all nominal species (Razouls, 1981).
6. A complete bibliography (Vervoort, 1986-87).
7. A catalogue (in MS only, W. Vervoort, Leiden).
8. Collections from modern, selective sampling programmes all over the world.

All we need as yet are: (1) time, (2) money, and (3) qualified scientists to incorporate these eight items into active research and do the job.

In Leiden, we have made a start by producing the first cladogram of a copepod genus, viz., *Euchirella* (cf. Von Vaupel Klein, 1984). This is only a first step: by the time all groups of planktonic copepods will have been given the same thorough treatment, a detailed knowledge of species definitions will be available within a robust scheme of phylogenetic and zoogeographic relationships.

This will undoubtedly result in a better understanding of (1) zooplankton communities at the level of secondary production. Also (2) the conditions in which mass deaths of plankton communities produce siliceous or calcareous layers composed of phytoplankton exoskeletons which contain deposits of free oceanic lipids derived from the high fatty oil contents of copepods are formed, can be investigated in detail. The latter results might well shed more light on the conditions of mineral oil formation and hence be instrumental in enhancing the efficiency of oil prospection.

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INFLUENCE OF EUTROPHICATION ON THE DOMINACE OF PHYTOPLANKTON SPECIES: ROLE OF THE COLONY FORMING ALGA PHAEOCYSTIS POUCHETII IN THE NORTH SEA.

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In the eutrophicated coastal zone of the North Sea phosphate was indicated as the factor limiting phytoplankton growth. The peak of the bloom coincides with undetectable phosphate concentrations and high alkaline phosphatase activities, with still excess nitrogen available. The phytoplankton composition at that time is dominated by Phaeocystis pouchetii. Present as single cells, with cell diameter of c. 7 µm and colonies, up to 20 mm with hundreds of cells. Because two cell types of a single species co-occur at a whole range of nutrient levels the phosphate metabolism of Phaeocystis was studied under experimental conditions.

Growth rate and the percentage of Phaeocystis cells in either of the two growth forms appeared to be influenced by the phosphate level of the medium. Moreover, both cell types have developed different strategies to provide themself with nutrients. The prescence of a colonial structure appeared to be of benifit to the cells in it. Colony carbon was utilized for catabolic and metabolic purpose during the night. Providing e.g. the colony cells with the energy required to maintain the phosphate uptake in the dark at a high rate.

The two growth forms of Phaeocystis are therefor regarded to be adapted to rapid changing nutrient levels. Such conditions are found along the North Sea coast with its input of various nutrient rich rivers. These observations may be the explanation of their yearly massive occurrence in spring.

ECOSYSTEM RESPONS TO MONSOONAL WIND DIRECTION CHANGES IN THE BANDA SEA.

A multidisciplinary study during
Indonesian-Dutch Snellius Expedition.

by
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The monsoons characterize the climate of South East Asia. In the Northern summer the Asian landmass is much warmer than the sea, the air masses over Asia are heated and the low pressures creates the SE monsoonal wind from Australia to Asia. During the Northern winter the situation is reversed and the low pressure over Australia results in the NW monsoon. As the wind direction controls to a great extent the direction of the surface currents, large shifts in horizontal water movements occur due to the sequence of monsoons. In certain topographic conditions, with shallow seas bordering deeper seas, the monsoonal periods may coincidence with upwelling and downwelling. One of the waters in the Indo-Pacific which may demonstrate these events is the eastern Banda Sea, as described by WYRTKI. He compared 6 hydrographic stations performed in October 1929 during the first Snellius Expedition with repeatments by the Indonesian vessel Samudera in March 1957 and showed that the water type at a depth of 60 m at the end of the NW monsoon was found at the surface at the end of the SE monsoon.

Theme 3 "Pelagic systems" of the Snellius II Expedition investigated under the leadership of ZIJLSTRA (Nioz) and PURWITO (Fish. Res. Inst. Jakarta) the physical and biological oceanography of the Banda Sea during both monsoonal seasons in order to check the findings of WYRTKI and to study the consequences for the ecosystem and the fish stocks. Upwelling is the rising of relatively colder water masses from below into the photic zone, and the higher nutrient concentrations in this water do increase the algal growth. The primary production increases and subsequently enhances secondary and tertiary production. For this presentation a small part of the Theme 3 results was chosen from the huge amount of information collected by the different research groups onboard of the RV Tyro, RV Samudera and RV Tenggiri in August 1984 and February 1985.
The temperature distribution at a depth of 40 m, taken from the oceanographic work of TIJSSEN, ILAHUDE & WETSTEYN, shows that during August 1984 the lowest values occured in the NE part of the Banda Sea. In accordance with the upwelling hypothesis the depth of the nitracline in this area is shallower than in the other parts of the area studied. During February in the NW monsoon temperature differences are less outspoken and the nitracline is everywhere located relatively deep. Analysis of the vertical movements of the waterlayers during the

cruises (not shown) by ZIJLSTRA, BAARS & WITTE indeed indicated upwelling in some areas in August and downwelling in February. The chlorophyll distributions recorded by GIESKES, KRAAY, NONTJI & SUTOMO reveal higher values in the SE monsoon, especially again in the NE Banda Sea as well as in the shallow Arafura Sea. Phytoplankton analysis showed that in these areas diatoms were numerous whereas in the open Banda Sea and during the NW monsoon very small algae (cyanobacteria) dominated.

VOSJAN & NIEUWLAND found that the vertical distribution pattern of all organisms smaller then 50 μm (including both autotrophs and heterotrophs) was different between the two cruises. In August the biomass was the highest at depths less than 40 m, in February the maxima lie deeper. Integrated over a water column of 300 m the total biomass of these organisms was more or less the same in the two seasons. This suggests that the "small food web" typical for oligotrophic areas —with tiny algae consumed by bacteria and other small heterotrophs— dominates the ecosystem during the NW monsoon. Contrarely, the biomass of the zooplankton closely followed the chlorophyll pattern: highest concentrations in the NE Banda Sea and Arafura Sea in August, and on average two times lower values in February (BAARS, A.B. SUTOMO, OOSTERHUIS & ARINARDI). Typical upwelling copepods were found during the SE monsoon, while these indicator species were completely absent in the NW monsoon. Only some fine filter-feeding copepods, probably capable to profit from the small food web, were equally numerous in both seasons.

Echo-patches recorded by ZIJLSTRA, SCHALK & WITTE showed highest densities of shoals of larger animals, presumably different species of fish and squid, in the NE area of the Banda Sea in August. In February shoals were less frequently observed and also more evenly distributed over the area. With comparable acoustic equipment RV Tenggiri came to estimates of the total pelagic fish stock of 900 000 tons for August 1984 and 260 000 tons for February 1985 (AMIN,, DUTO & SOEWITO). One of the future goals is to determine what fish species represent the observed backscattering, and whether economic exploitation is feasible.

Conclusions

—the suggestion by WYRTKI for upwelling and downwelling in the Banda Sea caused by monsoonal winds was confirmed.

—during the upwelling season in the SE monsoon roughly 2-3 times more algal, zooplankton and fish biomass was recorded than in the NW monsoon.

—the biological communities in the upwelling area differ largely from those in the neighbouring more oligotrophic areas, whereas the small food web important in the latter type of water showed no important biomass changes between the seasons.

—the relatively short food chain,-nutrients-diatoms-copepods-small fish-large fish, during the rich upwelling season results in a considerable increase in fish stocks compared with the poor season of the NW monsoon.

PHYSICAL OCEANOGRAPHY

DISPERSIVE EFFECT OF SUB-GRID BOTTOM TOPOGRAPHY

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Analysis of results from 10 km and from 1½ km grid numerical flow computations in the North Sea has shown that for areas with a pronounced small scale bottom topography the 1½ km vorticity averaged to 10 km scale will be significantly different from that directly determined from the 10 km grid computations [1]. This implies that a significant production of vorticity at the 10 km scale is induced by that part of the bottom topography which is of sub-grid scale in the 10 km grid computations.

The depth averaged vorticity is a measure for the rotation of an element of fluid in the x-y plane. The above finding therefore implies that the advection track at 10 km scale, derived from 10 km grid computations, may be different from that derived from 1½ km grid computations. In addition, vorticities (circulations), induced by the bottom topography which in the 10 km grid computation is of sub-grid size, provide sub-grid stirring, the dispersive effect of which is not included in 10 km grid computations of the concentration field, unless parameterized.

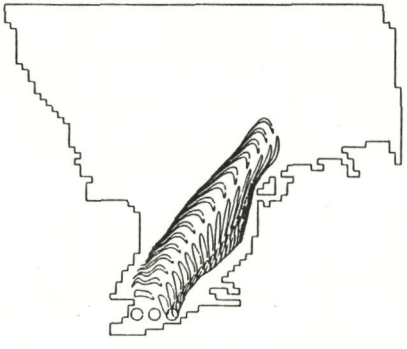
Whether or not sub-grid vorticity influence can be accepted depends on the inaccuracies in the advection tracks and the magnitude of the dispersive effect it induces. Particle track simulations are a proper tool to quantify the inaccuracies in the advection tracks. Recently, such simulations were made both with a fine and detailed 1½ km grid velocity field and with the same velocity field having filtered variations over a characteristic length Δs. They show that in North Sea circumstances, sub-grid effects are a factor to be considered.

The effect of the sub-grid stirring can be expressed in a sub-grid dispersion coefficient, the magnitude of which can be determined knowing the positions of particles of a given cloud in the 1½ grid velocity field, and both the 1½ km grid and the Δs grid velocities at these locations. Sub-grid dispersive effects are to be considered for any grid size Δs for which the sub-grid dispersion coefficient derived in this manner is large compared with the sum of the diffusion coefficient due to large scale turbulence in the horizontal plane and the dispersion coefficient due to variation of velocity and concentration over the depth.

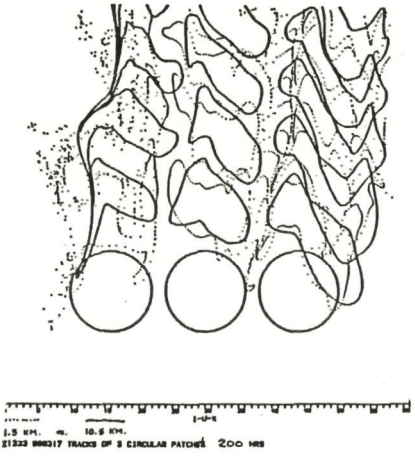
Sofar the above comparison has been made between the 1½ km grid and the 10 km grid velocity field. Where the small scale bottom

topography is pronounced, the difference in the lengths of the advection tracks derived from both velocity fields was about 30%, and the effect of the sub-grid stirring on the instantaneous concentration distribution was to be expressed by a dispersion coefficient to the order 50 $m^2 s^{-1}$ for 10 km grid computations of the variation of the concentration over the tidal cycle. Much lower values were found along the Dutch coast where the bottom is relatively flat.

[1] G. Abraham, H. Gerrritsen, G.J.H. Lindijer, "On sub-grid tidally-induced residual circulations. Continental Shelf Research 1986, to appear.



10 km grid advection of particle clouds



1.5 and 10 km grid advection of particle clouds

THE ROLE OF ARCTIC INTERMEDIATE WATERS IN THE RECENT FRESHENING OF THE ATLANTIC DEEP WATER

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Opposite to the suggestion given in most textbooks it is known nowadays that the T-S characteristics of the North Atlantic deep water complex are not fixed forever. Changes in salinity of the order of several hundreds with a typical time scale of the order of ten years are reported recently for the North East Atlantic Deep Water (NEAD).

This NEAD has as source water type the Iceland-Scotland Overflow Water (ISOW) which is formed by mixing of Arctic Intermediate Water (AI) with the Norwegian Sea Deep Water. The two existing explanations of the recent freshening of the NEAD point to the role of AI. Explanation one poses that the salinity of AI varies due to variations in the flux of salty Atlantic water into the Norwegian Sea. These variations in Atlantic influx are ultimately reflected in the salinity of NEAD. Explanation two stresses the role of fresher intermediate water of polar origin. Due to minor changes in the circulation this low salinity water may be diverted from the East Greenland Current via the East Iceland Current towards the Faroese Waters. From this viewpoint the fresheninig of NEAD reflects a changed circulation of polar waters in the Norwegian Sea.

Observations carried out in the summer of 1983 on board R.V. Tyro disclosed that north of the Faroese Islands two different intermediate arctic water types were present simultaneously; AI1 (S = 34.72) with a polar origin and AI2 (S = 34.98) with an Atlantic

origin. The overflow of ISOW over the Iceland Faroe Ridge as well as through the Faroe Bank Channel mainly contained AIl with proportions of up to nearly 50%. This pronounced presence of AIl is seen as the cause of the recent freshening of NEAD. Published timeseries indicate that this presence of fresher AI from polar origin became clear after 1975 and our observations indicate that this presence lasted at least till 1983. Also in the year 1907-1911 such an episode was observed.

Concluding one can remark that the observed freshening of NEAD reflects the increased importance of water from polar origin for the formation of ISOW and ultimately NEAD. This conclusion leaves the question "what caused the increased transport of polar waters from the East Greenland Current toward the Faroese Waters?" unanswered.

EDDY SIMULATION OF 2D HORIZONTAL DISPERSION

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In shallow seas and beyond a certain length scale, dispersion is largely determined by the horizontal velocity structure. Shear due to large eddies, combined with exchange at shorter distances by smaller eddies, is a wellknown agent of spreading.
If there are only two classes of eddies with a large 'spectral gap' in between, we have a case of shear dispersion and if the large eddy is so extended that the shear in the area of interest can be considered uniform, the spread from instantanous point sources (IPS) can be described analytically (Okubo, 1966). In practice there are many more than two size classes of eddies and spectral gaps are small or virtually absent. Qualitatively the dispersion of a cloud of matter in such a compound velocity field can be regarded as a cascade of shear dispersion processes at successive scales. If the velocity amplitudes are distributed over the eddy sizes L as (:) L^m, it can be derived that the diameter of the clouds from IPS will grow (:) $t^{p/(1-m)}$ if p = number of space dimensions and $m < 1$.

