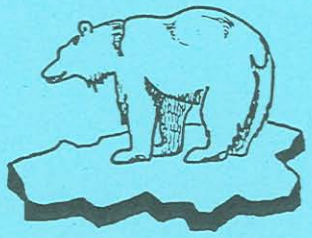
Expeditionsprogramm Nr. 21



FS „Polarstern“

ARKTIS VIII / 1 und 2
1991

ARK VIII / 2 = Second European Polarstern Study (EPOS II)
ESF-Study of the European Arctic Shelf (SEAS)

Koordinator: D. Fütterer

Chief Scientists / Fahrtleiter
ARK VIII / 1: G. Kattner
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Alfred-Wegener-Institut für Polar- und Meeresforschung
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Zusammenfassung

Im Sommer 1991 wird Forschungsschiff "Polarstern" auf seiner achten Expedition in die Arktis ein weitgespanntes wissenschaftliches Programm mit starker internationaler Beteiligung und in Kooperation mit anderen Schiffen absolvieren. Die in diesem Heft dargestellten Fahrtabschnitte ARK VIII/1 und ARK VIII/2 führen in die Grönlandsee/Framstraße bzw. in die nördliche Barentssee. Nach den geplanten Untersuchungen im Ausstrombereich des Arktischen Ozeans in der Framstraße werden Arbeiten in der nördlichen Barentssee über ozeanographische und biologische Prozesse auf dem Schelf durchgeführt. Diese Prozesse sind wahrscheinlich entscheidend für die Lebensbedingungen in den tiefen arktischen Becken, welche während des Abschnitts ARK VIII/3 untersucht werden (Expeditionsheft Nr. 22).
FS "Polarstern" wird am 1. Juni zum Abschnitt ARK VIII/1 von Bremerhaven Richtung Framstraße auslaufen. Ozeanographische, ökologische und geologische Arbeiten ergänzen die bisherigen Untersuchungen in diesem Gebiet und dienen zudem der Vorbereitung künftiger Aktivitäten im Bereich der Nordostwasser-Polynya an der grönländischen Küste. Geräte-Verankerungen, die im vergangenen Jahr zur Messung des Ausstromes polaren Wassers ausgebracht wurden, sollen geborgen werden; neue Verankerungen auf 79° N sollen diesen Ausstrom besser quantifizieren helfen. Messungen der Pflanzennährstoffe und verschiedene planktologische Untersuchungen auf einem Schnitt entlang dieser Breite werden ebenso wie geologische Arbeiten (über Sedimentablagerungen) bisherige Kenntnisse vertiefen helfen; außerdem dienen sie als Voruntersuchungen für ein 1993 geplantes Polynya-Programm.
Im Bereich westlich von Spitzbergen werden die Plankton-Arbeiten sich mit denen des nachfolgenden Fahrtabschnitts verzahnen lassen.

Dieser Abschnitt, ARK VIII/2, beginnt am 20. Juni in Tromsö und wird dort auch wieder am 30. Juli enden. Als 2. Europäische "Polarstern"-Studie (EPOS II) der European Science Foundation (ESF) wird er über 50 Wissenschaftler aus 15 Staaten zu hauptsächlich ökologischen Forschungen zusammenbringen. Die Arbeiten beginnen in der zentralen Barentssee, wo im Bereich der Polarfront und dann an der Eiskante intensive hydrographische, chemische, planktologische, benthologische und sedimentologische Studien durchgeführt werden, die sich alle um die Frage des organischen Partikelflusses zwischen der Deckschicht und dem bodennahen Wasser kümmern.
Vor allem im Bereich des Storfjordes und dann nördlich von Spitzbergen wird als zentrale Fragestellung der Ozeanographen die Entstehung und die Zirkulation des spezifisch dichten Bodenwassers neben der Beschreibung der Wege des atlantischen Wassers entlang des nördlichen Schelfhanges hinzukommen. Diese Wasserversetzungen dürften für die Erneuerung des Tiefenwassers des Arktischen Ozeans und zugleich für den Transport von Lebewesen, Nahrungspartikeln und anorganischen Sedi-

menten von entscheidender Bedeutung sein. Auf Schnitten vom Schelf hinab ins tiefe Nansen-Becken sollen diese Verhältnisse vor allem nordöstlich von Spitzbergen studiert werden.
Die Arbeiten werden ergänzt durch geologische Beprobungen und durch Untersuchungen der Eisverhältnisse und der möglichen Partikelimporte aus den Eisfrachten. Auf der gesamten Reise werden zudem genaue Registrierungen des Vorkommens von Vögeln, Walen und Robben durchgeführt.

Summary

The eighth expedition of RV "Polarstern" to the Arctic in summer 1991 will cover a diverse scientific programme with strong international participation as well as cooperation with other vessels. Legs ARK VIII/1 and ARK VIII/2 will go to the Greenland Sea/Fram Strait and to the northern Barents Sea.
RV "Polarstern" will leave Bremerhaven at June1 for oceanographic, ecological and geological investigations in the Fram Strait, which are complementary to previous work in this area and at the same time preparatory for activities planned in the northeast water polynya off Greenland. Moorings for measurements about the export flux of polar water will be recovered; and new moorings will be deployed along 79° N. Measurements about plant nutrients combined with plankton work along this latitude as well as geological sampling for sedimentation studies will enlarge our knowledge about the area and provide preliminary information for a polynya study planned for 1993. West of Spitsbergen the plankton work will be linked to the studies of the subsequent "Polarstern" leg.
This leg, ARK VIII/2, from June 20 to July 30, will start and terminate at Tromsö. More than 50 scientists from 15 countries will be on board for multidisciplinary ecological research (EPOS II: "Study of the European Arctic Shelf" of the European Science Foundation, ESF). This research will start in the frontal zone and near the ice edge in the central Barents Sea, including extensive hydrographic, chemical, planktological, benthological and sedimentological work focussing at the vertical flux of organic particles (pelago-benthic coupling).
In the Storfjord and thereafter in the area north of Spitsbergen the formation and circulation of cold, dense bottom water will be the main objective of the oceanographers, as well as the description of the circulation of Atlantic water along the northern shelf slope. The advective processes related to these water motions are regarded essential for the renewal of the bottom water of the deep Arctic Ocean as well as for the transport of organisms, food and anorganic particles. The water circulation and the related biological phenomena will be studied mainly along transects from the shelf down into the Nansen Basin northeast of Spitsbergen. Geological sampling, ice research and observations of birds, whales and seals will complete the effort of the ESF study.

1 Fahrtabschnitt ARK VIII / 1

Bremerhaven - Tromsö : 1. Juni - 19. Juni 1991
Fahrtleiter: Gerhard Kattner

Grönlandsee / Framstraße

1.1 Einleitung

Die ozeanographischen, biologischen und geologischen Arbeiten dieses Fahrtabschnitts in die Framstraße ergänzen die Untersuchungen der bisherigen Fahrten in dieses Gebiet. Verankerungen, die im letzten Jahr ausgebracht wurden, sollen geborgen werden und neue Verankerungen auf 79°N ausgebracht werden, um den Ausstrom polaren Wassers durch die Framstraße besser quantifizieren zu können. Diese Arbeiten werden mit ökologischen Untersuchungen auf einem Schnitt entlang dieser Breite kombiniert, der nach Westen bis an die grönländische Küste in die Nordostwasser-Polynya gehen soll und somit als Vorstudie für das 1993 stattfindende Polynya-Programm dienen wird; nach Osten soll bis in die Nähe Spitzbergens vorgestoßen werden, um das Programm mit den Forschungen des anschließenden Fahrtabschnitts zu verknüpfen. Geologische Arbeiten sollen erste Daten über Sedimentablagerungen im Polynya-Gebiet erbringen.

1.2 Forschungsprogramme

1.2.1 Physikalische Ozeanographie

1.2.1.1 CTD-Messungen (AWI)

Nachdem in den Jahren 1989 und 1990 umfangreiche ozeanographische Untersuchungen im Rahmen des Grönlandseeprojekts durchgeführt wurden, sollen auf diesem Fahrtabschnitt nur hydrographische Messungen begleitend zu den anderen Programmen durchgeführt werden.

Einen besonderen Schwerpunkt bilden dagegen Untersuchungen über die Meßgenauigkeit einer CTD-Sonde. Die extrem hohen Anforderungen, die von solchen Geräten in den polaren Gebieten zur Bestimmung von Wassermassen und Austauschprozessen verlangt werden, liegen an der Grenze der heute erzielbaren Meßgenauigkeit.
Bei der Auswertung der Meßergebnisse vergangener Expeditionen konnte auch im nachhinein keine befriedigende Kalibration erreicht werden. Nach Werksüberholung soll eine Sonde im Grönlandseebecken einer sorgfältigen Überprüfung unter Feldbedingungen unterzogen werden. Das Grönlandseebecken eignet sich besonders für dieses Vorhaben, weil die örtliche und zeitliche Variabilität der Wasserparameter außerordentlich gering ist.

1.2.1.2 Süßwasserexport des Arktischen Ozeans (IFMH, PMEL, NPI)

Der Arktische Ozean führt dem Atlantik schwächer salines Wasser zu und stellt mit ca. 4900 km^3 pro Jahr die zweitgrößte Frischwasserquelle für das Weltmeer dar. Ihre Lage in hohen Breiten macht sie für die globale thermohaline Zirkulation zum entscheidenden Faktor: Veränderungen der Quellstärke führen zu Übergängen in andere - auch stabile - Zirkulationszustände des Atlantiks und entsprechende Klimaveränderungen. Dokumentiert sind bisher Fluktuationen von 20%, die aber nur zur Reduktion der konvektiven Erneuerung im Europäischen Nordmeer geführt haben. Physikalische Begründungen für Fluktuationen im Zeitskalenbereich von Jahren fehlen.

Durch Verankerung von insgesamt 6 Systemen mit Strömungsmessern und ULS (Upward Looking Sonar)-Geräten soll ein mehrjähriges Meßprogramm begonnen werden. Die Verankerungen erfassen Eisdicke, Strömung und Salzgehalt über dem grönländischen Kontinentalabfall bei 79°N. Sie werden in Kombination mit hydrographischen Schnitten entlang der Verankerungslinie und Fernerkundungsdaten zur Eiskonzentration und Eisausdehnung Zeitreihen der Süßwassertransporte liefern.

Parallel zu diesen Arbeiten sind die Aufnahme und Neuauslegung von laufenden Verankerungen in der Grönlandsee und der Framstraße vorgesehen.

1.2.2 Meereschemie

1.2.2.1 Nährsalzuntersuchungen (AWI)

Die meereschemischen Arbeiten stehen in Zusammenhang mit den planktologischen und hydrographischen Untersuchungen. Dazu werden aus Wasserproben verschiedener Tiefen die Nährsalze Nitrat, Nitrit, Ammonium, Phosphat und Silikat mit einem Autoanalyser-System bestimmt. Insbesondere Silikat hat sich als besonders guter Tracer für den Ausstrom arktischen Oberflächenwassers erwiesen. Die Bestimmungen der stickstoffhaltigen Nährsalze sind auch Grundlage für die Untersuchungen des gelösten organischen Stickstoffs (DON) und der Huminstoffe.

1.2.2.2 DON und Huminstoffe (AWI)

Um eine Bilanzierung des Stickstoffkreislaufs im Meerwasser erstellen zu können, ist eine Abschätzung des Anteils des DON am gesamten Stickstoff-Pool notwendig. Ein Hauptbestandteil des DONs sind wahr-

scheinlich die Huminstoffe sowie die gesamten freien und gebundenen Aminosäuren. Daher sollen neben der DON-Bestimmung auch Huminstoffe angereichert und auf ihren Stickstoffgehalt untersucht werden. Weiterhin sollen die Wasserproben durch Bestimmung von Nährstoffen, gebundenen und freien Aminosäuren in den Originalproben und den Huminstoff-extrakten charakterisiert werden. Durch die Anreicherung größerer Mengen von Huminstoffen soll deren C/N- Verhältnis bestimmt werden.

1.2.2.3 Lipide (AWI, IPÖ)

Die Analysen der chemischen Zusammensetzung des Zooplanktons im Frühsommer sollen die während ARK VII/2 (Juli/August 1990) begonnenen Untersuchungen zur saisonalen Energiespeicherung im Meso- und Makrozooplankton vervollständigen. Eine wichtige Rolle spielen in diesem Zusammenhang die Lipide, die aufgrund ihrer chemischen Eigenschaften am besten geeignet sind, Energie schnell in kompakter Form zu speichern. Den herbivoren Planktonorganismen der Polargebiete gelingt es mit Hilfe dieser Stoffgruppe, den kurzfristigen Energieschub der Primärproduktion zu absorbieren und langfristig im Pelagial zu konservieren.

