INTERNATIONAL COUNCIL FOR SCIENCE

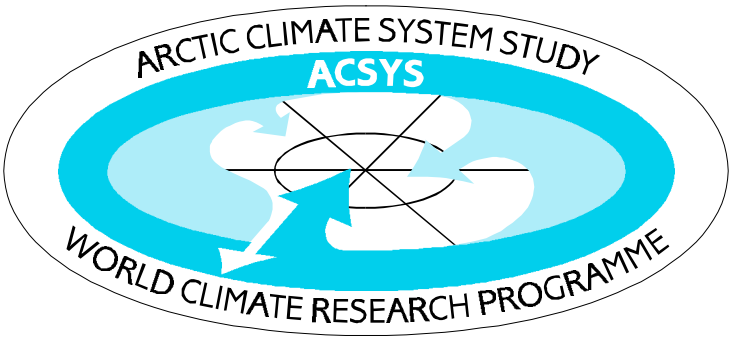
INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION

WORLD METEOROLOGICAL ORGANIZATION

World Climate Research Programme

ARCTIC CLIMATE SYSTEM STUDY

(ACSYS)



REPORT OF THE JOINT ACSYS/EMaPS WORKSHOP ON THE CO-ORDINATION OF PHYSICAL OCEANOGRAPHY IN THE NORDIC SEAS

(Tromsø, Norway, 23 August 1998)

December 1998

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Joint ACSYS/EMaPS Workshop
on the Co-ordination of Physical Oceanography
in the Nordic Seas

Tromsø, Norway, 23 August 1998

List of Participants

Dr Christoph Oelke (Chair) International ACSYS Project Office
Prof Knut Aagaard (Polar Science Centre, University of Seattle)
Dr Genrich Alekseev (Arctic and Antarctic Research Institute)
Dr Howard Cattle (Ocean Applications, Meteorological Office/ ACSYS SSG Chair)
Dr Roger Colony (Director, International ACSYS Project Office)
Dr Povl Frich (Hadley Centre, Meteorological Office)
Dr Reinert Korsnes (Norwegian Polar Institute)
Dr Harald Loeng (Institute of Marine Research, Bergen)
Dr Tom McClimans (SINTEF, Trondheim)
Dr Ole Anders Nøst (Norwegian Polar Institute)
Prof Olav Orheim (Director, Norwegian Polar Institute)
Dr Stig Falk-Petersen (Norwegian Polar Institute)
Prof Jan Piechura (Polish Institute of Oceanology)
Dr Carol Williams (European Marine and Polar Science Board, EMaPS)

Minutes

The working agenda for the meeting is attached as Annex A. Participants introduced themselves and their interests. Dr Oelke noted that the meeting was called by Roger Colony with the aim of assessing the merits of developing more pro-active international co-ordination of the Nordic Seas' physical and chemical oceanography. He also summarised three written statements received from Drs. Swift and Maslowski and from Professor Meincke (Annexes C-E). The participants were told about two major European Union-funded projects pertaining to the Nordic Seas: VEINS and ESOP. Brief descriptions of these projects are provided in a note by Dr. E. Fahrbach to the ACSYS SSG VI (Annex B).

In discussion, the following twelve key scientific issues relevant to the Nordic Seas and to their connection to both the Arctic Basin and the wider global ocean circulation were identified:

1. What determines the North Atlantic ice edge and its variability?
2. How are waters both from the North Atlantic and from the Arctic Basin modified within the Nordic Seas?
3. How do the Nordic Seas affect the global water cycle?
4. What drives changes in the Nordic Seas fresh water balance?
5. What determines the size of the Nordic Seas' exchanges, both with the Arctic Basin and the North Atlantic?
6. What controls the modification of meridional heat flux through the Nordic Sea system?
7. How and why are time scales within the system changing?
8. How far does the oceanic stratification extend and how does this affect the impact which surface forcing has on it?
9. What role if any have the Nordic Seas played in the past in rapid climate change and what role may they be expected to play in future?
10. How does/will climate variability and change impact of the Nordic Seas?
11. How does/will climate variability and change affect biological productivity, CO2 draw-down etc.?
12. How well known is the variability of the Nordic Sea hydrographic structure?

The meeting noted that some of these issues were being addressed in part or whole by VEINS and ESOP-2 (in particular items 1-6 above). However, these projects have distinctly limited lifetime funding. This funding would be adequate for notable progress, but would not preclude the need for further work. ESOP-2, in particular, is primarily focused on the Greenland Sea only, rather than the Nordic Seas as a complete system. Within WCRP, Nordic Seas research is of interest not only to ACSYS; but also, in a wider global context, to CLIVAR (c.f. the CLIVAR Implementation Plan, WCRP-103, 1998).

