Hydrography Committee

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REPORT OF THE

WORKING GROUP ON SHELF SEAS OCEANOGRAPHY

Tenerife, Spain
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International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

Palægade 2–4 DK–1261 Copenhagen K Denmark

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1. Welcome and opening

The chairman Einar Svendsen opened the meeting and welcomed all the participants. The List of participants is given in Appendix II,

2. Appointment of rapporteur

Björn Sjöberg was elected as rapporteur.

3. Adoption of the agenda

The agenda was approved but with two subjects added under 13:

- Implications of the reorganisation of ICES on the WGSSO.
- Theme sessions for ASC 1998 and 1999.

The agenda is at Appendix III and the terms of reference and their justification is at Appendix IV.

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

Information on special observations/ findings/ reports/ new instrumentation etc. were presented as a general information to the individual WG participants. This included observations of extremely low temperatures, continuos inflow to the Baltic, increased use of and reduced input to the ICES database, changing strategy towards ships of opportunity in the Baltic Monitoring Program, early (January) spring bloom, low oxygen water (fall) and little inflow of German Bight water in the Skagerrak, a 10 year hydrographic monitoring program at the north Spanish coast, a towed (catamaran) ADCP & CTD package for fine structure current observations, volume transport monitoring of the atlantic water flow along the Norwegian shelf edge.

- Einar Svendsen reported on considerable winter cooling in 1996 with winter and spring temperatures below normal in the waters along the Norwegian coast, in the central and southern parts of the North Sea and in the Skagerrak. Sometimes sea ice were formed in the southern North Sea and in the Skagerrak, and still in July bottom temperatures were about 1.5 °C below normal in the Central North Sea. In the Barents Sea the temperatures were lower in 1996 than in 1995, due to reduced inflow of Atlantic water and increased surface cooling.. This had implications for the fisheries, and the catches in the so-called "Loophole" were considerably reduced. A statistical model and experience based system is currently in use to try to make next year prognosis for the ocean climate and the development of the fish stocks.

- Dirdrik Danielssen reported that in the autumn at 30-100 m he had found a layer of low oxygen concentration which must have been associated with organic material produced in the southern/ central North Sea.

- Hans Dahlin reported that the 4:th assessment of the Baltic Monitoring Program (BMP) was just being finalised. Oxygen concentrations are very high now, and there has been a "continuos" inflow of water for a long period. Nutrient inputs has been reduced, and there is an increasingly discussion about the need for nitrogen treatment seen in relation to the effects of blue-green algae and bacteria. Hans Dahlin mentioned also the ongoing revision of the BMP. Finally Dahlin accounted for development within real time data exchange.

- Stephan Dick reported that the MURSYS annual environmental report for 1996 was in print, and it was discussed that these quarterly and annual reports together with the Norwegian annual environmental report form a good basis for the last year environmental status especially of the North Sea, but also for the Baltic, the Barents Sea and Norwegian coastal shelf areas.

- Didrik Danielssen reported that in 1996 there were low runoff and the anthropogenic input of nutrients were very low in the Skagerrak area. Already in January 1997 there had been a "spring" bloom in the Skagerrak and the Kattegat which has not been known to happened before. Danielssen added that a scientific study had shown decreasing trends of oxygen content in the bottom water along southern coast of Norway.

- Jose Cabanas reported on some results from a monthly monitoring program along the Spanish Atlantic coast. The programme was initiated during the 80:ies. Long term variations in both temperature and salinity had been discovered. An upwelling index had been created which showed a positive correlation with the landings of Nephrops Norvegicus.

- Pekka Alenius reported (as Dahlin) on the current status of the assessment and the revision of the BMP. In Finland a new monitoring strategy is being implemented due to assessment results as well as economical realities. An increased use of Ships of Opportunity together with the use of 3D ecosystem numerical models (in co-operation with Estonia Marine Science Institute) are expected to increase the cost benefit relationship as compared with the more traditional use of research vessels. Research vessels will in the future only be used for winter cruises to map the nutrient pool.

- Wolfgang Fennel reported that the IOW are currently launching a new towed instrument, a CTD- ADCP, to study fine structure current shear and stratification . They had discovered coastal current systems, jets and under currents, with scales < 1 nm and duration of 1-2 days.

- Kjell Arild Orvik presented some results from current measurement program on the Norwegian west coast. The program aimed at monitoring the presence and variability of the Atlantic inflow to the Skagerrak/North Sea Area. Orvik noted a discrepancy between the observed current structure and the stratification. The currents were much more narrow than one would expect from the stratification probably due to the presence of both barotropic and baroclinic motion.

- Harry Dooley, the ICES Oceanography Secretary, reviewed the activities of the Secretariat's oceanographic data centre, specifically with regard to those aspects concerned with shelf seas. He informed the group that, because of various difficulties, the Data Centre had to pull out as data centre of the EC MAST Regional Seas Project BASYS. This had been very much regretted particularly as ICES acknowledges the high priority that must be given to Baltic activities. Harry Dooley added that for reasons which were not yet clear, the flow of data from the Baltic region had virtually come to a halt, with only 5 stations having been received for the period 1995-1996. The situation with regard to ROSCOP had become even worse, with no Baltic country, except Sweden, routinely contributing information to this system. This lack of interest from potential contributors to the data bank contrasts significantly with a huge increase in the number of requests and products from the Baltic area from both ICES working groups and marine scientists at large.

- Harry Dooley further noted that for most other regions, data supply remained at a healthy level, with much data being submitted well within a year of collection. As usual, most data were collected in the North Sea, encouraged by the intensive monitoring activities of OSPAR for whom ICES takes responsibility for the resulting data. Good data flows were also being generated from the Iberian shelf area, mainly as a result of activities of the EC-FAIR project SEFOS, as well as OSPAR. Summary information describing data locations and property distributions is now being made routinely available from the ICES website at www.ices.dk/ocean. This site now provides links to the web-published cruise reports of France, Sweden, Denmark and Poland which supplements the information provided by ROSCOP.

5. Evaluate the current ability of numerical (process and research) models to reproduce nature, and assess their effectiveness in support of monitoring programs

Einar Svendsen presented different papers on numerical models and validation procedures (without considering work on sea level). The information was partly collected through a direct email contact to the international modelling community. He started by making references to the book: "Quantitative Skill and Assessment for Coastal Ocean Models", Daniel R. Lynch and Alan M. Davies (Eds.), Coastal and Estuarine Studies, 47, American Geophysical Union (AGU), Washington D.C., USA, 1995, ISBN 0-87590-261-8. In this book they suggest a definition of "validation":

> **Validation** of a computational model is the process of formulating and substantiating explicit claims about the applicability and accuracy of computational results, with reference to the intended purposes of the model as well as to the natural system it represents.

Despite the title of the book, and seen in relation to this definition (and deleting results on sea level), very little validation is found, especially when it comes to claims about accuracy of the computational results. Results from the validation study in the Mutation Modelling Project MOMOP (Hackett et al., 1995) gives little (and not quantified) credit to the modelling of current and hydrographical structure on the shelf west of mid Norway. Simulations of the Hudson plume in the New York bight (Oey et al., 1995) looks more promising, and here simple modelled and measured areal means of temperature and salinity and mean and standard deviations of currents are compared.

Results from the ecosystem model ERSEM (10 boxes representing the North Sea) show that it reproduce the large-scale cycling of C and the macro nutrients N, P and Si quite well, but "quite well" is still very subjective (see Special issue of the Neth. Jour. Sea Res: Vol 33, (3/4), 1995). In relation to this type of modelling and studies of the functioning of the ecosystem system, it would be more preferable with "continuous" (at least weekly) monitoring of physical, chemical and biological properties at a few key sites than low frequency monitoring over large areas. The question is then if there exist a few key sites representing e.g. the larger North Sea. In the Skagerrak, resent studies has shown that on short time scales (days), the decorrelation length scale of the hydrographic variability is about 10 km, which raises question to the use of high frequency monitoring at a few sites.

Results were also obtained from a 3D fully prognostic ice/ocean North Sea/ Baltic Sea model run at the Univ. of Hamburg (Schrum, pers. com.). In agreement with climatological vertical sections of temperature and salinity, single year runs show that the development of thermal stratification, cold subsurface winter-water and the preservation of the halocline is simulated well (not quantified). Also the short term variability of the volume exchange between the Baltic and the North Sea seems realistic, but the absolute extremes are underestimated. The maximum ice cover is slightly overestimated, 15% of the total coverage. In comparison with weekly SST charts, the differences are typically of the order of 0.5 °C. However, this comparison was questioned since the model partly uses atmospheric surface temperatures (generally correlated with the SST) as input forcing. The comparison of calculated SST's to observed is important to estimate whether the chosen heat flux bulk formulae are able to estimate the fluxes over the sea surface realistically. This is important, because heat flux bulk parametrisation is still an unresolved problem in oceanography (and in meteorology) and depends strongly on model resolution and time step. However an estimate of the quality of 3-d transport simulations is this comparison normally not. Only the existence of observed small scale upwelling structures in model results indicate the quality of the modelled transport fields.

A two layer model of the Rhine Plume (J.M. de Kok, Jour. Mar. Systems 8, 1996) demonstrates very realistic salinity patterns and time series of residual currents in the Dutch coastal zone. However, simple statistical numbers are not used to claim the accuracy of the model.

Svendsen also presented some of the outcome from a Eutrophication Modelling Workshop (November 97 at RIKZ, The Hague) organised by the Environmental Assessment and Monitoring Committee (ASMO) of the Oslo and Paris Commission (OSPAR). Hydrographical, nutrients, chlorophyll and oxygen data had been collated from ICES and individual participants for common model validation. An agreement had been made to base the validations, both horizontal fields, vertical sections and time series, on averaged differences between model and data, normalised by representative measured standard deviations (also called "cost function"). 10 models from 8 institutes/ countries were participating:

- grater North Sea: ERSEM, ECOHAM1, NORWECOM, CSM-NZB
- southern North Sea: DYMONNS
- coastal regions of the North Sea: DCM-NZB, MIRO
- English Channel: ELISE
- estuaries: ECOWIN, Stratified Estuary Model

The exercise shows that the cost function is a valuable method for performing model validation and model comparison, and should be widely used in the future. This method gives simple integrated numbers which also can be used by individual models to check if changes in their models actual give quantified improvements. It also demonstrated that some of the modelled parameters from different models were several standard deviations off measurements and need more attention. Some of these problems relates to bad open boundary conditions, which in operational sense is a big problem. However, overall the results look promising, but it is desirable to continue with this method of validation which has been started within ASMO to be even more precise in the analysis of the results, evaluate how representative the data is, and ranking of model performance and applicability. A draft report of the workshop is at present available.

Svendsen also demonstrated their own work in Bergen with the NORWegian ECOlogical Model system (NORWECOM) which in many ways compare well with the work done in Hamburg with the ECOHAM1 (Andreas Moll and Thomas Pohlmann). NORWECOM is also used for studying drift of fish larvae, but in spite of quite good agreement with many years observations of spring spawning herring larvae, no quantitative skill assessment has so far been published. He also demonstrated a quantified method for comparing modelled hydrographic variability at various frequencies and at various depths with frequent measurements from a current meter rig deployed for one year at the coast of southern Norway. The good results means that the model correctly represents the statistics of the variability, and therefor it can be used to specify the frequencies and horizontal resolutions needed in monitoring programs to resolve given amounts of the variability at different time scales.

Svendsen concluded that if models should be used for management purposes and operationally within monitoring, the validation procedure must get beyond "it looks good" and instead comprise different kind of statistics which now are underway among some modelling communities.