However, the coefficient of this proportionality remains unknown. For less regular spectra also the time behaviour can no longer be predicted.
With present computer capacities, these and other questions can be solved numerically by advecting particle sets in artificial eddy fields. Results of 2D eddy simulations are presented, including

- influence of lifetime of eddies
- mass trapping when lifetimes are infinite
- influence of number of discrete 'lines' in a fixed interval of the velocity spectrum
- influence of the shape of the spectrum of velocity amplitudes
- magnitude of momentaneous effective 'diffusion' coefficients; magnitude of constant values beyond the largest eddy scale
- characteristics of the shape of dispersing patches

Most simulations are completely 'advective', i.e. no other mechanism (such as a 'random walk') is added to the proper eddies. Therefore the simulations start from a particle distribution of finite dimensions.
By comparing the simulations with experiments at sea, one acquires insight in the structure and variability of the natural fields. By the same token, velocity fields computed by hydrodynamic-numerical models can be analyzed and compared with nature. Spectral gaps in these computed fields can be filled by supplementing with components as used in the eddy simulation model.

Ref.: A. Okubo, J. Oceanogr. Soc. Japan, 22, 35, 1966

RESIDUAL CURRENTS AND TRANSPORT IN TWO-DIMENSIONAL MODEL COMPUTATIONS

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In calculations of horizontally two-dimensional (2 DH) advective transports in tidal regions on the basis of given velocity fields, no fundamental problems are met as long as residual velocity concepts are avoided and the complete time dependent velocity field is utilized (figure 1). In certain cases an approach based upon tidal averages is desired e.g. for computing a stationary concentration distribution by means of the diffusion-advection equation in time independent form. In such a case a sufficiently accurate approximation of residual displacements is needed which is generally not acquired by applying so called Eulerian residual current velocities (figure 2) or Eulerian residual transport velocities (figure 3). A procedure is presented for obtaining better results in certain cases.

The illustrations refer to computations for the southern part of the North Sea (tidal currents c.q. tidally averaged currents without wind). In each of the figures 1, 2 and 3 water masses enclosed by 23 circles (5 in the southern part and 18 in the northwestern part of the region) are advected by the respective current fields indicated above, during a period of 240 tidal cycles (M2).

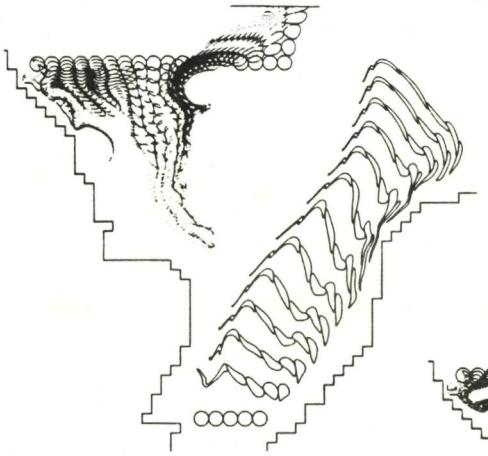

Figure 1

Figure 2

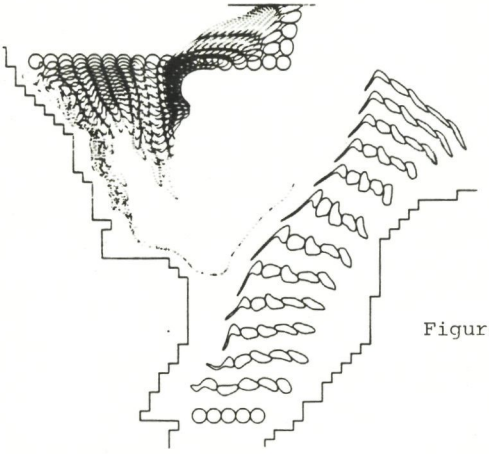

Figure 3

INFLUENCE OF FRICTION ON TIDAL CURRENTS

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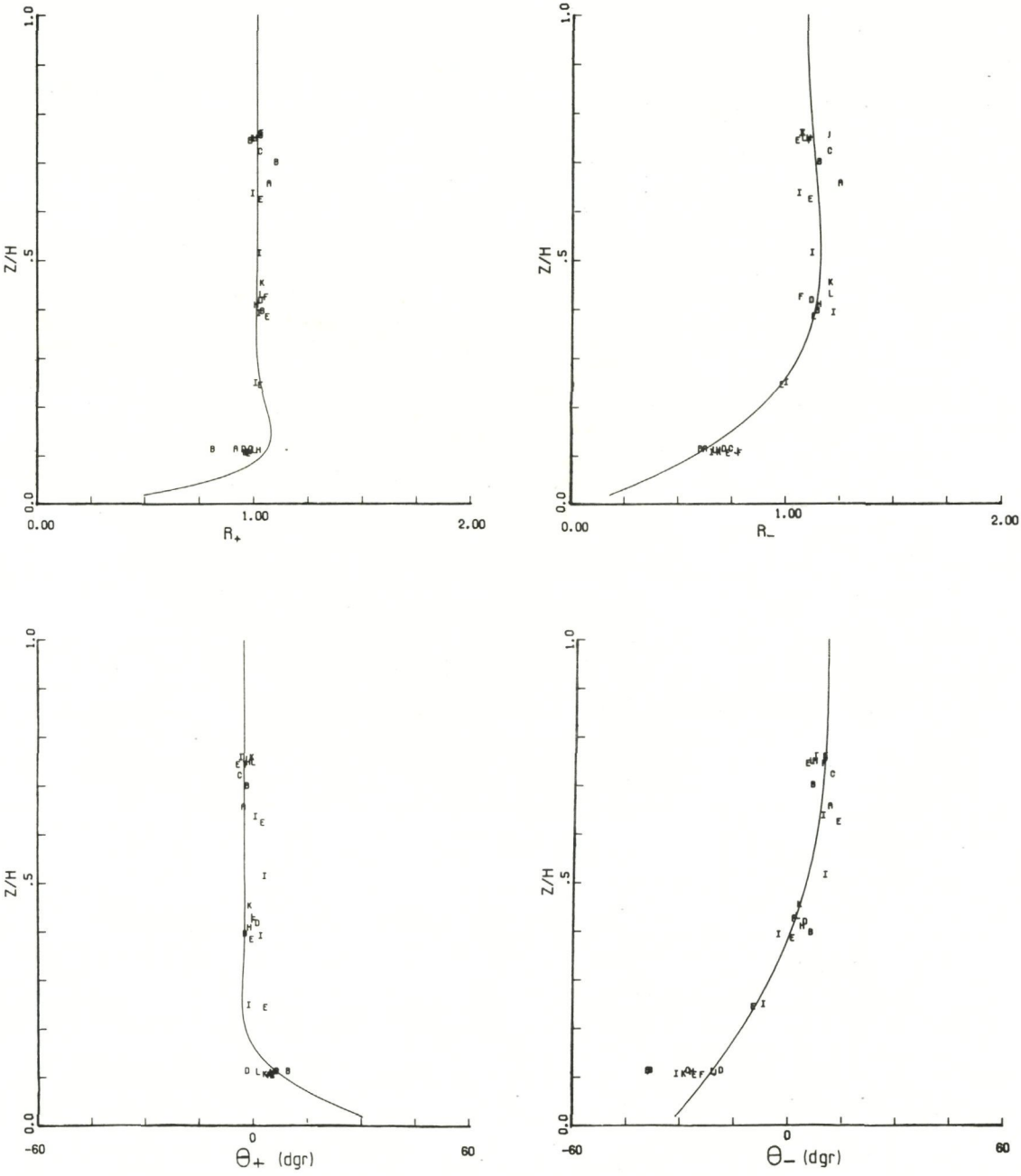
Current measurements in the Central North Sea reveal the presence of semidiurnal tides alligned in East-West direction. The amplitude of the currents drops towards the bottom, while the bottom North-South component also acquires a semidiurnal component. The currentvector traverses an ellipsoidal path. Amplitude decrease, opening up of the ellipse, rotation of the major axis and phase advance towards the bottom are the qualitative features which can be observed at different mooring positions. To explain these features the effect of bottom friction on a steady geostrophic current (Ekman-dynamics) is recalled. Combined with a formal decomposition of the ellipsoidal current motion into two counter-rotating circular current components, this theory, applied in two co-rotating frames, explains satisfactorily the scale separation and rotation sense of the observed rotational amplitudes $R_{\pm}$ and phases $\theta_{\pm}$ (see figure).

Maas L.R.M. and J.J.M. van Haren, (1986). Observations on the vertical structure of tidal and inertial currents in the Central North Sea. Submitted to Journal of Marine Research.



Normalized amplitudes R± and phases θ± of the cyclonic (+) and anti-cyclonic (-) rotating circular current components as a function of normalized depth. Observed values are denoted by a letter corresponding to different mooring positions. Theoretical curves are drawn (From Maas and van Haren, 1986).

ON THE DYNAMICS OF A TIDAL MIXING FRONT

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A prominent feature of continental shelf seas is the occurence of fronts between (seasonally) stratified and tidally mixed areas. The dynamics of such fronts are intricate, and have been studied theoretically, by a laboratory simulation and by oceanographic observations.
The along-frontal flow structure was analysed theoretically by examining the adjustment to a geostrophically controlled equilibrium of a stratified two-layer fluid and a homogeneous fluid of intermediate density, originally separated by a vertical barrier. This model calculates the frontal shape and the velocity distributions in the adjusted state as a function of density and depth ratios, and a baroclinic radius of deformation.
The instability behaviour of surface, bottom and tidal-mixing fronts was studied in laboratory experiments carried out on a rotating table.
Fronts were created by allowing a fluid column (either homogeneous or stratified) to collapse in a rotating, environmental fluid of different density. This experimental work has provided important information about the evolution of the subsequent instabilities and the formation of frontal eddies. These eddies are thought to contribute significantly to the exchange and mixing of properties across the front.
Useful information about the frontal dynamics was also obtained by in situ observations performed in the North Sea during 1981 and 1982.

THE STRUCTURE OF ISOLATED VORTICES

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Oceanographic observations have revealed the abundant occurrence of large- and meso-scale baroclinic vortices on several locations. Such eddies have varying diameters, ranging from a few kilometers to approx. hundred kilometers, and they are generated in several ways, e.g. by interaction with bottom topography, by "shedding" from a current (as e.g. the Gulf Stream), or from baroclinic instabilities at density fronts. Although one observes both eddies of cyclonic and anticyclonic rotation sense, the majority is anticyclonic.
Vortices have also been produced in various laboratory experiments, and it was found by careful analysis that the azimuthal velocity profiles of these vortices are similar, irrespective of the size, the type of generation, or the age of the particular eddy.
Unfortunately, accurate velocity measurements in oceanic vortices are very scarce, so that comparison with the detailed laboratory results is difficult. However, the few available velocity distributions of oceanic vortices show the same similarity structure as found for the laboratory vortices.
In order to study this vortex similarity structure in more detail, additional experiments were conducted, in which isolated vortices were generated from less well-organized initial conditions (viz. a baroclinically unstable bottom front, and stirring-induced turbulence). The eddies thus produced show the same similarity structure as the vortices mentioned previously.
A theoretical analysis (based on variational principles) of the vortex dynamics suggest that minimizing properties as enstrophy and angular momentum leads to the correct observed similarity behaviour.

CHARACTERISTICS OF TURBULENCE IN TERMS OF COHERENT STRUCTURES OF AN ESTUARINE ENVIRONMENT, SUBTIDAL AS WELL AS INTERTIDAL

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ABSTRACT:

Measurements of turbulence have been carried out in the Eastern Scheldt Estuary on several locations. The instrument was an acoustic three dimensional velocity meter, the Vector Aqua (VA). The horizontal velocity components u(t) in main flow direction and v(t) perpendicular to u(t), and the vertical component w(t) were measured with a sample frequency of 2 Hz. The VA was placed on a tripod on the bottom, measuring at a height of 0.5 or 0.8 m above the bottom. The locations involve three tidal channels, one at the mouth of the estuary (depth 14 m), one in the middle (17 m) and one at the head (10 m), but also a tidal flat.

The measurements were analysed in terms of coherent structures to study the bursting process. The bursting process is a quasi-periodical phenomenon in the Reynolds stress. The Reynolds stress in the u'-w' plane can be classified in four quadrants, depending on the sign of u' and w', which follow from the decomposition of $u(t) = U + u'(t)$ etc., in which U is the mean value and u' is the turbulent fluctuation. The two contributions to positive Reynolds stress are called sweep (positive u') and ejection. They form, together with the inward and outward interaction, the bursting process. To detect the intermittent character of the process the following detection scheme was used: $D(t)=1$ if $|u'w'| > K|u'w'|$, else $D(t)=0$, in which $K=2$. The detections of sweeps and ejections are considered as coherent u'w'-groups.

Ejections and sweeps appear to be the main contribuants to the Reynolds stress. Depending on the location ejections or sweeps are dominant, possibly caused by the position with respect to ripples.

From the detection of 'bursts' it was found that the mean sweep and ejection period is about 10 to 40 seconds. This is in agreement with the investigation of Soulsby (1983, in "Physical Oceanography of Coastal Shelf Seas", B.Johns(ed.),p 189-266, Elsevier).

Because there are strong indications that sediment transport is directly influenced by the bursting process, knowledge of the structure of turbulence, especially of the most important producers of the Reynolds stress, can contribute to the understanding of the process of sediment transport.