In considering these issues, the meeting reached the following consensus:

- that there are clearly a number of key large-scale scientific issues related to the role of the Nordic Seas for the wider global climate system

- that some of these issues are being addressed by existing projects, but that there is no overarching strategy for developing programmes in the Nordic Seas beyond the current informal arrangements between institutes (which to a large extent works well)

However, there are apparently a number of key questions which were not yet being pursued in relation to the role of the Nordic Seas for global climate, and which more formal international co-operation could play a role in fostering. These could be developed through, for example, the programmes of WCRP (ACSYS, CLIVAR and aspects of the emerging CLIC), EMaPS, or the Arctic Ocean Sciences Board.

The meeting therefore encouraged these bodies to give wider consideration to appropriate mechanisms by which greater international co-ordination of Nordic Seas research could take place. It considered the need for a wider workshop on Nordic Seas research and its co-ordination, but felt it to be premature. However, it noted the forthcoming International CLIVAR Conference (Paris, December 1998) which it expected would provide focus and stimulus in developing co-ordination of Nordic Seas research relevant to climate variability and change. A suggestion that it may also be useful to discuss wider international co-ordination of this issue at future VEINS and ESOP-2 meetings was considered. This would help canvas the views of the broader scientific community working in the area.

Finally, the meeting agreed on the need for attention to the Nordic Seas as well as to the Labrador and Barents Seas -- the whole coming under the umbrella of the sub-Arctic Seas in general.

ANNEXES

ANNEX A

AGENDA

ACSYS/EMaPS Nordic Seas Workshop

Sunday, 23 August 1998
12:00 - 18:00
Rica Ishavshotell, Tromsø, Norway

	Agenda Topics	
12:00-12:15	Welcome	Christoph Oelke/ Roger Colony
12:15-13:30	Scientific Issues Connecting the Arctic Basin and the Nordic Seas	All
13:30-15:00	Review of Advantages/Disadvantages of Internationally-Sponsored Programmes	All
15:00-15:15	Coffee Break	
15:15	Recommendations to the ACSYS-SSG and the WCRP-JSC	All
17:00	Conclusion	
18:00	Meeting Adjourns	

RESEARCH PROGRAMMES IN THE NORDIC SEAS

E. Fahrbach, Alfred Wegener Institut für Polar und Meeresforschung, Bremerhaven, Germany

The present international research in the Nordic Seas is organised into two projects funded by the European Union: ESOP and VEINS. They are complementary to a large extent. However, ESOP will end in 1998, and VEINS is presently funded until summer 2000. The goal of VEINS is to quantify the exchanges between the Nordic Seas and the adjacent ocean areas, and ESOP concentrates on processes occurring in the Nordic Seas, such as deep convection.

Variability of Exchanges in the Northern Seas (VEINS)
European Commission, Mast III Programme
Duration: 1.2.1997 - 30.06.2000

Exchanges between the North Atlantic and the Arctic Ocean result in the most dramatic water mass conversions in the World Ocean: warm and saline Atlantic waters flowing through the Nordic Seas into the Arctic Ocean are separated by cooling and freezing into shallow fresh waters (and ice) and saline deep waters. The outflow from the Northern Seas to the south provides the initial driving of the global thermohaline circulation cell, and the one to the north has a major impact on the large-scale circulation of the Arctic Ocean. Measuring these fluxes is a major requirement to quantify the turnover-rates within the large circulation cells of the Arctic and the Atlantic Oceans, and a basic condition to understand the role of these ocean areas in climate variability on inter-annual to decadal scales.

There are on-going national, European, and international research projects focussing on processes relevant to forming the characteristics of the individual regions of the Northern Seas. However, a study on the climate control of the Northern Seas primarily requires information on integrated fluxes from the Atlantic Ocean through the Nordic Seas into the Arctic Ocean -- and vice versa. This can be achieved by obtaining synoptic time series of water and property transports through key passages.

The overall objective of VEINS is:

To measure and model the variability of fluxes between the Arctic Ocean and the Atlantic Ocean, with a view on implementing a long-term system of critical measurements needed to understand the high-latitude oceans steering role in decadal climate variability.

