Mitt. POLLICHIA	**88** (Suppl.)	35 – 42	5 Abb.		Bad Dürkheim 2001 ISSN 0341-9665

Peter Wadhams

Memories of MIZEX

Kurzfassung

Die Geschichte des „Randeis-Zonen-Experiments" (MIZEX), das 1983–87 im Beringmeer und der Grönlandsee durchgeführt wurde, wird auf der Grundlage der persönlichen Erinnerungen des Autors beschrieben. Die Experimente wurden organisiert vom Büro des Arktischen Meeresforschungs-Programms unter der Leitung von Leonard Johnson; die Rolle, die er dabei spielte, war grundlegend für den Erfolg des Forschungsprogramms.

Abstract

The history of the Marginal Ice Zone Experiments (MIZEX), carried out in the Bering and Greenland seas from 1983–87, is described based on the author's personal memories. The experiments were organised by the Office of Naval Research Arctic Program while Leonard Johnson was Manager, and his role was central to their success.

Résumé

L'histoire qui décrit „l'expérience des zones glaciaires excentrées" (MIZEX) faite pendant les années 1983–87 dans les mers de Béring et du Groenland s'inspire des souvenirs personnels de l'auteur. Les expériences étaient organisées par l'équipe chargée d'élaborer le projet de l'océanographie arctique sous la direction de Leonard Johnson. L'influence qu'il y exerçait était indispensable pour la réussite du projet de recherche.

Keywords

Sea Ice, Oceanography, Ice Edge, Arctic

1. Introduction

The Marginal Ice Zone Experiment, or MIZEX, was one of the largest of the field-oriented research projects originated and supported by the Office of Naval Research Arctic Program, which together solved some of the most important fundamental problems of Arctic marine science. Its dates (planning from 1980; field work 1983–1987) cover the period when Leonard Johnson was manager of the ONR Arctic Program, and given his proactive approach to research management we can truly describe MIZEX as "Leonard's baby". As a tribute to Leonard Johnson, this lecture describes the history of MIZEX as seen by one of the scientists involved, and tries to assess the impact of MIZEX on the progress of Arctic marine science, especially its role in stimulating US-European co-operation.

2. The Gestation of MIZEX

MIZEX was the second major integrated science project created by the ONR Arctic Program. After two decades of supporting individual small-scale oceanographic and glaciological projects, and larger-scale monitoring programmes such as establishing camps on the drifting ice stations T-3, ARLIS-II and Station Alpha, ONR launched AIDJEX, the Arctic Ice Dynamics Joint Experiment, in 1968. AIDJEX broke new ground: it was international (the main collaborator was Canada); it was designed to solve a specific large-scale problem, the nature of ice dynamics in the Arctic Basin, rather than carry out exploration or long-term monitoring; it was driven by a scientific steering group who had the needs of modelling in mind; and it involved extensive collaboration between surface-based observations and airborne remote sensing. The need for a continuing core of logistical and scientific expertise through the AIDJEX period led to the establishment of an AIDJEX Project Office at the University of Washington, which later mutated into the Polar Science Center, one of the strongest polar research centres in the US. The ice-ocean dynamics model which emerged from AIDJEX was a large step forward towards a further model, itself tested with AIDJEX data and generated by an AIDJEX participant (HIBLER, 1979), which is still the basis of most ice dynamic-thermodynamic modelling today. AIDJEX results appeared in the proceedings of a 1977 conference (PRITCHARD, 1980) and in numerous papers.

By 1977 AIDJEX was running down and the question arose of the next important problem to tackle. AIDJEX had led to fundamental new understanding of the nature of Arctic Basin ice and ocean dynamics. The obvious need was to gain an equivalent understanding of the processes which occur around the edges of the ice cover, and which mark the interactions of the Arctic marine system with sub-polar regions. This region had no specific name, but became known loosely as the seasonal sea ice zone (SSIZ) or the marginal ice zone (MIZ). There is a real difference between these definitions. Strictly, the SSIZ is the 10 million km^2 area between the annual average sea ice maximum and minimum, the geographical region which is affected by sea ice but is not covered by sea ice year-round. The marginal ice zone is a smaller, movable region which at any instant is the outermost zone of the ice cover, some 200 km wide, where the characteristics of the ice are affected by proximity to the open sea. The MIZ moves with the ice cover; the SSIZ is fixed. But both are different from the central Arctic Basin on which AIDJEX concentrated its attention.

