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Lisbon Portugal

18-20 March 1996

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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Report on the meeting of the Working Group on Shelf Seas Oceanography Lisboa, 18 - 20 March 1996

1. Opening

The chairman Einar Svendsen opened the meeting and welcomed all the participants. Dr. Nicolas Gonzalez welcomed the meeting on behalf of the Instituto Portugues de Investigacao Maritim (IPIMAR)

2. Rapporteur

Roald Sætre was elected as rapporteur

3. Adoption of Agenda

The agenda was approved

4. National activities

Einar Svendsen reported on a flood in southern Norway in June 1996. A case study of modelling the impact of the increased fresh water outflow on the marine waters indicates an increase in harmless diatom production for the inner Skagerrak of about 100 %, well in agreement with measurements. This could also be regarded as a relatively large scale fertilisation experiment.

Gerd Becker reported on the SST of the North Sea during the cold winter 1995/96. The low temperature was most pronounced in the central and southern parts (APPENDIX 1)

Tom Osborn reported on a new instrument for measuring bottom stress which may also be suitable for measuring sediment transport and resuspension.

Kjell Orvik reported on some new current measurement along the Norwegian continental slope related to the northward flow of Atlantic Water. No clear seasonal cycle was present in the velocities, in contrast to previous geostrophic estimates from density fields and from numerical model simulations.

5. Physical/chemical fluxes

Gerd Becker presented different flushing time estimates and their statistics through the ICES boxes (APPENDIX 2). The results showed large variability and the different data set have used different geographical limits for the boxes. The most sophisticated models, however, show very similar results - much lower than the older estimates. Differences in chosen periods for the different models may explain at least part of the variability

Thomas Pohlman presented results on physical and chemical fluxes based on an 11 year model simulation.(APPENDIX 3). The traditional ways of estimating mean flushing times through boxes (based on the volume of the box devided by the mean fluxes through the boundaries) have the weakness of adding fluxes to the mean when the same water are transported in and out of the box several times. This also rizes the question on what time (and spatial) resolution the mean fluxes should be based on. Due to this, Pohlman demonstrated the benefits of using a tracer concentration for calculating the turn-over time and half life time of water in boxes, and this was compared with earlier estimates of flushing times (APPENDIX 3). From the 11 years half life-time simulations large quarterly and yearly variations occure.

Pohlman also presented the regional distribution of the net yearly mean advected phosphate in 1988 derived from the ecosystem model ERSEM. For most of the ICES boxes, these estimates are significantly lower than what was presented by Svendsen.

Einar Svendsen presented some 9-year model simulations coupled with nutrient measurements showing fluxes of nutrients through the different ICES boxes in the North Sea. The results were presented as 9 year monthly mean conditions (APPENDIX 4). A clear seasonal variability of both the nitrogen and phosphorous fluxes is seen, and the large amounts in the northern boxes are due to large volume fluxes of Atlantic Water.

Due to a discussion (see below) of the uncertain usefulness of estimating fluxes through large boxes, Svendsen also presented simulated monthly mean vertically integrated nitrogen fluxes (with 20x20 km^2 resolution) all over the North Sea for January and July, 1993. This was just an examle of the potential for more sophisticated products which can be derived from coupled 3-D ecosystem models.

In the discussion the participants expressed scepticism to the usefulness of terms like “flushing time” and “residence time” and it was proposed that a critical review on the meaning of these terms should be produced. In addition the need for estimates of flushing/ residence times through large boxes was unclear to the partisipants, and this question should be adressed to the ICES community. It was concluded that the whole concept of the traditional calculation and use of the flushing time terms related to ICES boxes should be revised.

6. Suitable data sets and procedure for model validation

All the participants expressed that there was a clear need for validation of the numerical models, although there was some discussion on whether “validation” was the correct term. It was agreed that “evaluation” was better. It was referred to the EU project NOMADS where the goal is to compare models, as well as to NOWESP which aim at collating “quality controlled” multidisiplinary historical data and produce good historical time series of environmental parameters from different regions of the North West European Shelf. It was agreed not to recommend any large field experiment to produce suitable data sets for validation, but rather recommend to improve the availability of the existing data sets and historical time series, and to keep updated on the progress of the ongoing activities. In this respect OSPARCOM/ ASMO is organizing a eutrophication modelling workshop in the Hague 5-8 November, 1996 where model evaluation will be central, and in 1997 a similar workshop on modelling of contaminants will be organized.

7. Review of different scale physical processes involved in horizontal and vertical transport of nutrients into the euphotic layer

Thomas Osborn reviewed this topic: Vertical transport of nutrients through the pycnocline can be accomplished on a variety of scales and with a variety of processes. Small-scale turbulent mixing draws its energy from the local shear and internal wave field. Measurements offshore suggest the eddy diffusivity in the order of 10^{-5} m^2s^{-1}. This value arises from both the microstructure measurements and the diffusion of inert tracers. It is likely that the inshore value will be comparable to the offshore values. The scaling is $K_p \sim 0.2\ \varepsilon/N^2$, and while N^2 gets larger in some inshore region, ε values from inshore waters are not dramatically larger. Surface forcing due to the wind, breaking waves and surface cooling can erode the top of the thermocline and lead to nutrient transport into the upper layer (entrainment). Turbulence due to wave breaking is strongest in a layer of thickness comparable to the wave height. Windforcing can typically reach down to 20 - 40 m in stratified water. The most effective process is surface cooling which uses potential energy to mix through the entire upper layer.

Mixing can also be forced by the bottom stress due to the mean flow, tidal currents, surface waves and internal waves. There is a bottom boundary layer - an analogue to the surface boundary layer. When the surface and the bottom boundary layers merge the water column becomes mixed with little density variations. The region of mixed water can vary in time due to variations in the forcing, with a local pycnocline forming and breaking down. This intermittent mixing at the pycnocline produces a flux of nutrients upwards.

Large scale circulation contain processes that include vertical motion of isolines, baroclinic and barotropic instabilities, frontal processes, Ekman pumping etc. Topographic interaction due to shore lines and bottom topography can enhance mixing by affecting wave energy and by mixing bottom sediments into the water column. Lateral mixing along sloping density surfaces produces a vertical flux of nutrients without having to transfer material across density surfaces. This lateral mixing is energetically easier to perform since no work is done to overcome buoyancy. Coastal regimes frequently contain fronts with large slopes to the density surfaces. Regions of semi-permanent wind-induced coastal upwelling of nutrients are normally very productive. Cyclonic circulation in semi-enclosed areas like the Skagerrak and in eddies can also lift new nutrients into the euphotic zone.

Clearly the increased transport of nutrients related to river floods and/or nitrogen supplies directly from the atmosphere can be important (although these processes are not in the ocean itself). These supplies can effectively be used for primary production since they are assosiated with light fresh water which normally stays at the surface whith the best light conditions. In heavy farmed districts, flooding rivers will generally cause increased transports of nitrogen compounds and sometimes silicate, while phosphorous concentrations may be reduced (dilluted) keeping the transports to the ocean relatively constant. This leads to changes in the relative amounts of different nutrients which can effect the phytoplankton species composition and growth (see excample in section 8 below).

8. Assist the WG on Phytoplankton Ecology in producing site-specific multidisiplinary description of the response of the marine environment to anthropogenic nutrient inflows in some example areas

This topic was addressed by the modellers of the North Sea (Thomas Pohlman and Einar Svendsen) and by Hans Dahlin for the Baltic who referred to an issue of AMBIO, Volume XIX number 3, May 1990. Pohlmann presented results from the ERSEM model used on boxes just outside some of the larger European rivers. This showed that reducing the nutrient inputs by 50 %, gives no significant reduction in vertically averaged chlorophyll concentrations throughout the year. This means that the primary production in these areas are mainly light limited, so with reduced loads, the production goes deeper. Svendsen mentioned the international NSTF Modelling Workshop (The Hague, 6-8 May, 1992). Here one of the scenarios was to reduce the nutrient inputs by about 50 % and study the effect throughout the North Sea. Apart from mentioning a general agreement of reduced winter nutrient levels and lack of model validation, these modelling results were little used in the Quality Status Report. Some results have later been published (e.g. Skogen et al., 1995. Modelling the Primary Production in the North Sea using a Coupled Tree-dimensional Physical-Chemical-Biological Ocean Model. Estuarine, Coastal and Shelf Science 41, 545-565. Aksnes et al., 1995. Ecological Modelling in Coastal Waters: Towards Predictive Physical-Chemical-Biological Simulation Models, OPHELIA 41: 5-36. A special issue of the Netherlands J. of Sea Res. 1995, Vol 33 (3/4)-July is dedicated to the ERSEM model.

Svendsen also presented model results and data from the flood in June, 1995 in the largest Norwegian river Glomma flowing into the northeastern corner of Skagerrak. The water flow was about 3 times larger than usual, but the nutrient concentrations was about normal. In the ocean the excess of inorganic nitrogen and phosphorous very near the river mouth were very rapidly used (nice weather in June), but some amounts of silicate were found in the mixed flood-water over larger areas. Concentrations of total phosphorous and nitrogen were high. Abnormal high concentrations of chlorophyll from the diatom *Skeletonema costatum* were found in this brackish water spreading southeastward in the Skagerrak. In agreement with the observations the model simulations gave during June an increased (relative to normal river flow) diatom production of about 100% in the northeastern area of Skagerrak, gradually decreasing with distance from the source.

Increasing amounts of model results related to this topic are now becoming available, but there seems to be a need for better/clearer formulations of the most interesting questions to be asked and where models can play an important part. As previously mentioned, evaluation of such models are strongly needed, and the eutrophication model workshop in the Netherlands in November will hopefully be an important step forward.

9. A conceptual framework for sampling and numerical modelling of the physics in relation to the population dynamics of harmful algae

Thomas Osborn gave an introduction to this point on the agenda: A conceptual framework for modelling and analysing the population dynamics of harmful algae bloom can be developed directly from the "conservation equation" for partial numbers. Such an equation can be written to include biological and physical terms. The application of this formalism requires simplifying assumptions. The same situation arises in the circulation modelling where the equations of motion are straight forward, but the application is difficult because of the non-linear terms and the large range of scales. The Reynolds stress and the often associated eddy diffusivities and sub-grid stresses are manifestations of these problems.

Nevertheless a broad framework for including the appropriate processes is available for HABs. This framework is focused on species concentrations rather than biomass, carbon, or other chemical concentration. This framework can be modified with appropriate simplifying assumptions for specific individual cases and used to assess the relative importance of different processes such as growth, advection, grazing, nutrient limitation, etc. Progress in these areas requires interaction of biological oceanographers and physical oceanographers.

The problem of Harmful Algae Blooms are multidisiplinary. WGDHAB must remain multidisiplinary with a component of the membership made up of physical oceanographers. The WGSSO and WGDHAB should meet jointly on a regular basis(every two or three years).
The dynamics of coastal regions needs to be measured and modelled on a fine enough scale to resolve the process affecting the bloom. An example is the structure of the convergent flow in the frontal region of a buoyant plume or coastal current. Another example is estuarine modelling to determine flushing of nutrients and algae from estuaries, lagoons and other coastal regions. There is a need for field investigations to better understand the initiation of harmful algal blooms, and such investigations should be planned in times and areas where such blooms regularly occur.

10. Development of GOOS, in particular with regard to a possible co-ordinated ICES input to the GOOS coastal zone module

Global Ocean Observing System (GOOS) consists of five modules of which four are within the working area of ICES. A further development of GOOS will probably rely on building up regional systems for operational oceanography. A first step towards such a system for parts of the ICES area is the establishment of EuroGOOS where several ICES countries are members. The Baltic Monitoring Programme, presented by Hans Dahlin, may be regarded as a regional GOOS system.

The role of ICES in the further development of GOOS should not be to establish a regional component for the ICES area, but rather to contribute in the planning activity, as data bank, and in quality assurance work. The role of ICES should further be seen in relation to the proposal of an Environmental Status Report for the ICES area as well as its aim of more integration of environmental data and knowledge into stock assessment work. There is also a need for ICES to clarify its role in operational oceanography which probably is the key element in GOOS.