Stephan Dick presented results and validation procedures from the BSH Operational Model System for the North Sea and the Baltic. The validation comprised a comparison between daily prognoses and observed water level, hydrography and currents. The currents at the "Darss" seemed to be quite well simulated, but no numbers were presented. The mean sea surface temperature difference each morning at Alte Weser through a two year period was just 0.3 K with a standard deviation of 0.6 K indicating a good representation of the surface heat flux. Hourly temperatures through a period of 8 weeks gives a mean difference of 0.8 K and 0.7 K std.dev.. Similar results were found at Kiel in the Baltic. These are simple numbers which can be compared between models and within new versions of models. The simulations of salinity show larger differences since the model do not include realistic freshwater inputs.

Hans Dahlin presented some preliminary results from numerical calculations (the HIROMB Model) in the Baltic. The model results compared well with observed waterlevel variations. However, the model was unable to create observed stratification, probable due to inadequate initial fields.

Wolfgang Fennel described some aspects of the DYNOCS experiment, and a few qualitative agreements with measurements were demonstrated. No quantitative comparisons with data were presented.

Didrik Danielssen presented a comparison between numerical model results and observations during the spring flood in the Skagerrak 1995. The NORWECOM failed to reproduce the very fresh surface water during the flood, probably due to the way the fresh water is introduced in the model (fully mixed in the upper 5 m).

Pekka Alenius noted that, to his mind, there is a lack of QA control in numerical modelling which comprise all aspects, initial fields, forcing and the model itself. As an example Alenius mentioned that in Finland they had had problems with wind-forcing, the fields created by HIRLAM generally created too low wind speeds.

Finally there was a discussion among all the participants on QA aspects of numerical models. There was a general agreement on that if the models should be used within monitoring there should be requirements on how to declare the results dependence on initial conditions, open boundaries and forcing. The meeting also stressed the need for both models and observations, and that the use of models increase the value of data. Although some of the models shows promising results, there is still a long way to go towards QA of models. Therefor a theme session: "Skill assessment of Environmental Modeling" for the ASC-1998 was suggested .

6. Evaluate the effectiveness of environmental monitoring programs (with focus on the Baltic Monitoring Program) in determining trends against the background of natural space and time fluctuations

Hans Dahlin introduced the subject by giving a short summary over the BMP. Although BMP is 15 y old it suffers from rather weak objectives, as do many other similar programs,. As a consequence the program has had a rather low status on a national level which has influenced the quality and performance. This means that the BMP has never fully functioned as planned. The program have provided general information on the variability of the environmental status of the Baltic. However, the program have failed in not being able to provide a coupling between load and concentrations.

The BMP sampling frequency is about 6 time pr. year, and Dahlin demonstrated the effect of undersampling. The need for continuous monitoring versus "monthly" was discussed in combination with ships of opportunity. As mentioned earlier (in paragraph 4), an increased use of ships of opportunity together with the use of 3D ecosystem numerical models are expected to increase the cost benefit relationship as compared with the more traditional use of research vessels. Research vessels will in the future only be used for winter cruises to map the nutrient pool. It was mentioned that mapping of the volume of substances within a basin can drastically reduce the need for high frequency observations.

Harry Dooley presented some results from OSPARs monitoring program in the North Sea. He concluded that a normalisation of nutrient data (to 0 psu) gave a consistent picture and clearly showed the effects of changed runoff.

Danielssen and Cabanas presented some monitoring results from the Skagerrak and the Iberian coast, but no conclusions towards the main theme was drawn. This will be further evaluated at the next year WG meeting with focus on the North Sea monitoring.

7. Summarise information on the influences of fluctuations in freshwater inflow to the marine environment (with special attention to estuarine processes and coastal plumes)

Wolfgang Fennel presented some results from model calculations of a buoyancy driven plume outside St Lawrence and the river Oder. He also made the following summary of the dynamics of such buoyant plumes:

River runoff generates density anomalies and resultant density driven alongshore flow. River plumes are forced by two mechanisms: (i) momentum added to the ocean at the river mouth and (ii) intrusion of buoyancy at the river mouth. The shape of the plumes is affected by both the wind and the tide.

It is useful to study the response to a sudden onset of the river discharge. The motivation twofold: First, the response to a sudden onset of forcing shows the dynamical features of a system. Second, there are cases where the river inflow is blocked for a period of time if, for example, wind forcing produces a sea surface set up (windstau) in front of the river mouth. When the wind ceases and the blocking is terminated, the river discharge starts again. Those effects are observed at the outlet of the Oder river in the Baltic Sea.

The response to an onset of river runoff basically consists of two parts: The formation of a freshwater bulge right in front of the river mouth and the set up of a coastal current by Kelvin waves. After 15 to 20 days a secondary bulge develops downstream. The properties of the Kelvin waves depend on the stratification of the sea. For an unstratified sea the baroclinic Kelvin wave modes are missing and the spreading of the river water is mainly confined to the near field and a slow alongshore propagation of the freshwater, while for a stratified sea the baroclinic Kelvin waves propagate alongshore and establish the far field response. Thus the preconditioning of the sea, i.e., whether the sea is stratified or not strongly affects the plume development.

A clue to understand this eddy formation might be the weakly nonlinear effect introduced by the changed stratification after the spreading of the buoyant river water. Within the river plume the local Brunt-Väisälä- Frequency is enhanced and the phases of the baroclinic Kelvin waves propagate faster. The propagation of Kelvin waves slows down if the wave fronts reach the undisturbed water. This deceleration implies an accumulation of energy and additional divergences which can force offshore flows which are necessary to produce a secondary bulge. Behind the Kelvin wave fronts an undercurrent develops.

If wind forcing is taken into account, the plume pattern is strongly affected by the on- or off-shore Ekman transport. The strongest dispersion and entrainment of freshwater occurs during upwelling favourable winds while during downwelling conditions the plume is maintained.
Studies of the effect of tidal mixing on a freshwater-influenced region involves the process of tidal straining which imply a periodic change between stratified and well-mixed regimes.

How important are theses plumes in relation to harmful algal blooms? Harry Dooley mentioned that the WG on Harmful Algal Blooms are considering an experiment on how to elucidate on Harmful Blooms. The meeting continued to discuss how the WGSSO could support this experiment, but with no conclusions.

8. Review results of a sensitivity analysis

Stephen Dick presented some results of a sensitivity analysis of a North Sea model. The analysis had been performed by T. Pohlman. Pohlman had tested how the model responded if the salinity conditions are changed at the boundaries. A change of +/- 1psu at the southern border (the English channel) resulted in strong effects locally but low elsewhere. A similar change of salinity at the north boundary had a profound influence on the whole model area and obviously changed the model dynamically. It was questioned if the sensitivity analysis represented reality. Due to the severe results the meeting urged Pohlman to present a written summary (Appendix VI) and suggested that the subject should be brought up again at the next meeting. In the Appendix VI it is concluded that it was not possible to conclusively discriminate between the pure advection/ diffusive influence of the salinity change at open boundaries and (partly unrealistic) barotropically induced effects which influenced the modelled circulation in the whole North Sea.

9. 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

Einar Svendsen presented an overview of the program, the objectives and some results. Svendsen also cited some written comments from A.J. da Silva. It was recognised that some of the sections in the program will be maintained by Spain and Norway. There was a general feeling that it was not possible to recommend a general continuation of the complete program. However, the meeting agreed on that research ships passing through the area should be encouraged to sample at the sections (hydrography, nutrients and plankton). This implies that lists of station positions must be distributed to the relevant institutions.

10. Review the outcome of a first compilation of information on the availability of long (> 20 year) time series

Einar Svendsen introduced the subject and Harry Dooley presented a first compilation of long (>20y) time series, Appendix V. The information was collected through a direct email questionnaire to the members of the three Hydrography Committee Working Groups and from a search on the WWW. The meeting recognised the importance of Dooleys work and urged him to compile a second version. There had been a rather low response from the members of the Working Groups so there is probably much more information to collect. It was suggested that the inventory also should include time series of different indexes, e.g. climatological index, icecover index etc.

The meeting recognised the importance of long time series and discussed how to enhance their use. It was agreed that within climate and ecosystem research one should recommend increased use of long time series and distribute relevant information hereof. Dooley was urged to suggest an inventory of long time series to the Marine Data Management Group.

As a first example of a complex long time series data base the meeting urged its participants to compile a set of all kinds of long time series for the Skagerrak area until the next meeting.

11. ICES role in operational oceanography in the context of GOOS

Einar Svendsen introduced the subject and Hans Dahlin continued to give an overview over the present status of GOOS and EUROGOOS. Dahlin stated that there are few new activities initiated within GOOS and that GOOS is more focused on keeping existing measurements/ systems/ activities than inventing new ones. Dahlin continued to give a short background on EUOROGOOS. He stressed that EUOROGOOS is a voluntary association between agencies and differ in that respect from ICES and GOOS. The EUOROGOOS strategy aim at organising the European commitments to GOOS. During spring 1997 the EUROGOOS Implementation Plan will be ready.

Dahlin felt that work already co-ordinated within ICES should be natural part of the European contribution to GOOS. Dahlin also stressed that ICES should act as an observer within GOOS as a representative for those members within ICES who are not represented within GOOS. Clearly ICES can have a central role in the networking of GOOS

12. Catalogue of data that could form a basis for ICES relevant products displayed on the WWW

There was an introductory discussion on what was available and examples were presented by Loeng, Danielssen, Dooley, Svendsen, Sjöberg and Dick. The meeting agreed to suggest for the Hydrographical committee that ICES home page should,

- have pointers to national pages.
- display climatological indexes for different ocean areas including model results
- contain and compile information on special events.
- include home pages for the different working groups.
- include German weekly SST maps and model results

Harald Loeng stressed that ACME expect an increasing amount of results presented on the WWW

13. Any other business

I. Implications of the new ICES on the WGSSO.

There was only a short discussion on possible effects on the WGSSO due to the reorganisation of ICES. It is expected that the work within WGSSO will continue as before.

II. Theme sessions

There was a discussion over appropriate theme session for 1998 and 1999. The meeting agreed on suggesting ”Skill assessment of environmental monitoring” for 1998 and a joint session for 1999 (together with WGCC and WGOH) under the theme ”Long time series”.

14. Place, date and topics for next meeting

The Swedish delegates, Hans Dahlin and Björn Sjöberg, invited the WGSSO to hold the next meeting at SMHI Oceanographical laboratory in Göteborg Sweden. The time was agreed to 16 to 18 March 1998.

The topics should be:

1. Evaluation of environmental monitoring programmes with focus on the North Sea (responsibility G. Becker)

2. The role of fluctuations in freshwater inflow to the marine environment. Review the outcome of the theme session in the Asc-1997. (responsibility T. Osborn)

3. Progress of ICES-relevant products on the WWW. (responsibility all)

4. Current and future applications of remote sensing in Shelf Seas studies. (responsibility E. Svendsen)

5. Sensitivity studies of open boundaries (responsibility T. Pohlman/ E. Svendsen)

6. Compile a complete set of time series in the Skagerrak area as to illustrate the usefulness of the same. (responsibility D. Danielssen/ H. Dooley)

7. Compile information on long time series in the ICES area. (responsibility H. Dooley)

The terms of reference and justification for these agenda items are at Appendix I.

15. Closing

The meeting was closed 12 March 1997 at 16.00 hour.

16. APPENDIX

I. Recommendations and Justifications

The Hydrography Committee recommends that;

The Working Group on Shelf Seas Oceanography (chairman Einar Svendsen, Norway) will meet in Göteborg, Sweden from 16 to 18 March 1998 to,

1. continue the evaluation of the effectiveness in environmental monitoring programmes (with focus on the North Sea) in determining trends against the background of natural space and time fluctuations, and the possible support from models.

2. continue to summarise the role of fluctuations in freshwater inflow to the marine environment, and review the outcome of the theme session in the Asc-1997.

3. review the progress of ICES-relevant products on the WWW.

4. review the current and future applications of remote sensing in Shelf Seas studies.