The first formal effort to develop a research programme for the SSIZ/MIZ was an International Workshop on the Seasonal Sea Ice Zone, held at the Naval Postgraduate School (NPGS), Monterey, California, from February 26 to March 1 1979. The meeting was organised by ONR and NPGS, with local arrangements by the late Warren Denner, first holder of the newly-established annual ONR Chair in Arctic Marine Science. The meeting was divided into seven panels, each of which featured a review paper on the state of knowledge and perceived research problems. The panels were on ice; oceanography; meteorology and climatology; biology; acoustics; coastal processes and engineering; and modelling. I was survey author for the ice panel. The idea was that each panel would try to evolve a research strategy to solve problems in their own discipline. Then the whole output would be brought together by a steering committee (chaired by Willy Weeks) into an overall strategy which could form the basis of a research programme. The review papers and discussions were published as volume 2 of the recently established journal Cold Regions Science and Technology (ANDERSEN et al., 1980).

From the results of this meeting it was clear that two kinds of research were needed: a field-oriented set of process studies, in the tradition of AIDJEX but inevitably using ships rather than drifting camps, to determine the nature of MIZ processes; and a larger-scale modelling and data assessment programme to determine the role played by the MIZ or SSIZ in the overall scheme of both Arctic and global energy interactions. To take the planning process further, Ola Johannessen (then at University of Bergen, but soon to set up the Nansen Environmental and Remote Sensing Centre) called a meeting to be held at Voss, a mountain resort above Bergen, on October 5–8 1980. I vividly remember Voss, as it cut across my marriage plans, which were for a ceremony on October 4 in Italy. My wife rightly objected to the concept of a honeymoon at a scientific conference, even in the Norwegian mountains, so we postponed our wedding until October 11.

The Voss meeting included Walter Munk, who was interested in the concept of acoustic tomography in Arctic regions, and who supplied fundamental scientific insight to many aspects of the deliberations. The outcome of the meeting was that the two scales of necessary research were to be embodied in two research plans. A mesoscale research plan for the ship-based process research was to be drawn up by a writing group of which I was asked to be chairman, and a large-scale research plan for the wider aspects was to be drawn up by a group chaired by Norbert Untersteiner. I was about to leave for Monterey to be the third occupant of the ONR Arctic Chair, so found myself with the mission of holding several meetings with a group of colleagues and coming up with a research plan. This involved sessions in various US locations and kept me away from such Monterey joys as watching palm trees grow outside my office window. Nevertheless, to a deprived Englishman California was a real eye-opener; one visit was to Walter Munk at Scripps, and when he spotted me gazing in wonder as the faculty took to surfboards at lunchtime, he said “You don’t have to suffer to do good science!” I often wish that I had taken this advice to heart. Instead I returned to Cambridge.

The MIZEX research plan was published in June 1981 (WADHAMS et al., 1981). It called for summer and winter experiments in which a 200 x 200 km sector of the East Greenland MIZ in the Fram Strait region was chosen as the focus of attention, the so-called “Voss Box”. This was because Fram Strait handles most of the heat and water exchange between the Arctic Ocean and the rest of the world ocean. Shipborne ice drift and process studies would be closely correlated with airborne remote sensing studies, partly to provide proper mapping of the processes on several scales and partly to provide urgently-needed data on the interaction between sea ice types and electromagnetic waves, prior to the launch of a new generation of polar remote sensing satellites. The first work was scheduled for summer 1983, with a larger-scale summer programme for 1984 and a winter experiment to follow some time later.