11. The feasibility and potential contribution to an environmental status report for the ICES area on an annual basis.

This topic was reported to ACME, January 3, 1996. There are clearly different opinions between the members of the WGSSO on both the feasibility to produce an Environmental Status Report (ESR) on an annual basis and on the actual need for such a report. However, the WGSSO noted with satisfaction that the Working Group on

Oceanic Hydrography plan to prepare the climate part of such report. The members of the WGSSO could contribute to the proposed chapter on "Regional Seas" with data and processed products from time series on the shelf seas.

It was mentioned that several ongoing monitoring activities were partly worthless mainly due to undersampling in time and/or space compared to the variability of the system. Due to this it may be more relevant to monitor integrated effects of changes in environmental parameters than the parameters themself. This must be considered when desitions are made on what to include in a status report, which also are relevant for section 12 and 13 below.

12. Consider the requirements for a project designed to investigate the mechanisms by which "ice winters" affects various aspects of the North Sea ecology.

This was an action item following from the conclusion of the 1995 Aarhus Symposium. The WG participants who also partisipated in this symposium were not sure of the background for this request, since this was not a hot topic at the symposium. One paper suggested that macrozoobenthos populations in the tidal flats of the Wadden Sea are negatively sensitive to extremely low or high winter temperatures.

It was emphasised during the discussion that "ice winter" was a part of the long term natural variability. Studies of such events have to rely on historical data, time series and the litterature. "Ice winters" are not a phenomenon specific to the North Sea, but could also be studied in other areas such as the Baltic or the Barents Sea. The WG felt it was difficult to design a project for studying future "ice winters ". Then one would have to establish a scientific team which like a fire brigade was waiting for the right climatic events to occur. A more general and at the same time a more specific formulation of this request could be to study the ecological effects of extreme events either climatic or other types. The best way to start such a study is for ICES to produce an inventory and collate as many long term (> 20 years) multi-disiplinary marine and atmospheric time-series as possible, and then to formulate a project/study group on the subject.

13. Minimum requirements to monitor and identify significant temporal (eutrophication) trends under different hydrographic conditions.

A minimum requirement to identify and monitor temporal trends is to have a broad overview of the natural temporal and spatial variability for the specific area of interest. This is also important in order to be able to distinguish between natural and anthropogenic effects. Where few data are available, numerical models can be of help to estimate these natural temporal and spatial variabilities. The measurements should aim at observing the integrated effects of eutrophication rather than on concentrations of nutrients. Such effects could be characteristics of the phytoplankton community, light transmission and turbidity, sedimentation rates, oxygen consumption or characteristics of the benthic community. Studies should be made to find the most sensitive parameter for the specific area Special attention should be given to the statistical aspect of the monitoring programme in order to obtain a reasonable signal/noise ratio in the observations as well as being aware of the possibilities for non-linear trends, both temporal and spatial. Dutch papers have shown that possible trends in nutrient concentrations due to increased/decreased anthropogenic inputs will only be detectable in low salinity water near the sources.

A multi million ECU EU project proposal, OPTIMON, is submitted to OPTImize marine MONitoring programs for nutrients and trace pollutants. This means that today there is not a general and simple answer to this topic

14. Any other business

There was no other business, but Tom Osborn stated that it was good for marine science to have ICES outside the EU system.

15. Place, date and topics for the next meeting

The Spanish deligate, Dr. Nicolas Gonzales, invited the WGSSO to hold the next meeting at the IEO in Tenerife in Canarias. The time was agreed to 10-12 March, 1997. The following topics were proposed (see recommendations in appedix):

a) Model evaluation (responsibilty: E. Svendsen)
Review staus on the ability of models to reproduce nature.
Process models/Research models.
Role of models in monitoring.

b) Applied monitoring strategies (responsibility: H. Dahlin)
Review the Baltic Monitoring program with special attention to natural time and space variability/scales.

c) The role of fresh water in the marine environment (responsibility: T. Osborn)
Estuarine processes.
Coastal plumes.

d) North Atlantic - Shelf Seas exchanges
Sensitivity analysis of the need for operational data on open model boundaries. (responsibility: T. Pohlmann)
Review the importance to continue hydrographic monitoring sections along the shelf edge from Portugal to Norway. (responsibility: A.J. da Silva)

e) Inventory and collation of long time series (responsibility: Harry Dooley ?)
Oceanographical
Meteorological
Fisheries
Astrological (sun spots, tides etc.)
Model results

Justifications

a) The need for better quantified knowledge (within reasonable costs) of the marine environment has strengthened the need for numerical simulations. Results from such simulations are increasingly being used by management. So far there is a grate lack of evaluation, or "quality assurance" of model results claiming to reproduce nature.

Numerical models can also be used for estimating the typical scales and magnitude of natural environmental variability, which is a crusial factor to know for evaluating ongoing or planned monitoring activities.

b) Some ongoing monitoring programs have problems with funding and some are heavily critizised. Therefore it is important to evaluate the effectiviness of individual environmental monitoring programs in determining possible trends against the the natural variability. Since H. Dahlin is central in the Baltic Monitoring Program, which seems well organized, it is practical to start the evaluation with this program, see what general conclusions can be drawn, and continue later with evaluation of other monitoring programs.

c) The frontal dynamics and variability of coastal plumes and prosesses over very sharp pycnoclines typical for estuaries are generally not resolved by standard measurement programs and large scale numerical models. Estuaries and coastal zones are also areas where harmful algae blooms occure, and it is important to increase our knowledge on how these finer scale processes influence the environment and how this varies with varying amounts of freshwater input.

d) Open boundary conditions are a crusial point for numerical models, especially those claiming to simulate nature. Since the North Atlantic shows a strong variability on different scales, it must be investigated how these variabilities influences the shelf seas and to what extent these variabilities have to be included in the boundary conditions. This study can also give input for the configuration of monitoring stations that are able to provide the necessary boundary data.

The North West European Shelf is one of the target areas for EUROGOOS. A number of (21) standard hydrographic sections across the shelf edge from Portugal to Norway has been monitored several times a year during the EU, AIR project SEFOS (1994-1996), and some of these has been monitored for several decades. The importance of continuing (some of) these sections should be evaluated to possibly urge the relevant nations/institutions to continue the monitoring.

e) In order to predict possible changes in regional seas due to climate change, the understanding of large scale long-term climate variability and its affects to the physical, chemical, biological and geological system of shelf areas is of fundamental interest. Questions arisingin this context are:

- How can we separate anthropogenic actions (pollution, eutrophication, fisheries) from natural variability?

- What has happened in the 1930's and in 1978 when abrupt changes in the marine ecosystem occurred?

- Can we reconstruct single events e.g. the change in 1978?

- Can we predict an event such as the Great Salinity Anomaly?

- What are the effects of "ice winters" to the whole system?

- Can we reconstruct the internal dynamics and the functioning of the whole system during the last centurary?

- What are the driving mechanisms of interannual and interdecadal variability? Can we reconstruct these mechanisms from historical time series?

- Can existing theories of interannual and interdecadal variability be unified to one theory?

The answers to these questions are of fundamental interest for management activities as well as for sustainable development. The WGSSO agrees that the understanding of interannual and interdecadal variability and the functioning of the system is a great challenge in marine science and important for human society living in coastal areas.

16. Closing of the meeting

The meeting was closed 20 March 1996 at 1400 hour.

APPENDIX 1:
North Sea SST Anomalies in February 1996

by

Gerhard Becker

a) The cold anomaly of the surface temperatures of the North Sea has strengthend. The geographical distribution pattern of the anomalies however remained largely unchanged. The average seasonal decrease in temperature of 1.4 °C exceeds the climatological rate of change by 50%. The areal mean SST of 4.8 °C in February stays behind the climatological monthly mean for 1971-93 by 0.9 °C (January: 6.2 °C, -0.4 °C). Such cold February temperatures (4.8, 4.4, 4.8 °C) occured in the years 1985-1987 for the last time.
The SSTs of 59% of the entire North Sea clearly fall short of the climatological means ($\Delta T < 0.5°C$). In 40% of the surface area SSTs are too cold by at least 1 °C or 2.2 °C on average. In the sea area off the Frisian Islands to about 56 °N and 4 °E (13% of the entire domain) SSTs differ from climatological SSTs by more than 2 inter-annual standard deviations or 2.4 i. s. d. on average.
b) The anomaly chart shows the spatial distribution of the SST differences for February 1996 minus February climatology for 1971-1993. Contours are drawn at intervals of 0.5°C. Values at the grid points of a 20 nm grid used in data assimilation are given in 10^{-1} degrees centigrade.

P. Loewe

APPENDIX 2:
Flushing times and statistics of the North Sea

by
Gerhard Becker

Background: estimates of fluxes are based mainly on numerical model results. Therefore, model results have to be compared and the variability within the model due to the atmospheric forcing have to be checked.

Here different flushing times estimates and their statistics are presented:

Sources:

ICES Flushing times estimate 1983 (based on different information, mainly physical data, but also chemical and biological findings. At that time model results have been used only to a very limited degree.

MUMM Flushing times numbers for boxes 3,4,5,7',7" only. Barotropic 2-dimensional storm surge model.
Coarse grid 20' resolution, finer grid 6,666' resolution.
Forcing by tides and 3-hourly pressure/wind fields. Simulation of six months duration (May to Nov 1989).

POL (D.Prandle) 2-dimensional model to investigate spreading and mixing of ^{137}Cs released in Windscale.
Grid about 35 km resolution.
Forcing by tides and wind stress averaged over three months. Here we use the model results obtained with a dispersion coefficient of 5000 s.

BSH 3-dimensional operational model, resolution increasing from 20 km to 10 km, and finally in the inner German Bight to 1.8 km. In the vertical ten layers. Driven by tides, wind, air pressure, waves and density distribution (prognostic calculation of density distribution; air-sea heat flux and fresh water input are taken into account). Climatological values of T/S at the open boundaries). Simulation of flushing times from 1993 to 1995.

IfM Hamburg (two different calculations are presented)
IfM1 (Luff and Pohlmann) and IfM2 (Lenhart and Pohlmann). Both models use the same or nearly the same 3-dimensional baroclinic (semi)-prognostic 20 km resolution model with 19 layers. Also the forcing is the same: M_2 tide, 3-hourly wind pressure, weekly SST, climatological monthly river run-off. Both models hindcast the period 1982 to 93.
In IfM1 a disperion model to estimate the decay (37% limit) is applied, IfM2 uses the conventional turn-over approach.

NORWECOM is a 3-dimensional baroclinic, prognostic model with 20 km horizontal resolution and 12 sigma layers. The model is driven by tides, wind, density, heat and fresh water. At the open boundaries climatological data have been used.
The hindcast period ist Aug 1986 to June 1994.

Unfortunately the subdivision of the North Sea in the ICES boxes has changed to some degree over the years, however, the changes are neglected in this comparison.

Conclusions

The ICES flushing times estimate and the barotropic, 2-dimensional model results probably result in too large flushing times numbers for all boxes.

The most advanced 3-d models (BSH, IfM and NORWECOM) result in comparable flushing times. At a first glance no systematic differences between these model results are detected.

The differences between the minima seems to be rather small in all boxes.

The relation between minima/maxima is in the order 1 to 4 or 5 or even higher; therefore the use of average numbers is not recommended.

Here only model results have been compared. Model validation against observations seems to be necessary.

Hamburg, March 1996 G.Becker

APPENDIX 3:
Physical and Chemical Fluxes. Response of the marine environment to anthropogenic nutrient inflow
by
Thomas Pohlmann

1 Figures presented at the WGSSO meeting in Lisboa, 18-20 March 1996

Thomas Pohlmann, Institut für Meereskunde der Universität Hamburg

1.1 Related to the topic: Physical and Chemical Fluxes

Fig. 1+2: Brief description of the Circulation Model (Pohlmann, 1996).

Fig. 3: Domains of the Model System.

Fig. 4: The modified ICES box division of the North Sea used.

Fig. 5: Comparison of different Flushing-Time approaches
Approach a-d: in the conventional form, i.e.:
Flushing Time = Box Volume / Box Inflow
Approach e: Reduction of concentration in a box to 37% calculated with a transport model (Luff & Pohlmann, 1996).

Fig. 6: Concentrations in percent of the initial value in the surface layer after one half-life time (reduction of 50% in the release box). Additionally the underlying circulation pattern is displayed.

Fig. 7: Seasonal variability of half-life times for the years 1983 to 1993.