The VEINS is a three-year programme of synoptic flux measurements through the key passages between the Atlantic and the Arctic Oceans. The key passages form two boundary lines between the Arctic and the Atlantic, encompassing the convective/adjective regime of the Nordic Seas (Greenland/Iceland/Norwegian Seas). With measurements planned along these two lines, it will be possible to monitor

changes (known to occur in the Nordic Seas because of horizontal and vertical re-circulation) and exchanges across the air-sea interface.

For organisational purposes, the project is divided into four regional components (Iceland-Scotland ridge area, North-eastern boundaries, Fram Strait and Denmark Strait area), one modelling component and a data management component.

European Sub Polar Research Programme (ESOP)

Phase 2: The Thermohaline Circulation in the Greenland Sea
European Commission, Mast III Programme
Duration: 1.2.1996 - 31.12.1998

The goal of ESOP-2 is to understand the thermohaline circulation in the Greenland Sea, its sensitivity and impact on global ocean circulation; building on a unique combination of novel experimental techniques, modelling, and experience gained under ESOP-1.

Nordic Seas Workshop

J. Swift, Scripp's Institute of Oceanography, La Jolla, CA, USA, 18 August 1998

Contribution of dense East Greenland Current waters to the northern North Atlantic.

The densest waters present in quantity in Denmark Strait

Overflow Water at the Denmark Strait sill are relatively warm, and saline intermediate waters of Atlantic origin, sometimes termed "lower Arctic Intermediate Water (AIW)" but more accurately termed "warm, salty AIW". But the densest Northwest Atlantic Bottom Water (NWABW) found in quantity is a cold/fresh extremum, not a warm/salty one. The cold/fresh AIW is the source of this dense NWABW, but the fate of the warm/salty AIW is not well understood.

Mauritzen speculated that the two components switch places vertically as they descend south of Denmark Strait by virtue of the colder component's greater compressibility. This is clever, but may be problematic to achieve in a hydraulically-active system. There are other problems to solve here, for example having to do with getting the mixes to satisfy all the tracers. The Atlantic-derived water circulating in the Arctic Ocean forms a significant part of the intermediate waters in the East Greenland Current. Considering recent research results regarding variations in the characteristics and volume of Atlantic-derived waters in the Arctic Ocean, we need to know more about the pathways, modification, and fate of Atlantic water, including that from the Arctic Ocean, in the Nordic Seas, and in its dense outflows.

Contribution of East Greenland Current waters to the Nordic Seas. Arctic Ocean Deep Water mixes with Greenland Sea Deep Water to make Norwegian Sea Deep Water. The same sort of spreading and mixing goes on in the intermediate waters. The AIW in the East Greenland Current is ventilated as it passes the Greenland Sea, and the propagation of salty intermediate waters into the Greenland Sea from the west is also well known. The Iceland Sea must also exchange characteristics with the East Greenland Current; some of the contributions to the East Icelandic Current are well known. There is, however, a need for a careful examination of these exchanges. Recent work in the Norwegian Sea shows that inter-annual variability is going to make interpretation difficult, but perhaps when one considers the different waters available to individual isopycnal surfaces, the choices will not be too overwhelming and sense can be made. As we come to an improved understanding of the role of Atlantic-derived waters in the Arctic Ocean, and the inter-annual-to-decadal variations in the characteristics and volume of these waters, we see that these waters and their fluctuations must be impressed upon the Nordic Seas and eventually the dense layers of the northern North Atlantic.

I would like the opportunity to work with the community on these problems, for example including carrying out and interpreting closely-spaced, densely sampled WOCE-like vertical sections (of reference quality and with a suite of useful tracers), such as one from ca. Iceland to Spitsbergen (more or less), and the other from Greenland to Norway just north of Iceland. There are other similar possibilities of equal interest. I wish to be involved in this sort of CTD/hydrographic work in the future. I know that Peter Schlosser and Bill Smethie share many of my interests, and I have corresponded with others. I will be pleased to help draft, review, and/or rewrite some elements of a plan for these activities, and to otherwise contribute to any present and future ACSYS

initiatives related to understanding the hydrography of the waters of the Nordic Seas and their dense outflows.

Speaking more generally to your letter, I think it clear that one cannot understand "the response of the Arctic to global change" or "the global response to changes in the Arctic" without carefully and explicitly considering the role played by and within the Nordic Seas. This region is not a water mass conduit between the Arctic and Atlantic Oceans. The WCRP WOCE program more or less ignored everything north of the Greenland-Scotland sills. WCRP ACSYS can help to rectify that error by recognizing that the Nordic Seas and Arctic Ocean are a closely coupled, interdependent system, the "Arctic Mediterranean Seas". ACSYS goals cannot be achieved with an Arctic Ocean-only focus.