3. MIZEX-West

Before the first Greenland Sea field season could get under way, an experiment was carried out in the Bering Sea in the winter of 1983 under the auspices of Seelye Martin at the University of Washington. This became known as MIZEX-West and was an opportunity to test some of the MIZEX experimental strategies in the context of the thinner ice of the winter Bering Sea. Two ships were involved, the NOAA ship “Discoverer" and the USCG "Westwind", one of the famous Wind class of veteran wartime icebreakers. "Westwind" worked deep inside the ice while "Discoverer" carried out experiments using drifting buoys and instrumented ice floes to map the dynamics, wave field and melt rates of MIZ ice in the vicinity of St. Matthew Island as well as the structure of the ocean under the MIZ. This was a fairly simple shelf structure, with a front coinciding with the shelf break and with the average winter ice limit. Results of MIZEX-West were summarised in an EOS article (MIZEX-West Study Group, 1983), in a Journal of Geophysical Research special issue on marginal ice zones (1983), and in an issue of a newly established newsletter, MIZEX Bulletin, published by US Army Cold Regions Research and Engineering Laboratory, Hanover N.H. and edited by HIBLER and myself (MIZEX Bull., 1981–1986).

Fig. 1: "Discoverer" on MIZEX-West deploying radar reflector in the Bering Sea, 1983

4. MIZEX-83

MIZEX-83 was carried out in June–July 1983 in the Voss Box. The main ship involved was the chartered ice-strengthened vessel "Polarbjørn" of Rieber Shipping, with Ola Johannessen as Chief Scientist, although there was also participation by the splendid and then-new icebreaking research ship "Polarstern" of Alfred Wegener Institute. ONR had appointed Dean Horn as MIZEX Co-ordinator, who did a fine job in smoothly locking together the shipborne work and the many airborne studies, which eventually involved seven aircraft (Convair 580 of Canada Centre for Remote Sensing; P-3s of Naval Research Laboratory, NOAA and Norwegian Air Force; Convair 990 of NASA; B-17 of CNES, France; and Falcon 20 of DFVLR, Germany). The ship was used for CTD measurements and to tend arrays of buoys used to track ice motion (using radar transponders), wave energy and upper ocean structure, including internal wave action using 500 m-long suspended thermistor chains. An ambitious meteorology programme involved wind measurements from the surface to the top of the atmosphere, finding that the drag coefficient over the MIZ was significantly higher than over open water or interior ice. The oceanographic studies focused on a large 60 km-wide ice-ocean eddy located over the Molloy Deep, a 5500 m-deep depression at 79° 10'N, 3° E. The eddy had originally been surveyed during the 1980 Swedish "Ymer-80" cruise (WADHAMS & SQUIRE, 1983) but was extensively resurveyed (JOHANNESSEN et al., 1984) and was later hypothesised (SMITH et al., 1984) to be a topographically trapped feature rather than an ice edge instability. A biological programme involved nutrient and plankton sampling, and found a maximal phytoplankton biomass over the Molloy Deep eddy.