Fig. 8: Horizontal net transport for the ICES boxes in $km^3 \cdot d^{-1}$ derived as annual mean from 11 years of simulations from the hydrodynamical model (Lenhart & Pohlmann, 1996).

Fig. 9: Regional distribution of the net advected phosphate for the year 1988 derived from the ecosystem model ERSEM (Radach & Lenhart, 1995).

1.2 Related to the topic: Response of the marine environment to anthropogenic nutrient inflow.

Fig. 10: Horizontal box setup for the ERSEM application COCOA (Continental Coastal Application).

Fig. 11: Reduction scenario for COCOA comparing a reference run (run01-88) from the ERSEM standard version V10.4 with a run using half the nitrogen input as nitrate and ammonium as well as organic nitrogen compounds.

This reduction scenario was started by using start values from a 30-year run with this reduced nitrogen input. The scenario run presented here (run03-NIN-half) then uses actual physical forcing for the year 1988 (Lenhart, pers. comm.).

Box 91 (Fig. 12a) represents the box where the river Rhine and Meuse enter the model. The reduced nitrogen input by the two rivers is shown in form of ammonium (top left). The resulting box concentration of ammonium (top right) shows a clear response to the reduced river input by lower concentration of about the same factor as the input in the scenario run. The chlorophyll concentration (lower left) shows an interesting similarity between the two runs, even with a higher spring peak for the scenario run. The time series for the detritus (lower left) are also similar between the two runs, but also give higher values for the scenario run during the period of the spring peak in chlorophyll.

For Box 78 (Fig. 12b), representing the input box for the river Elbe and Weser, the reduced nitrogen input is also shown in form of ammonium (top left). The resulting box concentration of ammonium (top right) shows a clear response to the reduced river input only for the period before the spring bloom and towards the end of the year. Despite the reduced nitrogen input in the scenario run, the chlorophyll concenration time series (lower left) for the scenario run shows higher values for most of the summer. Only occasionally there are higher concentrations in the standard run. The time series for the detritus (lower left) clearly shows higher concentrations for the scenario run throughout the summer period.

1.3 Literature

Lenhart, H.J. & T. Pohlmann, 1996 The ICES-Boxs Approach in Relation to Results of a North Sea Circulation Model Submitted to: Tellus.

Luff, R. & T. Pohlmann, 1996 Calculation of the water exchange times in the ICES Boxes with an eulerian dispersion model using a half-life time approach. Submitted to: Deutsche Hydrographische Zeitschrift.

Pohlmann, T., 1996 Predicting the Thermocline in a Circulation Model of the North Sea - Part I: Model Description, Calibration and Verification. Continental Shelf Research, Vol. 16, No. 2, pp. 131-146.

Radach, G. & H.J. Lenhart, 1995 Nutrient dynamics in the North Sea: Fluxes and Budgets in the Water Column derived from ERSEM. Netherlands Journal of Sea Research. 33(3/4):301-335 (1995)

1. Model Description

Governing Equations:

1. primitive equations (shallow water eq.)
2. equation of continuity
3. transport equation of heat + salinity
4. equation of state (UNESCO, 1982)

Resolution:

- horizontal: $\approx$ 20 km
- vertical: 19 layers

  Layer Thickness: up to 50 m depth: 5 m
  from 50 m depth to bottom: 10 – 400 m
- simulation period: 1982 – 1993
- time step: 20 min

Figure 1

Driving Forces and Boundary Conditions:

1. M_2-tide
2. wind- and atmospheric pressure
   (3-hourly)
3. salinity
   semi-prognostic parameter
   (climatological monthly river runoff data)
   → restored to climatological monthly means
4. temperature
   (weekly sea surface temperatures (SST)
   prescribed at the surface)
   → Dirichlet's boundary condition

Figure 2

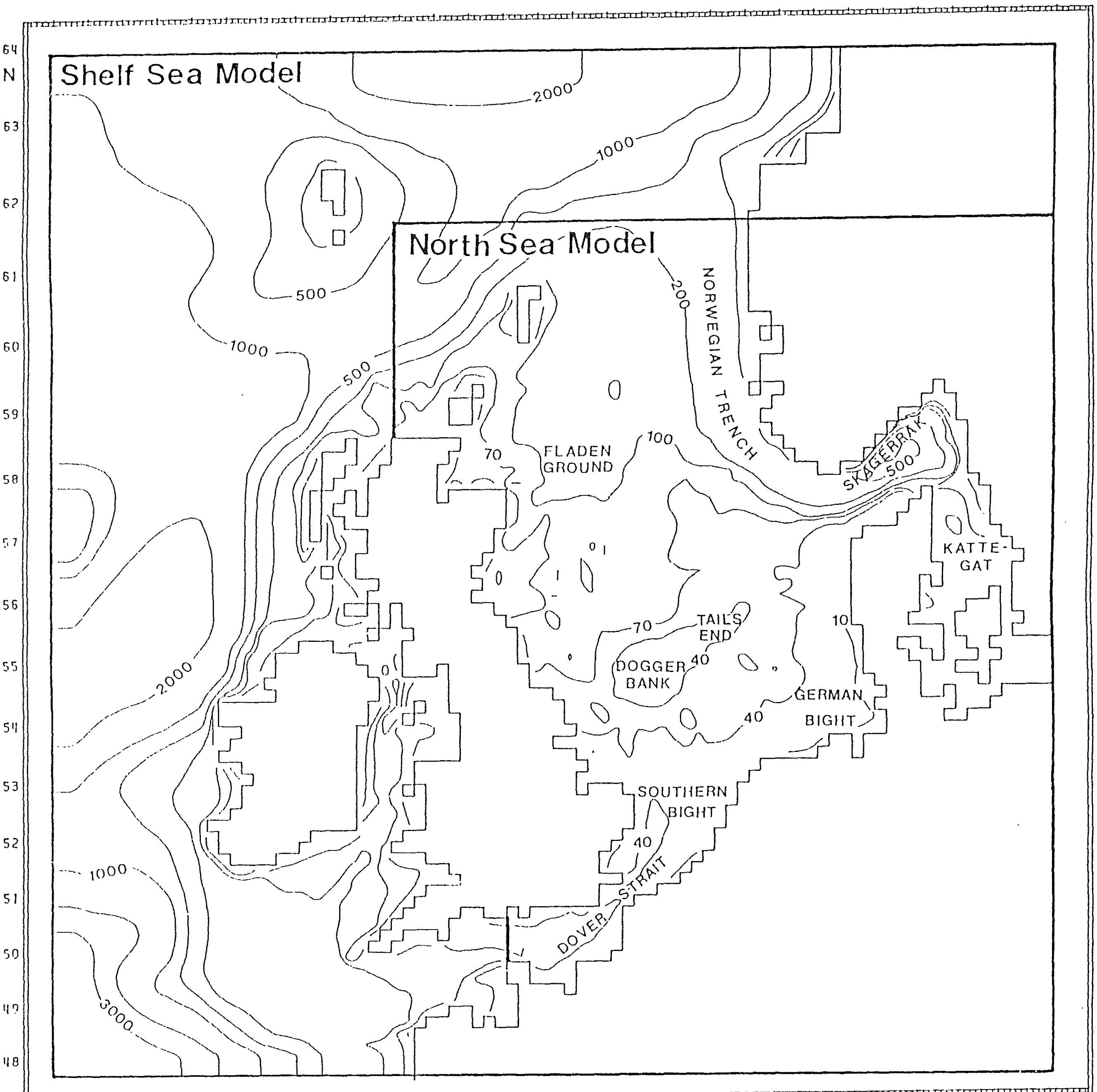
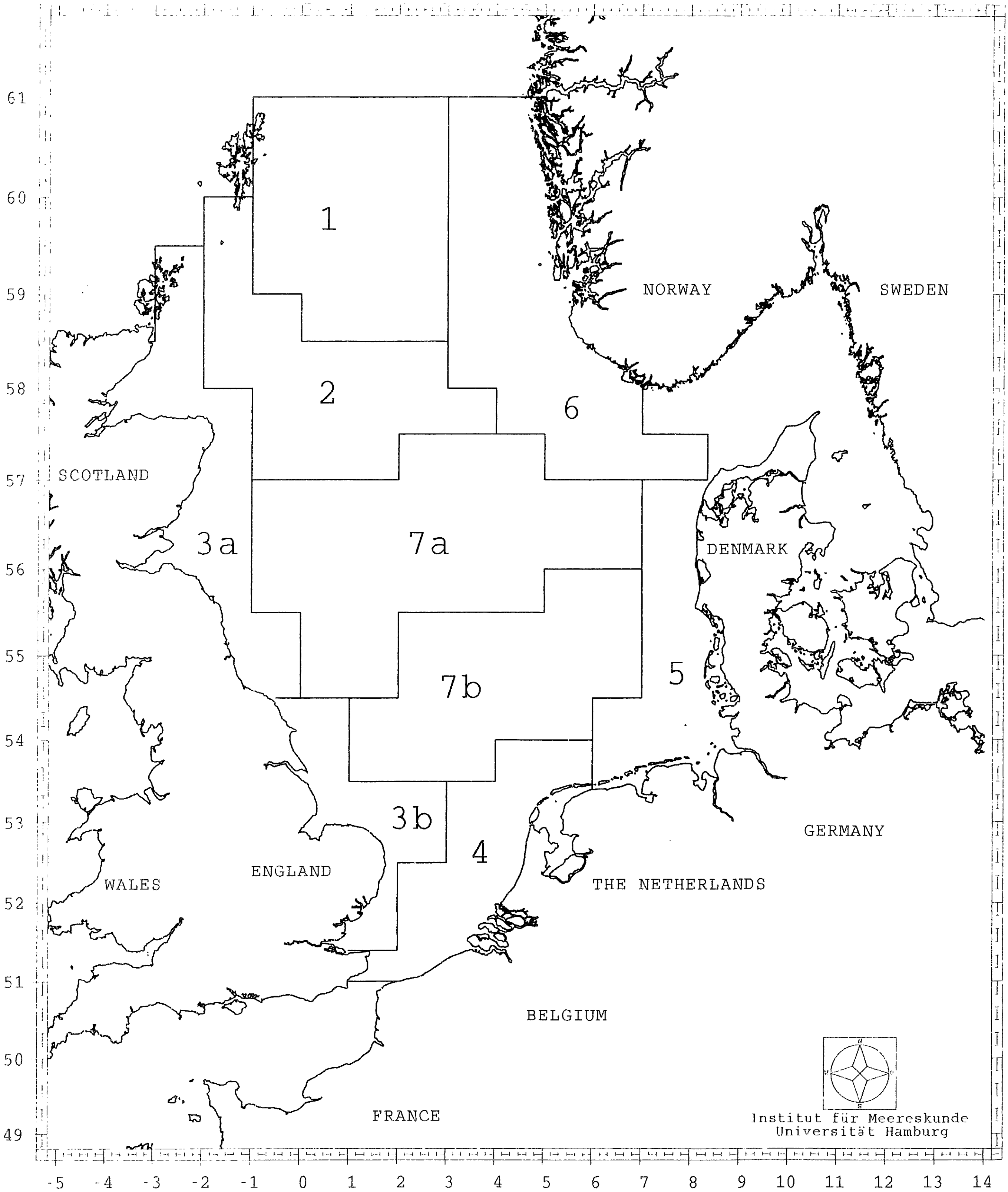


Figure 3 Domain of the 2- and 3-dimensional model, topography (m), and mentioned locations



61
60
59
58
57
56
55
54
53
52
51
50
49
-5
-4
-3
-2
-1
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
1
2
3a
3b
4
5
6
7a
7b
NORWAY
SWEDEN
SCOTLAND
DENMARK
WALES
ENGLAND
GERMANY
THE NETHERLANDS
BELGIUM
FRANCE
Institut für Meereskunde
Universität Hamburg

Figure 4

	a) Davies		b) Backhaus		c) Lenhart			d) Lenhart&Pohlmann			e) turn-over times		
BOX	Min	Max	Min	Max	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
1	180	1200	35	48	27	54	41	21	50	38	22	87	61
2	80	480	9	39	18	37	28	14	49	28	17	74	46
3a			13	41	19	50	33	18	73	36	36	107	75
3b			15	30	11	37	21	10	50	30	16	38	29
4	40	190	21	29	8	40	19	7	49	28	19	143	80
5a					9	49	26	10	56	33	16	131	73
5b					3	25	10	2	29	11	3	45	18
6a	140	650	41	61	33	60	47	20	57	38	20	75	50
6b											46	173	100
7a	110	350	32	49	25	54	38	19	68	40	51	193	119
7b	60	180	31	39	16	48	30	13	57	34	17	172	88

Figure 5 Comparison of the flushing-times from Davies (1983), Backhaus (1984), Lenhart (1990) and Lenhart & Pohlmann (1995) with the flushing-times (minimum, maximum and mean value) calculated with the definition given by Prandle (1984) in days.