5. continue the sensitivity studies of open boundaries

6. compile a complete set of time series in the Skagerrak area as to illustrate the usefulness of the same..

7. continue to compile information on long time series in the ICES area.

Further it is suggested that:

a theme session for ASC-1998 will be

"Skill assessment of Environmental Modeling"
Convener Einar Svendsen, Co-convener Björn Sjöberg

a theme session for ASC-1999 (together with WGCC and WGOH) will be

"Long time series"

Justification

1. From last meeting discussion (this report) on the Baltic Monitoring Program, some clear criticism were raised especially with respect to undersampling, weak objectives and general status. Changes in strategy are underway, but before firm conclusions on the general functioning of monitoring programs, the WG wants at least also to review the monitoring in the North Sea. Some ongoing monitoring programs have problems with funding and some are

heavily criticised. Therefore it is important to evaluate the effectiveness of individual environmental monitoring programs in determining possible trends against the natural variability. Since Bundesamt fur Seeschiffahrt und Hyrographie is responsible for the production of the MURSYS environmental status report for the North Sea and the Baltic, we suggest Dr. G. Becker to precent the monitoring behind this to see what general conclusions can be drawn.

2. The frontal dynamics and variability of coastal plumes and processes 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 algal blooms occured, thus it is important to increase our knowledge on how these finer scale processes influence the environment and how this influence varies with varying amounts of freshwater input.

3. In the ACME discussion on the feasibility of an ICES Environmental Status Report, it was concluded that relevant oceanographic and environmental information should be readily available to potential users (including fisheries biologists) in a timely way, and this could best be achieved by making use of WWW capabilities. ACME also noted that electronic dissemination of data is quicker and more economical than the production of a printed report. Products to be put on the web pages were clearly suggested on the last WG meeting (this report).

4. The basic marine research tools today is observations from ships and fixed (or drifting) platforms/buoys, remote sensing from satellites (and aircraft), numerical modelling, and laboratory/ mesocosm experiments The WG therefore feel the need to be updated on the current and future application of remote sensing in shelf areas and will invite an expert in the field to present the topic.

5. Open boundary conditions are a crucial point for numerical models, especially those claiming to simulate nature. Since the North Atlantic exhibits strong variability on different scales, a study on how these variabilities influence the shelf seas and to what extent these variabilities have to be included in the boundary conditions is necessary. . Due to the severe results presented in the last meeting (this report), modellers are urged to make similar studies to check the sensitivity in different model set-ups. This study can also give provide advice for the configuration of monitoring stations that are able to provide the necessary boundary data.

6. A first overview of long time-series have been collated (this report), and it was decided as an example to compile a complete set of oceanographical, meteorological and fisheries data (+ model results) for the Skagerrak (in many ways also representing much of the North Sea) to see the usefulness of such integrated information.

7. From the first compilation of available time-series, it was suggested to include not only measurements, but also indexes (e.g. the NAO) and information on how to get the data. 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 seas are of fundamental interest. The answers to questions arising in this context (see report from 1996) are of fundamental importance to management activities, as well as to sustainable development. 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.

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 crucial factor to know for evaluating ongoing or planned monitoring activities. Therefor we suggest a theme session on this topic for the ASC 1998.

For the reasons stated under 7) above, a theme session on the use of long time series for ecological and climatological research is suggested for the ASC 1999.

II. List of Participants

Name/address	Email	Phone#	Fax#
Pekka Alenius Finnish Institute of Marine Research P.O. Box 33 Fin-00931 Helsinki Finland	alenius@fimr.fi	+358 9613941	+358 961394494
Jose M. Cabanas Instituto Espana de Oceanografia P.O. Box 1552 362 80 Vigo Spain	insovigo@canga.es		+34 86 492351
Nicolas Gonzales Inst. Espanol de Oceanografia	ieo@udc.es	+34 981205362	+34 981229077
Hans Dahlin SMHI S-601 76 Norrköping Sweden	hdahlin@smhi.se	+46 11 158 305	+46 11 158 350
Björn Sjöberg SMHI Göteborg S-426 71 Västra Frölunda Sweden	bsjoberg@smhi.se	+46 31696500	+46 31690418
Harald Loeng Institute of Marine Research P.O. Box 1870 Nordnes 5024 Bergen Norway	harald.loeng@ imr.nor	+47 55238466	+47 55238584
Kjell Arild Orvik Geophysical Institute University of Bergen Allegaten 70 N-5007, Bergen Norway	orvik@gfi.uib.no	+47 55582607	+47 55960566
Einar Svendsen Institute of Marine Research P.O. Box 1870 Nordnes 5024 Bergen Norway	einar@imr.nor	+47 55238458	+47 55238584
Didrik Danielssen Institute of Marine Research 4817 His, Arendal Norway	didrik.danielssen@ imr.no	+47 37059000	+47 37059001
Stephan Dick	dick@bsh.d400.de	+49 4031903131	+49 4031905032

Federal Maritime and Hydrographic Agency Postfack 301220 Hamburg Germany			
Harry Dooley ICES	harry@ices.dk	+45 33154225	+45 33934215
Wolfgang Fennel Baltic Sea Research Inst. Seestraβe 15 D-18 119 Rostock Germany	wolfgang.fennel@ io-warnemunde.de	+49 3815197 110	+49 3815197 480

III. Agenda

for the Working Group on Shelf Seas Oceanography meeting at IEO Santa Cruz, Tenerife, Canarias, Spain from 10-12 March 1997

i) Welcome and opening (Monday 10 March, 1030 am)

ii) Appointment of rapporteur

iii) Approval of the agenda

iv) Reports on national activities of specific interest to WG members

a) evaluate the current ability of numerical (process and research) models to reproduce nature, and assess their effectiveness in support of monitoring programmes.

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

c) summarize information on the influences 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 astronomical observations, and model results. (How to proceed?).

g) clarify the ICES role in operational oceanography in the context of GOOS.

h) prepare a catalogue of available data that could form a basis for ICES- relevant products which may be displayed on the World Wide Web

v) Any other business

vi) Place, date and topics for the next meeting

vii) Closing of the meeting (Wednesday 12 March, 1600)

IV. Terms of Reference and Justifications

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

a) evaluate the current ability of numerical (process and research) models to reproduce nature, and assess their effectiveness in support of monitoring programmes (responsibility: E. Svendsen);

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

c) summarize information on the influences of fluctuations in freshwater inflow to the marine environment (with special attention to estuarine processes and coastal plumes) (responsibility: T. Osborn)

d) review results of a sensitivity analysis of the need for operational data on open model boundaries (responsibility: T. Pohlmann)

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 (responsibility: A.J. da Silva)

f) review the outcome of a first compilation of information on the availability of long (>20 years) time series of oceanographic, meteorological, fisheries and astronomical observations, and model results (responsibility: Harry Dooley);

g) clarify the ICES role in operational oceanography in the context of GOOS (responsibility R. Sætre, H.Dahlin);

h) prepare a catalogue of available data that could form a basis for ICES- relevant products which may be displayed on the World Wide Web

The working Group will report to the Hydrographic Committee at the 1997 Annual Science Conference

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)

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 crucial 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 effectiveness of individual environmental monitoring programs in determining possible trends against the natural variability. Since Dr. H. Dahlin is central in the Baltic Monitoring Program, which seems well organized, it is appropriate 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 processes 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 algal blooms occure, thus it is important to increase our knowledge on how these finer scale processes influence the environment and how this influence varies with varying amounts of freshwater input.

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

e) 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 with a view to encouraging the relevant nations/institutions to continue the monitoring.

f) 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 seas are of fundamental interest. The answers to questions arising in this context (see report from 1996) are of fundamental importance to management activities, as well as to sustainable development. 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.

g) ACME considers it vital that ICES explores all avenues in ensuring an appropriate ICES involvement in GOOS and EuroGOOS. The WG is asked to identify those current and planned ICES programmes in which ICES has an involvement (e.g. BMP), which may be adapted to meet GOOS objectives.

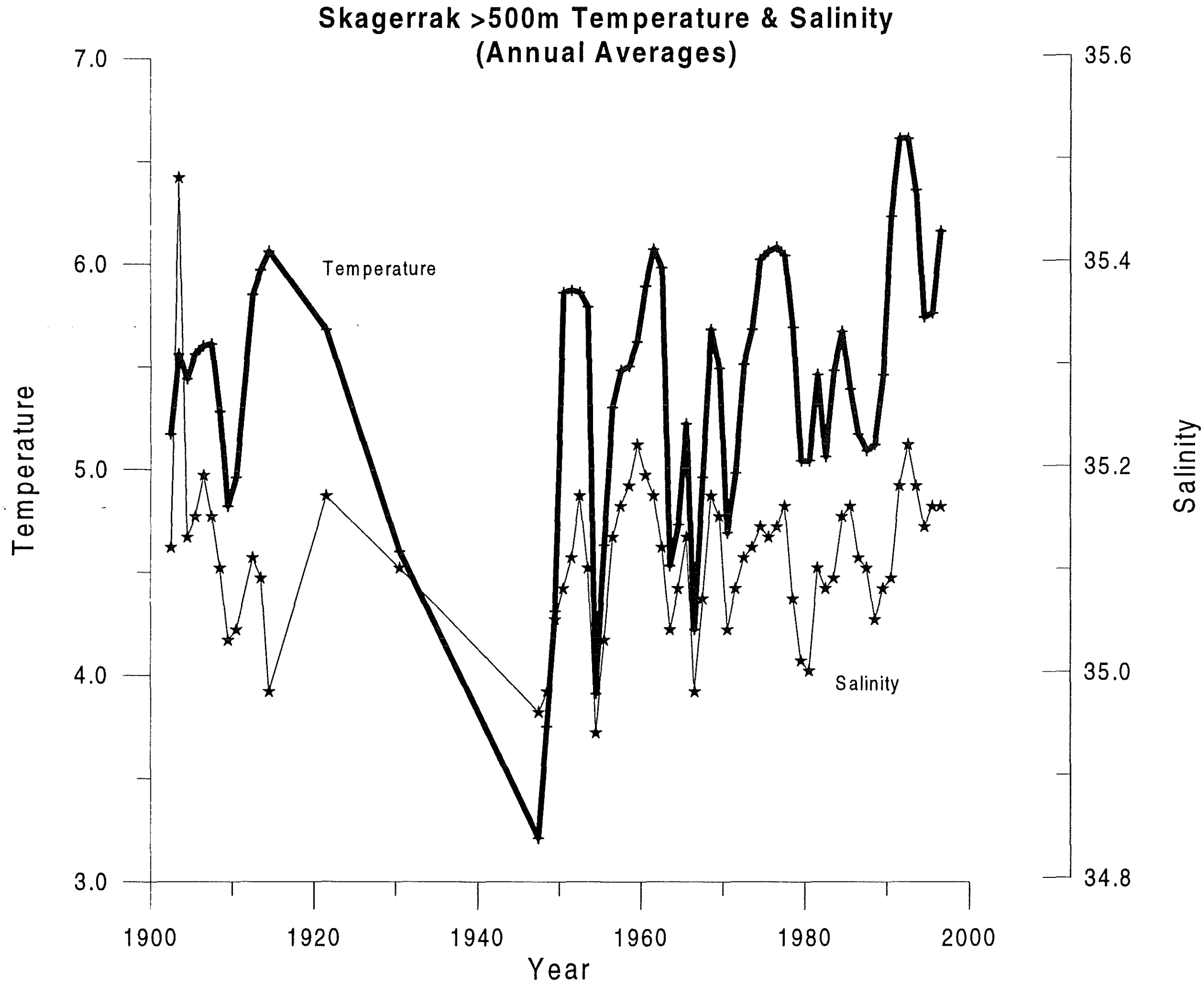
h) In the ACME discussion on the feasibility of an ICES Environmental Status Report, it was concluded that relevant oceanographic and environmental information should be readily available to potential users (including fisheries biologists) in a timely way, and this could best be achieved by making use of WWW capabilities. ACME also noted that electronic dissemination of data is quicker and more economical than the production of a printed report.