In der Grönlandsee treten drei bestandsbildende calanoide Copepodenarten auf. Die in den Lipiden des Phytoplanktons enthaltenen, mehrfach ungesättigten Fettsäuren werden vom herbivoren Zooplankton weitgehend unverändert in ihre Speicher- und Membranlipide eingebaut. Mit Hilfe der Fettsäuren als Markersubstanzen lassen sich deshalb Rückschlüsse auf den Energiefluß zwischen Phyto- und Zooplankton ziehen. Das Fettsäuremuster wird direkt an Bord gaschromatograpisch bestimmt. Dieses Muster soll in Hälterungsexperimenten durch Zugabe von geeigneten Phytoplanktonkulturen weitgehend umgestellt werden. Zur Erfassung kurzzeitiger Umsetzungen sind Experimente mit C-14 markiertem Phytoplankton vorgesehen.

Neben diesen Versuchen sollen auch der Zusammenhang zwischen Eiproduktion und Lipidgehalt sowie die Lipidanreicherung in Abhängigkeit vom Entwicklungsstadium untersucht werden. Die Analyse der Lipidklassen soll Aufschluß über die Art der Lipidspeicherung geben. Daraus lassen sich z.T. Hinweise auf Überwinterungsstrategien ableiten. An verschiedenen Stationen werden dafür Proben genommen und nach Art, Geschlecht und Stadium sortiert, bei -80°C oder in Chloroform/ Methanol konserviert und im Labor extrahiert und chromatographisch aufgearbeitet.

1.2.3 Meeresbiologie

1.2.3.1 Marine Pilze/Protisten (AWI, IBSS)

In arktischen Geässern kommen sowohl saprophytische als auch parasitische, marine niedere Pilze vor (einige Gruppen werden auch als Protozoen angesehen). Auch im Meereis der Arktis konnten diese protozoenähnlichen Mikroorganismen während "Polarstern"-Expeditionen nachgewiesen werden. Daneben fanden sich im Eis zahlreiche Keime höherer, überwiegend terrestrischer Pilze, deren Vitalität und Keimfähigkeit erhalten geblieben war. Weder über die Einschlußprozesse noch die Aktivitäten dieser Pilze liegen gesicherte Erkenntnisse vor, so daß über ihre ökologische Bedeutung z. Zt. allenfalls spekuliert werden kann.

Ziel der jetzigen Arbeiten ist es, neben qualitativen auch quantitative Daten über die Verteilung, Dichte, Vitalität und Aktivität der Pilzkeime zu gewinnen, eine repräsentative Anzahl der vorkommenden Arten zu isolieren und mit Hilfe geeigneter Laborexperimente Anhaltspunkte über ihre spezifischen Adaptationsmechanismen an die extremen Lebensbedingungen ihrer Umwelt zu erhalten.

Außer Meereis sollen insbesondere die Untereiswasserschicht und die Wassersäule bis etwa 200m Tiefe sowie das darin vorkommende Zoo-, Mikro- und Phytoplankton auf saprophytische und parasitische Pilze hin untersucht werden. Dabei werden neu entwickelte Methoden zum direkten Nachweis der Pilze und ihrer Aktivitäten zur Anwendung kommen. Parallel dazu werden Bakterien- und Chlorophyllgehalte bestimmt. Die Planktonstudien werden in Zusammenarbeit mit den entsprechenden Arbeitsgruppen an Bord durchgeführt.

1.2.3.2 Mikrozooplankton (IFMK)

Die Mikrozooplankter, insbesondere die in dieser Größenklasse oft vorherrschenden Ciliaten, nehmen eine Schlüsselposition zwischen dem vor wenigen Jahren entdeckten "Microbial Loop" und der klassischen "Nahrungskette" ein, die vom Phytoplankton über das Zooplankton zu höheren Konsumenten führt.

Die im "Microbial Loop" umschriebene Nahrungskette der Mikroorganismen, die aus freilebenden Bakterien, heterotrophen Nanoflagellaten und Ciliaten besteht, basiert auf der gelösten organischen Substanz im Wasser. Diese entstammt im wesentlichen dem Phytoplankton und wird von den Bakterien in partikuläre Substanz, in Bakterienbiomasse, umgewandelt. Mit den Ciliaten mündet diese neue Nahrungskette in die klassische Nahrungskette dadurch ein, daß diese wiederum höheren Konsumenten als Nahrung dienen.

Im Untersuchungsgebiet kommen auto-, mixo- und heterotrophe Ciliaten vor. Diese Ernährungsvielfalt soll vor allem durch Feldbeobachtungen und Fütterungsexperimente in Labor näher untersucht werden, um das Nahrungsspektrum und den Stoffumsatz der Ciliaten und damit die ökologische Bedeutung des "Microbial Loop" im arktischen Ökosystem besser beurteilen zu können. Zusätzlich soll versucht werden, dominante Ciliatenarten der Arktis für spätere experimentelle Studien in Kiel in Kultur zu nehmen.

1.2.3.3 Kontinuierliche Partikel- und Fluoreszenzmessungen (IEMR)

Es ist bekannt, daß in Frontengebieten die biologische Aktivität und die Biomasse erhöht sind. Die geringe zeitliche und räumliche Auflösung der herkömmlichen Sammelmethoden machen es schwierig, ökologische Aspekte in den zeitlich variierenden und dynamischen Frontengebieten zu studieren. Mit Hilfe der kontinuierlichen Messung von Partikeln in verschiedenen Größenklassen und der Chlorophyllmessung der *in vivo*-Fluoreszenz kann die Planktonverteilung mit einer Auflösung von 200m bestimmt werden. Chlorophyll wird üblicherweise als Maß für das Phytoplanktonvorkommen benutzt. Da jedoch die Chlorophyllmessung das gesamte Phytoplankton erfaßt, ohne die Arten- und Größenverteilung zu berücksichtigen, ist es wichtig, das Chlorophyllsignal zu differenzieren. Die Unterteilung in verschiedene Partikelfraktionen macht es möglich, die Planktonverteilung mit der kleinskaligen Hydrographie zu verknüpfen.

Die bisherigen Erfahrungen unserer Untersuchungen in der Grönlandsee haben gezeigt, daß die Phytoplanktongemeinschaften erheblich variieren können und zwar innerhalb von Entfernungen, die unterhalb der Auflösung durch den normalen Stationsabstand liegen. Mit Hilfe einer speziellen Software kann der Anteil der verschiedenen Größenklassen am Gesamtchlorophyll abgeschätzt werden.

1.2.3.4 Zooplankton (AWI, IEO, FCM)

Die Arbeiten beinhalten Felduntersuchungen und Laborexperimente.

a) Nordostwasser-Polynya

Die Felduntersuchungen auf dem Ostgrönlandschelf im Gebiet der Nordostwasser-Polynya dienen zur Vorbereitung auf die große Expedition zu dieser Polynya im Rahmen des International Arctic Polynya Project, 1993. Die diesjährige Fahrt wird dabei erstmals die Gelegenheit bieten, das Plankton im Polynyagebiet zu einem frühen Zeitpunkt im Jahr zu untersuchen. Im Mittelpunkt der Feldarbeiten stehen die Erfassung der Phytoplanktonbiomasse (Chlorophyllmessung) und der Zooplanktonbiomasse (Bongo- und Multinetz). Mit Hilfe der Eiproduktionsmethode

soll die Sekundärproduktion des herbivoren Zooplanktons bestimmt werden. Untersucht werden dabei die beiden dominanten Copepoden *Calanus finmarchicus* und *C. glacialis*.

b) Vertikalprofile der Zooplanktonverteilung in der Framstraße

Vertikalprofile der Zooplanktonverteilung auf einem Schnitt über die Framstrasse sollen verglichen werden mit Zooplanktonfängen auf den beiden anschließenden Polarsternabschnitten ARK VIII/2 und 3 im Bereich des atlantischen Einstromes im Eurasischen Becken und so die Untersuchung der Ausbreitung des Grönlandsee-Zooplanktons im Arktischen Ozean ermöglichen.

c) Experimentelle Untersuchungen zur Reproduktionsphysiologie von *Calanus finmarchicus*.

Die Messung der Eiproduktion kann als Methode zur Erfassung der Nettosekundärproduktion im Feld angewendet werden. Dazu müssen die äußeren Einflüsse auf die Eiproduktion und die inneren regulierenden Prozesse während der Eiproduktion im Detail verstanden werden. Fragen wie die maximale Eiproduktion, Legefreqenz und durchschnittliche Gelegegrösse, Gesamteiproduktion der Weibchen während ihres Lebens, der Einfluß der Temperatur auf die Eiproduktion sowie die Ansprechzeit der Eiproduktion auf Hunger- und Fütterungsperioden wurden in den letzten Jahren geklärt.

Während dieser Expedition sollen vor allem der Einfluß der Nahrungskonzentration und -qualität auf die Eiproduktion untersucht werden. Das Ziel ist ein Modell zur vollständigen Beschreibung der Energieflüsse von der Nahrungsaufnahme bis zur Eiablage der Weibchen. Dieses Modell erlaubt dann, aus im Feld gemessenen Eiproduktionsraten aktuelle Wachstumsraten und die dazu benötigte Nahrungsmenge zu berechnen.

d) Beitrag der herbivoren Copepoden zum vertikalen Partikeltransport.

Der Beitrag der herbivoren Copepoden zum vertikalen Partikeltransport und damit zur pelagisch-benthischen Kopplung ist ein wichtiger Bestandteil des Nordostwasser-Polynya-Programms. Hier soll versucht werden, über den in c) untersuchten Zusammenhang zwischen Nahrungsaufnahme und Eiproduktion aus der Messung der Eiproduktionsrate gleichzeitig die Kotballenproduktion der Copepoden abzuleiten. Dazu soll im Experiment die Fäzesproduktion verschiedener herbivorer Copepodenarten und ihrer Entwicklungsstadien bestimmt werden bei unterschiedlichen Futtermengen und -qualitäten.

e) Vergleich der Eiproduktionsmethode mit enzymatischen Methoden der Bestimmung der Sekundärproduktion

Im Gegensatz zur Primärproduktion gibt es kein Standardverfahren zur Bestimmung der Sekundärproduktion des Zooplanktons. Nach mehreren vergeblichen Ansätzen setzt man im Moment große Hoffnung auf das Enzym Transcarbamylase als Indikator für die Sekundärproduktion. Während dieses Abschnittes soll die Transcarbamylaseaktivität von Copepoden mit Eiproduktionsmessungen verglichen werden, deren Eignung zur Bestimmung der Sekundärproduktion einzelner Arten bereits mehrfach nachgewiesen wurde. Dazu sollen Parallelmessungen mit beiden Methoden an frisch gefangenen und unter unterschiedlichen Futter-bedingungen gehälterten adulten Weibchen der Art *Calanus finmarchicus* durchgeführt werden.

1.2.3.5 Meso- und Makrozooplankton (IPÖ)

Die Untersuchungen schließen an die während ARK VII/2 begonnenen Forschungsarbeiten an. Das Zooplankton befand sich im Juli/August 1990 bereits in der Spätsommerphase, während die für Juni 1991 geplanten Untersuchungen den Beginn der Produktionsperiode erfassen und wichtige Hinweise auf die Entwicklung des Planktons im Frühsommer ermöglichen.

Ein Schwerpunkt der Untersuchungen behandelt die bislang in der Arktis wenig untersuchte Frage, welche Bedeutung das räuberische Zooplankton (Chaetognathen, gelatinöse Arten, räuberische Copepoden etc.) im hocharktischen Nahrungsnetz hat. Als Arbeitshypothese wird angenommen, daß der selektive Wegfraß insbesondere von jungen Entwicklungsstadien der dominanten *Calanus*-Arten sowie anderer kleinerer Beuteorganismen einen prägenden Einfluß auf Dichte und Zusammensetzung polarer Zooplanktongemeinschaften hat. Bei ausreichendem Nahrungsangebot, z.B. während der Phytoplanktonblüte, kann das räuberische Zooplankton regulierend auf das Populationswachstum der Herbivoren einwirken. Bei Nahrungsknappheit, z.B. im Winter oder unter dem Eis, kann der Freßdruck der Räuber den Herbivorenbestand stark dezimieren, was wiederum erhebliche Auswirkungen auf die Sekundärproduktion der nächsten Saison haben kann. Dabei spielt auch die saisonal unterschiedliche Vertikalverteilung der Herbivoren und Carnivoren eine wichtige Rolle. Ergänzend zu den Netzfängen sollen an Bord Freßexperimente an verschiedenene Räuber-Beutekategorien durchgeführt werden, um Freßraten abzuschätzen und Verdauungszeiten zu bestimmen. Im Institut werden diese Daten durch Untersuchungen des Darminhalts und der Enzymaktivität der gefangenen Organismen sowie der Zusammensetzung der Kotballen aus den Freßexperimenten vervollständigt. Der Freßdruck

auf die Beutepopulationen soll mit Hilfe der Freßraten und der jeweiligen Räuber-/Beuteabundanzen - wenn möglich für verschiedene Tiefenzonen - ermittelt werden.