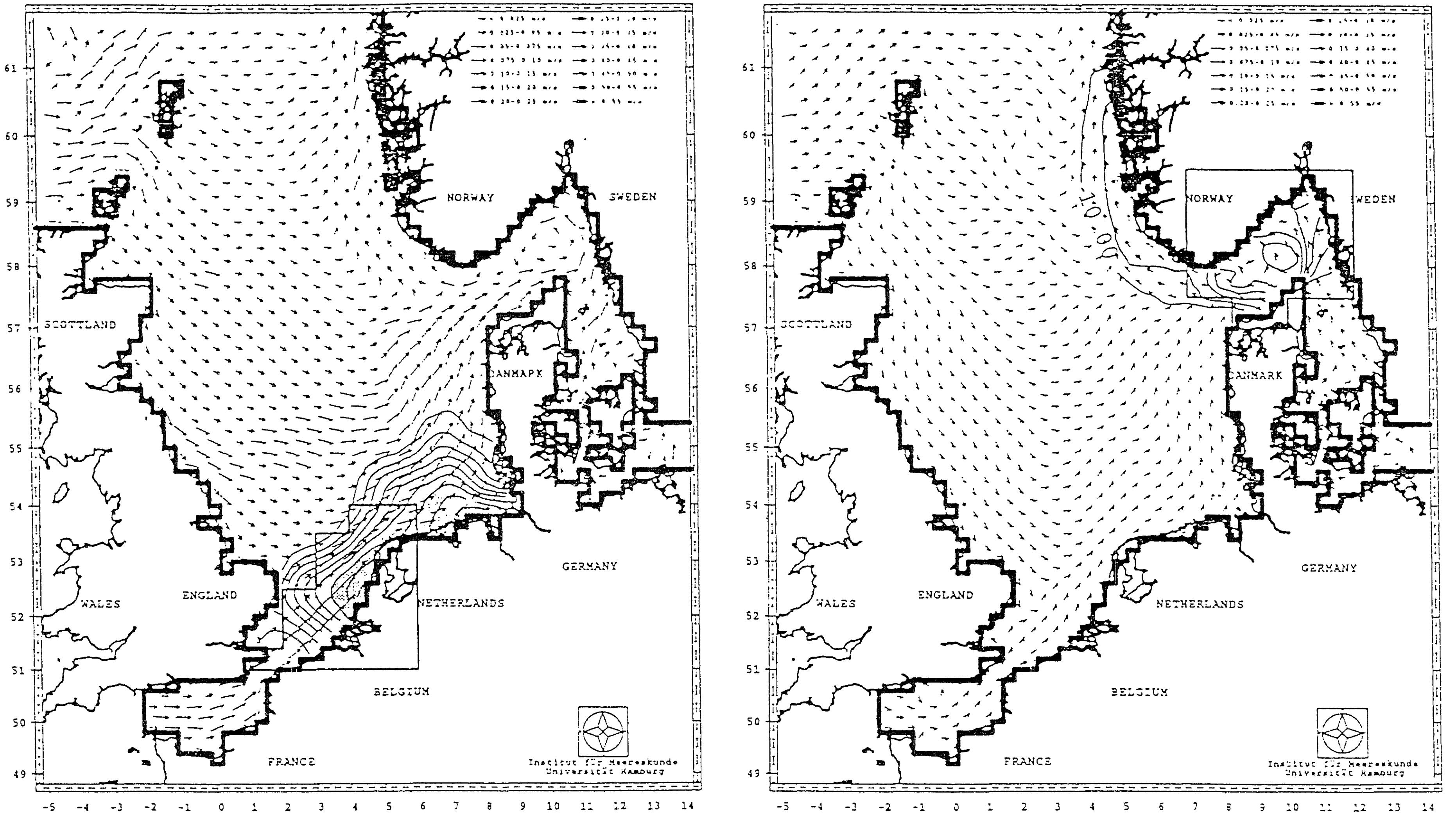
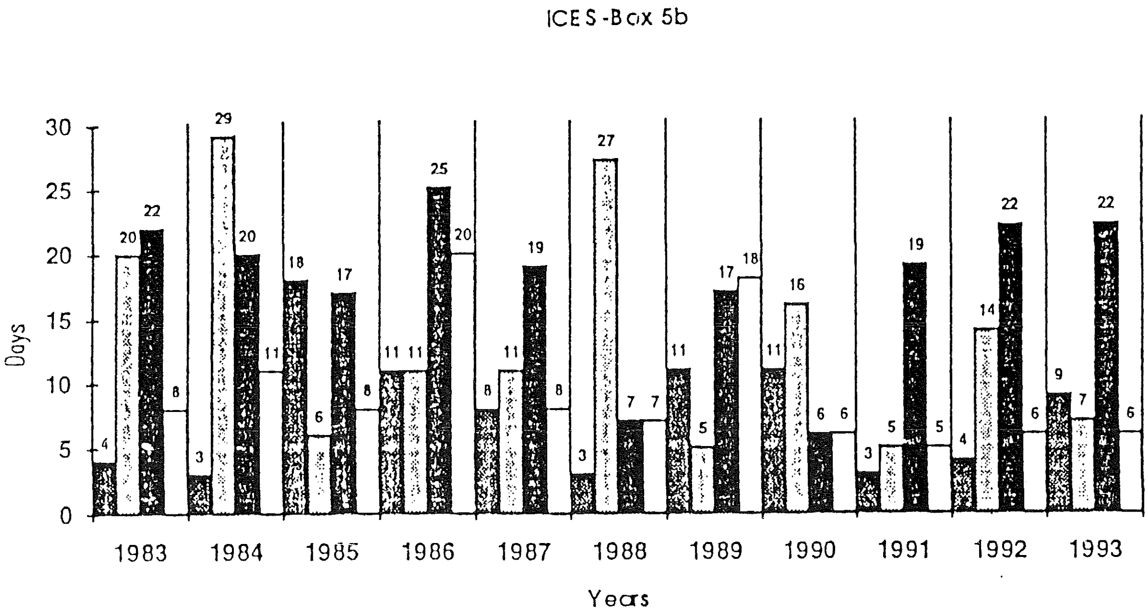


Figure 6 Distribution of the concentration in percent of the initial values on the surface after one half-life time together with the corresponding currents in m/s for ICES-Box 4 and ICES-Box 6b. In addition the relevant box boundaries are outlined. The contour line interval is 10 percent beginning with 10 percent.



Half-life times of water exchange in ICES-box 5b in days for the 11 years of simulation depending on the starting date of the calculation.

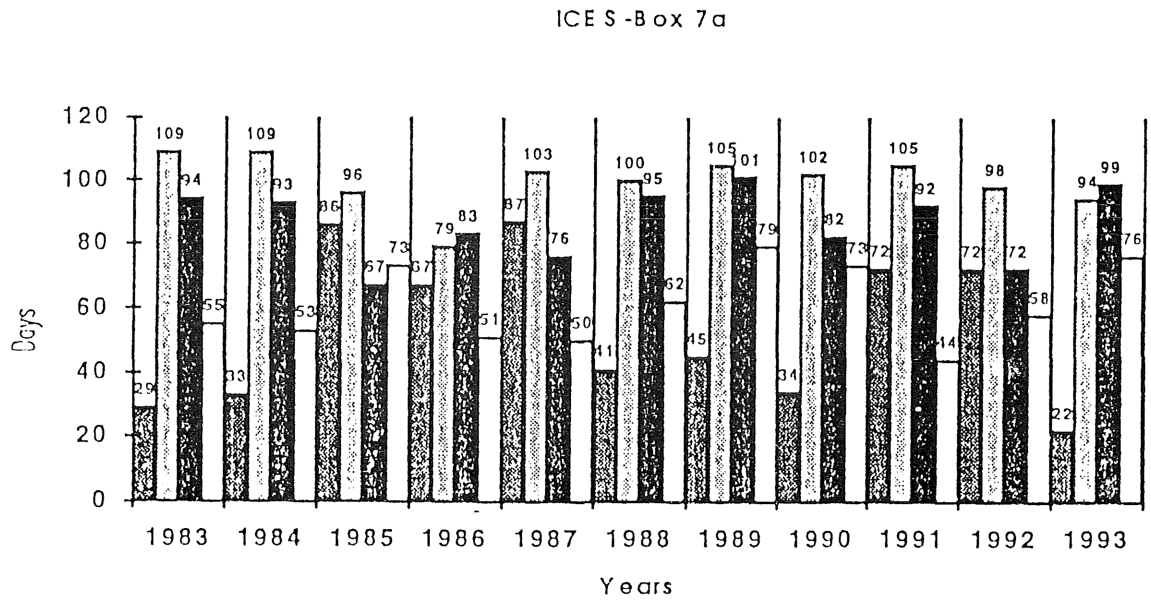
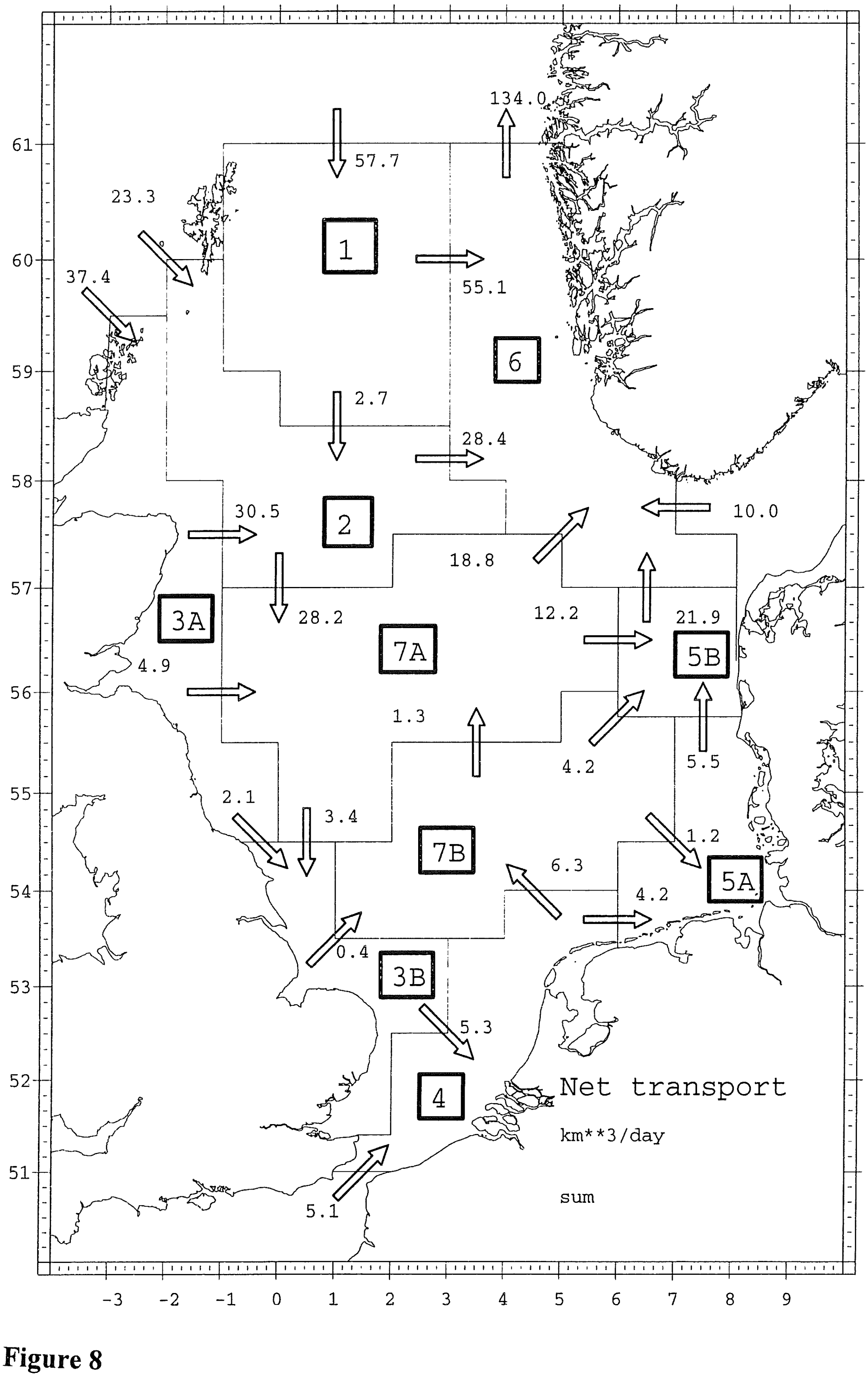
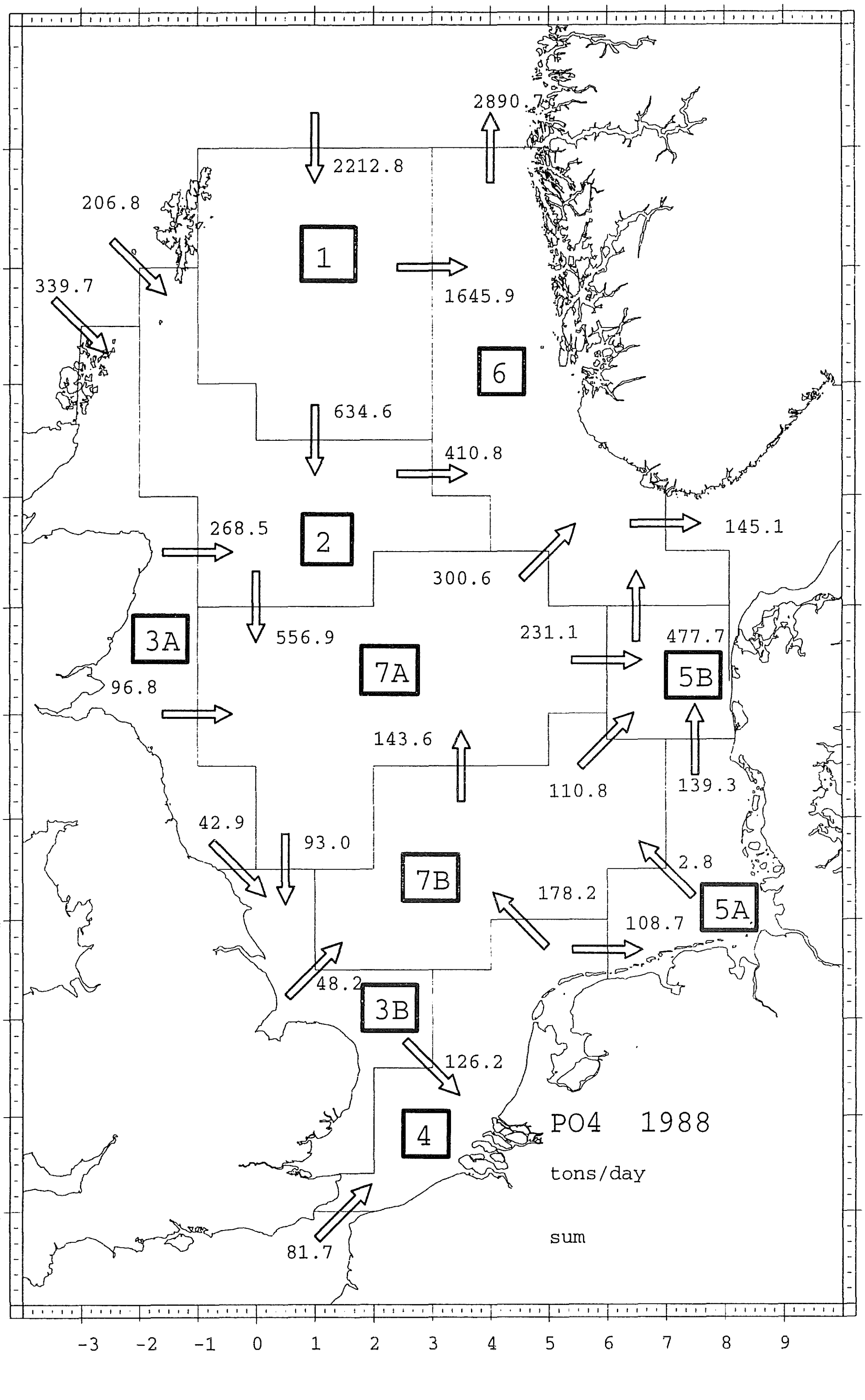