V. Inventory of long time series.

ICES Shelf Seas Oceanography Working Group, 1997

Inventory of long (>20 years) time series of Oceanographic, meteorological, fisheries and astronomical observations and model results

A First Compilation



Background

The Working Group decided to develop an inventory of time series of observations and model data during its 1996 meeting. The decision followed from its discussion on how to set up a programme of work in the North Sea to establish the ecological effects of cold "Ice" winters in the North Sea. According to the background justification for this compilation, the working group believed that, in order to predict changes in regional seas due to climate change, the understanding of large-scale, long term, climate variability and its effects on the physical, chemical, biological and geological systems of shelf seas are of fundamental interest, especially in the coastal zone where the vast majority of the human population resides.

Sources of Information

For this first compilation, information on time series was collated from a circular email to the three Hydrography Committee Working Groups, and also by a cursory search on the World Wide Web. In addition, time series available from within the ICES Data Centres were also surveyed and summarised.

There was a low number of responses from the Working Groups, nevertheless the following pages probably provides a useful first attempt at identifying those time series that do exist. Emphasis has been put on those time series that are readily available free of charge. For example, amongst the many time series that are not included are much of the light vessel data from around the North Sea which is only available at considerable cost from respective meteorological agencies.

For this initial compilation, no attempt is made to sort the time series by discipline. Instead the listings are provided by "Source" but with a clear identification of the type of time series.

SOURCE : WORLD WIDE WEB

Meteorology:

Climate data for ADVANCE-10K

Source of Information: http://www.cru.uea.ac.uk/advance10k/climdata.htm

Unix	MS-DOS	Size	Description
cuwld.all02.Z	cruwlda2.zip	3.6MB	monthly temperature station data up to 1990
glform9196b.dat.Z	glf9196b.zip	120KB	above updated to 1996
gridbox.f		1KB	Fortran code to read the above file format
Average temperature anomaly (relative to 1950-79) in each 5°x 5° box from a variable number of stations. Not normalised. See: *The Holocene*, vol. 2 no. 2 (1992)			
globalnew91.Z	glonew91.zip	3.3MB	5°x5° gridded monthly temperature data 1854-1991
globjandec92.dat.Z	globjd92.zip	76KB	above updated for 92/93
globjandec94.dat.Z	globjd94.zip"	35KB	above updated for 94
globjandec95.dat.Z	globjd95.zip	36KB	above updated for 95
sstcoads.f		2KB	Fortran code to read the above file format
presmslpup.dat.Z	prmslpup.zip	1.3MB	mean monthly SLP 1873-1991. For millibar divide by 100 and add 1000 (eg. 555 = 1005.55mb)
PRES.FOR		1KB	Fortran code to read presmslpup.dat

MET-OCEAN

Comprehensive Ocean-Atmosphere Data Set (COADS)

SOURCE: http://www.scd.ucar.edu/dss/pub/COADS.html

Overview of COADS

The Comprehensive Ocean-Atmosphere Data Set (COADS)* has been created by combining, editing, and summarizing global in situ marine data from many different sources. Merchant ship observations back to 1854 have been supplemented in more recent years by automated measurements, e.g., from drifting and moored buoys. COADS currently covers the period 1854-1992. Two COADS products are most often requested by users (decadal summaries and other products are also available):

I) Marine reports: These contain the basic individual observations (e.g., of air and sea surface temperatures, winds, atmospheric pressure, cloudiness, and humidity) taken from the ocean-atmosphere boundary layer.

Ii) Global monthly summaries for 2-degree latitude x 2-degree longitude boxes. Fourteen statistics, such as the median and mean, were calculated for each of 19 observed and derived variables. The statistics are global only to the extent that observations were actually recorded at a given time and place (i.e., statistics were calculated for each year, month, and 2-degree box containing "acceptable" data). Due to data volume, statistics are often requested in the form of group files, each group containing eight selected statistics for four variables.

Ordering COADS products

COADS products for Release 1 (1854-1979) and Release 1a (1980-92) are available from:

Steve Worley
Data Support Section
e-mail: worley@ncar.ucar.edu
National Center for Atmospheric Research
P.O. Box 3000
Boulder, CO 80307
Phone: 303-497-1248, Fax: -1298 U.S.A.

Data requests are filled by NCAR at a one-for-one copy cost (currently $6 per 10 Mbytes) plus additional cost for tape media and overseas shipping if required. Any subsetting not part of the general storage file structure is subject to an additional charge (individual marine reports are generally available in global monthly files, while the 2-degree monthly summaries are normally distributed in global annual files).

In addition, Release 1 individual marine reports can be obtained from:

Director
National Climatic Data Center
NOAA, Federal Building
Asheville, NC 28801
U.S.A.

Selected Data for Oceanographic Research

SOURCE: http://www.scd.ucar.edu/dss/catalogs/odl.html

1. Definitions
2. Ship Observations
    - COADS Documentation, ASCII (version, 6 April 1994)
    - COADS Documentation, Hypertext (version, 6 April 1994)
3. Sea Surface Temperature
4. Surface Wind and Wind Stress
5. Air-sea Heat Budgets
6. Ocean Depth and Land Elevation
7. Moored and Drifting Buoys
8. Sea Ice
9. Data Derived from Satellite Sensors
10. Subsurface Climatology / Model Input and Output
11. Datasets from Operational Atmospheric Analyses
12. Miscellaneous
13. Data Requests and Further Information

2. Ship Observations

DS540.0 :>Comprehensive Ocean-Atmosphere Data Set (COADS), Marine Observations

Geographic Coverage :
  global oceans
Temporal Coverage :

1854 - 1993

ProductType:

CMR, Compressed Marine Reports (1854-1979), 71 million observations - 29 most used parameters, 1.7 GB.

DS540.1 :>Comprehensive Ocean-Atmosphere Data Set (COADS), Statistical summaries of DS540.0

DS535.0 :>Observations from Ocean Weather Ships

Geographic Coverage :
approx. 14 locations
Temporal Coverage :
1945 - 1992
Dataset Size :
470 MBytes

DS285.0 :>Levitus' World Ocean Atlas, 1994

Geographic Coverage :
global analyzed 1 x 1 grids and observed profiles

Temporal Coverage :
based on data approx. 1900 - 1992
Dataset Size :
928 MB analyzed, 2278 MB observed

DS533.0 :>USSR Marine Ship Archive

Geographic Coverage :
global oceans
Temporal Coverage :
1888 - 1990
Dataset Size :
2.7 GB

DS277.0 :>Global SST from Natl. Centers for Environ. Prediction (formerly NMC), by Reynolds, Stokes, and Smith

ProductType:

In situ and global blended analyses. These were the first developed SST analyses. Work on this time series has been discontinued. The OI and Reconstructed SST products superceed these products.

DS289.1 :>Global Ocean Surface Temperature Atlas (GOSTA) March 1990, by Bottomley et. al.; UK Met. Office and MIT

Geographic Coverage :
global, 5 and 1 degree resolution
Temporal Coverage :
longterm climatology
Dataset Size :
68 MBytes

DS277.2 :>GISST.1 UK Met. Office Global Ice an SST

Geographic Coverage :
global, 1x1 degree resolution
Temporal Coverage :
1948-1993, yr-mo
Dataset Size :
150 MB Descripiton : SST observations for ship have been analyzed by Parker to form a monthly time series. This is a proprietary dataset and special permission is required for data access.

DS552.0 :>UNESCO: Flow Rates of Selected World Rivers

Geographic Coverage :
global
Temporal Coverage :
approx. 1800 - 1972
Dataset Size :
2.1 MBytes

Free datasets available via ftp (ftp://ncardata.ucar.edu/pub/)

Data files for the following sets may be compressed (.Z) and groups of files may be combined with tar (.tar). If you are unable to use the files in this form, the data can be provided in other forms using our standard pricing. For some datasets, only certain files or subsets are available for free.

Some data files are also available via our special projects page, which points to our ftp "pub" directory.

ds010.1 Monthly mean NH Sea Level Pressure grids
ds090.1 NMC Global Reanalysis Anals, 6-hrly, monthly monthly files only
ds085.1 Monthly mean 700- 500- mb heights/temperatures
ds195.5 NH Time Series Grids monthly only
ds205.0 NCDC/NCAR Climatology
ds207.0 Rand's global climatology
ds209.0 Esbensen - Kushnir, Global Ocean Heat and Wind
ds209.3 Hastenrath's Tropical Atlantic heat budget, monthly
ds215.0 Jones long period gridded temp anomalies
ds232.0 Hellerman, GFDL Monthly Global Wind Stress
ds233.0 Walsh's Arctic Ice Anals, monthly 1953-1988
ds234.0 Ropelewski's CAC Antarctic Ice Anals, monthly 1973-1990
ds237.0 Willmott's Terrestrial Water Budget, monthly
ds270.2 Monthly SST and Ice-Pack Limits (Alexander &)
ds277.0 Parts of the monthly SST set
ds280.0 Seasonal World Ocean Surface Currents
ds289.0 Global Monthly SST Climatology (D. Shea)
ds290.0 Climatology by D. Shea, NCAR
ds315.0 Dewey&Heim's Snow Cover, wkly monthly 1966Nov-1988 monthly files only
ds318.1 GFDL Climate Model Outputs for CO2 Studies
ds318.2 UK Climate Model Outputs for CO2 Studies
ds318.3 CCC Climate Model Outputs for CO2 Studies
ds318.4 GISS Climate Model Outputs for CO2 Studies
ds318.6 German Climate Model Tropo Anals for EPA CO2 studies
ds474.0 Univ Washington Russian Ice Station Obs, daily 1950-1990
ds483.0 Indonesian monthly data from Asian Station set
ds552.0 River discharge from UNESCO publications
ds564.0 Global Historical Climatology Net (GHCN) Temp,Precip,Pressure

ds570.0 World Monthly Sfc Station Climatology, 1738-cont US stations onl y
ds572.0 So. American Monthly Precip (Harnack)
ds578.1 China monthly temp and precip
ds582.0 Univ Wisconsin Antarctica Sfc Obs, monthly 1980-1989
ds718.5 Arkin's 1/2 Monthly Outgo LW Radia, 1974Jun-con
ds728.1 Xie and Arkin Merged Monthly Precipitation Estimates
ds740.1 Highly Reflective Clouds Longterm Means/Std.Dev
ds750.1 One degree global elevation values
ds754.0 Navy 10 minute Elevation
ds756.1 Defense Mapping Agency (DMA) U.S. 30-Sec Elevations
ds757.0 2.5 degree global elevation and land-sea mask
ds759.1 NGDC ETOPO5 Global Ocean Depth & Land Elevation, 5-Min
ds759.2 TerrainBase Global 5-minute Ocean Depth and Land Elevation
ds765.0 Vegetation, Land Use, and Albedo (Matthews)
ds765.5 Matthew's GSFC Global Wetlands & Methane Emission, 1-Degr
ds766.0 Argonne Land-use & Deposition Data, 0.2-Degr
ds767.0 Vegetation, Soils (Wilson, Henderson-Sellers)
ds768.0 Global Precip Climatology & Topography (Cogley&Briggs)
ds769.0 World Ecosystems (Olson)
ds770.0 Staub&Rosenweig's GISS Soil & Sfc Slope, 1-Degr
ds780.0 Continental Outline Data Set
ds808.0 NSSFC Severe Local Storms Log (SELSLOG), 1955-1972Jun
ds816.0 Wind Energy at Global Stations, Battelle PNL
ds824.0 NCDC Global Tropical Cyclone Position Data, 1886-1991
ds825.0 Central England Temperatures, Manley, 1659-con
ds834.0 Sunspot Numbers from NGDC
ds863.0 SPECMAP Ocean Core Data, 400,000 yr record
ds866.0 GISS Methane & Livestock Distribution, 1-Degr
ds867.0 Matthew's GISS Methane from Rice Cultivation
ds885.1 NCDC TD9640 U.S. Palmer Drought Indices, monthly 1895-1987
Basic station dictionary info
- ds900.0 WMO station library from USAF
- ds900.1 WBAN station library
- ds901.0 COOP station library