GEOSTROPHICAL FRONT IN THE NORTH SEA

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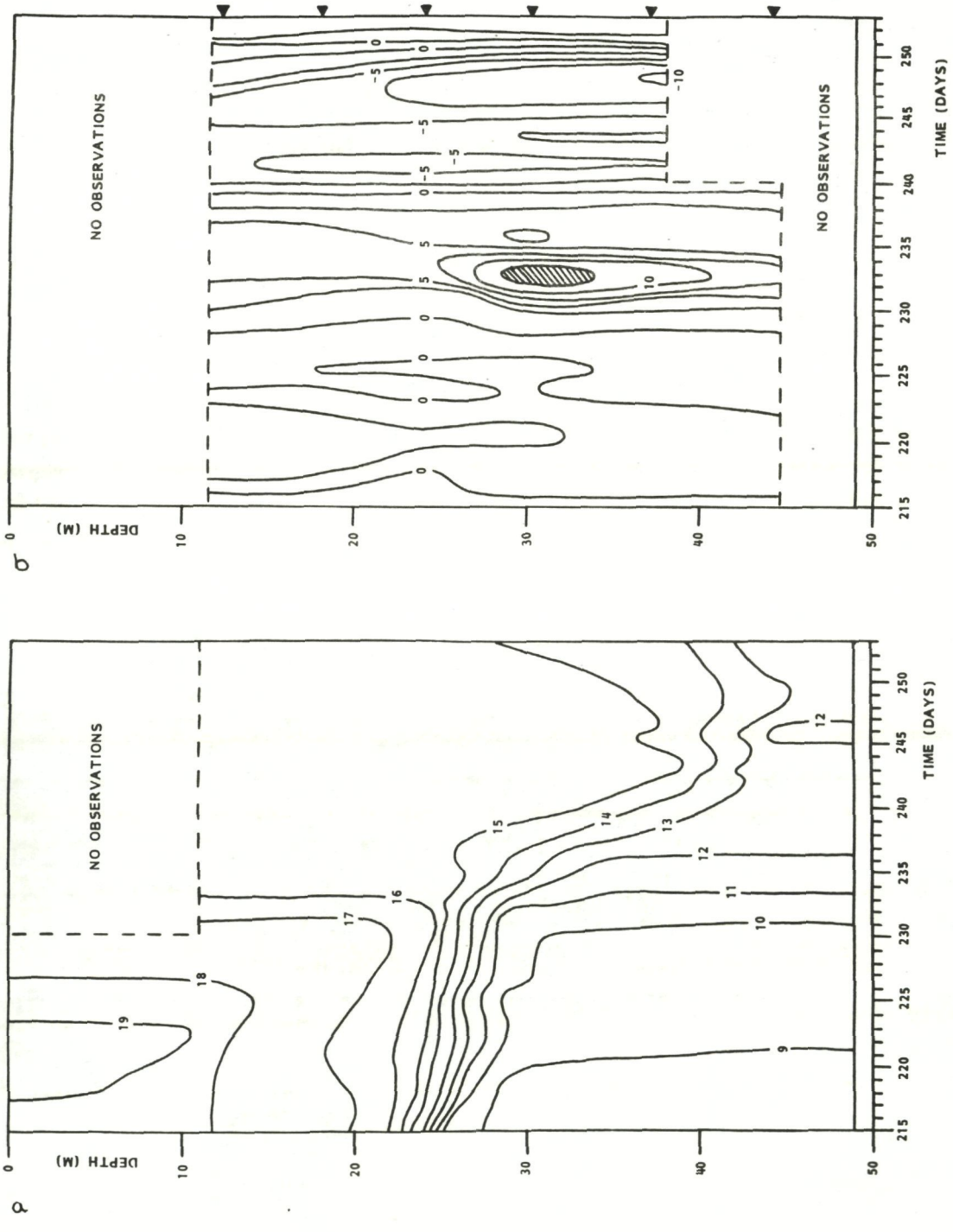
Climatological and actual observations demonstrate the presence of so called frontal zone's (separations between vertically stratified and homogeneous watermasses) in the North Sea. Theory, predicts the simultaneous presence of an intensive mean current (jet) parallel to the front, such that the pressure gradient force associated with the front is in equilibrium with the Coriolis force acting transversely on the current. Projection of the actually observed low-passed current vectors into the inferred frontal direction and its normal direction confirm the presence of this jet in the cross-frontal plane (see figure).

Van Aken H.M., G.J.F. van Heijst and L.R.M. Maas, 1986. Observations of fronts in the North Sea (in preparation).

Lowpassed distributions of a) temperature (^{0}C) and b) along frontal velocity (cm s^{-1}) as a function of depth and time (from van Aken et al., 1986).



Lagrangean motion in the North Sea near the Dutch coast.

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In recent years it has become clear, theoretically and experimentally, that within a shallow (nearly) homogeneous sea tidal and residual currents show an intriguing meso scale spatial variability well above the level if instrumental errors. One simple and immediate consequence of this variability is the limitation which it imposes upon the understanding of the motion of marked water particles within a certain sea area with only one moored current meter station. Several authors were able to find explanations by considering the interaction of tidal and residual currents with bottom topography. One step further brings us to the implications of the tidal whirl pool idea for dispersion of matter which was recently reviewed by Zimmerman (1986).

In here we give a short account of an experiment that aimed at the simulation of Lagrangean motion avoiding the above mentioned problems. A full report of the experiment was presented by Riepma (1985).

In September 1976 rhodamine was released by Rijkswaterstaat within a dense network of current meter stations deployed by KNMI near the Dutch coast in homogeneous sea water. The subsequent spreading of the dye was also observed by Rijkswaterstaat.

To simulate the motion of the dye patch we distinguished mean and turbulent velocity contributions. The mean, horizontal, velocity included the tidal and residual currents. By interpolating between the current meter stations we were able to resolve horizontal and vertical velocity shears which are of course important to simulate dispersion of matter.

To include turbulent velocity fluctuations in our simulation we applied a Monte Carlo technique. The turbulent intensities of the vertical and horizontal velocity fluctuations were estimated according to the similarity theorie of turbulent boundary layers.

The final outcome of the simulation showed good agreement with the rhodamine observations with respect to the mean motion of the dye and with respect to the spreading. Worse agreement was found once the rhodamine drifted out of the current meter network upon which the measurements of the currents had to be extrapolated.

Riepma, H.W., 1985. Current meter records and the problem of the simulation of particle motions in the North Sea near the Dutch coast- Oceanol. Acta 8: 403-412.

Zimmerman, J.T.F., 1986. The tidal whirlpool: A review of horizontal dispersion by tidal and residual currents - Net. J. Sea Res. 20 (2/3): 133-154.

SPREADING OF RIVER RHINE WATER AT HIGH DISCHARGE AND STRONG WINDS

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The water quality of the Dutch coastal zone, including the ecologically important Wadden Sea, is highly determined by pollution loads from the river Rhine. Knowledge about characteristic scales of and windeffects on hydrodynamic processes is indispensible for an appropriate coastal zone management.
To assess the contribution of wind- and discharge conditions, measurements were taken during a high river discharge event (> 6000 m^3/s) of the river Rhine following an extended period of dry weather (fig. 1). This took place under strong winds that changed direction during the event. The relatively saline background coastal water made it possible to distinguish the outflow and spreading of this plume.
Due to persistent northwesterlies during the two weeks before the beginning of the measurement campaign, a deep upper layer of relatively fresh water had formed, reaching a depth of 10 - 12 meter at Noordwijk (fig. 3). Strong winds combined with tidal mixing have generated a distinct two layer system with a large density jump and thus very stable interface. As a result the upper layer shows a very strong response to variations in wind direction. When the wind turned to a southwesterly direction (Jan. 28^{th}), the accumulated buoyant river plume was driven along the coast over the "slippery" interface (40 km/day; fig. 2^a and 2^b). On the final day the wind had turned southeast (Bf 6-8), spreading the upper layer in offshore direction (fig. 2^c).
A decoupling of the upper and lower layers appeared in that windeffects near the bottom were confined to only slight variations in magnitude of the cross-shore flow. During the event in the coastal zone the lateral density gradient was such that the cross-shore bottom current was mainly directed onshore. Under average conditions there are strong indications for this to be the case as well.

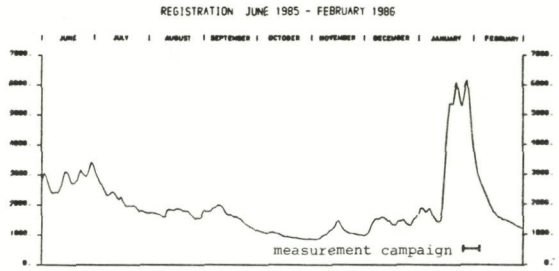

Fig. 1. RHINE DISCHARGE AT LOBITH (M3/S)

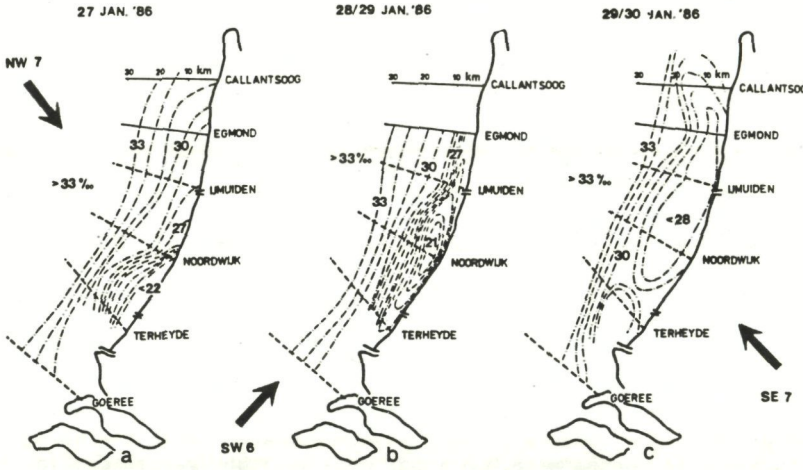

Fig.2. Surface salinity distributions, showing very strong response of the upper layer to wind variations.

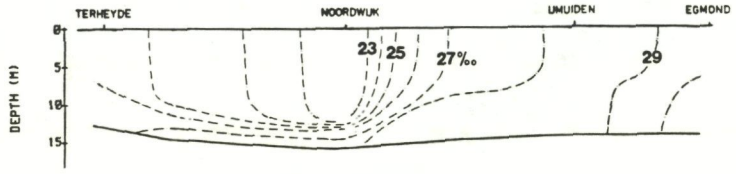

Fig.3. Vertical salinity distribution in a longshore section taken at 4 km offshore on the 27th of January 1986 .

GRAVITY FIELD INVESTIGATION AT SEA

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An extensive gravimetric experiment has been carried out on the North Sea in spring 1986 as part of the NAVGRAV project.

By partly re-measuring and densifying an already surveyed gravity network, it becomes possible to investigate the spatial resolution, external accuracy and systematic biases of sea gravimetry. Two sea gravimeters were used to investigate the internal accuracy and instrumental characteristics.

Main purpose of this gravimetry experiment is to investigate to what extend satellite altimetry can replace sea gravimetry in the future. One may ask how far satellite altimetry can contribute to gravity field investigations, since it provides a topographic opposed to an equipotential surface.

A precise altimeter (e.g. SEASAT-A) provides an accurate profile of the sea surface. By subtracting the ocean effects geodesists can derive the equipotential surface which is the geoid.

The precision of gravity differences derived from satellite altimetry is estimated to be between 5 and 20 mgals (1 mgal is $10^{-5} ms^{-2}$). The maximal spatial resolution of gravity field chracteristics is 10 km.
In some areas (trenches, subduction zones) a higher resolution is desirable from the geophysical point of view

Sea gravimetry can provide this higher spatial resolution. The (internal) precision of a modern sea gravimeter is 0.5 to 2 mgal. The mean difference of the two gravimeters in the NAVGRAV project was 0.9 mgal in good weather conditions.

The external accuracy of sea gravimetry will be investigated with the NAVGRAV data. It will be possible to determine in what situation sea gravimetry or satellite altimetry should be preferred.

POSITIONING AT SEA WITH GPS

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To make gravimetric and geophysical experiments at sea successful, accurate positioning can be of paramount importance. In areas near the coast positioning is performed with the classical radio navigation systems. Worldwide navigation is only possible with the radio positioning system Omega and the U.S. Navy Navigation Satellite System (Transit). Omega has an accuracy level of one nautical mile. Transit has as disadvantage the irregular fix intervals.

Since the early seventies a new Global Positioning System has been in developement. The Global Positioning System (GPS) enables weather independent and continuous observations. The Transit system is based on range difference measurements (doppler). GPS is based on pseudo range measurements.

Once the full configuration of 18 satellites is completed in 1992, 4 satellites will always be visible above the horizon. GPS satellites transmit their ephemeris, GPS system time and a satellite specific pseudo random noise code modulated on the carrier wave of 1.57GHz.

Through measuring pseudo distances to 4 satellites the user can compute his position and the unknown receiver clock offset. Thus the user has not to be equipped with a precise clock.

An instantaneous position accuracy of 30 meter or better can be obtained worldwide.

To establish the perspectives of the Global Positioning System at sea, extensive navigation experiments have been carried out on the North Sea in April 1986.

Position accuracy was better than the specified 30 meter. Through observing carrier phase of the received signals as well, velocity estimates of 0.1 m/s (0.2 knot) were obtained. Experiments with reference stations on land showed that a real real time relative position accuracy between the vessel and a reference point ashore of several meters was obtained. This technique is called differential GPS.

During the experiments the Global Positioning System came up to its expectations. In the future, sea gravimetry and especially geophysicists will benefit from this new technique.

At the moment favourable satellite coverage is available during two four-hour periods a day.

Determination of spectral signatures of natural water by optical airborne and shipborne instruments

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1. INTRODUCTION

Investigation and experiments in the past decade have demonstrated applicability of the remote optical measurements for the study and monitoring of the distribution of the materials suspended and dissolved in the seawater. Diverse theoretical models, (semi)empirical approaches and statistical methods provide different algorithms for the retrieval of the concentrations of the phytoplankton and other suspended materials and of the dissolved organic matter. This is not surprising, considering the diversity of the aquatic conditions, algal populations and atmospheric and environmental influences. Since no general spectral behaviour of the substances suspended and dissolved in the seawater can be expected and predicted, the problem of the radiative transfer in and above water is not generally analytically solvable and thus no universal algorithms can exist.

Despite this, the optical remote sensing of the oceanic and coastal processes can supply striking results if supported by the bio-chemical and optical in situ measurements (sea truth) combined with the knowledge of the oceanography of the sensed region. Instruments must be employed specifically designed for the optical measurements in and above the waterbodies. Measuring conditions and specific objectives of the research determine spectral, spatial and time resolution of such intruments and data acquisition systems.