Figure 7 Half-life times of water exchange in ICES-Box 7a in days for the 11 years of simulation depending on the starting date of the calculation.



134.0
57.7
23.3
37.4
1
55.1
6
2.7
28.4
30.5
2
10.0
18.8
3A
28.2
7A
12.2
21.9
5B
4.9
1.3
4.2
5.5
2.1
3.4
7B
1.2
6.3
5A
4.2
0.4
3B
5.3
4
Net transport
km**3/day
5.1
sum

Figure 8


2212.8
2890.7
206.8
339.7
1
1645.9
6
634.6
410.8
2
268.5
145.1
300.6
3A
556.9
7A
231.1
477.7
5B
96.8
143.6
110.8
139.3
42.9
93.0
7B
2.8
178.2
5A
108.7
48.2
3B
126.2
4
PO4 1988
tons/day
sum
81.7
61
60
59
58
57
56
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51
-3
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-1
0
1
2
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Figure 9

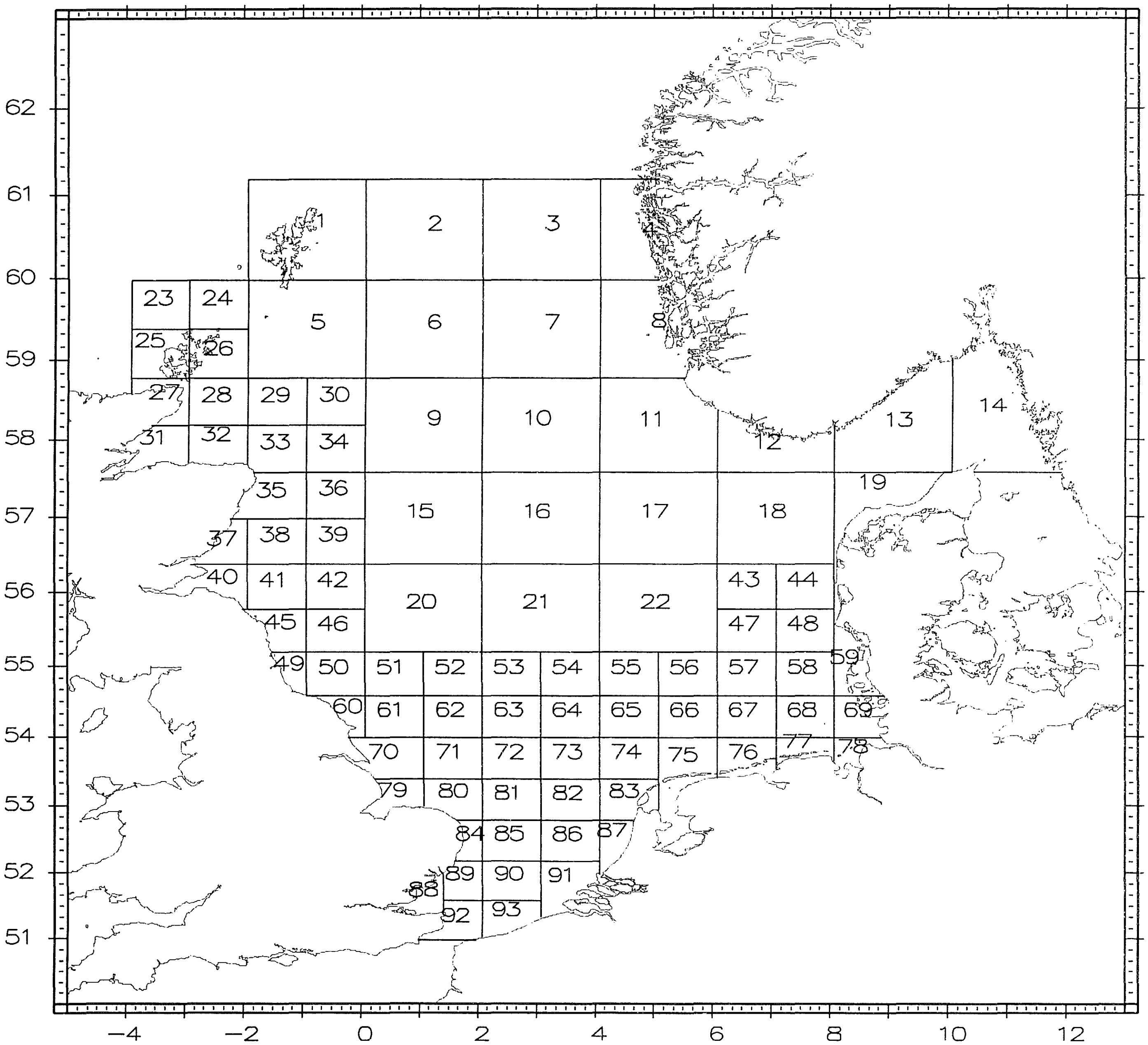

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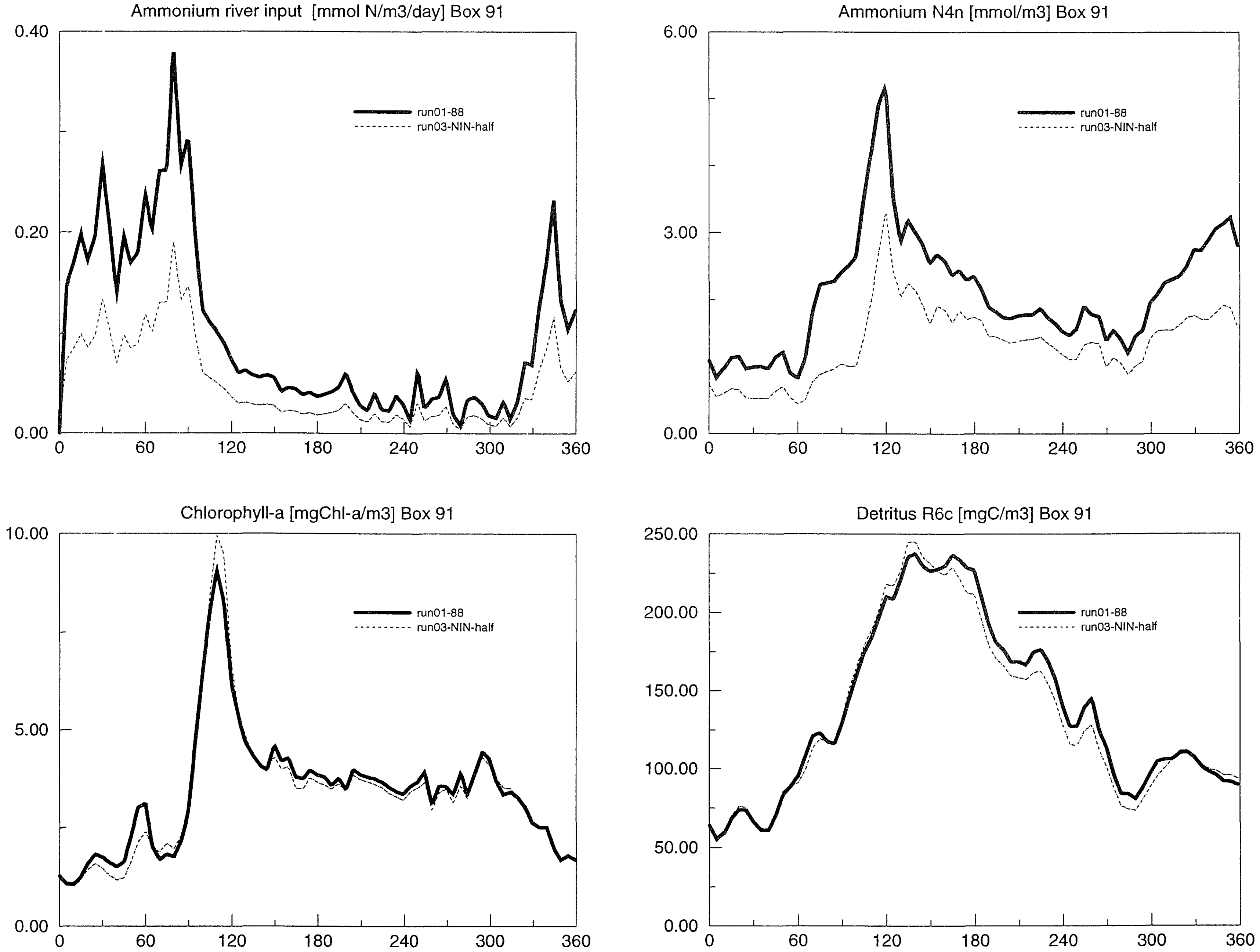
Figure 11