SOURCE : ICES and its Secretariat

Ocean Time Series at ICES (including working groups)

ICES Standard Stations (Oceanic Hydrography WG (OHYD))

Location	Position	Depth	Period at ICES	No at ICES (Hyd/Che)
Greenland Sea	75°00N 05°00W 71°00N 04°00E			
West Greenland	63°53N 53°22W	900 to 1300	1934-1994	157(82)
Norwegian Sea	64°30N 06°00W	3250	1953-1993	9(3)
Iceland Basin	60°00N 20°00W	2730	1977-1991	1(0)
Faroe-Shetland Channel	61°28N 03°42W	860	1905-1995	156 (9)
Faroe Bank Channel	61°16N 08°00E	1260	1959-1972	2(1)
Porcupine Abyssal Plain	50°00N 17°00W	2700	1976-1990	11(8)
Weathership A	62°00N 33°00W		1954-1974	1444(0)
Weathership B	55°47N 51°53W		1928-1974	2234(0)
Weathership C	52°45N 35°30W		1910-1990	10393(2974)
Weathership D	44°00N 41°00W		1962-1984	1668(3)
Weathership E	35°00N 48°00W		1910-1979	2116(24)
Weathership H	38°00N 71°00W		1927-1982	730(98)
Weathership I	59°00N 19°00W		1955-1975	708(0)
Weathership J	52°30N 20°00W		1950-1975	994(0)
Weathership K	45°00N 16°00W		1949-1973	505(0)
Weathership L	57°00N 20°00W		1975-1989	454(0)
Weathership M	66°00N 02°00E		1948-1990	8011(46)
Weathership R	47°00N 17°00W		-	0(0)
Canadian Eastcoast				
Prince 5	44°57N 66°49W		-	0(0)
Station 27	47°33N 52°35W		-	0(0)

OHYD List of Standard Sections in the North Atlantic

COUNTRY/NAME	STARTPOINT	ENDPOINT	NO at ICES	PERIOD
CANADA				
Flemish Cap	47°00N 52°02W	47°00N 42°00W	1191 (49)	1913-1991
Bonavista	48°44N 52°58W	50°00N 49°00W	199 (4)	1931-1989
White Bay	50°40N 55°00W	52°07N 49°45W	134 (1)	1950-1989
Seal Island	53°14N 55°39W	59°38N 44°09W	302 (4)	1931-1994
DENMARK				
C. Farewell	59°38N 44°09W	58°46N 45°50W	46 (19)	1952-1988
C. Desolation	60°50N 48°45W	60°02N 51°27W	26 (9)	1928-1988
Frederikshaab	61°57N 50°00W	61°34N 52°30W	110 (53)	1924-1987
Fylla Bank	63°57N 52°22W	63°48N 53°56W	669 (276)	1908-1988
Sukkertop	65°06N 52°55W	65°06N 54°58W	294 (134)	1908-1988
Holsteinsborg	66°53N 54°10W	66°41N 56°38W	308 (133)	1908-1988
FAROES				
Northern Section	62°20N 06°05W	64°30N 06°05W	366 (20)	1904-1989
Nolsey-Shetland	62°00N 06°12W	61°01N 01°36W	2099 (746)	1902-1993
Troellhoevdi - Faro Bank	61°50N 07°00W	60°28N 09°20W	159 (18)	1904-1989
GERMANY				
Dohrn Bank I	65°27N 28°38W	65°53N 30°53W	56 (11)	1903-1988
Dohrn Bank II	65°58N 29°24W	65°21N 30°06W	38 (4)	1955-1988
Gauss Bank	65°22N 34°30W	64°50N 33°33W	12 (1)	1933-1988
Heimland Ridge	64°09N 37°12W	63°33N 36°33W	7 (0)	1932-1988
Cape Moesting	63°38N 40°05W	63°04N 39°12W	13 (2)	1933-1988
Cape Bille	62°10N 41°24W	61°56N 40°27W	42 (16)	1933-1988
Discord Bank	60°57N 42°17W	60°48N 40°18W	14 (2)	1958-1988
ICELAND				
Faxafloi	64°20N 22°25W	64°20N 28°00W	627 (342)	1903-1991
Latrabjerg	65°30N 24°34W	66°09N 27°15W	680 (255)	1904-1990
Kogur	66°30N 23°00W	67°20N 23°40W	829 (293)	1904-1990
Siglunes	66°16N 18°50W	68°00N 18°50W	1066 (448)	1908-1990
Langan N	66°37N 14°16W	68°00N 12°40W	508 (239)	1929-1990
Langan A	66°22N 14°22W	66°22N 09°00W	813 (308)	1904-1990
Krossan	65°00N 13°30W	65°00N 09°00W	468 (187)	1902-1990
Stokksn	64°12N 14.50W	63°40N 13°40W	414 (204)	1933-1990
Selv.B.	63°41N 20°41W	63°00N 21°28W	820 (495)	1934-1990
Iceland Sea	68°15N 16°32W	70°35N 13°25W	29 (3)	1958-1986
NORWAY				
Torungen	58°24N 08°46E	57°38N 09°52E	4489 (1993)	1902-1993
Oksø	58°03N 08°05E	74°14N 08°33E	1596 (742)	1906-1994
Hansth.-Aberdeen	57°00N 07°57E	57°00N 01°28W	3208 (1010)	1903-1995
Utsira	59°17N 05°02E	59°17N 02°14W	5159 (1642)	1902-1994
Feie	60°45N 04°37E	60°45N 00°40W	3356 (612)	1902-1994
Svinøy	62°22N 05°12E	64°40N 00°00E	1315 (158)	1901-1990
Gimsøy	68°24N 14°05E	70°24N 08°12E	883 (24)	1923-1990
Bjørnøy	70°30N 20°00E	74°15N 19°10E	1963 (49)	1926-1995
Vardø	70°30N 31°13E	76°30N 31°13E	1356 (79)	1913-1995
Sem Islands	69°05N 37°20E	76°30N 37°20E	691 (40)	1904-1990
Bjørnøya-W	74°30N 18°30E	74°30N 07°00E	1104 (108)	1929-1993

COUNTRY/NAME	STARTPOINT	ENDPOINT	NO at ICES	PERIOD
SCOTLAND				
FIM	60°10N 03°44W	61°12N 06°22W	651 (322)	1902-1993
FS (see Faroe)	62°00N 06°12W	60°56N 01°00W	1827 (635)	1902-1993
MR	56°40N 06°08W	57°35N 13°38W	597 (48)	1908-1993
JONSIS (see Norway)	59°17N 05°02E	59°17N 02°14W	Utsira	
SPAIN				
Vigo	42°08N 09°18W	42°13N 08°51W	28 (13)	1952-1992
La Coruna	43°25N 08°26W	43°21N 08°22W	2 (0)	1987-1992
Santander	43°30N 03°47W	43°42N 03°47W	6(1)	1952-1994
Cudillero	43°36N 06°08W	43°46N 06°10W	5 (0)	1992-1993

FIXED North Sea Stations for surface temperature and salinity at ICES (not exhaustive list)

LIGHT VESSELS

Platform	Name	Position	Year	Nos. of Stations
06HR	Helgoland Reede	5410N ; 750E	1933-1937	456
11WH	West-Hinder	5122N ; 228E 5123N ; 226E	1905-1961 1961-1979	6194
64GE	Goeree	5156N ; 340E	1955-1993	3072
64NH	Noordhinder	5139N ; 234E	1955-1982	19.932
64TB	Terschellingerbank	5328N ; 508E	1950-1970	4630
64TE	Texel	5301N ; 422E	1952-1975	9860
74BY	L.H. Bardsey*	5245N ; 448W	1957-1985	3199
74GA	Galloper	5144N ; 158E	1920-1977	2715
74LP	Liverpool*	5245N ; 448W	1934-1956	3318
74LV	Liverpool Bar	5332N ; 319W	1957-1973	1489
74MB	Morecombe Bay	5355N ; 329W	1957-1965	1215
74SK	Smith's Knoll	5243N ; 217E 5244N ; 218E	1920-1951 1952-1971	4395
74SS	Seven Stones	5003/5004N ; 604/605 W	1906-1987	5990
74VA	Varne	5056N;116/117W 5104N ; 124E	1905-1967 1967-1985	6771

Examples of Other Time Series at ICES - fixed Profile data

Name of Station	Location	Number of Stations	Period	Parameters
E1	50 02N 4 22W	454	1903-1992	t, s, nutrients
Cypris (IOM)	54 05N 4 50W	1014 (996)	1954-1982	t, s, nutrients
Breakwater (IOM)	54 05N 4 46W	28810	1904-1982	t
Norwegian coastal stations	various	1770	1927-1994	t,s,oxygen
Skagerrak >600m includ-ing M6	58 08 -58 12N;9 10 - 9 32E	659 (357)	1902-1996	t,s,oxygen,nutrients, etc

SOURCE: EDMED

Time Series referred to in EDMED (European Directory for Marine Environmental Data)

Rockall Channel CTD section time series (1975-)
Rockall Channel surface temperature and salinity time series (1948-)
Hunterston Power Station, Clyde sea area, temperature time series (1960-1985)
Hunterston Power Station, Clyde sea area, biological time series (1960-1985)
A long time series of meteorological data from Genova, Italy
French national archive of time series data, particularly current meter and thermistor data
LPO Current meter and temperature time series in the North Atlantic
LPO Subsurface Lagrangian floats time series from the Atlantic
Sea level time series in the Indian Ocean
Sea level time series in the Tropical Atlantic
Lagrangian time series from drifting buoys in the Tropical Global Ocean
ORSTOM current meter and time series data from the global tropical ocean
Sea surface temperature time series from German Baltic Sea coastal stations (1953-90)
Sea surface salinity time series from German Baltic Sea coastal stations (1953-90)
Meteorological and sea surface hydrography time series from KIEL Lightship, Baltic Sea (1936-39,47-67)
Hydrographic station time series at UFS KIEL Lighthouse, Baltic Sea (1985-90)
Meteorological, sea surface hydrography and hydrographic station time series from ELBE 1 Lightship, German Bight (1920-39,47-88)
Meteorological, sea surface hydrography and hydrographic station time series from ELBE 2 Lightship, German Bight (1935-39)
Meteorological, sea surface hydrography and hydrographic station time series from ELBE 3 Lightship, German Bight (1935-39)
Meteorological, sea surface hydrography and hydrographic station time series from FEHMARN BELT Lightship, NE Germany (1922-9,47-84)
Hydrographic station time series from FEHMARN BELT Buoy, NE Germany (1985-89)
Meteorological, sea surface hydrography and hydrographic station time series from ELBE 4 Lightship, German Bight (1920-39)
Meteorological, sea surface hydrography and hydrographic station time series from AUSSEN JADE Lightship, German Bight (1935-39)
Meteorological, sea surface hydrography and hydrographic station time series from MINSENERSAND Lightship, German Bight (1921-39)
Meteorological, sea surface hydrography and hydrographic station time series from NORDERNEY Lightship, German Bight (1935-39)