2 INSTRUMENTS

For the interpretation and correction purposes of satellite imagery, special requirements are put on the in situ measuring procedures. Design and application of the underwater and of the abovewater (low altitude) instruments substantially differ.

2.2. Underwater measurements

The developed Advanced Spectral Irradiancemeter (ASIR) can scan simultaneously 22 spectral channels between 400 nm and 720 nm within several seconds. Spectral bandwidth of each channel is within 10 nm. Radiation is collected by two cosine diffusers at each side (up and down) of the instrument mounted in gimbals. The upwelling and downwelling irradiance is simultaneously detected and recorded on board by means of an HP data acquisition and

storage system controlled by microcomputer.

2.2. Spectral measurements above water
Coastal Remote Sensing Airborne Radiometer (CORSAIR) was constructed employing a zoom objective lens for the radiance measurements, cosine collector for the downwelling irradiance measurements, liquid light guides, automatic optical switch and correction filters assembly, detector, polychromator, optical multichannel analyser, console and a microcomputer system providing rapid data acquisition and storage. Field of view and tilt of the objective can be adjusted. 125 channels between 400 and 720 nm can be scanned within 32 ms.

3 INDONESIAN MARINE ENVIRONMENT REMOTE SENSING EXPERIMENTS (IMERSE)
Combination of the data obtained from the sets of measurements in water and above water at low altitudes is most advantageous for the final processing and interpretation of the satellite imagery. During the extensive campaign IMERSE performed in the coastal waters of north east Java, within the framework of the Snellius II expedition, numerous measurements were done of the underwater reflectance along with sampling of concentrations of the organic and inorganic materials suspended and dissolved in the water. Airborne measurements of the upwelling radiance and collection of multispectral imagery were provided simultaneously with the shipborne operations. Collected satellite imagery will be interpreted in cooperation between Indonesian, German and Netherlands scientists.

The spectral signature will be calculated from the underwater measurements in combination with the sea truth data using a radiative transfer model. From the absorption and scattering signatures, the algorithms will be determined. The airborne radiometer data will serve for the final tuning of the algorithms as well as for the evaluation of the atmospheric and glitter effects. The airborne imagery can be then processed and interpreted for the representative coastal and open sea regions. From these underwater and low altitude data the satellite imagery will be corrected for the atmospheric effects and interpreted in terms of the concentrations of suspended and dissolved materials.

DETAILED TIDAL FLOW AND STORM SURGE MODELLING ON THE NORTH WEST EUROPEAN CONTINENTAL SHELF

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In the years 1985/1986 Rijkswaterstaat, Tidal Waters Service, and Delft Hydraulics jointly set up and calibrated a very detailed nonlinear numerical flow model for the whole North West European Continental Shelf, see Fig. 1. The location of the one open sea boundary at deep water allows for the inverse barometer effect to be used. Together with the small grid size of 1/12 degree latitude by 1/8 degree longitude, these are two factors which make the model an ideal tool for storm surge calculations and long term flow computations in view of water quality studies.

The model is based on the WAQUA program package which solves the full non-linear shallow water equations on the 173 by 201 numerical grid. Along the open boundary the water level is prescribed in terms of 6 tidal constituents (O_1, K_1, N_2, M_2, S_2, K_2), with a correction for the atmospheric pressure, i.e.

$$\Delta\zeta = \frac{1}{\rho g} (\bar{p} - p), \quad \text{with } \bar{p} = 1012 \text{ mb.}$$

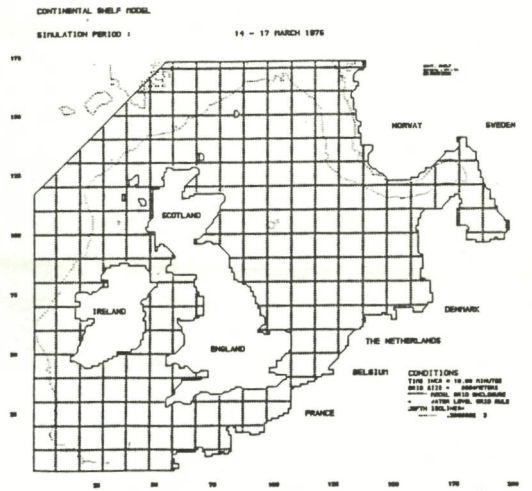
In the interior points, the pressure and wind are introduced as volume forces, using a quadratic formulation for the wind. For the tidal calibration the 14 - 17 March 1976 period of the JONSDAP - 76 measuring campaign was chosen. Apart from local tuning of friction and schematization parameters, overall shifts of the tidal phases along the Northern boundary were needed to realise a flow simulation in agreement with local coastal and offshore observations or hindcasts. Since the original tidal boundary conditions were obtained from (much) larger scale models, a grid size depedence cannot be ruled out.

The tuning for combined tide plus surge situation was performed hindcasting the 28 January - 3 February 1983 storm, which includes both a negative, and positive surges. To analyze the energy transfer from the atmospheric to the water system while within the quadratic wind stress formulation, various formulations of the drag coefficient were used.
The well known linear Smith - Bank formulation with offset $0.63.10^{-3}$ proved to give the best results:

$$C_D = 0.63.10^{-3} + 0.066/W/$$

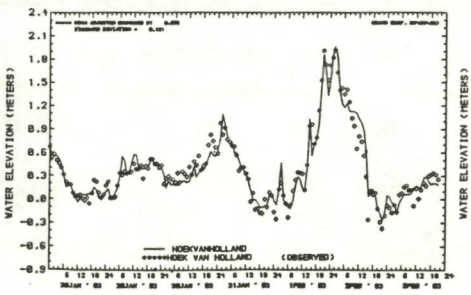
Figures 2 and 3 show time histories of the modelled surge height (from the hindcast with wind minus the hindcast without wind) and observed surge height (observation minus tidal prediction) at Lowestoft and Hook of Holland. The table shows the root mean square errors for the storm surge period at 11 coastal stations, plus their average and standard deviation.

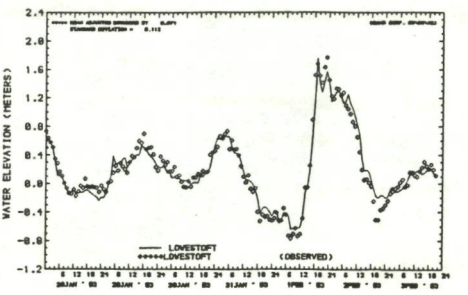
Further verification by means of hindcasts of other storm surge periods is under way.



Station	σ (in cm)
Wick	8.5
Aberdeen	11.8
North Shields	14.8
Lowestoft	11.2
Southend	18.9
Dover	15.0
Cherbourg	16.0
Hook of Holland	12.1
Scheveningen	12.5
IJmuiden	13.2
Den Helder	12.3
μ(σ)	13.3
σ(σ)	2.6

Table: Root mean square errors of the surge computations, Period: 28 January - 3 February 1983.





WAVE GROWTH ON SHALLOW WATER

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Measurements of significant waveheight show values for the southern part of the North Sea which are only half as high as those for the Nothern part. Growth of wind waves is limited by waterdepth, when the wavelength is more than three times the waterdepth. Existing wave prediction models use different parametrizations of shallow water effects. A recent intercomparison of some of these models, the SWIM-study, showed that this leads to large differences in predicted values for e.g. the significant waveheight or peakfrequency.

Wave evolution is described by the so called wave transport equation: the rate of change of the spectrum is given as the sum of propagation, refraction and sourceterms (windinput, dissipation and the non-linear interaction). Each of these terms is affected by finite depth, for some the extension to shallow water is straightforward , for others the correct shallow water expression is not known.

In the present investigation the wave transport equation is solved numerically. Where the correct shallow water expressions are unknown, I assumed that deep water concepts, expressed in wavenumber space, also hold for shallow water, and I added bottom dissipation to the sourceterms. For the non-linear transfer I use an exact expression, as computed by a set of programs, which were developed at the Max-Planck Institut für Meteorologie in Hamburg.

Operational wave forecasting models use parametrizations for the non-linear transfer, because the exact expression takes too much computing time. As it is thought that the non-linear transfer controles the shape of the wave spectrum, it is important to use the exact expression.

The most time-consuming part in the non-linear transfer routines is the calculation of the discrete phase space. For deep water it is possible to use a scaling relation, and this calculation is done only once. For shallow water this is not possible, so I had to devise a special scheme to update to phase space periodically, and this calculation now has to be done only

four or five times for one run.

The model now performs satisfactorily. I made runs for several waterdephts and will compare the results with the SWIM-study. The first results seem to confirm the picture of higher values for the peak frequency and lower values for the significant waveheight with lower waterdepth.

Later on I will concentrate on a better analytical description of depth-limitations (e.g. bottomfriction) and investigate the sensitivity of my model for these expressions.

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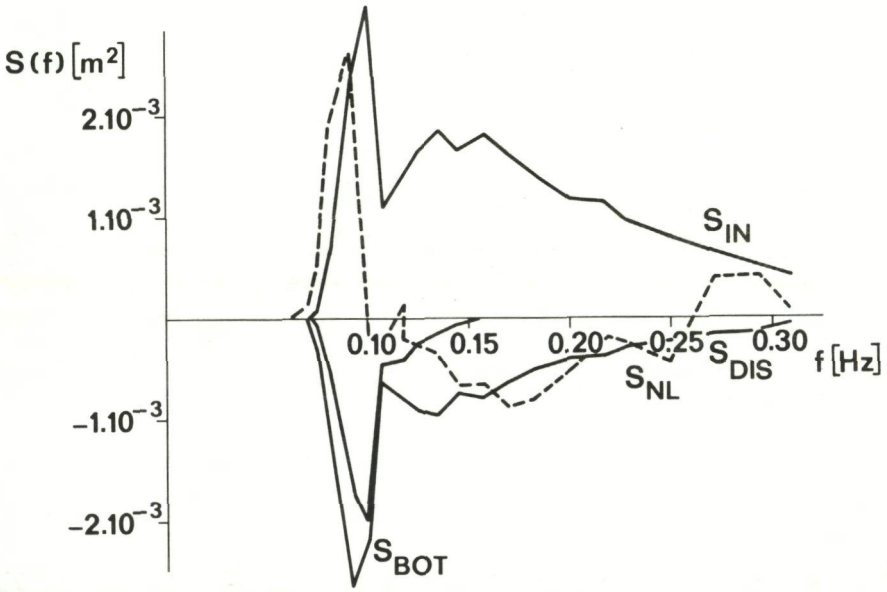

the relative importance of the various sourceterms at nearly full-grown stage (wavelength to waterdepth ration of five)

CHEMICAL OCEANOGRAPHY

DISSOLVED SILICA IN ANTARCTIC SURFACE WATER; SPATIAL AND TEMPORAL PATTERNS IN THE ATLANTIC SECTOR.

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In 1981, '83 and '86 hydrographic observations were made in various parts of the Weddell Sea, in cooperation with Becker and Koltermann (DHI, Hamburg). Concentrations of dissolved silica (Si) are the world's highest in surface waters, not only in an absolute sense, but also relative to other nutrients. As appears from comparison with other expeditions, the distribution pattern as well as the values of Si are strikingly similar in different years.
Hydrographic mechanisms are thought to be responsible for the maxima (upwelling and doming) while biochemical mechanisms probably cause the minima. There is only a vague relationship between the hydrographic features and those of the Si-distribution. Strong gradients in Si characterize the outflow from the Weddell Sea, but further eastwards these gradients do not coincide with the Antarctic convergence and divergence.Also the maximum in Si does not coincide with the center of the Weddell Gyre.
In some areas rapid dissolution of diatom frustules has been found, possibly caused by the low aluminium content of Antarctic diatoms; in other cases recycling of Si was relatively slow.
In the future, silica recycling will remain one focussing point in the framework of the Dutch Antarctic Research program.

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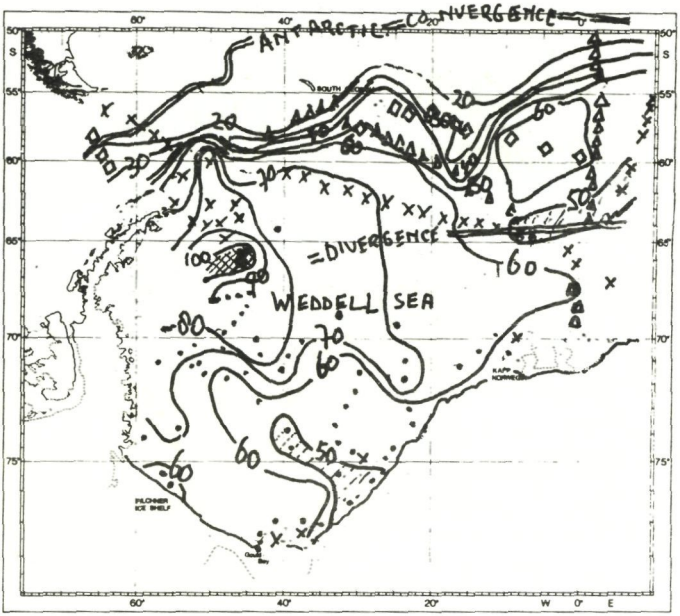

Concentration of dissolved silica (in uM) in surface waters

- ✗ Observations NIOZ 1981,1983,1986
- • International Weddell Sea Oceanographic Expeditions 1968,1969,1970. Data reports U.S. Coast Guard.
- ◇ Geosecs expedition 1972
- △ Ajax expedition 1983, Data reports Scripps/Texas A&M University

Nitrous oxide (N_2O), an important intermediate in nitrogen cycling in marine sediments.

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ABSTRACT:

N_2O is an intermediate in oxidative nitrogen cycle processes (nitrification) as well as in the reductive processes (denitrification).Depending on redox-conditions (O_2-concentration) N_2O can accumulate at a certain depth-horizon in marine sediment. Especially coastal marine sediments (Wadden Sea) are shown to be a net source of N_2O. N_2O is implicated in stratospheric ozone destruction and contributes to the radiative heat budget of the atmosphere.

The mechanism of N_2O production in sediment and its flux to overlying water and atmosphere will be discussed in our poster.