Für diese Untersuchungen ist vorgesehen, mit Hilfe des Multinetzes eine tiefenstratifizierte Beprobung des Mesozooplanktons vorzunehmen (0-1000m). Die fluchtfähigen Makrozooplankton-Arten sollen - wenn es die Eisbedingungen erlauben - mit einem horizontal geschleppten Rectangular Midwater Trawl (RMT) erfaßt werden. Zur Beschaffung von Planktonmaterial für experimentelle und biochemische Untersuchungen werden außerdem Bongonetz und Ringtrawl ("Schonnetz") eingesetzt. Die Netzfänge dienen der Ermittlung von Abundanz, Biomasse sowie von populationsdynamischen Parametern (Größe, Altersstruktur, Stadien- und Geschlechterverteilung etc.).

1.2.3.6 Seevögel und marine Säuger (VUB, DQG)

Ziel der Untersuchungen ist die quantitative Bestimmung der Verteilung und die ökologische Bedeutung der Seevögel, Robben und Wale in der Grönlandsee. Die Zählungen werden von der Brücke aus durchgeführt, während das Schiff fährt. Die Daten werden zum einen als Dichte (entweder aus einem eingeschränkten Zählgebiet oder einem unbegrenzten Gebiet und besonderen Umrechnungsfaktoren) und zum anderen als tägliche Nahrungsaufnahme über aus der Literatur bekannte Umrechnungen angegeben. Besondere Berücksichtigung werden Eissturmvogel, Alken, Ross-Möwe und Sabine-Möwe, Grönlandwal, Walroß und Grönlandrobbe finden.

Die Ergebnisse werden im allgemeinen Rahmen der ozeanographischen Daten (Wassermassen, Polynyas und Eisbedeckung) und der ökologischen Daten (Phytoplankton- und Zooplanktonbiomasse, Primär- und Sekundärproduktion, Fische, etc.) interpretiert.

1.2.4 Marine Geologie

1.2.4.1 Winterwassertransport und Sedimentakkumulation im Bereich der Nordostwasser-Polynya (GEOM, SFB 313, ENEA)

Über Schelfgebieten hoher Breiten können sich im Winter neue Wassermassen größerer Dichte bilden, besonders dort, wo es auf freien Wasserflächen zur Bildung von Neueis kommt. Die dichten Wassermassen können bei geeigneter Topographie über die Schelfkante abfließen und dabei auch Sedimentfracht zum Kontinentalhang transportieren. Sedimentiert die Fracht dort endgültig, kann es in geologischer Zeit zur Bildung von Hochakkumulationsgebieten kommen, wie z.B. an

verschiedenen Stellen des Kontinentalhangs vor Norwegen und der Barentssee.

Sedimentkerne aus Hochakkumulationsgebieten dokumentieren in einzigartiger Weise - zeitlich hochauflösend - die Veränderlichkeit klimatisch-ozeanographischer sowie biologischer und sedimentologischer Verhältnisse der Region für die jüngere geologische Vergangenheit. Die Untersuchungen sollen der Vorbereitung der geplanten Arbeiten in der Nordostwasser-Polynya 1992 und 1993 dienen.

Mit dem 3,5 kHz-Sedimentlot (sowie Parasound und Hydrosweep) lassen sich zu erwartende Akkumulationsgebiete am Hang, nordöstlich der Belgica Bank und der Rinne um die Bänke feststellen. Eine asymmetrische Füllung der Rinne mit jungen Sedimenten kann Hinweise auf gerichtete Bodenströmungen und Sedimenttransport geben, die ab 1992 mit Strömungsmessern, Nephelometern und Sedimentfallen an verschiedenen Positionen gemessen werden sollen.

Die Analyse kurzer Sedimentkerne gibt möglicherweise Auskunft über die Stärke und Richtung des Sedimenttransports sowie Qualität und Herkunft des Materials. Sie sollen an Positionen genommen werden, die mit dem 3,5 kHz-Lot vorerkundet wurden.

Eis- und Wasserproben zur rasterelektronischen Untersuchung der lithogenen Partikel dienen der Untersuchung von Eiseintrag und biologisch-physikalischer Resuspension vom Meeresboden. Bodenstrom-messungen mit einem am Meeresboden absetzbaren Strommessergestell (evtl. kombiniert mit einem Nephelometer) geben erste Aufschlüsse über Sediment-transportrichtung in der nördlichen Schelfrinne und in anderen Schelfgebieten.

1.2.4.2 Partikelfluß zum Meeresboden (GeoB)

Als Fortsetzung der seit 1983 laufenden Sinkstoffallenexperimente in der norwegisch-grönländischen See und der Framstraße sollen zwei Sinkstoffallen geborgen und zwei wieder ausgesetzt werden. Diese zeitgeschalteten Sinkstoffallen sollen den Jahresgang des Partikelflusses zum Meeresboden und damit indirekt auch die saisonale Veränderung der Produktivität im Oberflächenwasser erfassen. Ein weiteres Hauptziel ist die Untersuchung des Eintrags eistransportierten Materials und dessen saisonaler und räumlicher Veränderlichkeiten.

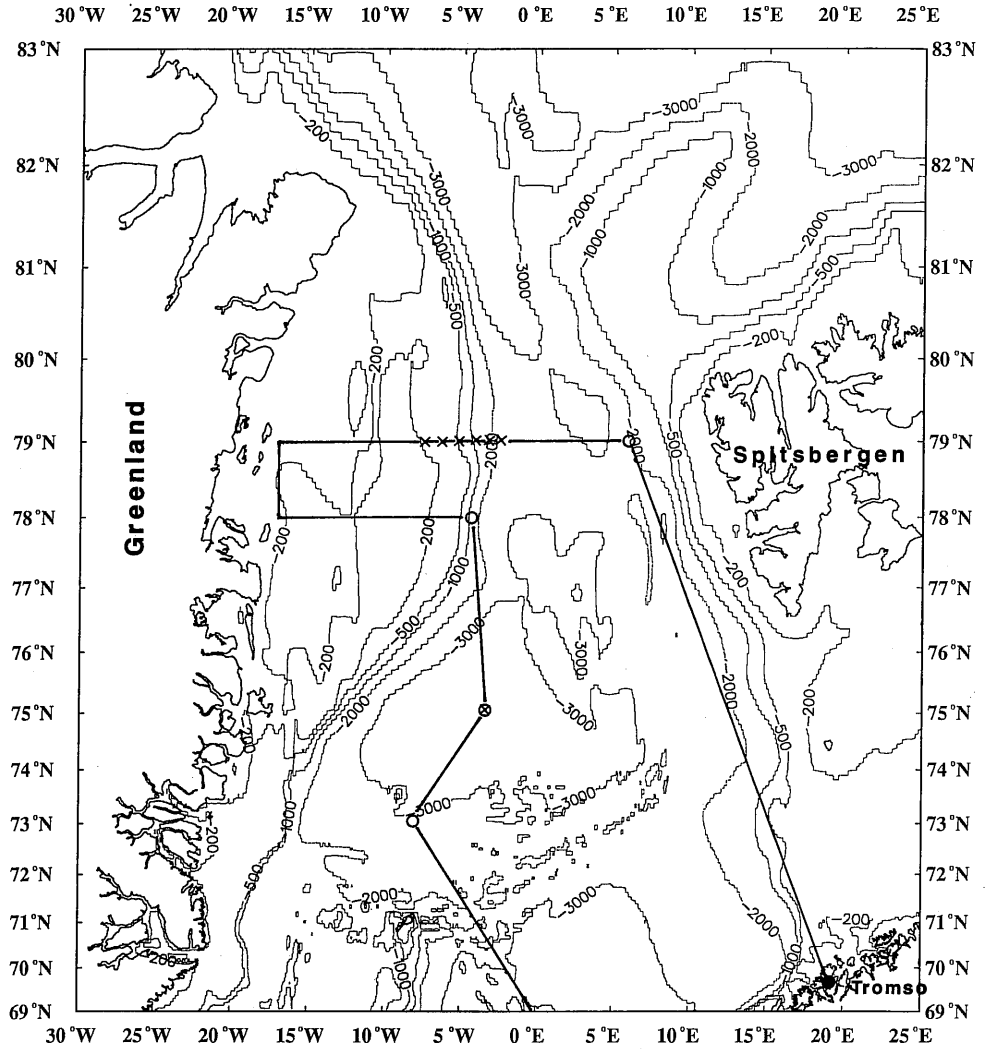

Fig. 1. Planned route on ARK VIII/1.
Moorings to be exchanged ⊗ , to be placed × and to be recovered o

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1 Cruise leg ARK VIII/1

Bremerhaven - Tromsö : 1 June - 19 June 1991
Chief Scientist: Gerhard Kattner

Greenland Sea / Fram Strait

1.1 Introduction

The oceanographic, biological, chemical and geological investigations in Fram Strait continue the studies in this region during other "Polarstern" cruises. Moorings from last year will be recovered and partly re-deployed. New moorings will be deployed to monitor the less saline water outflow of the Arctic Ocean through Fram Strait. These deployments are combined with ecological investigations following a transect along 79° N. While the eastern part of the transect will allow to connect the ecological studies of leg 1 and leg 2 near Spitsbergen, it is planned to continue the transect towards west to the Northeast Water Polynya off Greenland. The investigations there are pre-site studies for the NEW Polynya activities in 1993. Geological samples will give first information about sediment accumulations in this area.

1.2 Research Programmes

1.2.1 Physical Oceanography

1.2.1.1 CTD measurements (AWI)

After extensive oceanographical studies in the framework of the Greenland Sea Project in 1989 and 1990, measurements will be performed during this cruise leg which are necessary for other groups to characterize the hydrographic conditions.

A special programme will be devoted to investigations on the accuracy of a CTD probe. The extreme demands on such devices in polar waters to determine water masses and exchange processes range at the utmost limits of today's achievable accuracy. During data processing of previous expeditions no satisfactory results on the stability of calibration was achieved. After reconditioning of a CTD by the manufacturer a very careful field test will be carried out. Due to the low variability of the Greenland Sea water masses in space and time this area is well suited for such investigations.

1.2.1.2 Freshwater export from the Arctic Ocean (IFMH, PMEL, NPI)

The Arctic Ocean discharges approximately 4900 km^3 of freshwater per year as water of lower salinity into the Atlantic. It is thus the largest freshwater source for the oceans at high latitudes. Variations of its source strength effect the global thermohaline circulation system and may turn it into different - also stable - states of circulation with consequences for the climate. Fluctuations of up to 20% have been documented, resulting in a decreased convective activity of the Northern North Atlantic. No explanations for the causes of fluctuations in the period range of years are known.

A multi year monitoring effort on the freshwater flux from the Arctic Ocean will be launched by deploying six moored systems with current meters and ULS's (upward looking sonars). They are designed to record ice thickness, water transport and salinity over the Greenland continental slope along 79° N. They will be combined with hydrographic sections and remotely sensed ice concentrations and ice drifts into time series of freshwater flux. In addition, previously moored systems in the Greenland Sea and in Fram Strait will be recovered and partly re-deployed.

1.2.2 Marine Chemistry

1.2.2.1 Investigation of nutrients (AWI)

The determinations of nutrients are closely connected with the biological and physical investigations. From water samples, taken with the CTD sampler system, nutrients - nitrate, nitrite, ammonium, phosphate and silicate - are determined routinely with an autoanalyser-system. Especially silicate is a good tracer for the outflow of Arctic surface water. The determination of the nitrogen containing nutrients is also used for the investigations of dissolved organic nitrogen (DON) and humic substances.

1.2.2.2 DON and humic substances (AWI)

When investigating the balance of nitrogen compounds in marine waters, it is necessary to obtain an appraisal of the contribution of dissolved organic nitrogen (DON) to the global nitrogen-pool.