Meteorological, sea surface hydrography and hydrographic station time series from S2 Lightship, German Bight (1947-53)
Meteorological, sea surface hydrography and hydrographic station time series from DEUTSCHE BUCHT Lightship, German Bight (1948-86)
Temperature and salinity depth profile time series at UFS DEUTSCHE BUCHT Automatic Lightship, German Bight (1989-90)
Meteorological, sea surface hydrography and hydrographic station time series from TW EMS Lightship, German Bight (1947-78)
Temperature and salinity depth profile timc series at UFS TW EMS Automatic Lightship, German Bight (1989-90)
Meteorological, sea surface hydrography and hydrographic station time series from BORKUMRIFF Lightship, German Bight (1921-39,47-88)
Temperature and salinity depth profile time series at UFS ELBE Automatic Lightship, German Bight (1989-90)
Meteorological, sea surface hydrography and hydrographic station time series from WESER Lightship, German Bight (1921-39,47-81)
Meteorological, sea surface hydrography and hydrographic station time series from BREMEN Lightship, German Bight (1922-39)
Meteorological, sea surface hydrography and hydrographic station time series from AUSSEN EIDER Lightship, German Bight (1921-39)
Meteorological, sea surface hydrography and hydrographic station time series from AMRUMBANK Lightship, German Bight (1921-39)
Meteorological and sea surface hydrography time series from ADLERGRUND Lightship, Baltic Sea (1921-39)
Meteorological and sea surface hydrography time series from FLENSBURG Lightship, Belts (1936-39)

SOURCE: Einar Svendsen

IMR Bergen, The Norwegian Met. Inst., Oslo, Norway

OCEANOGRAPHY

Fixed stations (50 +/-20 years)

9 hydrographic stations (vertical profiles) along the Norw. coast
20 surface T,S along the Norw. coast and across the North Sea
20 fjords (hydrography, nutrients and oxygen)
Station M-Norwegian Sea (hydrography)

Fixed sections (20-30 ++ years)

12 hydrographic sections normal to the Norwegian coast into deep water (one with oxygen)
Russian Kola section since 1901

Regional Observations (20-30 years)

Hydrography in the "whole" ice-free Barents Sea 3 times a year.
Norwegian Coast (hydrography) twice a year
North Sea (northern & central) twice a year
Lofoten once a year

METEOROLOGY

Standard coastal weather stations:

40-50 standard weather stations at the coast/islands of Norway, including
Jan Mayen,
Svalbard,
Bear Island and
Hopen.

This "covers" an area from 58 to 79 degrees northern latitude, and from 11 degrees east to 8 degrees west. Some of these includes sea state and sea surface temperature. Most of the monitoring started in the early 1900.

Gridded (75x75 km) wind, atmospheric pressure and wave parameters every 6 hour since 1955 over parts of the North Atlantic and Arctic ocean and the total Nordic, North and Barents seas. (3000 grid-points/ time-series).

Gridded sea ice coverage and ice type once a week since 1966

Gridded SST once a week since 1972

FISHERIES (ICES/IMR, Bergen, Norway/other Many long time-series from the commercial fish stocks on recruitment, individual age classes and spawning stock biomass are available at ICES, together with catch distributions.

Indexes of the amount and maps of distribution of Atlanto Scandian Herring and Norwegian Arctic Cod larvae/ 0-group from IMR and russian research cruises.

ASTRONOMICAL

The main astronomical periods which also are found in measured time-series (in addition to the standard short term tidal and yearly cycles) is the: 11.2 years (mean) solar activity cycle

- 18.61 years nodal tide
- 8.85 years
- 2.3 years

The solar activity cycle (from the average number of sunspots and the mean area) fluctuate over time in a more or less regular manner with a mean period of about 11.2 years.

The Nodal tide, Mn: 18.61 yr tidal component. From Burroughs (1992): "The 18.61 yr period in the regression of the longitude of the node - the line joining the points were the Moon's orbit crosses the ecliptic".

8.85 yrs: Tidal component connected to the variation in the alignment of the Moon's perigree and the Earth's perihelion. From Burroughs (1992): "The 8.85 yr period in the advance of the longitude of the Moon's peri gee which determines the times of the alignment of the perigee with the Earth's perihelion"

SOURCE: H Van Aken, NIOZ, Texel

Timeseries of Sea Surface Temperature and Salinity from the Marsdiep estuary.

Samples are taken daily at 08:00 local time. In order to remove oscillations due to the interference of tides and sample time these daily values are reduced to monthly mean values. The time series started in July 1860 in Den Helder and was continued there until 1962. From 1947 onwards a similar timeseries is collected from the Texel side of the Marsdiep, near 't Horntje, the present location of NIOZ. From the 16 years overlap monthly mean correction have been determined to transform the monthly mean values from 't Horntje to Den Helder.

The data from 1860 to 1981 have been described by P.C.T. van der Hoeven in "Observations of surface water temperature and salinity, State Office of Fishery Research (RIVO): 1860-1981" KNMI Scientific Report W.R. 82-8, KNMI, De Bilt, 1982

This report also contains time series from several other positions in the Wadden Sea and in the former Zuiderzee, as well as from Dutch light vessels. KNMI owns even more timeseries of sea surface temperature along the whole Dutch coast, but colleagues of NIOZ who tried to obtain these data from KNMI did so in vain. Possibly they were lost some time. Perhaps you can put some pressure on KNMI to uncover these data.

Only the Marsdiep data are available from H. Van Aken (aken@nioz.nl) as computer files (Excel).

Algal timeseries from the Marsdiep estuary

Dr. G. Cadee from NIOZ maintains this time series.

Timeseries of shellfish from plates in the Wadden Sea of at least 25 years.

Beukema of NIOZ maintains this time series .

SOURCE: Finnish Institute for Marine Research (Ari Seina)

Baltic Sea:

1) **Maximum extent of ice cover 1719/20-**

In Seina and Palosuo 1996: the classification of the maximum annual extent of ice cover in the Baltic Sea 1720-1995.-MERI-report series of the Finnish Institute of Marine Research No 27.

2) **Ice seasons 1830-1996.**

Further information from http://ice.fmi.fi

3) **Freezing, maximum annual ice thickness and breakup of ice on the Finnish Coast 1830-1984**

Published in Geophysica 21(2) by Lepparanta and Seina, 1985. Data used in the paper is published in FIMR Internal report 1985(2), email: parkkonen@fimr.fi.

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SOURCE: NERC, UK (L Rickards - The "Environment in Time")

Marine Biology

- **Zooplankton and fish larvae densities, 1924-1988**

Western Approaches of English Channel. Maintained by MBA, Plymouth

- **Pelagic zooplankton and phytplankton, since 1931**

NE Atlantic and North Sea, funded largely under CPR programme. Regular work along 20W by SOC (to 100m and 10 degree intervals)

- **Littoral-sublittoral communities, 1963-1986**

In Firth of Clyde, by DML, Oban.

- **Pup production of grey seals, since 1959**

All major UK seal colonies by SMRU.

Physical Oceanography

- **Mean Sea Level, since 1806**

Worldwide, POL coordinates data for IOC, 400 stations in GLOSS.

- **Tidal Changes since 1950s (some since mid-19th century)**

- **Wave Height, 1954-1988**

North Atlantic. Data from OWS. UK wave climate atlas in press.

SOURCE: J Dippner (DKRZ, Germany)

Various links concerning time series are available from:

http://www.dkrz.de/forschung/project/klimadatenkatalog.html

Including:

Climate Data Catalog - Germany

A list of climate research centers in Germany and available datasets.

Climate Data Catalog - Europe

Information on European centers for climate, atmospheric and oceanographic research.

Climate Data Catalog - Worldwide

Climate data centers with online accesable data and informations all over the world.

Climate Models and Diagnostics

Links to technical reports on climate models and diagnostic programs.

SOURCE: PICES Inventory of Long Term Series relevant to the North Pacific

http://pices.ios.bc.ca/data/longterm/lttsintr.htm

The Technical Committee on Data Exchange (TCODE) has undertaken the task of assembling a list of important datasets that are relevant to the study of long term trends in the physical, chemical and biological environment of the North Pacific. These datasets are particularly important for the retrospective analyses that are to be carried out in the PICES Climate Change and Carrying Capacity (CCCC) studies.

The primary objective of TCODE in assembling this inventory was to provide short descriptions and "pointers" to the locations of the datasets, to assist researchers in selecting and accessing a diverse set of long term data. The criteria for inclusion were loose - we were interested in any data that was considered to be relevant to the PICES area that spanned (or will eventually span) a period of 10 years or more. We have included references to some global datasets, as well as references to some observations in equatorial waters which are know to
have impacts on the North Pacific.

For convenience, we have classified the datasets into four types: 1.Biological Oceanographic Data 2.Fisheries data 3.Meteorological data 4.Physical and Chemical Oceanographic data

1 Biological Oceanographic Time Series

TINRO Biological Oceanographic Profile data - Russia
OWS Papa - Chlorophyll and primary production
OWS Papa - zooplankton biomass and compition
HOTS- Hawaii Ocean Time Series

2 Fisheries Time Series

Auke Creek- Salmon escapement and envioronmental conditions
North Pacific Salmonid Coded Wire Tag (CWT) Database
Pink Salmon escapement and env. factors - Sashin Creek
US/Japan Fisheries Resource Assessment Surveys
NMFS Longline Survey
Pacific Coast Acoustic/Trawl Hake Survey
Standard Trawl surveys - West Coast of US to BC
US Commercial Fishery Landing Statistics
Standard Trawl surveys - West Coast of US to BC
Groundfish catch and Composition - U.S. Observer Program
Standard Trawl Surveys - Gulf of Alaska and Aleutians
Standard trawl surveys - Eastern Bering Sea (US)
Northern Fur seals - Pribilof Islands
Groundfish stomach contents - U.S. Waters
TINRO - fish biomass and composition from trawls- Russia
Aboriginal Catch Database (Canada)
Recreational Catch Database (Canada)
Groundfish Catch Database (Canada)
Herring Catch Landings (Canada)
Herring Spawn Data (Canada)
Herring Biological Sample Data (Canada)
Mark Recovery Program (Canada)
Groundfish Biological Database (Canada)
Eastern Bering Sea Acoustic/Trawl Pollock Survey
Bogoslof Island Acoustic/Trawl Pollock Survey
Commercial Catch Database (Canada)
Salmonid Enhancement Program (Canada)
Mark Recovery Program Commercial Biological Sampling (Canada)
Mark Recovery Program Multiple Finclip Database (Canada)
Gulf of Alaska Acoustic/Trawl Pollock Survey
Shellfish Harvest Log Databases (Canada)

3 Meteorological Time Series

COADS SST and surface met. data - NODC CDROM-56/57
NOAA Climate Prediction Center-Teleconnection Indices (See entry below)
Canada-Regional air temperature anomalies 1895 - present

FNMOC SLP, winds and upwelling indices
Global air temp anomalies - with and without ENSO
NOAA Marine Environmental Buoy Database
Offshore meteorological.oceanographic buoys (Canada)
global and hemispheric air temperature anomalies

4 Physical and Chemical Oceanographic Time Series

OWS Papa - Nutrient profiles
OWS Papa - Temp, Salinity and Oxygen profiles (WOCE PR6)
JODC Temp, Salinity, Oxygen and nutrient profiles
JODC Currents (includes ADCP)
Sea Level Heights - Japan - 1961 to present
Offshore meteorological/oceanographic buoys - Canada
JODC Moored Current Meter data
Sea Level heights (Canada -West Coast)
World Ocean Atlas 1994
Canada-MEDS Sea Level Height database
Canada - MEDS oceanographic data profiles
NODC/WDC-A Oceanographic Station Profile Time Series
NOAA/NODC Sea Level Height CD-ROM
FNMOC Sea Level Pressure and Ocean flow fields
Arctic and Southern Ocean Sea Ice Concentration
T&S profiles - NW Pacific, Bering, Okhotsk (Russia)
Joint Archive for Shipboard ADCP (JASADCP) at the UH
Lighthouse SST and SSS - (Canada-West Coast)
TINRO Temperature and Salinity Profiles - Russia
Canada- MEDS world archive for drifting buoy data (DRIBU)
Monthly SST and anomalies - WC US, Alaska, Eastern Pacific
Temperature and Salinity profiles - Gulf of Alaska (GAK 1)
CALCOFI Temp, salinity and nutrient profiles (US-Calif)
NODC Ocean Current Drifter Data