MARINE POLLUTION RESEARCH AND CONTROL
CASE STUDY: NORTH SEA WATER QUALITY PLAN

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Within the framework of drawing-up a water quality management plan for the Dutch part of the North Sea, studies have been carried out to quantify the impact of anthropogenic (human derived) pollution inputs on coastal water quality, sediments and biota. Based on the results of these studies the Dutch Government has formulated a set of policy and managerial measures to control the Dutch contribution to North Sea pollution. The framework of analysis for these studies includes:

- o the characterization and quantification of sources of pollution, including river inputs, waste water outfalls, sea dumping and atmospheric deposition
- o the analysis of physical, chemical and biological components and processes which together determine the functioning of the North Sea ecosystem
- o the analysis of the impact of pollution inputs on coastal water quality, sediments and biota
- o an assessment of the present status of North Sea pollution and possible future trends in relation to the exploitation of marine resources
- o recommendations for priorities on pollution research and control in the Dutch coastal waters

Mass-transport and water quality modelling

Mathematical modelling techniques are used to quantify the transport in the southern part of the North Sea of pollutants from various inputs. In this shallow shelf sea the influence of density gradients is relatively small in comparison to the influence of tide, wind and topography. Therefore a vertically integrated 2-dimensional hydrodynamical model has been used to simulate wind and tide-induced currents. With the boundary conditions given in terms of Fourier components a fully cyclic flow over the diurnal tidal period is simulated. From these results time-independant residual flow patterns were derived and used as an input for the mass transport and water quality model DELWAQ (DHL).
Steady residual flows and pollution loads have been used to simulate the transport of pollutants in the southern North Sea.
Based on data on pollution inputs from rivers, dumps, wasteloads, atmospheric deposition and cross boundary inflows, the model has been

used to simulate spatial distributions of concentrations of various pollutants.
From the results for nutrients (N,P) and heavy metals (Cd, Hg, Pb, Cu, Cr, Zn), it was included that the highest concentrations are calculated for the Dutch coastal zone and the German Bight. Especially the input from the river Rhine is a dominant factor in pollution of the Dutch coastal waters.
Based on simulations of pollutant transport from individual sources, the proportional contributions of each pollution input to local concentrations in the North Sea has been calculated.
From these contributions it can be derived that Hg and Cd pollution in the North Sea is dominated by coastal inputs, whereas Pb and Zn pollution have relatively high contributions from atmospheric deposition as vell.

Impacts analysis and assessment

Based on the modelling results, the pollution of the southern North Sea has been assessed from the viewpoint of:
- o The influence of human activities on North Sea pollution (rate of anthropogenic influence), and
- o the (potential) impact of hazardous substances on the marine ecosystem and human resources (rate of risk).
- o the (potential) impact of increased nutrient (N, P) inputs on primary production, phytoplankton biomass and species composition

From the calculated concentrations for the present pollution inputs and the calculated concentrations for 'natural' inputs the anthropogenic contribution in the local concentrations was derived. It was shown from these results, that in large parts of the southern North Sea the anthropogenic fraction of the pollutants considered exceeds 50%, corresponding to a doubling of the reference concentration.

From a review of literature on dose-effect experiments for various pollutants and marine organisms, risk assessment levels have been derived to assess the risk to organisms of North Sea pollution. From the ratio between calculated concentrations and lethal concentrations of the most sensitive organisms it was concluded that Cd, Hg and Cn are among the contaminants that need high priority in pollution research and control for Dutch coastal waters.

Simulations with the primairy production model SEAWAQ (DHL) have shown that the anthropogenic increase of N and P concentrations can cause significant changes in phytoplankton biomass and species composition. This may have serious implications, yet to be unraveled, for the productivity higher up in the food-webs, and/or for the oxygen content in the stratified regions of the deeper North Sea.

CHEMICAL SPECIATION FOR COPPER IN INDONESIAN WATERS COMPARED WITH RESULTS FROM EUROPEAN WATERS

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During the Dutch-Indonesian Snellius II expedition (1984-85), water samples were collected to study the chemical speciation of copper in the estuaries of the Solo and Porong rivers (eastern Java, Indonesia) and in the coastal and offshore waters.

Titration of a natural water sample with ionic copper results in the apparent complexation capacity for copper (CC_{Cu}), a parameter indicating the concentration of potential ligands, which are able to bind copper into non-labile complexes. From the titration curve, the conditional stability constant K' also can be calculated (Kramer, 1985), indicating the stability of the complexes formed.

The results indicate a rather constant CC_{Cu} of about 70 nM Cu for the offshore waters of the Java Sea and Indian Ocean. In the vicinity of the river mouths, the coastal waters of eastern Java show a CC_{Cu} of 100 nM Cu. Dissolved copper concentrations in the estuaries are 30-40 and 15-20 nM Cu for the rivers Solo and Porong respectively, a difference which can be explained by their different origin. The Solo estuary has an almost constant pH (8.1, increasing towards 8.2 in the freshwater region). The pH in the Porong estuary increases from 8.2 towards 8.6 in the upper part of the estuary. These high values are the result of the high calcium carbonate content. The CC_{Cu} in these estuaries also varies. The Porong results show a non-conser- vative increase with decreasing salinity, starting at 60 nM Cu at the seaward end ($S > 12 \times 10^{-3}$) to 200 nM Cu ($S = 3 \times 10^{-3}$). Below this salinity the CC_{Cu} drops to 120 nM Cu. The complexation capacity of the Solo estuary doesnot change that much. There is an increase from 100 to 150 nM Cu at S = 25 towards 3×10^{-3}. Possibly also here a drop towards 115 nM at $S < 3 \times 10^{-3}$ is observed. The reason for this decrease in the freshwater region of the estuaries is not understood yet.

The conditional stability constants in the offshore waters does not show much variation ($\log K' = 8.2 - 8.4$). In the coastal waters we found a nearly constant $\log K' = 7.9$. In the Solo estuary a $\log K'$ of about 7.9 was observed in a major part of the estuary ($S > 5 \times 10^{-3}$), with an increase

in log K' to 8.3 towards the river end part of the estuary. The Porong estuary has comparable results for the saline part of the estuary, where an increase also is observed (log K' = 8.5 at S = 0.2×10^{-3}).

Comparison of these results with observations in the river Scheldt estuary, North Sea and North Atlantic Ocean (Kramer & Duinker, 1984; Kramer, 1986) results in some interesting differences between the two regions (Table 1).

Table 1. Comparison of Indonesian and West European estuarine, coastal and open ocean waters for complexation capacity (CC_{Cu}, in nM Cu) and stability constants (log K')

	Indonesia (Porong/Solo)	Europe (Scheldt)
CC_{Cu}		
river(s)	60-200/100-150	200-300
coast	100	80
ocean	70	40-50
log K'		
river(s)	7.9-8.5/7.9-8.3	7.3
coast	7.9	7.9-8.1
ocean	8.2-8.4	7.9-8.4

The general pattern is a decrease in CC_{Cu} and an increase in K' going from river to ocean, with the exception of the high K' in the freshwater parts of the tropical rivers. The investigated tropical estuaries and ocean have a lower CC_{Cu} than the European waters, while the coastal waters have a slightly higher CC_{Cu}. Differences in the nature of the organic ligands can be seen from the differences in K'. This is very clear in the estuarine systems; coastal and oceanic waters show less difference.

Present work comprises the combination of chemical speciation studies of trace elements with biological and ecotoxicological effects.

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DISSOLVED OXYGEN AND THE DIAGENESIS OF TRACE METALS AND REE IN DEAP-SEA CARBONATE SEDIMENTS

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Profiles of dissolved oxygen in deep-sea carbonate sediments from the eastern Atlantic are presented. In large areas of the Angola Basin, at sufficient distance from the continent, and on slopes and local highs in the NE Basin, the oxygen concentration levels off at non-zero values below a depth of about 50 cm in the sediment.

In other areas, organic material settles in sufficient amounts to require for its mineralization all oxygen that diffuses into the sediment. Below the depth of oxygen depletion, the oxyhydroxides of Mn and Fe dissolve, which causes the mobilization of Mn, Fe, Co, and Ni to the pore water. These metals accumulate in the hydroxide phase of the oxygenated surface layer, a behaviour that is also found for As and Ce. Mobilization of other rare earth elements was not observed, but their phase distributions change when oxygen is depleted.

OLAF, TSJERNOBYL AND THE NORTH SEA CALAMITIES AND TRANSPORT STUDIES

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The first question asked in case of a contamination of water bodies, especially of moving ones, deals with the fate of the pollution, i.e. where does it go and how quickly will it be diluted to what degree. An answer must be given by those who study transport phenomena in natural waters. Biologists and chemists have to indicate the environmental risks of the anticipated concentrations of hazardous substances in specific threatened areas. In addition, they can predict whether and with what rate the considered substance(s) will be subject to chemical or biological processes which might affect the fate as well.
Before making up their minds about, e.g., permitting a waste disposal, the authorities responsible for some area, such as the North Sea Directorate of Rijkswaterstaat for the Dutch part of the Continental Shelf, can spend more or less time to take advice about the various aspects of the problem. However, in case of a disaster measures, if possible at all, have to be taken at a rather short notice. The sinking of the MS Olaf, in July 1986, turned out to present a potential calamity when it became clear what the origin and composition of her cargo were, namely noxious fly-ashes. A multidisciplinary team of chemists, biologists and physical oceanographers was recruted from the Tidal Waters Division to assist the North Sea Directorate in taking proper measures, which were only possible anyhow as long as the freight was confined in the vessel. Within a few days it was decided to recover the cargo by raising the ship.

The rate of *dilution* and transport direction of that fraction of the toxic substances that on exposure would follow the movement of the surrounding North Sea water were almost instantaneously estimated with rules of thumb derived from earlier experimental work, among others involving dye releases. These rules might apply to the chemicals to dissolve in the seawater or adhered to the smallest particles of the fly-ashes. No means were available to predict the transport of the heavier particles (with their contaminants) that do not completely follow the water movement, being subject, e.g., to sedimentation and resuspension processes. In predicting *concentrations* assumptions had to be made about the amounts and discharge rates of material set free in the environment. A sudden release, e.g. upon breaking of the vessel, and a continuous discharge during, say, 30 days were taken into account. Both the areas close to the ship (km-order) and further away (tens of kilometers) were considered. For various toxic chemicals of the freight relatively high concentration values might occur.

After the incident with one of the Tsjernobyl nuclear reactors an increased radioactivity has been found in, e.g., the river Rhine due to precipitation from the atmosphere. The North Sea water turns out to be hardly affected directly. This enables us, in principle, to follow processes related with the outflow of the Rhine. The radiation level of water samples appeared to be too low to be detected, so the water movement could not be studied with this method. However, the radiation of suspended sediments collected with a high-capacity centrifuge, and that of the top layer of the seabottom (mm-order) were in some cases amenable to detection. By so monitoring in time the transport of these materials, we hope to find clous about the rates of the involved processes. The derived knowledge might in turn be used in the future when new accidents occur, either of nuclear or of chemical nature like the one with the Olaf.

GEOLOGICAL OCEANOGRAPHY

ACTUOMICROPALEONTOLOGY PALEOCEANOGRAPHY NORTH ATLANTIC PROJECT (APNAP): GENERAL SCOPE AND PRELIMINARY RESULTS

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The surface circulation of the North Atlantic Ocean, especially the Gulf Stream is the most important factor which controls our climate in Northwest Europe. This circulation system is characterised by different currents, water masses, and oceanic fronts.
The main objective of APNAP is to trace the circulation system of the North Atlantic Ocean on a north / south traject between 25 and 55°N in terms of planktic foraminiferal horizontal and vertical distribution, morphologic ontogenetic and phenotypic variation, and stable isotope composition and to reconstruct changes of this system in place and time.
Modern foraminifera are studied in the four different seasons by horizontal and vertical fishing and linked to the hydrography. The sedimentation of the foraminifera will be examined with the help of sediment traps. On the sea-floor the surface water circulation is recorded by the foraminiferal distribution and morphologic variation of particular species in the surface sediments. This record forms the basis to analyse fossil sediments in order to obtain paleoceanographic interpretations and a reconstruction of changes in the North Atlantic Ocean circulation during extreme climatic situations of the Pleistocene (6k, 18k, 125k).
Sediments are collected on the eastern flank of the Mid Atlantic Ridge, on water depth not greater than 4000m in order to prevail artifacts caused by carbonate dissolution.
Other objectives are
- to compare the results obtained by foraminifera with those of other micropaleontological groups as coccoliths and pteropods in order to define watermasses in terms of combined nanno- and microplankton;
- to study the distribution and stable isotope composition of benthic foraminifera in relation to changes in bottom water circulation of the North Atlantic Deep Water in place and time;
- to compare slope and abyssal hill derived deep-sea calcareous sediments petrophysically and sedimentologically.
During the APNAP I expedition (14.8. - 15.9.1986) data and material have been collected to study the hydrography and the modern foraminiferal distribution and variation during the summer season. Part of the planned sediment sample net of APNAP has been obtained. Some first preliminary results from this expedition on the hydrography, the planktic foraminiferal distribution, and the sedimentology and petrophysics of the sediments are presented.

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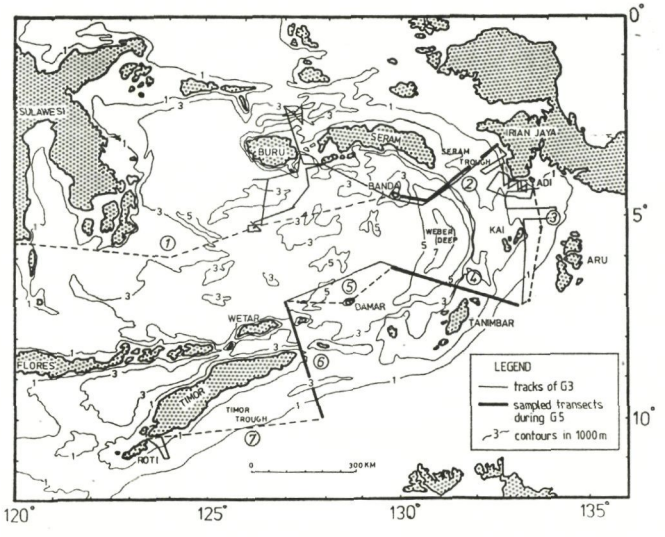
TECTONIC HISTORY OF THE BANDA ARC: A GEOPHYSICAL AND STRATIGRAPHICAL APPROACH

The Banda Arc is the site of active collision between the continental mass of Australia-Irian Jaya and other crustal plates. An important section of Snellius-II theme 1 - Geology and Geophysics of the Banda Arc and adjacent areas - was devoted to the study of this unique setting. The data for the present study were collected during cruises G3 and G5 of theme 1.