Important components of the DON are probably humic substances and total free and combined amino acids. Therefore, in addition to the determination of DON, humic substances will be extracted and analyzed for their nitrogen content. Furthermore, the water samples will be characterized by the determination of nutrients, free and combined amino acids in the original samples and in the humic extracts. The C/N

ratio of dissolved humic substances will be determined on humic material extracted from greater water volumes.

1.2.2.3 Investigation of lipids (AWI, IPÖ)

Analyses of the chemical composition of zooplankton in early summer will complement our investigations on seasonal energy accumulation in meso- and macrozooplankton during ARK VII/2 (July/August 1990). Lipids play an important role in this context due to their chemical properties which make them best-suited for fast and compact energy storage. These compounds allow herbivorous plankton organisms from polar regions to absorb the short seasonal energy pulse from primary production and preserve this energy over a long period of time in the pelagic zone.

In the Greenland Sea three calanoid species dominate the copepod stock. The polyunsaturated fatty acids (PUFA) in the lipids of the phytoplankton are incorporated largely in the storage and membrane lipids of the zooplankton. With the aid of the PUFA as markers, it is therefore possible to obtain more information about the energy flux between the phytoplankton and zooplankton. At various stations the dietary state of the copepod species, which is given by the fatty acid pattern, will be analyzed by gas chromatography. The diet of the copepods will be changed in cultivation experiments. The incorporation of the phytoplankton fatty acids will be analyzed by GLC on board. The short time turnover of the lipids will be investigated by means of ^{14}C labelled algae.

Beside these experiments, the relationship between egg production and lipid content as well as lipid accumulation depending on developmental stages will also be investigated. Analysis of lipid classes will provide further evidence on how lipids are stored. This may give hints about e.g. overwintering strategies. Wax esters, for instance, are known as longterm energy store of plankton organisms with a resting period during winter. Samples will be sorted according to species, sex, stages etc. and preserved at -80° C or in chloroform/methanol, extracted in the lab and analysed by different chromatographic methods.

1.2.3 Marine Biology

1.2.3.1 Marine fungi/protists (AWI, IBSS)

Saprophytic and parasitic lower marine fungi (some may be protists) live in the Arctic Sea and are also present in sea ice as found during "Polarstern" expeditions in Fram Strait and the Greenland Sea. Besides the protozoa-like lower fungi, higher fungal propagules were also found in the water and ice. They were mostly of terrestrial origin, but still viable

and able to germinate. Our knowledge about the processes of incorporation, the biochemical activities and the role of these fungi in the Arctic marine ecosystem is poorly developed and is mostly speculative at the moment.

The present study aims at qualitative and quantitative data on the distribution, abundance, viability and activity of fungi occurring in sea ice, under-ice waters and the water column down to about 200m. Fungi associated with the zoo-, micro- and phytoplankton will also be investigated in cooperation with the respective groups of biologists on board. Newly developed quantitative methods for the direct enumeration of fungi and their activities will be applied and parallel measurements of bacterial and chlorophyll concentrations will be made. Moreover, a representative number of fungal species will be isolated and cultivated. This is pre-requisite for experimental investigations on the physiological adaptions of fungi to the extreme conditions of the Arctic.

1.2.3.2 Microzooplankton (IFMK)

Microzooplankton, which is often dominated by ciliates, occupies a key position between the recently discovered "microbial loop" and the classical food chain leading from phytoplankton via zooplankton to higher ranking consumers. The "microbial loop" comprises the food chain of microorganisms consisting of free living bacteria, heterotrophic nanoflagellates and ciliates. It is based on dissolved organic substances originating mainly from phytoplankton, which are subsequently converted into particulate matter by the uptake of bacteria. The ciliates connect this new food chain with the classical one by serving as prey for larger zooplankton organisms. In the investigation area auto-, mixo- and heterotrophic ciliates are found. These diverse modes of feeding will be investigated by field observations and grazing experiments in the laboratory. The aim is to obtain better information on the food spectra and metabolic rates of the ciliates. The results will allow an evaluation of the ecological significance of the "microbial loop" within the Arctic ecosystem. In addition, it will be attempted to isolate dominating ciliate species for later culture experiments in Kiel.

1.2.3.3 Continuous particle and fluorescence measurements (IEMR)

Frontal regions in the ocean are known to be areas of locally increased biological productivity and/or biomass. However, due to the low spatial and temporal resolution of conventional sampling methods, the ecological aspects of the temporally dynamic oceanic fronts are difficult to study. Using quasi-continuous ("on-line") measurements of particle concentrations in various size fractions combined with measurement of chlorophyll *in vivo* fluorescence and temperature we intend to map the plankton distribution with a spatial resolution of 200m. Chlorophyll fluorescence

has traditionally been used as an index of phytoplankton abundance. However, chlorophyll is an integral parameter lumping together all phytoplankton without regard to the species and size structure. Therefore, it is important to meaningfully differentiate the chlorophyll signal. On-line particle counting in different size fractions represents a means of making high-resolution measurements of plankton distribution in relation to the meso- and small-scale hydrography.

Our previous experience from the Greenland Sea shows that the dominant phytoplankton populations change drastically within small distances relative to the normal station spacing. Using special software, the contributions of different plankton size fractions to the total chlorophyll concentrations will be estimated.

1.2.3.4 Zooplankton (AWI, IEO, FCM)

Plankton investigations include both field and experimental work.

a) Northeast Water Polynya

On the East Greenland Shelf in the region of the Northeast Water Polynya, our studies are planned in the context of the International Arctic Polynya Project with its main field phase in 1993. Leg ARK VIII/1 gives us the opportunity to study the polynya region in a very early season. In addition to phytoplankton (chlorophyll) and zooplankton biomass, the secondary production of the two dominant copepods *Calanus finmarchicus* and *C. glacialis* will be estimated with the egg production method. They will be sampled with bongo and multi-nets.

b) Vertical distribution of zooplankton across Fram Strait

Vertical profiles of zooplankton distribution across the Fram Strait will be compared with samples from the two following legs ARK VIII/2 and 3 in the region of the Atlantic Boundary Current in the Eurasian Basin. This will allow us to study the export of Greenland Sea zooplankton into the Arctic Ocean.

c) Reproductive physiology of *Calanus finmarchicus*

The measurement of egg production provides direct information of net secondary production in some species of herbivorous copepods. The application of this method requires detailed knowledge of environmental influnces on egg production and internal regulating processes. Important aspects such as maximum egg production, spawning interval and average clutch size, total fecundity, response time to changing feeding conditions and influence of temperature on egg production have been studied

during the last years. Now the effects of food concentration and quality will be assessed in the dominant species *Calanus finmarchicus.*

The ultimate aim is to develop a model that describes the flux of energy from feeding to spawning. This would allow calculation of actual growth rates and minimum food requirements from in situ measurements of the egg production rate.

d) Pelago-benthic coupling

The contribution of herbivorous copepods to vertical particle flux and hence to pelago-benthic coupling is an important aspect of the Northeast Water Polynya Study. During the cruise we shall try to estimate faeces production of copepods from the relationship of ingestion and the egg production, which is subject of the studies described above. In laboratory experiments fecal pellet production of various stages of the species *Calanus finmarchicus* and *C. hyperboreus* kept under different feeding conditions will be determined.

e) Enzymatic estimation of secondary production

In contrast to primary production there is no standard method to determine secondary production of marine zooplankton. After several unsuccessful attempts, there are great expectations in the use of transcarbamylase activity as an indicator of secondary production. Therefore we shall compare transcarbamylase activities of copepods with egg production measurements, which have already proven their usefulness for the estimation of secondary production in several copepod species. Parallel measurements of enzyme activities and egg production rates will be performed using freshly collected female *Calanus finmarchicus* and specimens kept in the laboratory under different feeding conditions.

1.2.3.5 Meso- and Macrozooplankton (IPÖ)

The investigations continue the work of last year (ARK VII/2). In July/August 1990 zooplankton development was already in its late summer stage, whereas the investigations planned for June 1991 will cover the beginning of the production period, when we hope to obtain important information on the plankton development during early summer.

One major objective of our studies is to assess the significance of the carnivorous zooplankton (chaetognaths, gelatinous species, raptorial copepods etc.) in the high Arctic food web, which so far has found little attention. As a working hypothesis it is assumed that selective removal of especially the younger developmental stages of the dominant *Calanus*

species as well as other smaller prey organisms will strongly influence abundance and composition of polar zooplankton communities. When food is plentiful, e.g. during phytoplankton blooms, carnivorous zooplankton may counterbalance population growth of herbivores. During food scarcity, e.g. in winter or under the ice, predators may reduce the stock size of herbivores significantly, which could also have a strong impact on secondary production in the next season. The seasonally different vertical distributions of herbivores and carnivores may also play an important role in this context.

In addition to the net catches we will carry out feeding experiments with different predator/prey items on board to estimate feeding rates and digestion times. At the institute these data will be supplemented by investigations on gut contents and enzyme activities of sampled specimens as well as analyses of the composition of faecal pellets from feeding studies. Predation impact on prey populations will be assessed by applying feeding rates to predator/prey abundances - if possible for different depth strata.

For the investgations of mesozooplankton samples will be taken with the multinet at different depth strata (0-1000m). The macrozooplankton, which avoid smaller nets, will be caught by the Rectangular Midwater Trawl RMT, if ice conditions permit. Plankton organisms for experimental and biochemical work will also be obtained by bongo net and ring trawl ("Reeve net"). Net catches will yield plankton abundance, biomass as well as data for population dynamics (size, age structure, stage and sex distribution etc.).

1.2.3.6 Sea birds and marine mammals (VUB, DQG)

The aim of this programme is the quantitative determination of the distribution and the ecological role of seabirds, pinnipeds (seals) and cetaceans in the Greenland Sea. Transect counts will be realized from the bridge when the ship is moving. These counts will be expressed as densities (either by using fixed width transects, or with unlimited width transects and specific conversion factors), and as daily food uptake by using existing allometric equations from the literature.

Special attention will be paid to the fulmar, the alcids, Ross'gull and Sabine's gull, bowhead whale, walrus and harp seal.

The results will be interpreted in the general frame of oceanological data (main water masses, polynyas and ice coverage) and ecological information (phytoplankton biomass and primary production, zooplankton biomass and secondary production, fish etc.).

1.2.4 Marine Geology

1.2.4.1 Sediment transport and accumulation due to winter water runoff in the Northeast Water Polynya (GEOM, SFB 313, ENEA)

Dense water masses are formed in shelf areas of high latitudes especially where new ice formation is involved in open water (e.g. polynyas). Given a suitable topography, the dense water will run off and cascade across the shelf edge and by this will discharge suspended material to the continental slope. In places of final deposition high accumulation areas will develop during geological times as for example on the continental slope off Norway and the Barents Sea.
Sediment cores from high accumulation areas reveal an unique document with high time resolution of climatic and oceanographic changes as well as biological and sedimentological conditions during Holocene time.

The investigations during this cruise are pre-site studies for the Northeast Water Polynya (NEW) activities in 1992/93. Expected areas of sediment accumulation on the slope, northeast of Belgica Bank and in the trough around the banks, will be ascertained by using 3,5 kHz sediment-echosounder (additionally Parasound and Hydrosweep). Asymmetric sediment infill of the trough will display prevailing bottom current directions. These will be measured in more detail with current meter, nephelometer and sediment trap deployments in 1992 and 1993.
Analysis of short sediment cores may be indicative for the amount and direction of nearbottom sediment transport and the source of fine grained particles. Sample locations are first examined by 3.5 kHz-echosounder.

Ice and water samples will be investigated with SEM to distinguish between ice derived and physically or bioentrained particles from the bottom. Short term bottom current measurements (ev. combined with nephelometer) will give information about sediment transport directions and tidal currents in the northern trough (80°20' N) and in other shelf areas.

1.2.4.2 Particle flux to the sea-floor (GeoB)

As a continuation of the sediment trap experiments in the Norwegian-Greenland Sea and Fram Strait, which have been carried out since 1983, two sediment traps will be recovered and will be deployed again. These time-controlled sediment traps will determine the seasonal pattern of the particle flux to the sea-floor and will thereby also indirectly determine the seasonal changes in surface water productivity. Another main topic of this work is the investigation of the input of ice-rafted material and its seasonal and spatial variabilities.