NOAA Climate Prediction Center-Teleconnection Indices

http://nic.fb4.noaa.gov/data/cddb/

CPC - Data: Current Monthly Atmospheric and SST Index Values Updated around the 10th of each month. Also available thru anonymous ftp to nic.fb4.noaa.gov:/pub/cac/cddb/indices

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Winds
•200 MB Zonal Winds Equator (165W-110W): Data, Graphic
•850 MB Trade Wind Index(135E-180W) 5N-5S West Pacific: Data, Graphic
•850 MB Trade Wind Index(175W-140W) 5N-5S Central Pacific: Data, Graphic
•850 MB Trade Wind Index(135W-120W) 5N-5S East Pacific: Data, Graphic
•QBO.U30.Index (replaces 30 MB Singapore Winds [see FAQ]: Data, Graphic
•QBO.U50.Index (replaces 50 MB Singapore Winds [see FAQ]: Data, Graphic

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Sea Level Pressure
•Darwin Sea Level Pressure: Data, Graphic
•Tahiti Sea Level Pressure:Data, Graphic
•Darwin (SLP) 1882 - 1950: Data
•Tahiti (SLP) 1882 - 1950: Data

Southern Oscillation Index (SOI)
•(Stand Tahiti - Stand Darwin) Sea Level Pressure: Data, Graphic

•(Stand Tahiti - Stand Darwin) SLP 1882 - 1950: Data

Sea Surface Temperature
•Nino 1+2 (0-10S)(90W-80W) Nino 3 (5N-5S)(150W-90W) Nino 4 (5N-5S) (160E-150W) Nino 3.4 (5N-5S)(170-120W): Data, Graphic
•North Atlantic (5-20N, 60-30W), South Atlantic (0-20S, 30W-10E), Global Tropics (10S-10N, 0-360): Data
•West Coast of Americas SST (Known as Ship Track 1): Data
•Hawaii Fiji SST (Known as Ship Track 6): Data
•West Coast of Americas SST 1921 - 1950 (Ship Track 1): Data
•West Coast of Americas SST 1921 - 1950 (Ship Track 6): Data

Temperatures
•Zonally Average 500 MB Temperature Anomalies: Data, Graphic

Outgoing Long Wave Radiation
•Outgoing Long Wave Radiation Equator (160E-160W): Data, Graphic

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Northern Hemisphere Teleconnection pattern indices
•Standardized Amplitudes of NH teleconnection patterns

SOURCE - CPC: STANDARDIZED NORTHERN HEMISPHERE TELECONNECTION INDICES

http://nic.fb4.noaa.gov/data/cddb/

column 1: Year (yy)
column 2: Month (mm)
column 3: North Atlantic Oscillation (NAO)
column 4: East Atlantic Pattern (EA)
column 5: East Atlantic Jet Pattern (EA-JET)
column 6: West Pacific Pattern (WP)
column 7: East Pacific Pattern (EP)
column 8: North Pacific Pattern (NP)
column 9: Pacific/ North American Pattern (PNA)
column 10: East Atlantic/West Russia Pattern (EA/WR)
column 11: Scandinavia Pattern (SCA)
column 12: Tropical/ Northern Hemisphere Pattern (TNH)
column 13: Polar/ Eurasia Pattern (POL)
column 14: Pacific Transition Pattern (PT)
column 15: Subtropical Zonal Pattern (SZ)
column 16: Asia Summer Pattern (ASU)

•Documentation for teleconnection patterns

VI. Review results of a sensitivity analysis

Sensitivity analysis of the need for operational data on open model boundaries

by Thomas Pohlmann and Robert Schmidt-Nia
ZMK, Institute fur Meereskunde der Universitat Hamburg
(shortened by Einar Svendsen)

Existing North Sea models always have to face the problem, that not enough open boundary data are available. This is especially true if the model is intended to simulate realistic periods in a prognostic mode for salinity and temperature. In general due to lacking boundary data at open boundaries, climatological means are prescribed. Obviously these data do not include phenomena like a North Atlantic salinity anomaly, which produce strong deviations from the climatological mean at the outer edge of the North Sea.

One suggestion to circumvent this problem is based on the assumption that the major Atlantic water masses enter the North Sea either through the Fair Isle Passage, east of the Shetlands or through the Dover Strait. This would imply that only three operational stations are needed to provide all the North Sea modellers with adequate boundary condition. As in general the vertical stratification in all the three regions is very weak probably only surface data would be sufficient.

The aim of this study is to demonstrate the actual importance of these correct boundary data for the whole North Sea domain. In a first approach this has been done by using the Hamburg North Sea Model, which has proved its reliability in a large number of different applications. The model study was carried out as an excample for the year 1982. Altogether 5 simulations have been performed in order to illustrate the influence of the open boundary conditions on the interior of the North Sea domain. These 5 runs only differ with respect to the salinity data which are described at the open boundaries. All the other model settings are taken in the standard configuration.

Exp.1: Reference run: unchanged climatological monthly mean salinity at all open inflow boundaries

Exp.2: -1 psu at NW: values at open northwest boundaries reduced by 1 psu

Exp.3: 1 psu at NW: values at open northwest boundaries increased by 1 psu

Exp.4: -1 psu at EC: values in the English Channel reduced by 1 psu

Exp.5: 1 psu at EC: values in the English Channel increased by 1 psu

I can be observed that the salinity values at the northern entrance are more relevant for most parts of the North Sea compared to the values in the English Channel (Fig. 1 and 2). The result of the change of the northern boundary conditions reaches the central North Sea at the end of July. At the end of the year the difference has reached about 0.5 psu, which is 50% of the prescribed change. In the German Bight the impact of of Channel water dominates. At the end of the year tge effect is 10% of the prescribed change.

The horizontal distributions indicate that the changes propagate from both boundaries relatively smoothely into the inner part of the North Sea (Fig. 3). The direction and strength of this propagation seems to agree with the expected effect of the residual circulation in combination with diffusive processes. Only the Skagerrak area is exceptional. Here strong disturbances in the horizontal salinity distribution are noticable after one year. In this context it must be pointed out that at the open boundaries sea surface elevations are provided by an additional model which covers the entire northwest European shelf. This model uses climatological monthly means of salinity and temperature treating them as diagnostic quantities. This implies that salinity changes at the open North Sea boundaries will produce inconsistensies between the prescribed sea surface elevations and the density field. As these changes for each of the three boundaries is applied along the whole section, no additional geostrophic fluxes across these boundaries are induced. On the other hand it must be expected that these inconcistensies produce artificial barotropic pressure gradients between the three open boundaries of the model, i.e. the northwestern boundary, the English Channerl and the western Baltic. Thus, the disturbances in the Skagerrak may probably be related to the artificial barotropic pressure gradient between the northern boundary and the Baltic. This hypothesis is supported by the strong annually mean velocity deviations from the reference run (Fig. 4).

In this study it was not possible to conclusively discriminate between the pure advection/ diffusive influence of the salinity change at open boundaries and barotropically induced effects. Since the latter influence the circulation in the entire North Sea, this question needs further specific investigations.

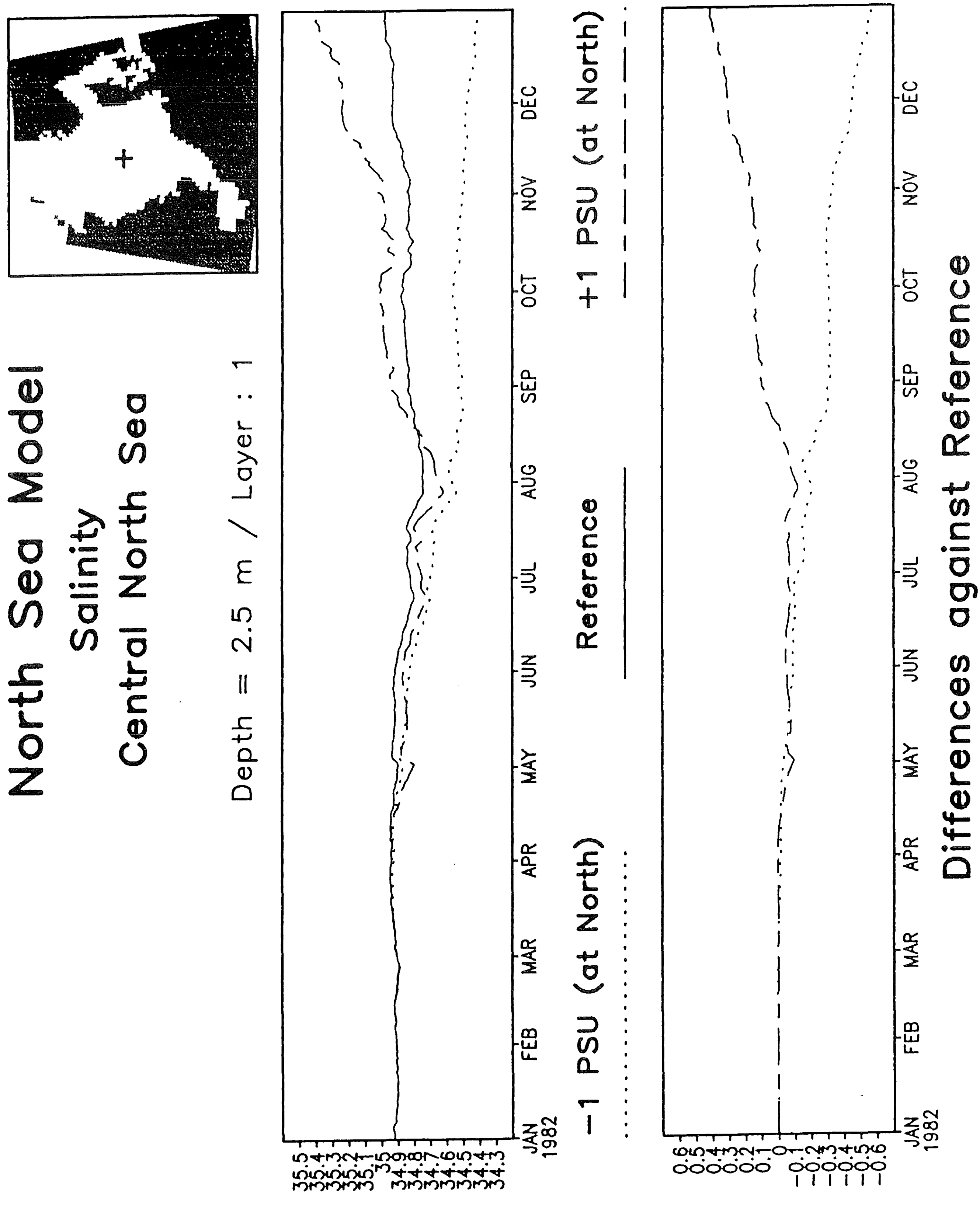

Figure 1 Time series of salinity development in the central North Sea in the surface layer (0 – 5 m). Determined with Exp. 2 and 3, i.e. change of boundary values at northwestern model boundary by -1 psu and +1 psu, respectively. Lower panel gives the differences against the reference run.