Fig. 2: "Polarbjørn" on MIZEX-83, Greenland Sea

Fig. 3: "Polarstern" MIZEX-83 and -84

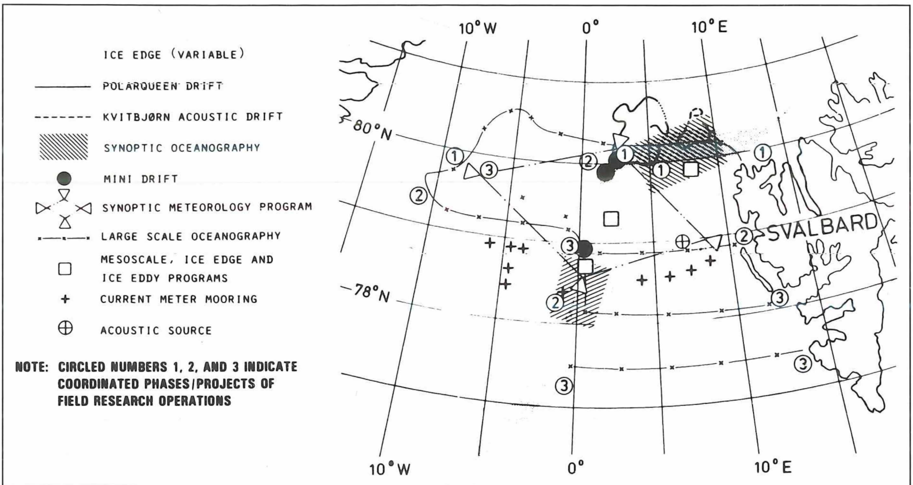
5. MIZEX-84

MIZEX-84 was a more ambitious summer experiment, covering the May-July period and involving work by 7 ships in all, 8 aircraft and more than 200 scientists from Canada, Denmark, Finland, France, Germany, Ireland, Norway, Sweden, Switzerland and the UK as well as the US. Co-ordination of the various ships was done in situ from "Polarstern". One ship, the "Polar Queen" of Rieber Shipping (Miles McPhee, Chief Scientist) was used for a long-term drift in the northern part of the Voss Box. Among the topics studied was the oceanic boundary layer under ice. McPhee remembers: "I think the MIZEX 84 drift was possibly the most productive I have ever been on in terms of increasing our understanding of the ocean boundary layer. We measured ocean turbulent heat flux directly for the first time ever, established that basal melting rate was controlled by salinity in molecular sublayers, and documented the effect of internal wave generation on momentum and energy transfer in the boundary layer."

A smaller Rieber ship, “Kvitbjørn” (very recently a sealer to judge by the smell in the hold) was also used initially for a drift experiment in which acoustic propagation was studied by a group from MIT. Transmissions were carried out from ship to ship and from buoys to ships and much was learned about MIZ acoustics, as well as permitting high-resolution studies of ice kinematics to be done. During the latter part of the experiment “Kvitbjørn” continued to drift in the MIZ as a centre for the last of three “minidrift experiments”, in which radar transponder arrays were tracked so as to measure ice dynamics, wave decay and currents. The meteorology programme was expanded to included rawinsondes, tethersondes and low-level aircraft overflights. The oceanographic programme from the various ships focused on smaller, shorter-lived ice edge eddies of 20–40 km diameter which were clearly the products of instabilities in the polar front. Typically they extended to 500 m depth with current speeds of 30–50 cm s^{-1}, with the eddy propagating downstream at 10–15 km d^{-1} and lasting about 20 days. An expanded biological programme was carried out, and modelling studies on MIZ processes began to appear.

Fig. 4: “Kvitbjørn” on drift experiment, MIZEX-84

Fig. 5: MIZEX-84 map and program overview



The experiment was summarised by the MIZEX Group (1986) and many of the results appeared in the second and third JGR special issues on the MIZ (JGR, 1987, 1991).

6. MIZEX-87

It had always been planned to carry out a winter marginal ice zone experiment, and indeed with hindsight one wonders why this was not done from the outset, since all thermodynamic processes of ocean-atmosphere interaction, and most dynamic processes, are far more vigorous during the winter months. Nevertheless it was felt at the time that since we knew nothing about the MIZ it would be better to start with experiments during a relatively benign period of the year. After publication of a science plan by DAVIDSON et al. (1986), an experiment took place during winter 1987. Three ships took part. ONR chartered Rieber's "Polar Circle" for work inside the ice, while the University of Bergen's "Håkon Mosby" and Hamburg's "Valdivia" worked in the open water. The same set of experiments was done as during MIZEX-83 and -84, but with a special emphasis on acoustics. It was found, for example, that "hot spots" of especially high ambient noise occurred in the centres of ice edge eddies in winter, possibly due to the ice shear and floe collisions occurring here.

SPRI involvement is described by ROTTIER (1989), and main results are summarised by the MIZEX Group (1989) and in specific papers such as JOHANNESSEN et al. (1994).

7. The Legacy of MIZEX

As a result of the MIZEX experience in Europe's "backyard" of the Greenland Sea, Europe began to organise its own serious efforts in Arctic marine research, with laboratories from more than one country learning to share ships and other resources in collaborative research projects such as the Greenland Sea Project. These acted as a prelude to subsequent EU-sponsored projects in the Arctic such as ESOP, VEINS and CONVECTION, with once again MIZEX being a pioneer in its emphasis on the Greenland Sea and its climatic role. Thus the excellent European Arctic set-up of today owes much to US generosity and vision. The research strategy of MIZEX, involving multi-level collaboration among ships and ice camps, aircraft and satellites, has also been a model for the design of all subsequent experiments on air-sea-ice interaction.

A whole new generation of scientists was introduced to the Arctic by MIZEX and given serious responsibilities in a complex programme. Again, Miles McPhee speaks for many Arctic scientists of today when he writes "Leonard had enough faith to invest a fair amount in a young, pretty much unproved scientist, and for that I am forever grateful."