2 Cruise Leg ARK VIII / 2

Tromsö - Tromsö : 20 June - 30 July 1991
Chief Scientists: Gotthilf Hempel and Eike Rachor

Second European Polarstern Study (EPOS II) :

- *Study of the European Arctic Shelf* ***(SEAS)*** -
of the European Science Foundation, Strasbourg

Northern and Central Barents Sea

Preface (G. Hempel)

In 1988/89 RV "Polarstern" had carried out the European Polarstern Study (EPOS), an ecological expedition into the Weddell Sea. EPOS was the first project of the Network of Polar Sciences of the European Science Foundation (ESF). About 130 scientists of 11 countries of Western Europe participated in the cruise, which was divided into three legs with different scientific themes. The running costs of the vessel were provided by Germany, but ESF and the Commission of the European Communities (CEC) contributed to the costs for the planning of the project as well as to the working up of the results and to the hire of a helicopter. EPOS was a great success in obtaining excellent results in various fields of Antarctic marine ecology and in fostering European collaboration in polar research.

In the course of the working up of EPOS data and of the planning for a Barents Sea study in 1991 we felt that the necessary multidisciplinary work on the shelf and at its slope would again offer a good opportunity of international cooperation under the the auspices of the European Science Foundation. Moreover, thanks to the political developments in eastern and central Europe there was suddenly an opening for participation of scientists of the eastern European countries who could substantially contribute to the study.

At the same time we believed that the intended long-term research on the Eurasian shelves was no longer unrealistic in the new political climate which inter alia was reflected in the establishment of the International Arctic Science Committee.

The Alfred Wegener Institute therefore proposed the leg ARK VIII/2 of RV "Polarstern" to be included into the Polar Science Network of ESF as a second European Polarstern Study (EPOS II). Although there was not much time left for preparation, ESF acknowledged the plan and invited the international scientific community through its member organisations and other mediators to make proposals to a Study of the European Arctic Shelf. When the General Assembly of ESF definitely launched EPOS II in the mid of November 1990, about 100 scientists from 16 countries had presented proposals. Therefore, a selection committee of scientists from several countries met in Bremerhaven early in December and made a decision about the participants, considering the maximum figure of 50 berths available on board of "Polarstern" and the idea of including a substantial number of scientists from Poland and the USSR.

In February 1991, a workshop was held in Bremerhaven, providing information of the Barents Sea environment and the details of the planned cruise track as well as allowing for specific plannings in smaller groups.
Until that time there were good reasons to expect a Soviet permission to work in the eastern Barents Sea up to the border of the Kara Sea at the St. Anna Trough east of Franz-Josef-Land, especially as the Murmansk Marine Biological Institute of the Academy of Sciences of the USSR was interested in a joint venture with AWI in these waters. By the end of March, however, AWI was informed that Soviet authorities refused permission for research in those areas.
Therefore, all the further planning has been restricted to the north-western Barents Sea around Svalbard, for which a Norwegian permission will be given. The intended route is indicated in Fig. 1. While a part of the original programme cannot materialize under these limited conditions, it is hoped that other lines can be strengthened to make EPOS II still a worthwhile international expedition.

2.1 Introduction

The significance of processes on the Eurasian shelves for the formation of Arctic water masses, the generation of ice, and for life in the Arctic Ocean is far from being understood.
The decreasing influence of Atlantic water along the Eurasian shelves from the Barents through the Kara and to the Laptew Seas and the increasing importance of continental runoff are expected to be critical and governing factors in these processes.
Scientists of the Alfred-Wegener-Institut are very much interested in assessing mechanisms and dimensions of carbon flux on the shelf and the advection of organic matter to the deep Nansen basin in a long-term. The intended research will incorporate the goals of the Joint Global Ocean Flux Study (JGOFS); and by contributing to the understanding of ice and deep

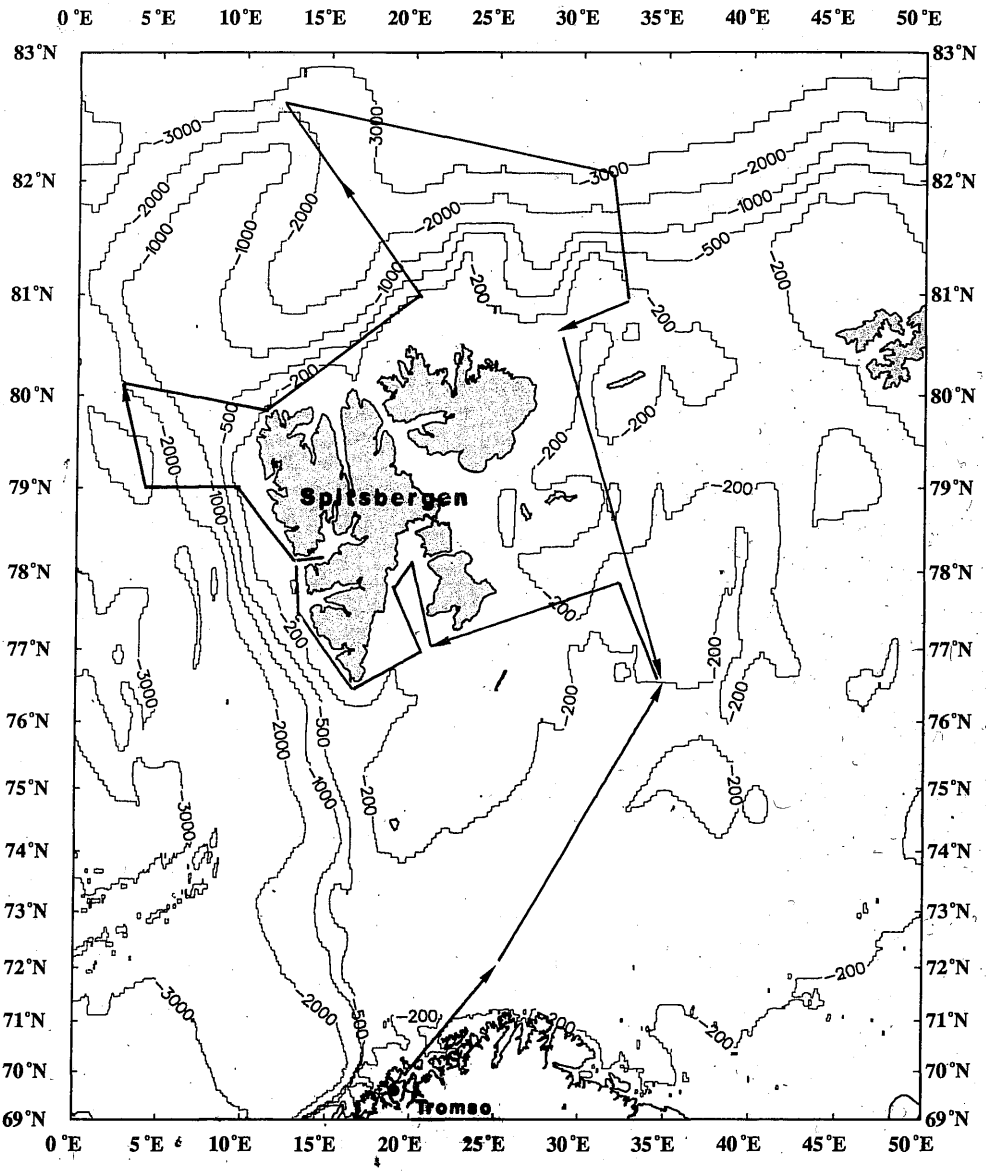

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Fig. 1. Planned route of ARK VIII/2 (1991)

water formation as well as sediment transport and distribution, this research will also help to understand climatic changes, especially the Quarternary history of the Barents Sea.

The leg ARK VIII/2 is closely related to the other legs of the 1991 "Polarstern" expedition and thus connects the studies on the European shelf of the Arctic with the work in the Greenland Sea and in the deep Arctic Basins.

RV "Polarstern" will leave Tromsö at the 20th of June, and, after a meeting with the Soviet RV "Dalnie Zelentsy" from Murmansk and the Polish RV "Oceania" from Gdynia for intercalibration and cooperation arrangements, research will start with studies in the frontal zone between Atlantic and Arctic water masses in the central Barents Sea. "Dalnie Zelentsy" will work along a track east and "Oceania" west of "Polarstern's" cruise track. The work at the central Barents Sea station will include a sediment trap mooring for about 4-5 weeks and thereafter for about one year.
Then we plan to go to the ice edge for an intensive production study, thereafter to the Storfjord for mainly oceanographic work and via Longyearbyen to the Kongsfjordrenna, where the main shelf slope work will be started along an E-W-transect at 79° N. Two other transects will be at the south-western and eastern edges of the Yermak Plateau north of Svalbard, depending on the actual ice conditions, and another one will be as far east as possible (about 32° E), allowing for sampling down to a depth of 3000m and for deployments of other moorings for oceanography (and sedimentation).
Several shelf areas north and northeast of Svalbard will be selected for more intensive studies of biological productivity, particle fluxes and sediments, benthos, fish distribution etc.
On our way back from the shelf edge to the trap mooring in the central Barents Sea there will be a long transect of stations for additional studies of shelf ecology.

2.2 Scientific background

The Barents Sea is a deep shelf area (depths mainly between 100 and 300 m) at the border of the north-eastern Atlantic and the Arctic Ocean. The influences of Atlantic water and weather are strong and provide an environment, where rich marine biocenoses with organisms from either biogeographical regions have developed in a relatively short time after the last glaciation period.
A good knowledge about the ecology of the Barents Sea proper is available due to a long tradition of Norwegian and Russian research, including studies of other countries. Our knowledge about the water circulation, the distribution of organisms, the main ecological processes

(production and fluxes of organic matter) and the Quarternary geology of the n o r t h e r n Barents Sea, however, is only sketchy, as this area is mostly ice-covered.
A main focus of the intended work, therefore, is to investigate hydrological and ecological processes from the central to the northern shelf. Beyond these, the less known interrelationships of the Barents shelf with the deep Nansen Basin and the relative importance of Atlantic water in the intermediate area deserve a great part of our attention. Thanks to the ice-breaking capability of RV "Polarstern", we hope to be able to work not only on the proper shelf, but also at the northern margin of the sea, following the routes of dense, cooled water masses down the shelf slope into the deep sea and crossing the boundary current of intermediate (Atlantic) waters along the perimeter of the basin.

During ARK VIII/2 a great variety of different scientific approaches will be put together, all trying to contribute to a better understanding of the shelf ecology and its significance - via advection - for the environment and life on the northern shelf slope and in the adjacent Nansen Basin. Oceanographers, ice researchers, geologists, chemists interested in water properties, sediments and contaminations as well as bio-chemists, phyto- and zooplanktologists, benthologists, ichthyologists and bird and mammal observers will form a community taking up this challenge.

2.3 Research Programme

2.3.1 Physical and Chemical Oceanography : Water Masses, Circulation and Nutrient Distribution

Although the Barents Sea is the best investigated Eurasian shelf in the Arctic, even here the knowledge about denser water mass formation, transport processes and rates, interactions with water of the Arctic basins and, moreover, their ecological significance, is very sparse:
During recent years, however, it has become increasingly evident that the renewal of the central Arctic Ocean water masses is to a large extent controlled by processes on the shelves and their slopes. One such process, occurring mainly in winter on the shelves, is the formation and accumulation of cold saline water by brine release during sea ice production. It is assumed that this dense water spreds over the shelf bottom and - depending on its density - contributes either to the cold Arctic halocline (between the mixed surface layer and the thermocline) or sinks along the slope bottom into the deep central basins entraining surrounding water along its way. A part of the dense water may reach the greatest depths in the basins and contribute to the renewal of bottom water.
The linkage between shelf and central Arctic Ocean waters and the quantitative contribution of the shelf waters to the intermediate and

deep water renewal are open questions. The Atlantic water plays a special role in this context :
The Norwegian Current, carrying warm and saline water of Atlantic origin, branches at 70° N and, by its eastern branch, contributes a significant amount of water to the Barents Sea. The western branch continues northwards as the West Spitsbergen current and subducts in the Fram Strait below the cold Arctic surface water, providing an intermediate salinity and temperature maximum through most of the Arctic Ocean. Recent studies confirm that below the clockwise surface flow, such intermediate waters circulate as counterclockwise boundary currents along the perimeter of the deep basins. Hence, the dense water plumes descending the shelf slopes will be strongly modified when they entrain water of this boundary current.
The eastern branch of the Norwegian current enters the Barents shelf and forms a sharp, topographically guided front against the cold Arctic surface water of lower salinity which enters the Barents Sea from the north and east. The front is weakened towards the east.