During cruise G3 four single-channel seismic profiles were taken to get better insight into the marine geological and geophysical structure and seafloor morphology of the Banda Forearc. Based on these profiles site-selection for the box- and piston-cores collected during cruise G5 could be plannend. The combined results of both cruises will lead to a better understanding of the mechanics and magnitudes of the tectonic and sedimentary processes.

The poster shows the seismic profile across the Banda-Irian Jaya

transect with syperimposed the position of box- and piston-cores. Preliminary results of sedimentological and micropaleontological analyses indicate that distinct facies exist in the four separate elements of the arc-system e.g. the slope dipping towards the trench, the accretionary complex, the back-arc slope and the volcanic slope. Based on various parameters shown, the position of the lysocline in the Weber Deep can be placed at approx. 1800 m., that of the CCD at approx. 3300 m.



TRANSPORT OF SUSPENDED MATTER AND ASSOCIATED SEDIMENTAL POLLUTION IN THE SOUTHERN NORTH SEA

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The Southern North Sea is exposed to high inputs of various contaminants. The contaminants both occur in dissolved and particulate forms and the transport of these contaminants is thus determined by both the transport of water and suspended matter. The analysis of the suspended matter behaviour in the Dutch coastal zone (approx. 80 km wide) forms the basis for the study of contaminant transport in particulate form and the associated bottom sediment pollution in areas of deposition.

Suspended matter behaviour was analyzed using mass-balance calculations and long term suspended matter concentration patterns. The data for the methodology used were derived from samples collected by the Dutch Ministry of Public Works over a period from 1975 till 1983 in the top water layer at 76 locations in the Dutch coastal zone.

Long term averaged suspended matter concentrations vary from 3.0 $mg.l^{-1}$ in the northwest part of the coastal zone to over 100.0 $mg.l^{-1}$ in the coastal zone near Belgium. In general a decrease of suspended matter concentrations towards the outer parts of the coastal zone is observed. There is however, one exception between Hook of Holland and Texel, where suspended matter concentrations once more increase at 50 km off the coast. This local concentration maximum is tentatively explained by erosional activity near the Brown Bank.

Mass balance calculations were based on the quarterly weighed average concentration at 10 sampling transects and residual flows as computed by hydrodynamic models. The recirculation of suspended matter in the Dutch coastal zone is estimated on $21.4*10^6$ $ton.yr^{-1}$, using a discretization on basis of the 10 sampling transects and without corrections for size fractions or the vertical distribution of the suspended matter. Balance results are given in the table.
Permanent erosion is assumed to be located in parts of the Belgian coastal zone and east of the Brown Bank with quantities of respectively $6.0*10^6$ and $2.4*10^6$ $ton.yr^{-1}$. Permanent deposition is located out of the Dutch coastal zone. Deposition quantities of suspended matter coming from the coastal zone are estimated at $3.5*10^6$ $ton.yr^{-1}$ for the Wadden Sea and $8.7*10^6$ and $7.2*10^6$ $ton.yr^{-1}$ for respectively the northern parts and eastern parts of the North Sea. In the Dutch coastal zone only seasonal deposition during the summer period occurs.

From the mass-balance calculations suspended matter sedimentation rates were derived for permanent deposition areas that are strongly influenced by the river Rhine, e.g. Wadden Sea and German Bight. Together with river Rhine suspended matter contamination levels model computations resulted in time-scales of cadmium bottom contamination. The calculated averaged cadmium concentration for an active bottom layer of 10 cm with a suspended matter sedimentation rate of 2 mm.yr^{-1} is 1.1 ug.g^{-1}. On basis of the model calculations a still increasing average cadmium concentration in the active bottom layer under 1980 contamination levels is concluded. To achieve a stand still for sedimental pollution a reduction of the cadmium pollution of river Rhine suspended matter will be necessary from 25 ug.g^{-1} in 1980 to 9 ug.g^{-1}.

Specification of the components of the suspended matter balance in 10**6 tons/year

Transect	Balance	Specification (known)		(unknown)	
Channel	+ 4.6	+4.6	inflow		
	+17.0	+7.5	dredging/dump. Belgian Coast	+7.5	supply
Appelzak	- 2.3	-0.5	to Western-Scheldt	-1.8	removal
Walcheren	- 2.6	-0.1	to Eastern-Scheldt	-2.5	supply
Schouwen	- 1.9			-1.9	removal
Goeree-TerHeijde	- 4.5	+8.1	dredging from R'dam harbours		
		-6.8	to Rhine-estuary		
		+1.2	from Rhine-Meuse	-7.0	supply
Noordwijk	+ 2.9	+2.3	inflow from Western N-Sea		
		+/-1.5	to/from IJmuiden harbour	+0.6	removal
Egmond	+ 6.4	+4.6	inflow from Western N-Sea	+1.8	supply
Callantsoog	- 7.8	-2.9	outflow to Northern N-Sea		
		-3.5	to Wadden Sea	-1.4	removal
Terschelling	- 4.6	-5.8	outflow to Northern N-Sea	+1.2	supply
Rottumerplaat	- 7.2	-7.2	outflow to Eastern N-Sea		

ACCUMULATION AND PRESERVATION OF BIOGENIC OPAL IN QUATERNARY SEDIMENTS OF THE ZAIRE (CONGO) FAN

J.H.F.JANSEN, A.J.VAN BENNEKOM, S.J.VAN DER GAAST (Netherlands Institute for Sea Research, P.O.Box 59, Texel, the Netherlands)

The content of biogenic opal, measured by X-ray diffraction (XRD), is very high in all fan sediments (on an average ca 60%). In both surface samples and average core data it increases from slope to ocean, whereas opal accumulation rates decrease. This difference is caused by dilution with terrigenous material. Accumulation rates are the result of production and preservation. Since the preservation of recognizable tests is best in the deepest cores, the decreasing rates indicate that productivity of opaline organisms is largest near the shelf. This is true both for the present time and for the Late Quaternary.

Downcore opal percentages and accumulation rates are generally highest in glacial maxima and lowest in interglacial maxima. Because the same is true for the pre ervation, the rates do not give direct information on the paleoproduction of opal. However, the diatom and radiolarian associations of the cores indicate that the opal percentages reflect production rather than preservation processes. Oceanic production dominates during glacial stages, and production in the Zaire river plume dominates during interglacial stages. The cores from locations on the continental slope show extra high opal accumulation rates caused by coastal upwelling during the last glacial stage 2.

The silicate concentrations in the pore water of the fan sediments (250 - 350 μmol.l^{-1}) are far below the known saturation values. Dissolution tests of the material showed an extremely low silica relase-rate constant. We attribute this to strong enrichment with aluminium: Al/Si atomic ratios are 0.15 - 0.20. Incorporation of Al is known to decrease the solubility of amorphous silica. SEM and microprobe observations of artificially broken tests of diatoms and radiolarians evince that the Al enrichment occurs throughout the tests, and XRD analyses of bulk samples show a shift of the opal bulge towards smaller d-values, which can only be explained by incorporation of Al. Dissolution of Al from terrigenous clay minerals -candidates are kaolinite and gibbsite- and subsequent precipitation is the most likely mechanism for the formation of Al-rich opal.

CLAY MINERALS AS PALEOCLIMATIC INDICATORS IN QUATERNARY SEDIMENTS OF THE ZAIRE (CONGO) FAN

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The content of clay minerals in marine sediments is widely used as an indicator of the paleoclimate of adjacent continents. In such studies, X-ray diffraction (XRD) measurements are applied to calculate semi-quantitative or even quantitative clay mineral associations. Measurements of sediments of the Zaire fan, however, demonstrate that large amounts of clay minerals may escape from detection by XRD. Applying an internal standard, we found parallel downcore patterns of the major minerals, which suggests that there are intervals of either increase or decrease of all minerals. The only mineral available in sufficient amounts to be able to compensate this effect is smectite; its crystallinity curves parallel the mineral curves. Apparently, the compositions are greatly dominated by varying contributions of hardly detectable low crystalline smectites.

The sediments from the present Zaire river consist of kaolinite, low crystalline smectite, quartz, and minor amounts of illite and gibbsite. The shelf supplies high crystalline smectite and admixtures of zeolite and cristobalite originating from opal-rich Tertiary layers. The contribution by the river was large in interglacial periods. The supply of shelf-derived minerals was at its maximum in glacial intervals, giving evidence of glacial shelf erosion; they are absent in interglacial maxima. Illite is indicative of aridity, and its distribution points to expansions of the African deserts during the glacial stages 2 and 4 and the interstadial ca 150 kaBP.

A general decrease in supply of "glacial" minerals, coinciding with a general decrease in accumulation rate 400-350 kaBP, indicates a long-term transition to more humid climatic conditions at that time. This transition is a signal of a global long-term climatic change 400-300 kaBP, which may have been forced by the 413 ka orbital eccentricity cycle.

ODP LEG 101: CREEP AND SLUMPING ON A CARBONATE SLOPE, LITTLE BAHAMA BANK

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The spatial distribution of petrophysical properties on the northern slope of the Little Bahama Bank (LBB) is closely related to processes generating and modifying the slope and may be another expression of the presence of gravity flow processes and large scale mass wasting. Accumulation of carbonate slope sediment on the open ocean LBB slope basically is controlled by line source deposition from gravity flows and deposition from pelagic sources. Evaluation of bore-hole data from ODP LEG 101, sites 627, 628 and 630, situated along the transect of seismic profile LBB-18 (Fig.1), confirms the presence of large scale creep and slumping as being a major process in modifying the LBB slope configuration. For reasons of comparison the extension of a seismic sequence consisting of slided and slumped carbonate oozes and the related petrophysical properties available from bore-hole data were studied. Among them, shear strength is regarded as being a quantitative measure of cohesive strength and thus a measure of the stability of a submarine sediment. On the lower slope (sites 627 and 628) zones which exhibit extensive deformation structures coincide with a significant increase in the variability of shear strength, overprinting the general, gradual, increase of shear strength with depth. The upslope lateral equivalent of this

sequence (site 630), not affected by creep and slumping, however, shows a gradual increase in shear strength and a constant variability with depth. Submarine slope failures thus not only affect the spatial distribution of depositional facies but also modify the shear strength - depth profile of the LBB carbonate slope. On the northern slope of the LBB petrophysical properties, e.g. shear strength, are closely related to processes shaping and modifying the slope and may be another expression of the presence of large scale mass-wasting.

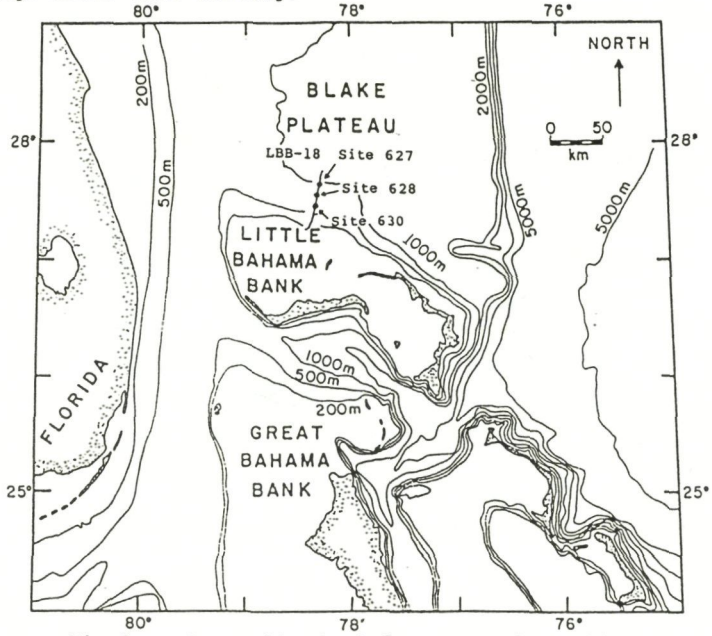

Fig.1. Generalized index map of northern Little Bahama Bank illustrating seismic transact LBB-18 and locations of sites 627, 628 and 630; index map modified after Mullins et al. (1984).

EVENT STRATIGRAPHY: GEOCHEMICAL FINGERPRINTS.

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H. Lo ten Haven
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The Cretaceous Tertiary boundary in marine pelagic sediments is characterized by an almost complete extinction of planktonic calcareous microfossils. The extinction level -essentially a bedding plane- is also characterized by one of the most profound geochemical anomalies known in the geological record. The detection of anomalous Ir, Os, Pd, Au, Pt, Rh, and Ni in approximately cosmic proportions, indicates a significant extraterrestrial component in this anomaly. However, the enrichments of Co, As, Se, Sb, Zn, U, and perhaps Cr cannot be explained this way. Box cores and Piston cores of the 1983 R.V. 'TYRO' cruise in the eastern Mediterranean contain numerous sapropel horizons (S1- S7) and active and inactive oxidation/reduction (O/R)horizons. Several profiles were analysed on carbonate content and organic C, and by INAA on trace elements. Both the sapropels and O/R zones contain enrichments of several elements, which may eventually shed light on some of the elemental anomalies at the Cretaceous -Tertiary boundary.