Nordic Seas Workshop

W. Maslowski, Naval Postgraduate School, Monterey, CA, USA, 13 August 1998

I believe that the Nordic Seas are a unique area where arctic climate variabilities can be detected, and the needed measurements are much easier, logistically, to make. A much better understanding of the Great Salinity Anomaly of the late 1960s and 1970s would be possible should we have some observations of fresh water fluxes through the Fram Strait starting in the 1960s. The observational database available from the Nordic Seas is probably the most significant in validation and further development of arctic ocean and sea ice models. The points listed below are major/critical issues that I believe are of particular interest to studying the Arctic Ocean and its role in climate:

1. Heat, salt, and mass transport and variability of the Norwegian Atlantic Current (NAC) from the North Atlantic into the Norwegian Sea: in particular; are we able to monitor this flow to understand the Arctic Ocean heat and salt sources and their variations better?
2. Separation of the NAC into the North Cape Current (NCC) and the West Spitsbergen Current (WSC): rates, seasonal and inter-annual variability, water mass structure, correlation with large scale atmospheric systems (Icelandic Low, NAO). Monitoring exchanges with the Barents Sea along the Norway - Spitsbergen line: can this be done?
3. WSC as the main supplier of the arctic-wide boundary flow distributing Atlantic water throughout the basin: is this true? What is its contribution relative to the outflow from the Barents Sea? How about the re-circulation of Atlantic water north of the Fram Strait (over the Yarmak Plateau)? Is this a problem in estimating the heat and mass fluxes into the Arctic Ocean?
4. Monitoring the sea ice, fresh water, and total mass fluxes to the south across the Fram Strait? Is it possible that the data collected there by Torgny Vinje and his colleagues be extended to include the ice thickness distribution across the strait, as well as some observations of the liquid fresh water outflow? Time-series of such parameters could serve as indicators of potential future climate variability as well as critical model constraints.
5. Water column structure and changes across the East Greenland Current (EGC) and the Greenland Sea: shelf-basin communication across the East Greenland Front, southward transport of sea ice and fresh water, open ocean convection, deep water formation, mixing of AODW with GSDW, deep water exchanges with the Norwegian Sea, deep water overflow onto the Icelandic Plateau, separation of the Jan Mayen Current (JMC) and its role in the overall Greenland Sea Gyre circulation.
6. Dense overflows across the Greenland-Iceland-Scotland Ridge system and their contribution to formation of North Atlantic Deep Water: temporal variability, relative importance of each of the exits, origin of Denmark Strait Overflow Water (DSOW) and Norwegian Sea Deep Water (NSDW), fresh water content of waters exiting the Nordic Seas.

I am sure there is a number of other important issues such as transport of contaminants, atmospheric moisture fluxes; etc., but those will probably be covered by other experts participating in this meeting. I hope it will be a good one. Please keep me informed about outcomes of this workshop, including its recommendations and future research strategy.

Nordic Seas Workshop

J. Meincke, University of Hamburg, Hamburg, Germany, 23 June 1998

I will be at sea during the proposed workshop, but there will be enough competent people available. Rüdiger Gerdes will know enough about ongoing VEINS-activities. With respect to international umbrellas for Nordic Seas work, I do not see a real pressing need. There is a solid and continuous base of physical oceanography field-work by the bordering countries because of their vital interest in sustained fishing. Most of these efforts are in joined programmes, often co-ordinated by ICES. From my experience, it is always easy to initiate joint projects, provided your colleagues are convinced that there was a healthy balance of give-and-take for their areas of responsibility. One should keep in mind that for countries like Iceland, Faeroes, and Denmark -- and partly also Norway-- the physical oceanography potential is there because of well-defined governmental needs and not so much for curiosity-driven basic research. This partly explains why much of the results from this work are published in the grey rather than in revised literature. However, past experience has shown that the boundaries between these two different types of work can be soft.

In essence, I want to point out that there is a good amount of ongoing work and well developed mechanisms of co-ordination for the Nordic Seas. This may not be so evident to the “outside” world of project-oriented science, but I consider this to be a fault of both sides. Therefore, instead of worrying that the Nordic Seas are not under the umbrella of large international programmes, one should rather try to foster communication between the international and the regional programmes.

These are “philosophical” remarks which may help to avoid a rush towards “helping the orphan”. Incidentally, under the new *EU-5th Framework Programme*, there will be a number of projects in the Nordic Seas under the heading *Regional Consequences of Global Change.*