Ammonium river input [mmol N/m3/day] Box 91
0.40
0.20
0.00
0
60
120
180
240
300
360
run01-88
run03-NIN-half
Ammonium N4n [mmol/m3] Box 91
6.00
3.00
0.00
0
60
120
180
240
300
360
run01-88
run03-NIN-half
Chlorophyll-a [mgChl-a/m3] Box 91
10.00
5.00
0.00
0
60
120
180
240
300
360
run01-88
run03-NIN-half
Detritus R6c [mgC/m3] Box 91
250.00
200.00
150.00
100.00
50.00
0.00
0
60
120
180
240
300
360
run01-88
run03-NIN-half

Figure 12a

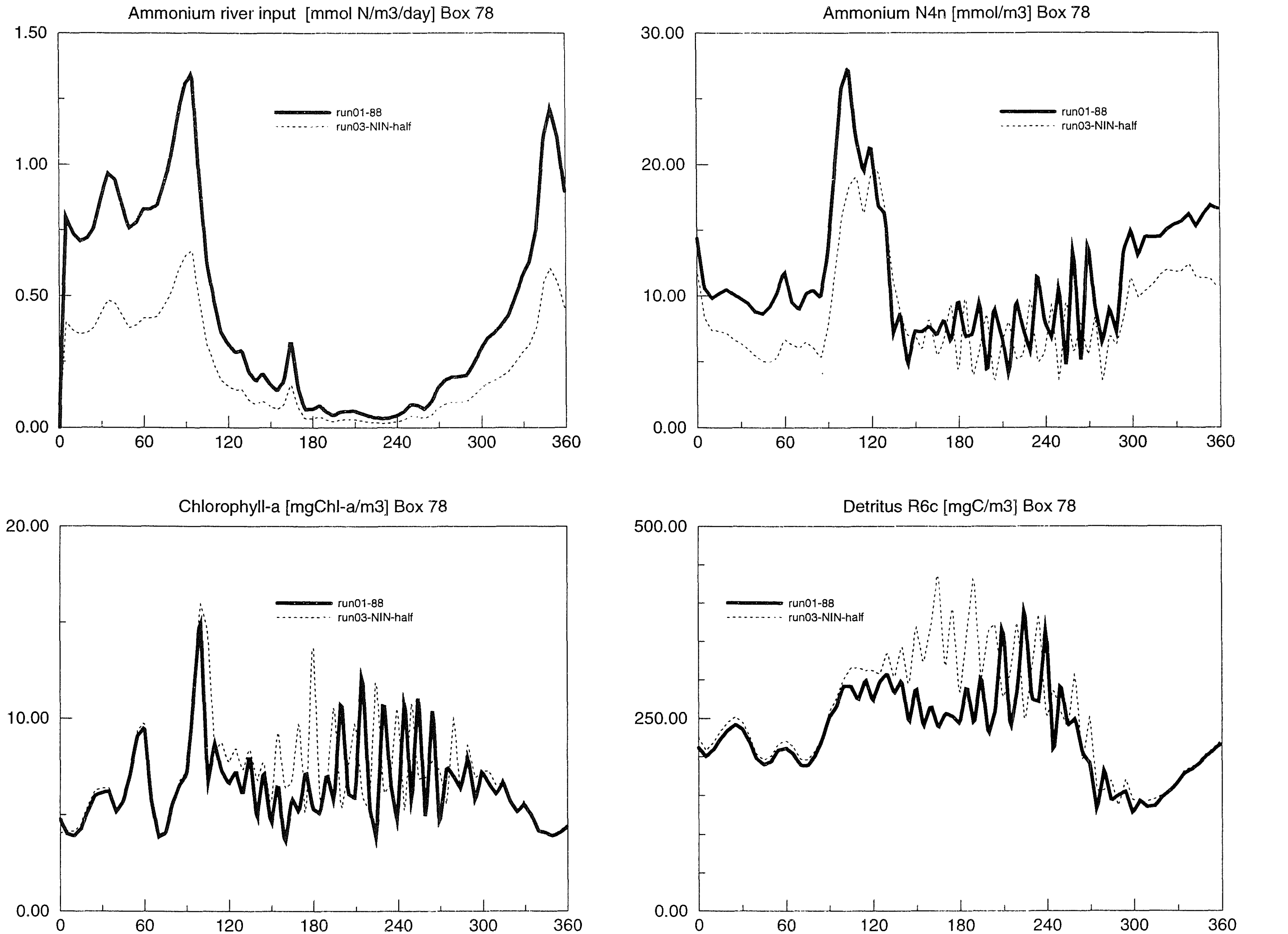

Ammonium river input [mmol N/m3/day] Box 78
1.50
1.00
0.50
0.00
0
60
120
180
240
300
360
run01-88
run03-NIN-half
Ammonium N4n [mmol/m3] Box 78
30.00
20.00
10.00
0.00
0
60
120
180
240
300
360
run01-88
run03-NIN-half
Chlorophyll-a [mgChl-a/m3] Box 78
20.00
10.00
0.00
0
60
120
180
240
300
360
run01-88
run03-NIN-half
Detritus R6c [mgC/m3] Box 78
500.00
250.00
0.00
0
60
120
180
240
300
360
run01-88
run03-NIN-half

Figure 12b

APPENDIX 4:
Nutrient Fluxes

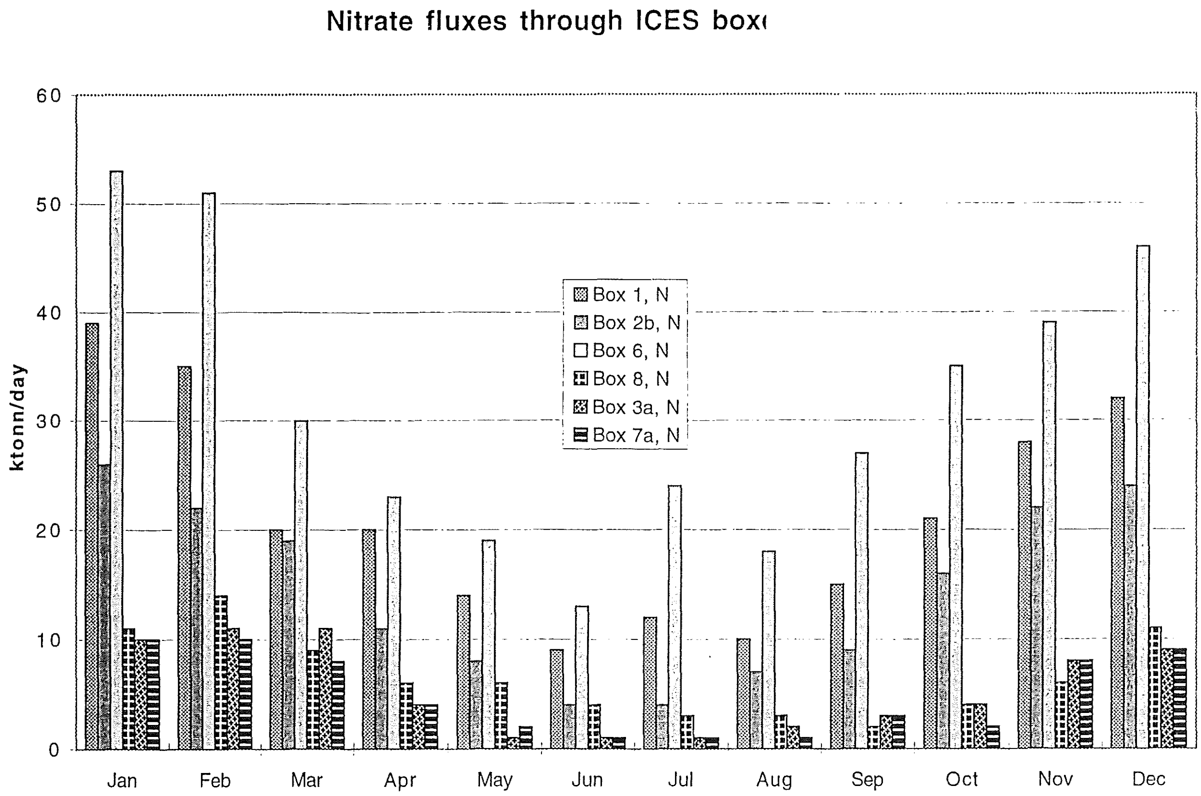
by
Einar Svendsen

The physical part of the NORWECOM (the NORWegian ECOlogical Model system) has been run for 9 years of the 1980´s, and the monthly mean water volume fluxes through the ICES boxes of the North Sea has been estimated. "Mean" concentrations for each box based on observations of phosphate and nitrate was obtained from ICES (Harry Dooley). As a first rough approximation to estimates of nutrient fluxes through the boxes, these mean concentrations were simply multiplied with the modeled volume fluxes (Fig. 1 and 2). The results are given in ktonn/day and clearly demonstrate the seasonal cycle and the large amounts in the northern boxes due to large volume fluxes of nutrient rich Atlantic Water.

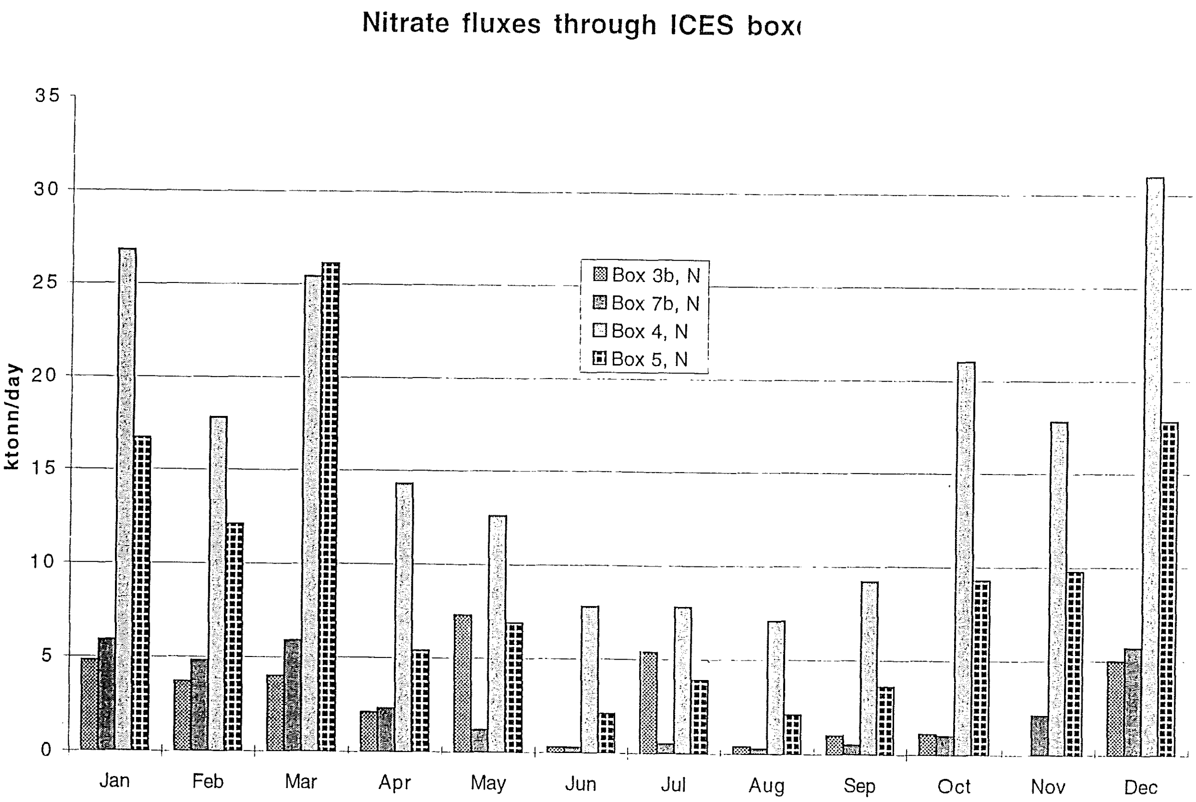
Since there are debate about the usefulness of estimating fluxes through and flushing/residual times of the ICES-boxes, the NORWECOM system were run for two years with full integration between physics and primary production, separating between diatoms and flagellates, and also with inorganic nitrogen, phosphorous and silicon as prognostic variables. From the results with 20 km x 20 km horizontal grid resolution and 11 layers in the vertical, the monthly mean and vertically integrated flux of inorganic nitrogen (pr. km length) for January and July, 1993 is presented in Fig. 3 and 4. The isolines are defined as:

$$(1/T)\iint (u^2+v^2)^{-2}\, C_{NIT}\, dzdt \quad [\text{tonn}\cdot\text{day}^{-1}\cdot\text{km}^{-1}]$$

where T is one month, $\iint$ is the integrals from the bottom to the surface and over one month of time, u and v are the modeled current velocity components east and north, C_{NIT} is the modeled inorganic nitrogen concentration. The results are scaled to $\text{tonn}\cdot\text{day}^{-1}\cdot\text{km}^{-1}$. On top of these isolines, the monthly mean current velocities of the upper 20 meter are presented. By multiplying the length of any line drawn normal to the flow pattern with the "average" nitrogen flux/km, this will give a rough estimate of the total inorganic nitrogen flux through the chosen section in tonn/day. Comparing results in Fig. 1 with estimates from a line through a box (e.g box 4 on the Dutch coast) with relatively well defined flow, the results are in good agreement.



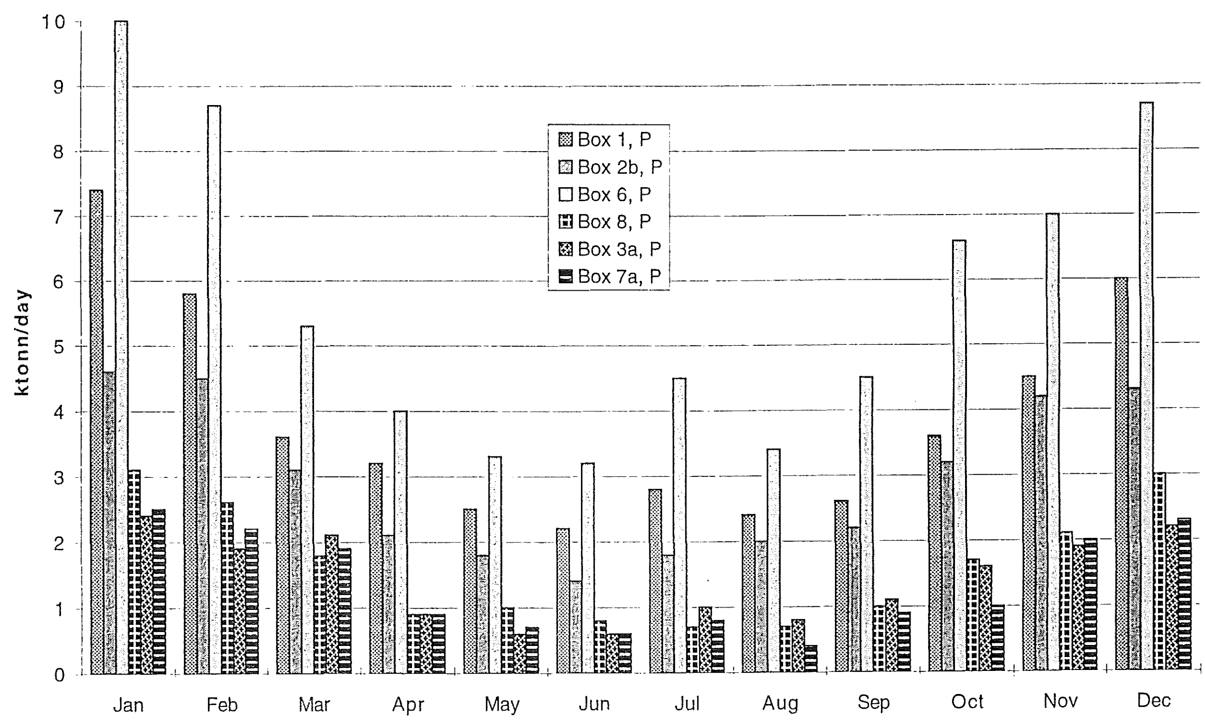
Nitrate fluxes through ICES box(
ktonn/day
0
10
20
30
40
50
60
Box 1, N
Box 2b, N
Box 6, N
Box 8, N
Box 3a, N
Box 7a, N
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec



Nitrate fluxes through ICES box(
ktonn/day
0
5
10
15
20
25
30
35
Box 3b, N
Box 7b, N
Box 4, N
Box 5, N
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

Figure 1

Phosphate fluxes through ICES box



Phosphate fluxes through ICES box

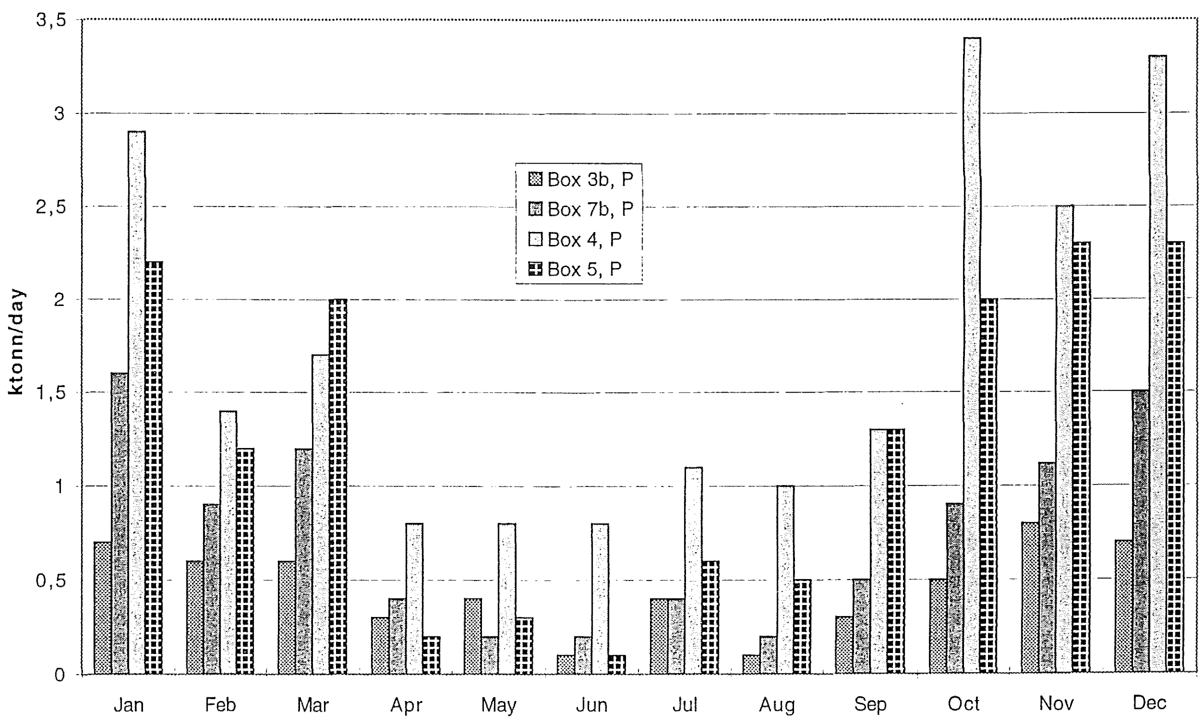
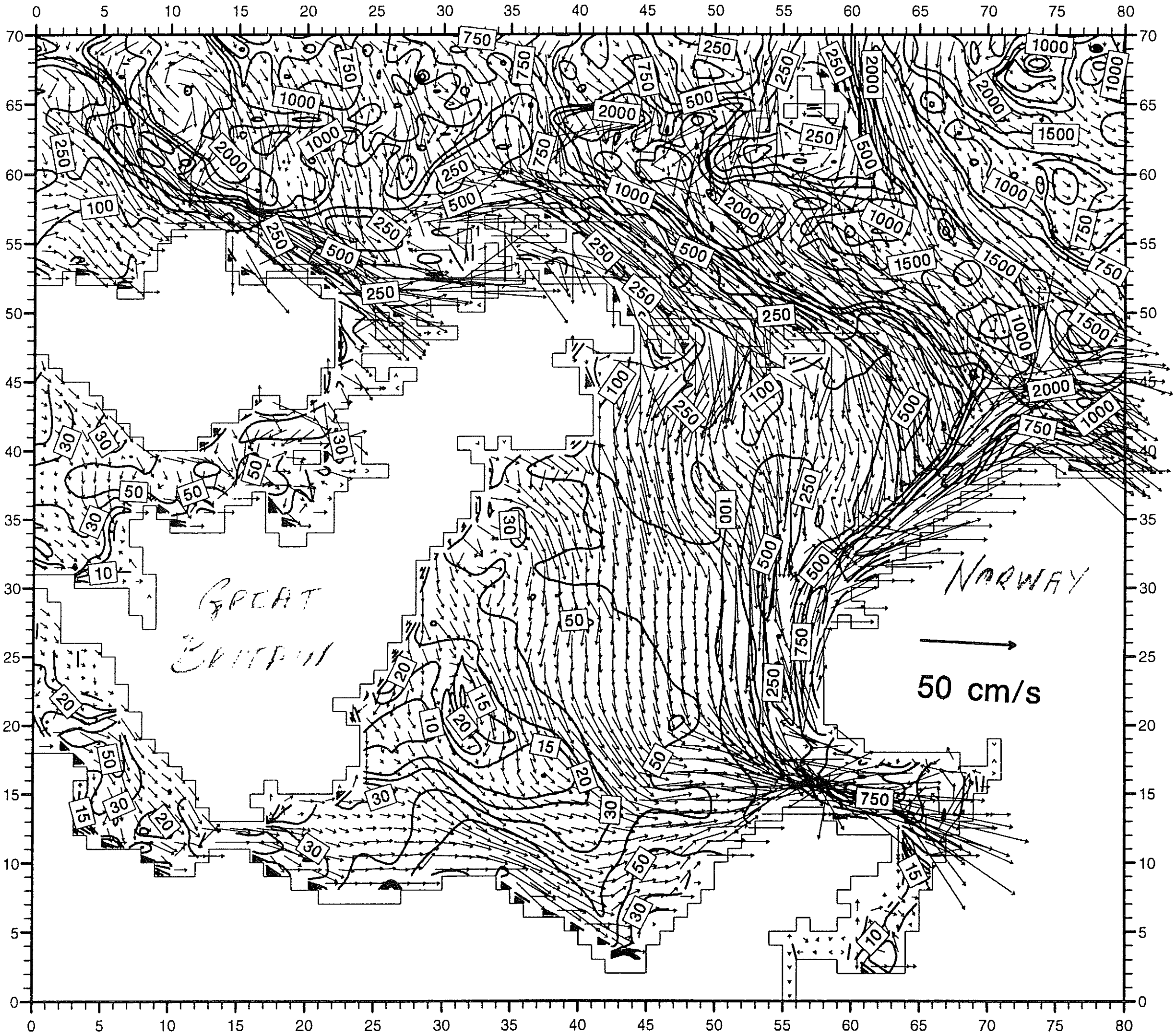
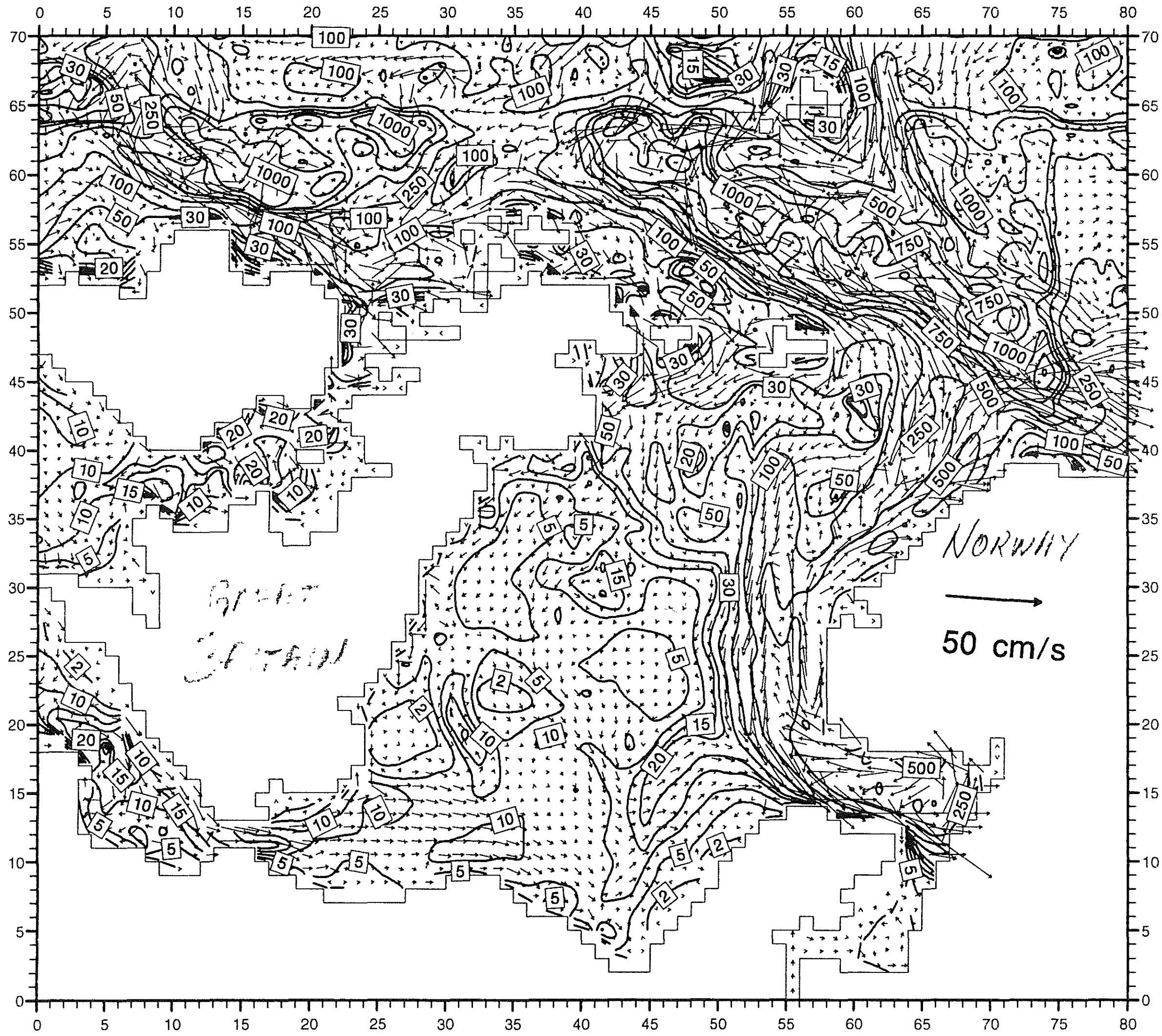