While the surface circulation pattern is fairly well documented, knowledge is poor of the origin, flow and transport processes of water in the deep layers. Time series of ice concentration and hydrographic data indicate that the production and drainage of dense bottom water probably concentrate in specific areas on the European Arctic shelf with varying intensity. Coastal polynyas off the islands of the Barents Sea provide obviously favourable conditions for enhanced ice formation and, maybe, temporarily high biological productivity. The characteristics of the resulting shelf bottom water and their influence on the central Arctic Ocean, probably depend strongly on the circulation of the water masses on the very shelf and along the continental slope.

Programme:

The aim of the oceanographic programme is to study the water masses, their chemical properties and their circulation in the Barents Sea and at its slope. Great effort will be made to investigate a typical dense water drainage trough and the spreading of shelf and Atlantic waters along the slope of the Nansen Basin. Therefore, an array of several long-term moorings with current and salinity meters, thermistor chains and sediment traps will be deployed in the Storfjord of Svalbard (outflow to the Norwegian Basin) and at the shelf slope (down to the Nansen Basin) northeast of Svalbard.
The mooring work will be combined with a series of hydrographic sections with dense station distances across depressions (troughs and channels) and slope areas. CTD, dissolved oxygen and nutrient measurements (ammonia, nitrate, nitrite, phosphate and silicate) will be performed, providing data also for the ecological work of the other

groups on board. At a few selected stations Helium, Tritium and water pollution by oil contaminants will additionally be measured.

Participants:

Guiseppe Civitarese and Anna Luchetta, ITT (Trieste): Nutrient and oxygen distribution; methods: water samples from "Rosette" multisampler, (auto-)analysed on board;
Ingo Harms, IFMH (Hamburg): Oceanographic modelling, circulation; methods: CTD and oceanographic moorings;
Dmitry Matishov, MMBI (Murmansk): Circulation and the pelagic environment, esp. near the ice edge; methods: CTD and oceanographic moorings, and assistence in water chemistry and planktology;
Georgina Owrid, US-O (Southampton): Chlorophyll variability; methods: continuous surface monitoring of fluorescence together with salinity and temperature; vertical profiling with fluorometer;
Vladimir Petrov, MMBI (Murmansk): Barents Sea circulation and interaction water - atmosphere; oil contamination; methods: CTD, and water samples for hydrocarbon analyses; and organisation of the cooperation with RV "Dalnie Zelentsy";
Ursula Schauer, AWI (Bremerhaven): Formation and circulation of dense water masses, description of the actual hydrography for ecological work; methods: CTD with Rosette multisampler (for water), and oceanographic moorings;
Anton Shaban, MMBI (Murmansk): Circulation in relation to bottom topography; methods: CTD, and assistence in chemistry and planktology;
Volker Strass, AWI (Bremerhaven): Formation and circulation of dense water masses, description of the actual hydrography for ecological work; methods: CTD with Rosette multisampler (for water), and oceanographic moorings.

Cooperation: Harald Loeng, IMR (Bergen-Nordnes): Water circulation; Slawomir Swerpel, IOS-PAN (Sopot): Oceanography of RV "Oceania".

2.3.2 Sea Ice Research

During ARK VIII/2, sea ice will be studied to contribute to the understanding of the ice regime of the Barents Sea and adjacent areas.
One aim is the validation of ice type algorithms from satellite sensors, another the study of ice types and motions which affect the ice regime along the northern sea route.
Moreover, in relation to the ecological work of the other groups on board, the environmental and sedimentary role of sea ice and iceberg rafting will be determined. Sea ice samples obtained in 1987-90 in the Eurasian Arctic Ocean, Fram Strait and Greenland Sea confirmed that multi-year ice especially can carry high particulate loads. Because much of this ice is thought to have undergone several years of surface melting, freezing on its underside and extensive deformations, the processes involved in sediment incorporation were difficult to determine from these samples.
By sampling sea ice in the Barents Sea we hope to obtain relatively undeformed, sediment-laden first- and second-year ice which preserves the original ice structure and sediment distribution characteristics. Sea ice investigations in the Arctic shelf regions are important therefore to "fingerprint" the shelf sediment source areas for comparison with the ice sediments and the deep sea record. Nature and dynamics of sea ice biota will also be covered by analyses of nutrients and algae in ice cores.
All these aspects will be combined with studies of pollutants in the ice as well as in the environment under the ice.

Programme:

A continuous video record, together with an hourly visual observations log, will be kept of the ice conditions (including icebergs) along track, from the ship's bridge. It is planned to fit a laser profilometer to the bridge wing to measure ridge heights en route, and also a multi-frequency scatterometer to monitor radar backscatter cross-sections.
During the longer stations, the following sampling/measurements may be done on accessable ice:

- Snow depths and conductivity profiles;
- area, depths and salinity of melt pools;
- thickness and draft distributions of sea ice (drilling holes at 5 m intervals along horizontal profiles);
- specific thicknes profiles across pressure ridges, with accompanying study of ridge sail structure and block sizes;
- ice core samples with in situ temperature profile measurements and following analyses of ice crystal fabric, salinity profile, sediment load, plant nutrients and small algae;
- through the core holes, under-ice samples of water and plankton will be taken for tracer analyses.

If ice growth is observed to be occurring in leads, a thermistor chain will be used to measure the temperature profile in the uppermost few metres

(deployed from ice), and a small parametric sonar, hanging from a float, will be deployed in the lead to measure frazil ice concentration as a function of depth.

Participants:

Mark Inall, and N. N., SPRI (Cambridge): Sea ice distribution and properties, including sampling for analyses of contaminants.

Cooperation: E.-M. Nöthig (AWI) for ice algae;
G. Civitarese and A. Luchetta (ITT) for plant nutrients;
C. Joiris (VUB) for visual ice observations;
A. Abelmann, M. Lange, M. Spindler (AWI), I. Wollenburg (GEOM) and Pfirman (Lamont) for complementary studies of ice cristallography, salinity, 0-18, deuterium, organisms and chemistry.

2.3.3 Biology

2.3.3.1 Phytoplankton, primary production and particle flux

Measurements of the vertical flux of organic matter in the oceans have become increasingly important for the understanding of ecosystem functioning and of the global carbon cycle. Sedimentation is influenced by the pelagic system itself, i.e. the primary production, microbial life and absence or presence of grazers; and the biological production in the water column will be reflected, via sedimentation, in the type and structure of the benthic communities.
The plankton distribution, production and particle flux on the Barents Sea shelf have been shown to be related to the various water regimes, strongly influenced by the inflow of water from the North Atlantic (e.g. during the Norwegian "PRO MARE" project).
The Atlantic water masses, rich in nutrients and organisms, are separated from the polar water regime by the Polar Front. In the frontal zone, mesoscale hydrographic dynamics support high phytoplankton production. The water north of the Polar Front is covered with ice for most of the year. Phytoplankton blooms have been observed in the wake of the receding ice edge. In addition, organic matter derived from ice algae, will be released during the ice melt.
In other areas enhanced biological activity can be expected due to regional climatic and hydrographic influences, of which the wind-induced polynyas are examples.
While a great part of the organic matter produced on the shelf will be deposited and thus allow a diverse benthic life, another part may be

transported by the bottom currents to the shelf margin and down to the deep Nansen Basin.
The relative importance of organic matter advected by these shelf processes, by import from the North Atlantic and of autochthonous production (by ice algae and phytoplankton), for life in the Arctic Mediterranean is to be investigated.

Programme:

Phytoplankton and related studies will focus on the structure of the pelagic community (species and assemblages) as well as on production, modification and flux of particles in the water column. This work will, in connection with the zooplankton studies, provide data about the input of food into benthic communities (pelago-benthic coupling). The advective transport of substances (including terrigenous material) is also to be investigated.
All these processes will be studied along transects, which run perpendicular to fronts separating water masses and to the shelf margin, and allow for comparison of areas with different productivity and advective transport regimes (e.g. frontal zones, ice edges and polynyas, depressions and troughs compared with shallower areas like banks).
Along each transect, in addition to oceanography and geology, a biological survey will be performed on the distribution of nutrients, chlorophyll, particulate matter, phytoplankton and micro-organisms in the entire water column. These data will be related to the distribution of zooplankton, of sediment properties and of benthic communities.
Each transect should include a few locations of intensified studies, where process oriented work on production and sedimentation as well as activity studies in organisms are to be initiated, for example measurements of the respiratory activities of microplankton and about the incorporation of plant material into zooplankton fecal pellets.

Multiple water samples ("Rosette") and plankton nets will be taken from different depths, and the short-term vertical particle flux will be studied with floating sediment traps. Long-term aspects will be covered by some sediment traps attached to the oceanographic moorings.
The following analyses of the collected matter will be carried out: dry weight, particulate carbon, nitrogen, phosphorus and silicate, chlorophyll a and phaeopigments as well as microscopic analyses (for remainders of organisms, aggregates, fecal pellets etc.); additional analyses will be done by the geochemists (s. 2.3.4).
Studies on the pelagic transformations of different nitrogen compounds will also be performed by determination of uptake rates of ^{15}N-labelled ammonium, nitrate and urea. The influence of varying ratios of the different nitrogen nutrients on production and the development of microbial populations will be investigated in long-time on-board incubations.

Participants:

Inger Andreassen, UT-F (Tromsö): Sedimentation; methods: s. E.-M. Nöthig;
Antonina Allegra, ISTM (Messina): Geographical distribution of microbial biomass; methods: water samples for direct counts (epifluorescence microscopy), and indirect counts of heterotrophs from cultures; ATP and lipopolysaccharid determinations;
Humberto Gonzales, AWI (Bremerhaven): Sedimentation and production of fecal pellets of protozoa and copepods; methods: water, net and trap samples; maintenance of copepodes for measuring the production of fecal pellets;
Y. Tosun Konuk, UI-M (Izmir): Sedimentation processes; methods: sediment trap sampling;
Rosa Martinez, CEAB (Blanes): Respiratory metabolism of microplankton; methods: ETS activity measurements in different size fractions from water samples; experiments on substrate and temperature kinetics of the enzyme assay;
Eva-Maria Nöthig, AWI (Bremerhaven): Primary production and sedimentation; methods: microsocopical analyses of sediment trap samples: phytoplankton, chlorophyll a, dry weight, particulate organic C, N and Si;
Vyacheslaw Ryzhov, MMBI (Murmansk): Phytoplankton and ciliate distribution patterns and species composition (as indicators of water masses); methods: microscopical analyses from bottle and net samples;
Giorgio Socal, IBMV (Venezia): Phytoplankton quantitative composition (diatoms, dinoflagellates and nanoflagellates); methods: countings of fixed rosette samples from the photic layer and direct analyses of net samples on board;
Fred Sörensen, UG-M (Göteborg): Pelagic nitrogen transformations; methods: on board incubations and measurements of uptake rates of ^{15}N-labelled ammonium, nitrate and urea;
Jozef Wiktor, IOS-PAN (Sopot): Measurements of primary production and studies of phytoplankton composition; methods: ^{14}C incubations and microscopical analyses;

Cooperation: G. Owrid (US-O) and T. Mathieu (UL-E): contributing to chlorophyll measurements;
P. Wassmann (Tromsö): sediment trap work.

2.3.3.2 Zooplankton:

Zooplankton species and assemblages are strongly tied to the different water masses of the Barents Sea area. They may be used as indicators to identify routes of water circulation and transport. The "Polarstern" study will contribute to the investigation of zooplankton small- and large-scale horizontal as well as vertical distribution patterns. Zooplankton biomass distribution will be related to phytoplankton patterns.
In relation to the productivity studies and the questions of particle flux and the pelago-benthic coupling, the pelagic consumption (grazing) and the production of sedimentary particles (especially fecal pellets) by the zooplankton will be the other main field of research during ARK VIII/2.
As large calanoid copepods are a main component of the Barents Sea zooplankton, much effort will be devoted to this group. By the egg production method their growth and production on scales comparable with the expected hydrographic scales at fronts and marginal ice zones will be estimated. In addition, small-sized species and larval stages will also be studied, to evaluate the developmental states of the populations as well as their productivity and fecundity, and to describe their life cycles. From the egg production and growth rates the minimum grazing requirements may be derived, which then allow to estimate the portion of primary production left for other consumers and for sedimentation.

Studies on the lipid metabolism of calanoid copepods will be done in continuation of ARK VIII/1; these and lipid analyses of other compartments of ecosystem will give information about energy storage and utilization.