8. Acknowledgements

This worm's eye view is entirely my own and is undoubtedly incomplete and biased. I have consulted many MIZEX participants but have refrained from incorporating their most outrageous memories (inevitably preceded by "Hey, you remember the time when...") into the necessarily brief text. Nevertheless, I would like to acknowledge those contributors to MIZEX who are no longer with us: Bill Campbell, co-author of the MIZEX Science Plan and enthusiast for science par excellence, who did so much to set up the airborne remote sensing programme; Arnold Hanson, a true pioneer of Arctic sea ice research; and Warren Denner, who set up the Monterey meeting that started the whole thing and who later helped to organise an equivalent project off Labrador, LIMEX. But most of all, MIZEX was Leonard Johnson's baby: the good science that flowed from it, and the scientific careers that it nurtured, are a tribute to him personally and to

the generous and broad view of how to do science that was a feature of the ONR Arctic Program.

9. References

ANDERSEN, B. G., WEEKS, W. F. & NEWTON, J. L. (1980) (Eds.): The seasonal sea ice zone. – Cold Regions Sci. Technol., **2**: 357 pp.

HIBLER, W. D. (1979): A dynamic thermodynamic sea ice model. – J. Phys. Oceanogr., **9**(4): 815–846

HIBLER, W. D. & WADHAMS, P. (Eds.): MIZEX Bulletin (1981–1986), Issues I–VIII. – US Army Cold Regions Res. & Engng. Lab., Hanover N. H., Special Repts

JOHANNESSEN, O. M., SANDVEN, S., BUDGELL, W. P., JOHANNESSEN, J. A. & SHUCHMAN, R. A. (1994): Observation and simulation of ice tongues and vortex pairs in the marginal ice zone. – In: JOHANNESSEN, O. M., MUENCH, R. D., OVERLAND, J. E. (Eds.): The Polar Oceans and their Role in Shaping the Global Environment. – Amer. Geophys. U., Washington: 101–136

Journal of Geophysical Research (1983, 1987, 1991): Marginal ice zone special issues, **88**(C5), **92**(C7) & **96**(C3)

MIZEX Group (1986): MIZEX East 83/84, The summer Marginal Ice Zone Program in the Fram Strait/Greenland Sea. – EOS, **67**(23): 513–517

MIZEX Group (1989): MIZEX East 1987, The winter Marginal Ice Zone Program in the Fram Strait/Greenland Sea. – EOS, **70**(17): 545

MIZEX-West Study Group (1983): MIZEX-West Bering Sea marginal ice zone experiments. – EOS, **64**(40): 578–579

PRITCHARD, R. S. (Ed.) (1980): Sea Ice Processes and Models. 474 pp., Seattle

ROTTIER, P. (1989): SPRI participation in the Winter Marginal Ice Zone Experiment, MIZEX-87. – Polar Record, **25**(152): 33–36

SMITH, D. C., MORISON, J. H., JOHANNESSEN, J. A. & UNTERSTEINER, N. (1984): Topographic generation of an eddy at the edge of the East Greenland Current. – J. Geophys. Res., **89**(C5): 8205–8208

WADHAMS, P., MARTIN, S., JOHANNESSEN, O. M., HIBLER, W. D., & CAMPBELL, W. J. (1981): MIZEX, A Program for Mesoscale Air-Ice-Ocean Interaction Experiments in Arctic Marginal Ice Zones. I. Research Strategy. – US Army Cold Regions Res. & Engng. Lab., Hanover N.H., Special Rept.: 81–19

WADHAMS, P. & SQUIRE, V. A. (1983): An ice-water vortex at the edge of the East Greenland Current. – J. Geophys. Res., **88**(C5): 2770–2780

(Manuscript received: 27 January 2002)

Author's address:

Prof. Dr. Peter Wadhams
University of Cambridge – Scott Polar Research Institute
Lensfield Rd.
GB – Cambridge CB2 1ER
e-mail: pw11@cam.ac.uk

Zeitschrift/Journal: Mitteilungen der POLLICHIA

Jahr/Year: 2001

Band/Volume: Sup_88

Autor(en)/Author(s): Wadhams Peter

Artikel/Article: Memories of MIZEX 35-42