Figure 2



JANUARY 1993

Figure 3



JULY 1993

Figure 4

APPENDIX 5:
Recommendations

The Hydrography Committee recommends that:

The Working Group on Shelf Seas Oceanography (chairman: Einar Svendsen, Norway) will meet in Tenerife, Spain from 10-12 March 1997 to:

a) evaluate the current ability of numerical models to reproduce nature, and assess their role in support of monitoring programs;

b) evaluate the effectiveness in environmental monitoring programmes (with focus on the Baltic Monitoring Program) in determining trends against the background of natural space and time fluctuations;

c) summarize the role of fluctuations in freshwater inflow to the marine environment with special attention to estuarine processes and coastal plumes;

d) review results of a sensitivity analysis of the need for operational data on open model boundaries;

e) assess the importance of, and feasibility to, continue (some of) the hydrographic monitoring sections, initiated during SEFOS, along the shelf edge from Portugal to Scotland;

f) review the outcome of a first compilation of information on the availability of long (>20 years) time series of oceanographic, meteorological, fisheries and astrological observations, and model results.

g) start planning for a joint meeting in 1998 with the Working Group on the Dynamics of Harmful Algal Blooms.

Further it is recommended that:

- ICES, through its individual committees, starts on an inventory and collation of long time series , and initialize a "brainstorming workshop" of specialists in all marine disciplines (see (f) above, justifications on page 9 and section 12 on page 7);

- also the Working Group on Oceanic Hydrography assess the importance of, and feasibility to, continue (some of) the hydrographic monitoring sections, initiated during SEFOS, along the shelf edge from Portugal to Scotland (see (e) above)

APPENDIX 6:
List of partisipants

Name/address	E-mail	Phone	Fax
Einar Svendsen Institute of Marine Research P.O. Box 1870 Nordnes 5024 Bergen Norway	einar@imr.no	4755238458	4755238584
Roald Sætre Institute of Marine Research P.O. Box 1870 Nordnes 5024 Bergen Norway	roald.saetre@imr.no	4755238602	4755238387
Kjell Arild Orvik Geophysical Institute University of Bergen Allégaten 70 5007 Bergen, Norway	orvik@gfi.uib.no	4755212637	4755960566
Hans Dahlin SMHI 601 76 Norrkøping Sweden	hdahlin@smhi.se	4611158486	
Gerd Becker Bundesamt f. Seeschiffahrt und Hydrographie Postfach 30 12 20 20305 Hamburg, Germany	gerd.becker@bsh.de	494031903200	494031905000
Thomas Pohlmann Institut fur Meereskunde der Universitat Hamburg Trplowitzstrasse 7 Hamburg 2000, Germany	pohlmann@ifm.uni-hamburg.de	494041233547	494041234644
Juan Brown Fisheries Laboratory Lowestoft NR33 OHT Suffolk United Kingdom	j.brown@dfr.maff.gov.uk	441502524394	441502513865
P.A. Gillibrand Marine Laboratory P.O.Box 101, Victoria Road Aberdeen, AB11 9DB Scotland	gillibrandp@marlab.ac.uk	441224295313	4412245511
Joachim Dippner Max-Plank-Institute for Meteorology Bundesstr. 55	dippner@dkrz.de	494041173207	4940441787

D-20146 Hamburg Germany			
Thomas Osborn Dept. of Earth and Planetary Sciences The Johns Hopkins University Baltimore, MD 21218 USA	osborn@jhu.edu	14145167039	14105167933
António Jorge da Silva Instituto Hidrografico Rua das Trinas 49 1296 Lisbon Portugal	none	35113955119	35113960515
Nicolas Gonzalez Inst. Espanol de Oceanografia Centro Oceanogr fico de Vigo Apdo 1552 36280 Vigo, Spain	none	3481205362	3481229077
Maria José Brogueira IPIMAR Avenida de Brasilia 1400 Lisbon Portugal	none	35113010814	35113015948
Graca Cebecadas Joaquim Pissarra Maria Antónia Sampayo Maria Teresa Aoita Graca Vilarinho Maria Helena Cavaco IPIMAR Avenida de Brasilia 1400 Lisbon Portugal	none	35113010814	35113015948

APPENDIX 7:
Agenda

1. Welcome and opening

2. Appointment of rapporteur

3. Approval of the agenda

4. Reports on national activities of specific interest to WG members

5. (a) Review and finalise a first compilation of physical/chemical fluxes in the ICES area

6. (b) Suitable data sets and procedure for model validation

7. (e) Review of different scale physical processes involved in horizontal and vertical transport of nutrients into the euphotic layer

8. (f) Assist the WG on Phytoplankton Ecology in producing site-specific multidisiplinary description of the response of the marine environment to anthropogenic nutrient inflows in some example areas (e.g. Kattegat, German Bight)

9. (c) A conceptual framework for sampling and numerical modelling of the physics in relation to the population dynamics of harmful algae

10. (d) Development of GOOS, in particular with regard to a possible co-ordinated ICES input to the GOOS coastal zone module

11. (g) The feasibility and potential contribution to an environmental status report for the ICES area on an annual basis.

12. (h) Consider the requirements for a project designed to investigate the mechanisms by which ´ice winters[a] affects various aspects of the North Sea ecology.

13. Minimum requirements to monitor and identify significant temporal (eutrophication) trends under different hydrographic conditions.

14. Any other business

15. Place, date and topics for the next meeting

16. Closing of the meeting

APPENDIX 8:
Terms of reference & Justifications

Terms of references:

The Working Group on Shelf Seas Oceanography (Chairman: Dr E. Svendsen, Norway) will meet in Lisbon, Portugal from 18-20 March 1996 to:

a) review and finalize a first compilation of physical/chemical fluxes in the ICES Area;

b) design an ICES programme to create suitable data sets for model validation;

c) continue the work on harmful algal bloom dynamics by creating a conceptual framework for sampling and numerical modelling on the physics of the population dynamics;

d) assess developments in GOOS, in particular with regard to a possible coordinated ICES input to the GOOS coastal zone module;

e) produce a review of different scale physical processes involved in horizontal and vertical transportation of nutrients into the euphotic layer, and report to ACME;

f) assist the Working Group on Phytoplankton Ecology in producing site-specific multidiciplinary descriptions of the response of the marine environment to anthropogenic nutrient inflows in some example areas (e.g. Kattegat, German Bight);

g) examine feasibility of, and potential contributions to, an environmental status report for the ICES Area on an annual basis, and report to ACME by the end of 1995;

h) consider the requirements for a project designed to investigate the mechanisms by which "ice winters" affect various aspects of North Sea ecology.

Justification

a) A need has been identified to study fluxes of physical and chemical constituents parallel to or instead of concentrations. The working group has started a compilation of estimates and will continue the work intersessionally by correspondence. A first version will be finalized at the WG meeting in 1996.

b) The use of model results for operational and management purposes is increasing. Often the accuracy of the models has not been sufficiently validated. Standard data sets for validation will not only increase the value of results from single models but also the comparability between models.
The collection of data exclusively for validation datasets demands a lot of resources. A joint ICES effort guided by a programme has the potential to reduce the extra requirements of resources by combining the data collection with other on-going activities.

c) Most physical sampling and modelling is too coarse vertically to detail the fine structure processes that appear significant in the advection of toxic algae. This resolution is available with modern physical instruments but special experimental/observational/modelling design is needed to take advantage of the technical capabilities.

e,f) The tasks arise from the OSPARCOM request for ICES advice concerning the effects of anthropogenic nutrient inflows in marine environment. These relationships are complex and affected by local hydrographic conditions. Descriptions from example areas might clarify the complexity of the interrationships

g) In the past the Annales Biologiques was used by ICES for the compilation of National Reports on the state of the environment. However the cessation of this publication meant that this need could no longer be fulfilled. Now, however, a number of ICES countries are preparing their own national reports on a wide range of marine topics, which suggests that a re-examination of this topic as it may well lead to a useful internationally coordinated product, taking advantage of modern technological and communication capabilities.

ACME considered this proposal for an ICES "QSR" at its May meeting, and has charged its members to develop this idea on a national basis. However, additional input is required from the Working Groups who have interests in the data types being proposed for this "QSR". Since ACME would like to consider a firm proposal during its next meeting, it requests that the Working Group consider this item urgently by correspondence, and report back to it by the end of the year.

The Report may include: Ocean Climate (Characterizing the ocean climate in relation to long-term means for different sea areas:), primary and secondary production (Characterizing the primary and secondary production in relation to long term means in the different areas, anthropogenic impacts (eg contamination, pollution,eutrophication, harmful algal bloom, fish diseases, habitat changes, environmental accidents)

h) This is an action item following from the conclusions of the 1995 Aarhus Symposium.