Mainly larger zooplankton (Euphausiacea and Mysidacea) will be investigated with respect to their local spatio-temporal distribution according to the in-situ irradiance changes and their diurnal vertical migration behaviour. The double "active flux" (up- and downward) of organic matter linked with diurnal and seasonal vertical migrations of zooplankton is superimposed on the passive flux of sedimentation and is regarded to be of significance in the pelago-benthic relations.

Moreover, abundant and larger zooplankton will be sampled also for measurements of contamination (by heavy metals and organochlorines like PCBs and pesticides).

Programme:

Zooplankton will be sampled for species and biomass analyses at selected stations of the oceanographic transects, especially across the Polar Front, in the marginal ice zone and in the transitional slope area from the Barents shelf to the deep Nansen Basin, including the selected locations for extensive biological studies. Samples will be taken with multinets

from different water layers down to the bottom water or to depths of at least 500 m, sometimes to greater depths. Mesh sizes of 50 up to 330 mm will be used.
In addition, bongo net samples mainly for experiments with living animals will be taken from the upper 100 m of the water column; other nets may be used for specific distribution and migration studies.

Several questions (egg production, growth rates, excretion, fecal pellet production, locomotor activity/migration behaviour) will be studied with live animals on board in laboratory containers.

Contributors / Participants:

H. George Fransz, NIOZ (Texel): Distribution, biomass and productivity of smaller metazooplankton; methods: in addition to the multinet a 50 mm meshed vertical net will be used; incubation experiments with key species for the estimation of daily fecundity and growth rates;

Martin Graeve, AWI (Bremerhaven): Spatial and temporal variability of lipids in zooplankton and zoobenthos; methods: Bongo net (and Agassiz trawl) samples for lipid analyses; experimental work as H.-J. Hirche.

Ute Meyer, AWI (Bremerhaven): Distribution and production of dominant copepods and their contribution to the vertical particle flux; methods: vertically stratified multinet samples for distribution, and Bongo net samples for experimental production studies;

Thierry Mathieu, UL-E (Liège): Vertical distribution of zooplankton biomass in relation to plant pigments; methods: biomass estimates from multinet samples; plant pigments from rosette water samples, and continuous fluorescence measurements during steaming.

Françoise Passelaigue, COM (Marseille): Contribution of the diurnal migrations of larger zooplankton to the fluxes of organic matter; methods: quantitative analyses from oblique closing plankton net samples taken at regular intervals during the day and combined with in situ irradiance recordings; experimental studies of locomotor activity and fecal pellet production;

Sergey F. Timofeev,MMBI (Murmansk): Zooplankton size structure patterns, and chaetognath ecology; methods: microscopic analyses of zooplankton size patterns from different water layers; gut contents of chaetognaths and directs observations of their feeding behaviour in aquaria;

2.3.3.3: Benthos and fish

The investigation of invertebrate bottom communities, their distribution, structures and responses to food availability as well as their relations to the higher trophic levels of fishes will be the other main objective of the biological studies about the pelago-benthic coupling in the Barents Sea and at its northern border. Sublitoral and bathyal benthic communities will reflect the vertical and advective particle flux/sedimentation regime as well as the oceanography integrated over longer periods. Especially in the temporarily and permanently ice covered northern Barents Sea, at its slope and in the deep Nansen Basin there is only deficient knowledge about the benthos and its ecology.
The extremely uneven Barents shelf topography and the bottom currents will not allow an even distribution of sedimenting particles, but rather enhanced deposition in the various depressions. The accumulation of dense water masses (see oceanography) will also be found in such depressions, and the bottom currents, originating from there, will convey different amounts of sediments and food to the shelf margin and down into the Nansen Basin.
Thus, we assume that the pelagic and benthic communities in the Arctic Mediterranean and at the slope are fed and structured to a great extent by these shelf processes.
Another important source for the advection of organic matter and organisms to the deep Arctic Ocean is Atlantic water, subducted in the Fram Strait below the cold Arctic surface water and flowing as a counterclockwise boundary current along the perimeter of the basins.

The distribution of benthos and fishes will reflect the various gradients in the research area: latitudinal changes related mainly to climate and the annual light cycle;
changes from west to east and north according to the decreasing influence of Atlantic water and the increase in Arctic conditions;
alterations from the shelf down its slope into the deep Nansen Basin.
All these main influences are interfering in the northern Barents Sea. Smaller scale variations e.g. in topography, sediment distribution, water circulation, ice coverage and biological productivity are superimposed on these large scale variations.

Programme:

Typical epi- and endofauna sampling will also be done along transects, being sufficiently distant to detect geographical differences as well as covering areas with strong environmetal gradients (e.g. frontal, ice margin and slope areas). Species composition, numerical abundances, biomass, dominances of feeding types of macro-epifauna, macro- and meio-endofauna (including juveniles) will be investigated. In addition,

the distribution, abundance and food of fishes and "supra-fauna" will be studied.
Endo-benthos will mainly be sampled with box grabs and multicorers, epifauna, fish and other mobile fauna by Agassiz and otter bottom trawls. Fishes will also be caught by baited traps.
At the selected stations for the extensive ecological studies, especially related to the actual productivity and particle flux processes, video observations of the sea floor, extensive sampling, fish trapping and experimental studies with captured animals about their metabolic activity and growth will be performed.

Participants:

Ichthylogy:
N. V. Chernova, MMBI (Murmansk), and
Alexey V. Neyelov, ZIL (Leningrad): Zoogeography, taxonomy and trophodynamics of Arctic fishes; methods: trawl and baited trap sampling;
Christian von Dorrien, IPÖ (Kiel): Ecophysiology of fishes; methods: experimental work (on board and at home) about activity, behavior, respiration rates; analyses of carbohydrates, proteins and lipids in the fishes;
Luiz Saldanha, UL-Z (Lisbon): Distribution and trophodynamics of Arctic fishes; methods: as Chernova and Neyelov; in addition: calorimetry of fish and their food organisms.

Invertebrates:
Julian Gutt, AWI (Bremerhaven), and
Dieter Piepenburg, IPÖ (Kiel): Macrobenthos distribution and community structures; methods: bottom imaging (video and stereo-photography), trawl and grab sampling; analyses of species composition, abundances, biomass, feeding types, especially epi- and some macro-endofauna;
Mike A. Kendall, PML (Plymouth): Latitudinal gradients (from the tropics to high latitudes) in the structure of benthic communities; methods: box and multicorer samples from (shallow) shelf stations, analyses for diversity and size spectra of macro- and meiofauna;
Eike Rachor, AWI (Bremerhaven): Structures of endofauna communities from the shelf across its slope down to the Nansen Basin; methods: sampling with grabs and multicorer; analyses of small macro- and meiofauna, their abundance, biomass, size spectra and feeding and reproduction types;
Michael Schmidt, IPÖ (Kiel): Ecophysiology of invertebrate macrobenthos; methods: Agassiz and otter bottom trawls (or benthopelagic trawl), and grabs or box sampler for selected fauna; experimental work similar to v. Dorrien;

B. I. Sirenko, ZIL (Leningrad): Zoogeography, taxonomy and community structures of macro-invertebrates; methods: analyses of macrofauna from trawl and grab samples;
Krzysztof Opalinski, IOS-PAN (Sopot): Phylogenetic relations and ecology of eurybathic Arctic and Subarctic bivalvia and crustacea; methods: analyses of mitochondrial DNA, enzymes and biochemical composition in combination with population studies; samples with all bottom gear.

Hjelmar Hoffmann, RF (Bremen), and
Eduard Vöhrs, RF (Bremen): Operation of Ocean Floor Observation System ("OFOS": deep sea video and stereo-camera system) and other imaging systems.

Cooperation:
C. Joiris, J.M. Bouquegneau (VUB Brussels) & G.-P. Zauke (U. Oldenburg): contamination by organochlorines and heavy metals;
M. Graeve (AWI): lipids;
Zoological Institute Leningrad: biogeography and taxonomy;
MMBI Murmansk (Averintshev): taxonomy, Barents Sea ecology;
I. Kröncke (AWI): relations with benthos of Nansen Basin;
J. M. Weslawski (IOS-PAN): phylogeny and ecology of eurybathic species.

2.3.3.4 Higher trophic levels: Sea birds and marine mammals

Sea birds and marine mammals as animals on the top of the marine food webs may be used as indicators of different oceanographic and biological conditions as well as indicators of the environmental state of their ecosystem.
To use these indicator functions for the study area, quantitative countings about the distribution and ecological role of sea birds, pinnipeds (seals) and cetaceans (whales, dolphins) will be carried out.
The results will be interpreted in the general frame of oceanological and the other ecological informations obtained during SEAS / ARK VIII/2.

Dead animals found during the expedition will be used to measure the degree of contamination with heavy metals and organochlorines. The data obtained will be compared with the values measured in other compartments of the food web as well as with results from other environments (North Sea, Antarctica).

Programme:

Transect counts will be realized from the ship's bridge. Special attention will be payed to the fulmar (*Fulmarus glacialis*), the alcids (*Uria, Cepphus,*

Alle, Fratercula), to Ross' and Sabine's gulls, and, hopefully, to bowhead/Greenland whale (*Balaena mysticetus*), walrus (*Odobaenus rosmarus*) and Harp seal (*Pagophilus groenlandicus*).
The counts will be expressed as densities and converted to figures about the daily food uptake (by using allometric equations from the literature). PCBs, several pesticides and heavy metals (Hg, Cd, Cu, Pb, Zn, Ti, Se and metallothioneins) will be measured in the suspended particulate matter, sediments, zooplankton, benthos, fish, birds and mammals on a macroscopic level. In addition, semi-quantitative studies will be done by scanning electron microscopy and disperse energy spectrometry.

Participants:

Claude Joiris, VUB (Brussels): Distribution and ecology (including food requirements) of birds and mammals; counts from ship's bridge according to international standards for estimating densities per surface area and the recommendations of the International Whaling Commission; and contamination.

Cooperation:
J. M. Bouquegneau, VUB (Brussels): Analyses of heavy metals and organochlorines in various compartments;
G.-P. Zauke, Univ. Bremen: Analyses of heavy metals in large zooplankton and bottom invertebrates.

2.3.4 Sedimentology and Geology

(including sediment **biochemistry and microbiology**)

Sediment dynamics, sedimentation rates and sediment distribution in the Arctic Ocean are not well understood. Today, the shelf areas surrounding the deep basins supposedly act as large depocenters for the mineral and organic sediment load of the large rivers. The formation and outflow of dense bottom water presumably controls the sedimentary processes on the shelf and the sediment supply into the Arctic deep basins.
During the Quaternary glacial maxima, the (western) Eurasian shelves were probably fully covered by grounded ice, and the continental shelf break acting as a depocenter prograded rapidly. The investigation of sedimentological features on the shelf and especially on its slope will provide information on the late Cenozoic history of the glaciation of the Barents Sea. In areas of high sedimentation rates on the shelf, a high resolution record of the last 20.000 years including the Holocene deglaciation period is expected. At locations of lower sedimentation rates on the continental slope, the record of older sedimentary cycles may provide information on the variations of the Quarternary Fennoscandian

and Sibirian ice sheets, sea level changes, sea ice coverage and thus of primary productivity and bottom water formation.

Recent and actual processes of productivity, particle and solution fluxes, benthic life und turbation will be revealed by the study of the topmost bottom layers. Special attention will be payed to the exchange rates of nutrients and products of reactions (O_2, CO_2, NO_3^-, NH_4^+ etc.) between sediments and overlying water. Microbial activity in anaerobic sediments will also be studied. These measurements will indicate the extent to which sediments receive detritus from the overlying water and the rate at which mineralized products are transferred back to the water column. The role of benthic organisms in these processes is a crucial one. Altogether, there are also great differences to be expected in sediment biochemistry according to geographic, topographic, circulation and small to mesoscale pelagic biology and sedimentation patterns.

Programme:

Sediment bio- and geochemistry

Intact sediment cores and the overlying water will be taken by a multicorer. Rates of production of dissolved substances (carbonate, dissolved organic carbon, dissolved organic nitrogen, N-, P- Si-nutrients) and of their fluxes (including oxygen) will be measured by time-series incubations in closed vessels on board. These flux studies will be combined with the sediment, pore water and overlying bottom water analyses to try to understand and quantify exchange processes between bottom and water in the investigation area and to relate them with pelagic and sedimentation processes. Denitrification will be measured on board by N_2 fluxes, and rates of nitrification by NH_4^+ flux from acetylene-inhibited incubations. More specific rate measurements will also be made at 2 cm intervals within the sediment. In this context, rates of sulfate reduction will be measured with ^{35}S-labelled sulfate, to give an assessment of the rate of anoxic mineralization of organic carbon. In sediments with high mineralization activity, ^{15}N-ammonium turnover will also be determined. Potential and actual microbial reduction of nitrate, sulfate and bicabonate with the generation of ammonia/dinitrogen, hydrogen sulfide/metal sulfides, and methane as well as fermentative processes in putatively organic-rich (anaerobic) sediments will also be considered.
In combination with oxygen consumption and the benthic fauna work, all these studies will help to obtain some indication of total sediment mineralization activity.