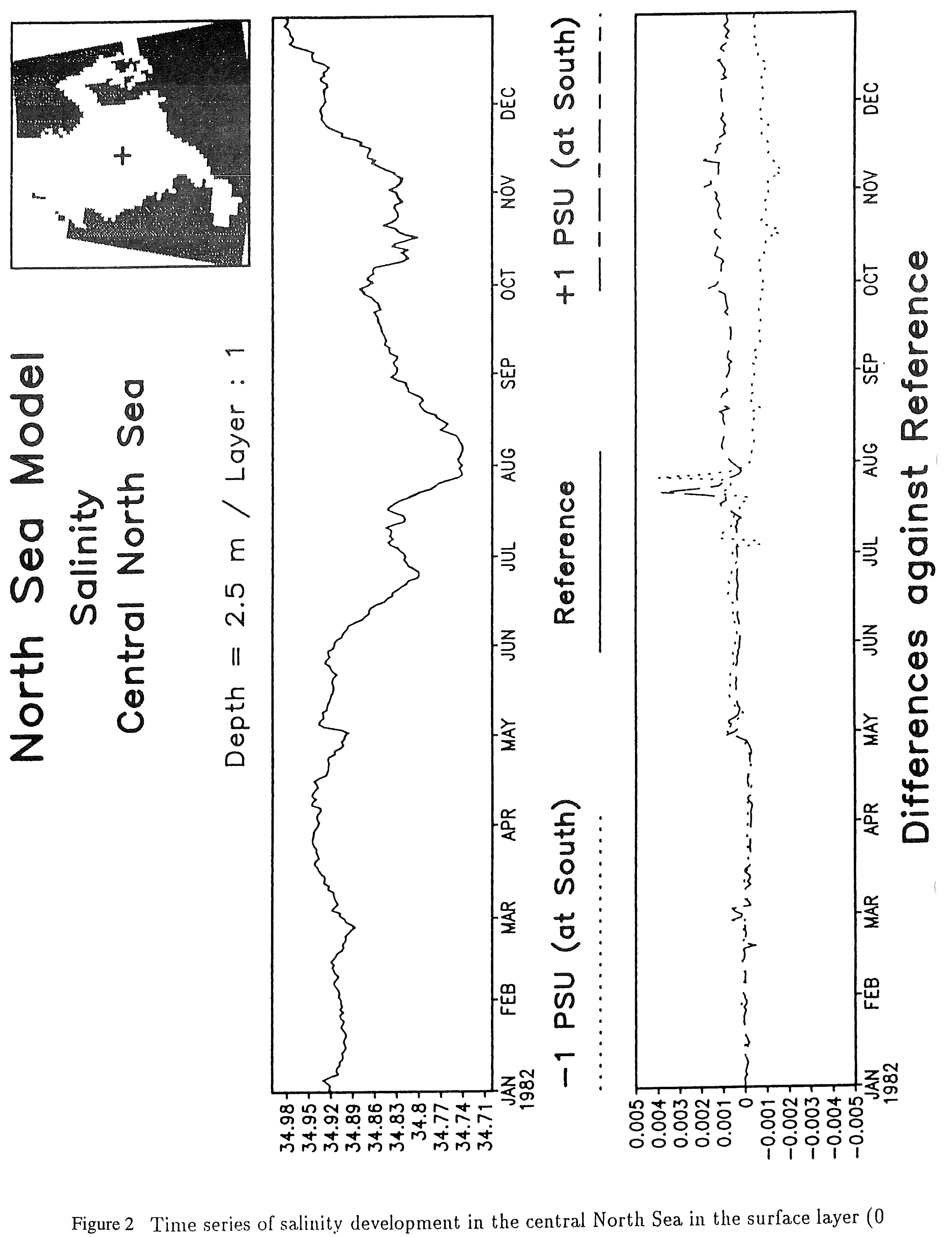

Figure 2 Time series of salinity development in the central North Sea in the surface layer (0 – 5 m). Determined with Exp. 2 and 3, i.e. change of boundary values at northwestern model boundary by -1 psu and +1 psu, respectively. Lower panel gives the differences against the reference run.

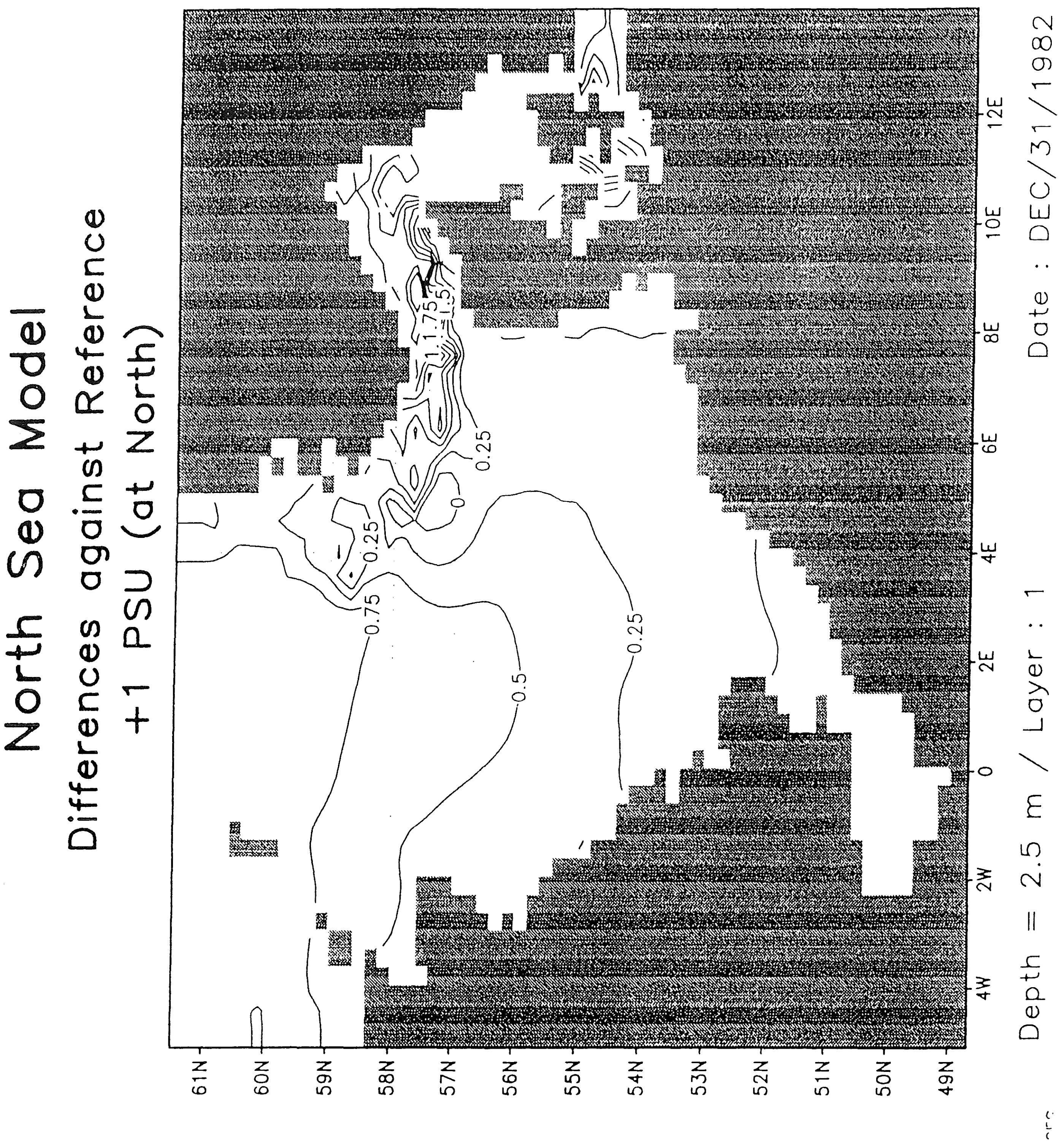

Figure 3 Horizontal distribution of the salinity difference against the reference run in the surface layer (0 – 5 m) at the 31. December 1982 for Exp. 3, i.e. change of boundary values at northwestern model boundary by +1 psu against the reference.

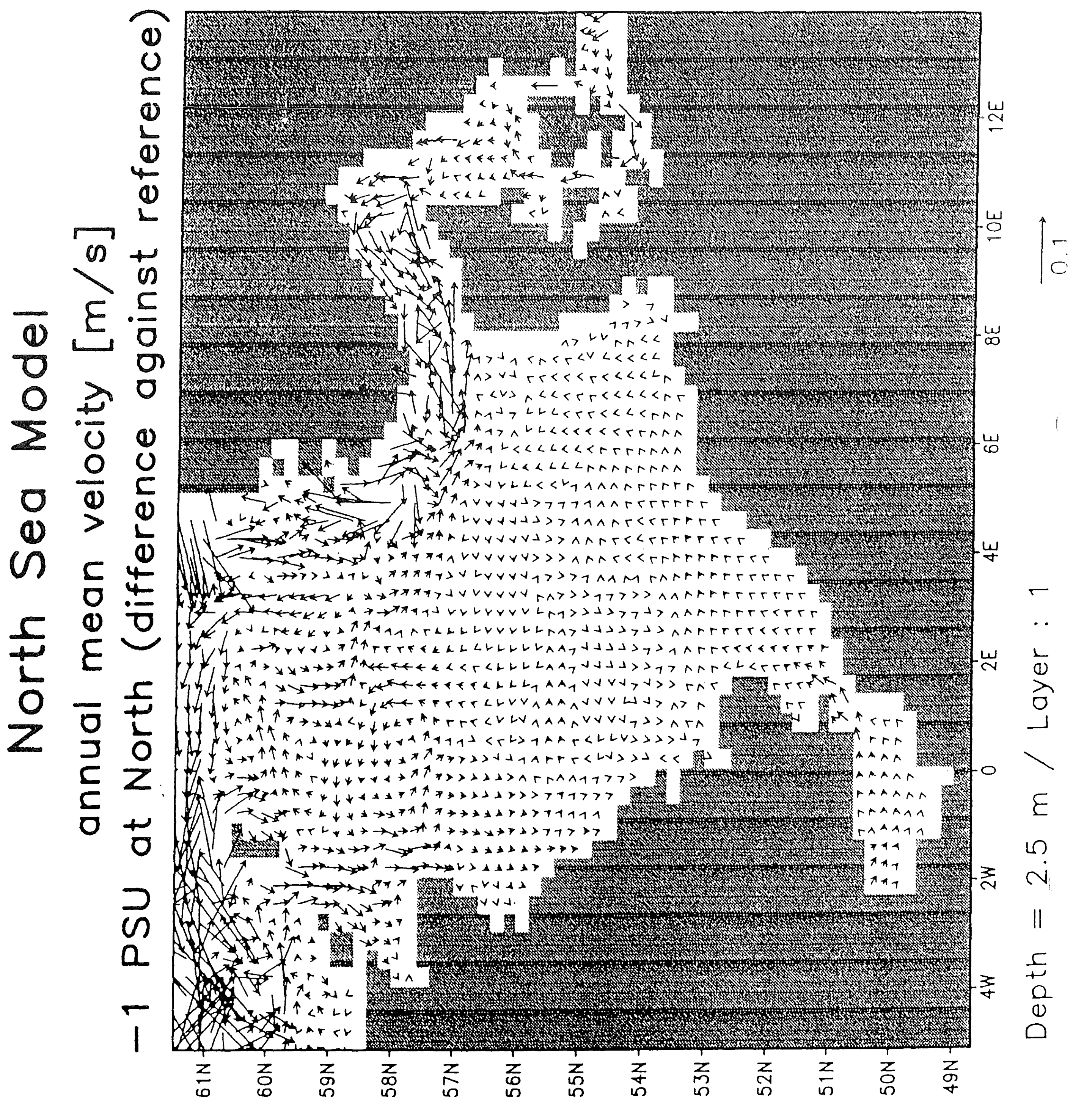

Figure 4 : Horizontal distribution of the velocity difference against the reference run in the surface layer (0 – 5 m) annually averaged over 1982 for Exp. 2, i.e. change of boundary values at northwestern model boundary by -1 psu against the reference.