Piston cores P48 and box cores T 54, T 10, and T 29 contain the S1, S6 and S7 sapropels and an O/R zone just on top of, or several cm above S1. At 80 cm in Piston Core 48 an inactive O/R zone has been preserved. In S1, S6, S7 enrichments of As, Ba, Sb, Br, Se, U, Fe over background values were found. Usually these elements correlate with organic C content, but only Br shows a good correlation with org. C. In O/R levels also Sb, As are enriched, as well as Fe, Mn. Co is somewhat unpredictable. It is usually enriched in both sapropel and O/R zone, but is often scavenged from the sapropel into the O/R zone. If the O/R zone is not in contact with the sapropel, Co may be not enriched at all. U, Br, Ba and Se are enriched in the sapropels but not in the O/R zone, whereas Mn shows the opposite, it is precipiteted exclusively at the O/R zone, because Mn remains soluble under reducing conditions. The U peak tends to migrate downwards, and is usually found at the base or slightly below the sapropels.

It is remarkable that almost the same elements are enriched both at the K/T boundary and in the Mediterranean sapropels and O/R zones, if we disregard the clearly cosmic elements. Al, Mg, Ti, Sc, Th, REE, Ta, Hf, V, K, Na, Rb, Sr, Cs, show little or no effects either at K/T or at the sapropels and O/R zones. At the K/T boundary a combination of both scavenging under reducing conditions as well as an O/R zone both situated at the lithological break at the base of the so-called "boundary clay" may have been operable. The extinction event probably has led to a short period of general anoxic conditions in the ocean, scavenging trace elements such as As, Sb, Co, U, Zn, Se. Later on an O/R zone remaining for a considerable time at the lithological break may have accentuated the As, Sb and Co enrichments, which are at some outcrops of the K/T boundary more enriched than in any of the sapropels. Unexplained remain then the absence of any anomalous Mn at any of the analysed K/T boundary sites. Also the Cr peak at the K/T boundary, which is not found either in sapropels or at O/R zones, cannot thus be simply explained, although it is not as ubiquitously anomalous at the K/T boundary as Co, As, or Sb are.

Further research in trace element enrichments in specific horizons in piston cores/box cores is in progress. Also a survey of well known anoxic episodes (the "Bonarelli level"), the Kupferschiefer, and Red Sea metal rich brines may help our understanding of some of the elemental anomalies at the Cretaceous Tertiary boundary.

TRACE ELEMENT DISTRIBUTION IN SURFACE SEDIMENTS OF THE SKAGERRAK, NORTHEASTERN NORTH SEA

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The Skagerrak is a semi-enclosed basin of 700 m waterdepth in the northeastern North Sea that acts as a sink for recent, fine-grained sediments.

The sediment distribution is governed by the anticlockwise rotating water circulation pattern in the North Sea, resulting in deposition of sands and silts in the shallower parts off NW Denmark, of clayey sandy silts in the eastern and of clays in the northern part of the Skagerrak. In 1984 we collected 28 boxcores along transects perpendicular to the depthcontours. Neutron activation analysis was carried out to study the distribution of trace elements in the surface sediments. In addition the vertical distribution was studied in three boxcores (9, 10, 11).

Results show that clays have up to 5 x higher contents of Sc, Rb, Cs, LREE (La, Ce and Sm) and Th, compared to sands and silts. The elements Na, HREE (Tb, Yb, Lu and Ta) have the same concentrations and Hf and Zr have up to 3 x higher concentrations in sands and silts.

The elements Co, Fe, As and Sb reach highest concentrations in clays (up to 10 x the values measured in sands or silts); this relative enrichment compared to Sc, Rb, Cs, LREE and Th is also shown in the vertical profiles of boxcores 9, 10 and 11 (Figure), and is the result of accumulation of these elements in the oxygenated surface layer. Na and Br contents were measured before (Na_{tot}, Br_{tot}) and after (Na_{sed}, Br_{sed}) removal of salt by dialysis. Results show that the clays have the highest salt contents. The concentration of Br in the salt is constant all over the Skagerrak and is comparable to the distribution of C_{org}(%) The Br/C_{org} ratios range from 30-80, with ratios from 30-40 in waterdepths of 500m and more and ratios of 40-50 in shallow waters. These ratios differ considerably from the values measured in sapropels from the eastern Mediterranean, where ratios have a constant value of 15.

The higher Skagerrak ratios are explained by the oxydation of a large proportion of the C_{org} originally deposited.

The trace element distribution apparently is related only to the distribution of the fine grained sediments and is furthermore influenced by the mobilisation of certain elements due to redox conditions.

"ARAGONITE/CALCITE CYCLES IN PERIPLATFORM CARBONATE OOZE OF EARLY PLIOCENE TO HOLOCENE AGE ; O.D.P. LEG 101, SITE 632-A, EXUMA SOUND , THE BAHAMA'S."

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Abstract

The starting point for this study was the significant vertical variation in mineralogy of periplatform carbonate ooze. These oozes are mainly made up of aragonite, calcite and magnesian-calcite and show distinct aragonite/calcite cycles due to the changing relative abundance of aragonite and calcite. These cycles can clearly be tied to the glacial-interglacial rythm of the Quaternary and are probably a combination of input - and dissolution cycles.

In order to examine the aragonite/calcite cycles in a more distant past I examined the upper 83.8 m. of a 141 m. thick stratigraphic sequence, i.e. 9 succeeding piston cores taken on the O.D.P. Site 632-A of Leg 101 in the Exuma Sound basin of the Bahama's (Figure 1). The investigated Early Pliocene to Holocene sequence consists of periplatform carbonate ooze alternating with largely platform derived turbidites and a single debris flow.

An aragonite/calcite curve was produced for the Late Quaternary, which shows an excellent correlation with curves of previous studies for the same time-span. In this study cyclic variations also were estimated in the Middle Pliocene to Early Quaternary, which also can matched with oxygen isotope curves of several other studies. Further down the hole, correlation of individual events between oxygen isotope and aragonite/calcite curves is hampered by poor recovery. However, the two curves remain similar, notably with regard to the overall decrease in amplitude of variatons down the hole.

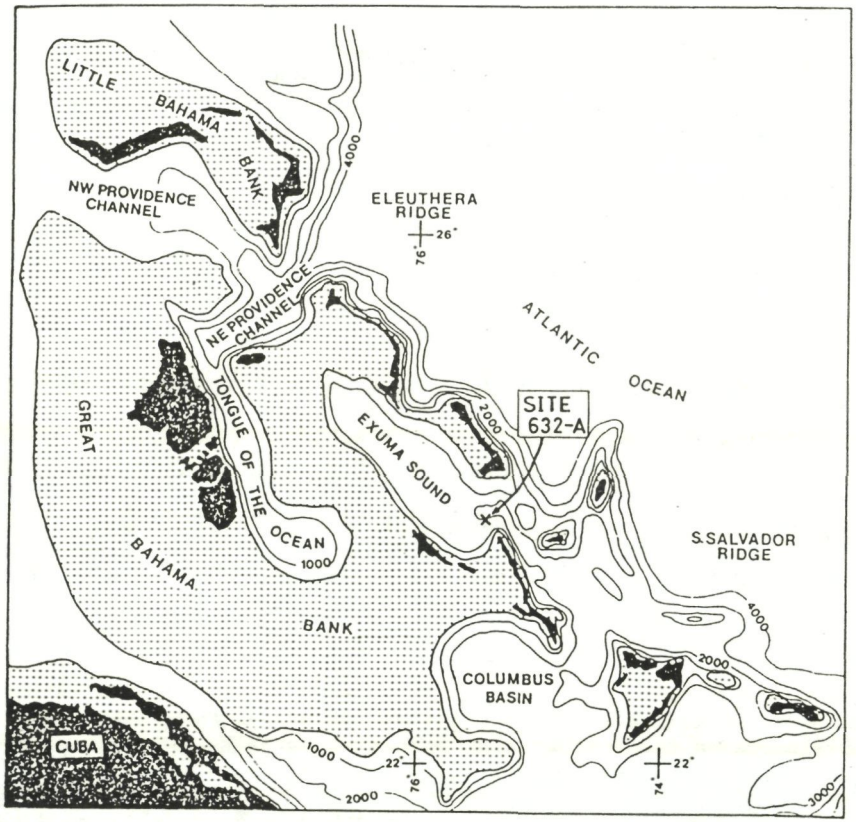

Figure 1.
Location map of O.D.P. Site 632-A, Leg 101, Exuma Sound, the Bahama's. Contours in meters after King, 1969. Dotted pattern delineates carbonate banks shallower then 100 fm.. Adjacent deep Atlantic east of the 4000 m. contour. (Modified after Droxler, 1984).

GEOTECHNICAL OCEANOGRAPHY

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Marine geotechnology is dividable into: (1) site investigations and foundation studies for offshore structures, emphasizing engineering, and (2) a methodology for quantifying some physical processes on and in sediments at all water depths, emphasizing geoscience. We call this latter field "geotechnical oceanography." This poster uses three examples from recent Fugro scientific research to illustrate. A geotechnical drillship and the Fugro conductivity probe were used in 1986 on the Norwegian continental shelf to obtain temperature gradients and in-situ thermal conductivities below the depth of seasonal thermal changes. Previously obtaining valid heat flow data was nearly impossible in this environment. A Fugro seismic piezocone, instrumented with sensitive seismometers and other sensors, permits the determination of shear wave velocity data in continental shelf and slope sediments. These data are used to calculate the shear modulus at low strain levels for the determination of sediment compressibility, earthquake potential, etc. Using the Fugro Seaspear free-fall expendable penetrator, together with a Fugro computer algorithm, shear strength profiles to sub-seabed penetration depths of 40 m can be rapidly obtained in water depths to 6000 m. These data quantify sediment stiffness and other diagenetic parameters, delineate stratigraphy and help validate seismic reflector depths.

THE IMPACT OF SEA LEVEL RISE ON THE NETHERLANDS

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There is no doubt that the atmospheric CO_2-level and related to it the global temperature will rise in the coming centure is. However an accurate prediction of it is very difficult to make. Recent calculations show an increase in temperature of 1,5 to 4,5° C if the CO_2 content doubles. Predictions of sea level rise are even more difficult to make. The latest figures are a rise of between 30 and 150 cm for the coming century. A rise may have great impact on the Netherlands with regard to

- safety
  dikes, and other defense structures along the coast but also along the main rivers. If the dikes along the rivers will have to be made higher and broader this will have a major social impact.
- morphology
  dunes and coastal foreland, reaction of estuarine systems on sealevel-rise (can the bed rise as fast?)
- environment
  when the estuarine systems change drastically what will happen to animal life (ie the Waddenzee plays a very important role for bird migration) and vegetation.
- water management
  increasing seepage of salt water into the polders, increasing salt intrusion via the rivers. Water will have to be pumped out of the IJssel lake instead of the present natural drainage. Decreasing amount of drinking water below the dunes.
- other structures
  harbors, bridges, locks etc, etc, etc.

At Rijkswaterstaat a preliminary study was performed to estimate the most important impact of sea level rise. For this study, an extreme scenario of 5 m rise in 200 years was chosen. Calculations were made to see how the tidal system would respond. In fig. 1, 2, 3 and 4 it is shown that the southern amphidromic point will be displaced to the north. Associated to that is an increase of the tidal difference in the southern part of the North Sea. In the vicinity of Den Helder there is a decrease.
Calculations of wave heights show a large increase in the shallow coastal waters. This increase in wave heights is dependent on whether or not the bottom of the sea rises at the same rate as waterlevel.
If no measures are taken the dunes will retreate over a distance between 26 and 750 m. In many cases the dunes are not that broad so that breaching will occur.
The area of the Waddenzee shows a transport of sand eroding from the northern part of the islands into the Waddenzee (fig. 6).
Espectation is that most islands will not survive a rise of 5 m. Also bottomlevel rise cannot keep in pace with the 5 m and the ecology will change drastically.
Salt intrusion trough the rivers is shown in fig. 5.
A number of possible solutions have been investigated in this preliminary study. The solution that came first to mind was, of course, the reinforcement of dikes and dunes. Two alternative solutions are shown in figures 7 and 8. A huge "Ring" dike is a typical Dutch solution, its impact however, is mostly negative.
The "Strategic Retreat" is certainly not a typical Dutch solution. To most Dutchmen, "surrender to the sea" is unthinkable. In this alternative, of the low-lying parts of the Netherlands, only the heart of the country (Rotterdam, Amsterdam, etc) would be saved. The advantages are that less dikes and coastal defense structures would be needed and that new beaches would be created.
Interested readers can get a complete report in Dutch of this study.

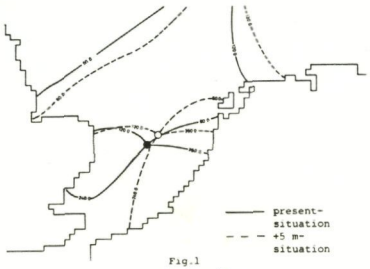

Fig.1
isofase lines

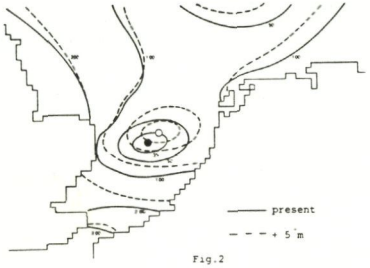

Fig.2
isoamplitude lines

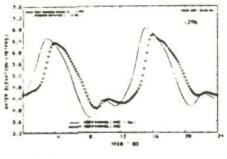

Fig. 3
Tide at Hoek van Holland
present
+ 5 m

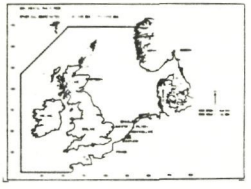

Fig. 4
Continental Shelf Model
computermodel used

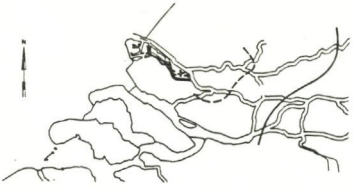

Fig. 5
Salt intrusion bij rivers
present
+ 5 m

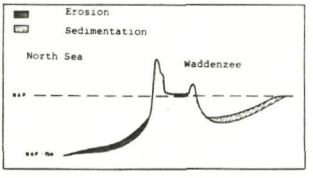

Fig. 6
Sand transport to the Waddenzee

Fig. 7
Extreme solution with
a "huge Ring Dike"

Fig. 8
Extreme solution
Strategic Retreat

MORPHODYNAMICS AND SURFACE SEDIMENTS OF THE MARSDIEP EBB TIDAL DELTA

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The tidal inlet south of Texel Island is the largest one of the Wadden Sea Islands. Tidal discharge is of the order of 10^9 m^3.
An extensive ebb-tidal delta complex has developed since the inlet came into existence about a thousand years ago.
The morphological and sequential evolution, sediment transport patterns, and distribution of sediments and sedimentary structures are subject of study.

The morphological evolution since the early 19th century could be reconstructed on the basis of loding maps. Changes have been significant.
Ebb as well as flood dominated channels occur, the first being dominant.
Due to shielding of the channels by ebb terminal lobes, the flood current is spread, more than the ebb current, over the whole complex.
In the channels, tidal currents decrease in strength in the seaward direction. Consequently sedimentary structures also decrease in size, and seawards, cross-bedded structures grade into even lamination. This is observed on echo-sounding profiles as well as in cores and box cores. In a similar way the sediments are finer seawards, and also they are better sorted and more mature.
The absence of crsoss lamination at the seaside of the terminal lobes reflects the dominance of waves over currents. Thus the lobes form a clear boundary between current and wave dominance.

Net sand transport directions in the channels, and on the shoals in between, them is reflected by the bedform geometries. In many places geometries do not change during the tidal cycle, indicating the presence of clear sediment transport paths. The alternation of ebb and flood dominated channels, together with the northward directed residual tidal current along the coast results in a zig-zag northerly transport of sand.
Transport of sand by wave-induced longshore drift is relatively unimportant.

Differences between the Marsdiep ebb-tidal delta and examples from elsewhere can be related to the specific current patterns and to the intensity and directions of wave action in the area.

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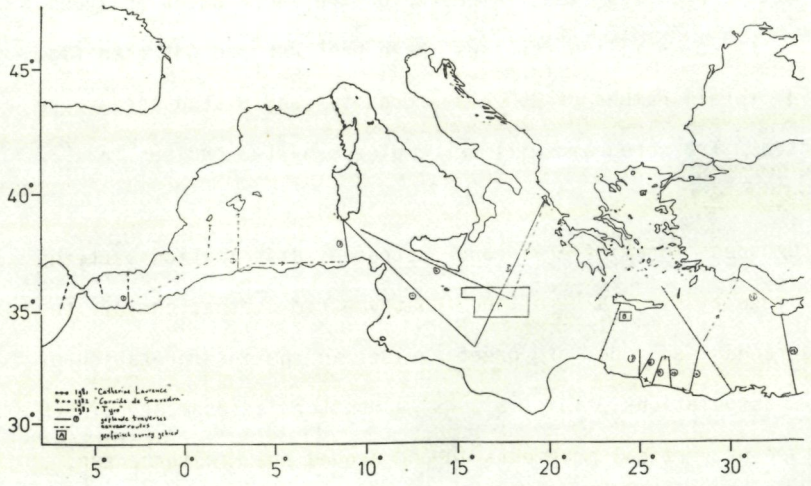
(ACTUO)MICROPALEONTOLOGICAL RESEARCH IN THE MEDITERRANEAN

The actuomicropaleontological program of the department concentrates on the bathymetric distribution of living benthic foraminifera and ostracods in the Mediterranean. A series of north/south traverses across the various sub-basins of the Mediterranean have been selected as indicated in fig. 1. A systematic box-core sampling of these traverses from shallow to deep water provides the framework for the shore-based analyses. So far three sampling cruises have been carried out (see fig. 1.); a total number of 250 box-, gravity- and piston-cores were collected. The program will be completed by two cruises in 1987 en 1989.

The combined foraminiferal and ostracod distribution-patterns will result in a refined bathymetric zonation of the Mediterranean and be of great value in the interpretation of fossil associations. This allows a better assessment of the magnitude of vertical movements in and around the Mediterranean.

Special attention is given to phenotypic variation within species as this may provide an additional tool. The piston-cores contain

the sedimentary record of the late Quaternary history of the Mediterranean. In the eastern basin this time interval is characterized by the presence of dark-coloured intervals, the so-called sapropels. These layers are indicative of an interrupted circulation pattern, leading to a stratification of the watercolumn and eventually to anoxic bottom-conditions. Detailed analysis of the planktic foraminiferal assemblages through such a sequence has revealed that many species exhibit phenotypic variation. On the poster two examples will be shown: Globorotalia scitula and Globigerina quinqueloba (Contributors: G.M. Ganssen, Y.A. Baumfalk, S.R. Troelstra, M.J.L. van Zanen and L. Moodley).



SLUMPING, SLIDING AND THE OCCURRENCE OF ACOUSTIC VOIDS IN THE SAVU BASIN, INDONESIA

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The SAVU Basin is a triangular shaped semi-enclosed forearc basin, surrounded by the inner arc volcanic islands Flores-Alor-Pantar to the north and the island chain Timor-Roti-Savu-Sumba to the east, south and west. Waterdepths in the basin are slightly below 3000 m; the basin is separated from the South Banda Basin to the north by a sill of $\pm$ 950 m and from the Indian Ocean by sills of $\pm$ 1100 m depth between Sumba-Savu and Savu-Roti-Savu. The basin in fact is a recent subsiding basin developed along uplifted outer arc ridge segments.

The relatively fast uplift of the Sumba-Savu-Roti-Timor ridge (Sumba $\pm$ 40cm/1000yr, Roti 30cm/1000yr in the Pleistocene has resulted in major sliding and slumping of presumably Plio-Pleistocene strata into the inner Savu basin, affecting an area of $\pm$ 4000 km^2. The recent charactur of the mass movements is reflected in both the seismic and 3.5. kHz profiles of the Basin obtained during legs G1c, G2 and G6 of the Snellius II expedition.

At the foot of the slumped deposits acoustic voids are present, preventing the penetration of sound in the surface sediments. These voids locally seem to rise out of the sediment cover but measurements on station show that they normally occur below 10 meter sediment depth. Deformation of strata is unclear, probably excluding clay-diapirism in an initial stage as responsible mechanism. Gas formation, i.e. methane gas cannot be excluded but normally methane in pore waters of sediments is shown as a strong black reflector on top preventing further penetration of sound. This is not the case in the Savu basin where the acoustic voids still exhibit layering. Formation of gas hydrates or clathrates can be ruled out as cause because sediment burial is unsufficient. I therefore ascribe the formation of acoustic voids to differences in pore water pressure induced by soft sediment fabric deformation by slumping.

RECENT SEDIMENT ACCUMULATION IN THE SKAGERRAK: APPLICATION OF Pb^{210} DATING

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The Skagerrak is the deepest of a series of basins that form the Norwegian Channel, an elongated narrow depression off the Norwegian Coast. The Skagerrak acts as a sink for fine grained sediments derived from the southern North Sea and transported into the basin by the anticlockwise circulation pattern in the North Sea.

Yearly 12-15 million tons of suspended matter are deposited in the Norwegian Channel, the Skagerrak and the Kattegat, of which 4-7 million tons in the Skagerrak (Eisma, 1981).

In this abstract we report sedimentation rates measured by Pb^{210} decay in 16 boxcores from the Skagerrak, collected in 1984 with the R.V. "Aurelia".

Pb^{210} activity was measured in 1 cm thick slices of sediment via its granddaughter Po^{210}, which is assumed in secular radioactive equilibrium with its parent. The precision of the measurements is 3% or better, based on counting error. Supported Pb^{210} activity values were obtained by Ra^{226} concentration measurements, assuming equilibrium with Pb^{210}.

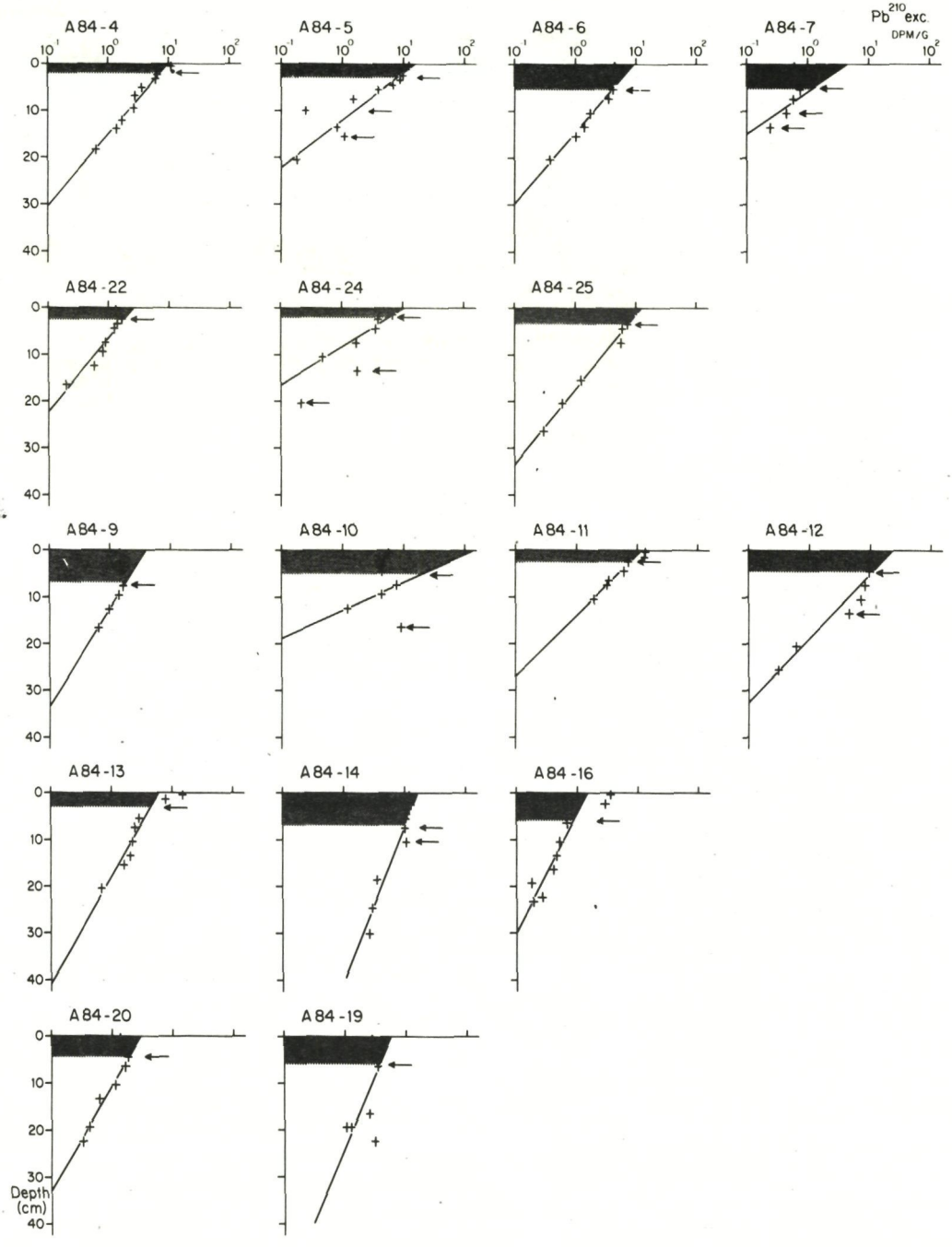
The Pb^{210} depth profiles normally show a surface mixed layer (SML) caused by intense bioturbation. The thickness of this layer varies, and ranges from 2-7 cm, depending on location. Sedimentation rates were calculated by least square fits for the logarithmic decrease of excess Pb^{210} below the SML.

Rates are highest, above 40 cm/100yr, in the northeastern and eastern Skagerrak (30cm/100 yr). Along both the southern and the northern slopes towards the central basin intermediate values (20cm/100 yr) are found, while in the central basin rates range from 8-14 cm/100 yr.

Indications for the influence of bioturbation at depth are found in cores 5,7,12 and 14 (indicated by arrows is the onset of non-equilibrium conditions). ETS (Electron Transport System) profiles at these stations also show a strong peak in activity at these depths.

Deviation from a logarithmic decrease in core 10 is clearly the result of changes in physical conditions.

The measurements show a striking relationship between Pb^{210} excess and the porosity of the surface sediments, reflecting the strong influence of grainsize on Pb^{210} activity and excess values.


A84-4
A84-5
A84-6
A84-7
Pb210 exc.
DPM/G
A84-22
A84-24
A84-25
A84-9
A84-10
A84-11
A84-12
A84-13
A84-14
A84-16
A84-20
A84-19
Depth (cm)

PHENOTYPIC VARIATIONS OF A MODERN PLANKTIC FORAMINIFER: GLOBIGERINA QUINQUELOBA

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The objective of this study is to determine the variations in test morphology of Globigerina quinqueloba . The test morphology seems to change with varying oceanographic circumstances. Establishing relationships between changes in test morphology and oceanographic circumstances would increase the usefulness of fossil foraminifera in paleoceanography.

Surface-water samples were collected during the voyage of the vessel M.S. TYRO from Amsterdam to Jakarta for the Indonesian-Dutch Snellius II expedition. The pump-method was used to obtain a continuous set of samples during the entire cruise. The results presented here were obtained from samples from the eastern North Atlantic and western Mediterranean.

Biometric analysis was carried out on 9 samples on an average of 30 specimens taken out of each sample. Nine variables were measured on each specimen using digitising equipment. The computer used for statistical processing of the data was a PDP 11/24, Unix system.
The measured variables are:
1) The number of chambers in the last whorl
2) Diameter of the last chamber
3) Diameter of the penultimate chamber
4) Ratio of the variables 2 and 3
5) Diameter of the last whorl
6) Degree of lobateness
7) Aperture types
8) Pore density per unit area
9) Pore density relative to total area

Preliminary results

The diameter of the last chamber and the penultimate chamber, the diameter of the last whorl and the number of pores per unit area seem to be dependent on salinity. With increasing salinity the average chamber- and whorlsize decrease, while the number of pores per unit area diminishes.
The aperture types do not show a clear relationship with temperature, salinity or water density.
Globigerina quinqueloba evidently adapts its test morphology to changes in salinity and can thus be used as a salinity-indicator for paleo-marine environments .

Test morphology does not seem to react to temperature, though it must be stated that the temperature range of the studied samples is very small (14.5 - 18.3).