Geology

The geological investigations will focus on the modern sediment distribution pattern and transport processes on the northern Barents shelf and on the continental slope of the Nansen Basin. Investigation of sediment cores will help in the reconstruction of the sedimentary and paleoceanographic environment of the Barents shelf and slope during the late Cenozoic.
Micropaleontological studies on organisms important for paleoclimatic and paleoceanographic interpretations, such as benthic and planktic foraminifers, will be an important part of the research programme.
Moreover, the sedimentological investigations are designed to study the present deposition regime and, together with biochemistry, to provide valuable background information for the biological research on the pelago-benthic coupling (e.g. grain size distribution, minerals, contents of organic carbon, various organic compounds and nutrients).

Gravity corers will be used for obtaining long sediment cores. Undisturbed surface sediments will be sampled by a (large) box corer and multicorers. Specific sampling sites may be selected after presite surveying using a sub-bottom sediment echo sounding system and the bottom imaging.

The geological and sedimentological investigations will follow the same transect areas as of the oceanographical and biological research groups. The coring will be concentrated on the continental shelf and margin with sampling profiles perpendicular to the slope. Those profiles are hoped to be extended into the central Arctic basin during the following Polarstern leg (ARK VIII/3).

Participants:

Bio-geochemistry

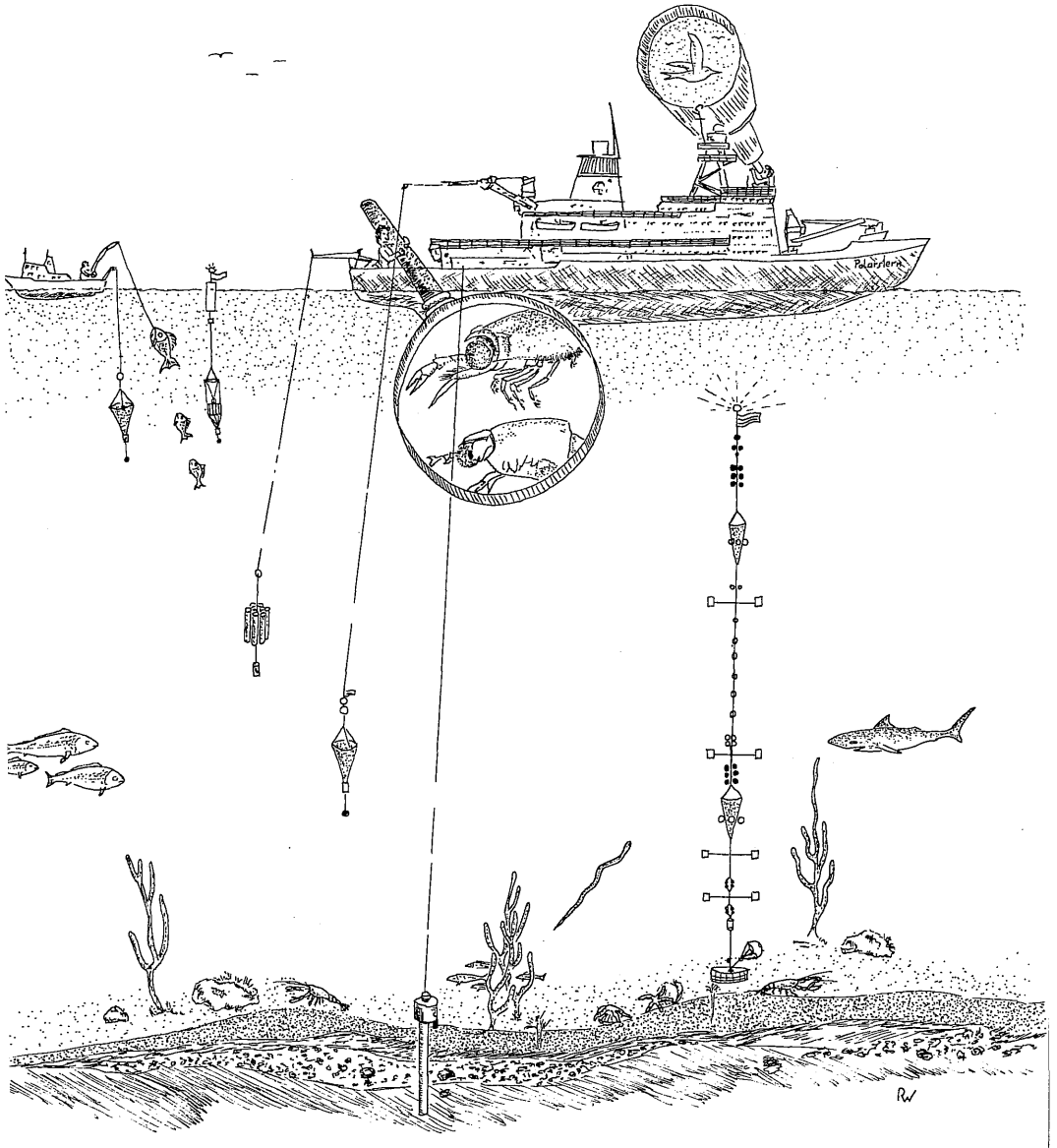
T. H. Blackburn, UA-E (Aarhus): Exchange rates of nutrients etc. between sediments and water; methods: incubations from multicorer samples
Per Hall and Stefan Hulth, UG-C (Göteborg): Biogeochemical recycling of C, N, P, Si and their fluxes, including oxygen; methods: incubations from multicorer samples; porewater and sediment analyses;
H. Gerberding, UGö-M (Göttingen)/WHOI, and
Holger Jannasch, WHOI (Woods Hole): Anaerobic microbial processes (in organic deposits), reduction of nitrate, sulfate and bicarbonate; methods: microbiological sub-samples of box- and multicorer samples, bacteriological enrichment and cultures, measurements of ^{14}C-labelled products.

Geology

Silvia Forti, ENEA (La Spezia): Transportation and disperion of suspended inorganic matter; methods: analyses of suspended matter from filtered and unfiltered water samples for TPM, OPM, IPM, granulometry (Coulter Counter), and mineralogical composition (X-Ray diffraction, Scanning Electron Microscopy and Energy Dispersive Spectrometry);
Hannes Grobe,
René Srodka, and
Andreas Veith, AWI (Bremerhaven): Modern sediment distribution patterns in relation to transport processes, and reconstruction of the sedimentary and paleoceanographic environment during the late Cenozoic; methods: operation of echo sounding system, sampling with gravity corer, box corers, multi-corers; measurements of grain size distribution, ice rafted debris, org. and inorg C, clay mineralogy, stable oxygen and C isotopes, opal content.

Cooperation:

D. Eisma & G. W. Berger, NIOS (Texel): Composition and deposition rates of fine grained sediments in the Barents Sea;
A. Mackensen, AWI: Foraminfera (microfossils).



Zeichnung: Rolf Wenzel

3 Fahrtteilnehmer / Participants

ARK VIII/1:

Name	Institut
Auf dem Venne, Herbert	IFMK
Bagry-Shakhmatova, Lydia	IBSS
Braun, Jose Gracia	IEO
Darnell, Clarke	PMEL
Drübbisch, Ulrich	IFMH
Ehmann, Volker	AWI
Elander, Magnus	DQG
Forti, Silvia	ENEA
Garges, Anita	AWI
Gebeler, Jens	IFMH
Goldschmidt, Peter	SFB 313
Graeve, Martin	AWI
Hagen, Wilhelm	IPÖ
Hannsen, Hinrich	IFMK
Haq, Syed, M.	IOC
Hebbeln, Dierk	GeoB
Hernandez Leon, Santiago	FCM
Hirche, Hans-Jürgen	AWI
Hubberten, Ulrike	AWI
Joiris, Claude	VUB
Kattner, Gerhard	AWI
Kirchhoff, Berit	AWI
Krack, Axel	AWI
Lara, Ruben	AWI
Lenz, Jürgen	IFMK
Maul, Andreas	AWI
Mehrtens, Gabriele	AWI
Meyer, Ute	AWI
Nommann, Sulev	IEMR
Ohm, Klaus	AWI
Preuß, Henning	SFB 313
Richter, Claudio	IPÖ
Rumohr, Jan	GEOM
Sauerland, Joachim	AWI
Schaumann, Karsten	AWI
Sildam, Jüri	IEMR
Stürken, Marthi	AWI
Tahon, Jaques	VUB
Tillmann, Urban	AWI
Wegner, Jan	AWI
2 N.N.	SWA

ARK VIII/2 = EPOS II = SEAS:

Name	Institute
Allegra, Antonina	ISTM
Andreassen, Inger	UT-F
Blackburn, T.H.	UA-E
Chernova, N.V.	MMBI
Civitarese, Guiseppe	ITT
von Dorrien, Christian	IPÖ
Forti, Silvia	ENEA
Fransz, H. George	NIOZ
Gerberding, Holger	WHOI/ UGö-M
Gonzales, Humberto	AWI
Graeve, Martin	AWI
Grobe, Hannes	AWI
Gutt, Julian	AWI
Hall, Per	UG-C
Harms, Ingo	IFMH / (AWI)
Hempel, Gotthilf	AWI
Hoffmann, Hilmar	RF
Hulth, Stefan	UG-C
Inall, Mark	SPRI
Jannasch, Holger W.	WHOI
Joiris, Claude	VUB
Kendall, Mike A.	PML
Kern, Horst F.	UM-Z
Konuk, Y. Tosun	UI-M
Luchetta, Anna	ITT
Martinez, Rosa	CEAB
Mathieu, Thierry	UL-E
Matishov, Dmitry G.	MMBI
Neyelov, Alexey V.	ZIL
Nöthig, Eva-Maria	AWI
Opalinski, Krzysztof	IOS-PAN
Owrid, Georgina	US-O
Passelaigue, Françoise	COM
Petrov, Vladimir S.	MMBI
Piepenburg, Dieter	IPÖ
Rachor, Eike	AWI
Ryzhov, Vjacheslav S.	MMBI
Saldanha, Luiz	UL-Z
Schauer, Ursula	AWI
Schmid, Michael	IPÖ
Shaban, Anton Yu.	MMBI
Sirenko, B. I.	ZIL

ARK VIII/2 = EPOS II = SEAS: cont.

Name	Institute
Socal, Giorgio	IBMV
Sörensen, Fred and N.N.	UG-M
Srodka, René	AWI
Strass, Volker	AWI
Timofeev, Sergey F.	MMBI
Veit, Andreas	AWI
Voehrs, Helmut	RF
Wiktor, Josef	IOS-PAN
2 N.N.	SWA

4 Beteiligte Institute / Participating Institutes

Belgien/Belgium:

UL-E University of Liège, Unité d'Ecohydrodynamique B5
B - 4000 Liège

VUB Vrije Universiteit Brussel, Faculteit Wetenschappen,
Laboratorium voor Ecotoxicologie
Plainlaan 2
B -1050 Brussel

Dänemark/Danmark

UA-E University of Aarhus, Department of Ecology and Genetics
DK - 8000 Aarhus C

Deutschland/Germany

AWI Alfred-Wegener-Institut für Polar- und Meeresforschung
Columbusstraße
D-2850 Bremerhaven

GeoB Fachbereich Geowissenschaften
Universität Bremen
Postfach 33 04 40
D-2800 Bremen 33

GEOM GEOMAR Forschungszentrum für marine Geowissenschaften,
Universität Kiel, Wischhofstr. 1-3
D-2300 Kiel 14

IFMH Institut für Meereskunde der Universität Hamburg
Troplowitzstraße 7
D-2000 Hamburg 54

IFMK Institut für Meereskunde an der Universität Kiel
Düsternbrooker Weg 20
D-2300 Kiel 1

IPÖ Institut für Polarökologie der Universität Kiel
Olshausenstaße 40
D-2300 Kiel

RF Reedereigemeinschaft Forschungsschiffahrt
August-Bebel-Allee 1
2800 Bremen 41

SFB 313 Sonderforschungsbereich 313
Christian-Albrechts-Universität
Olshausenstraße 40
D-2300 Kiel

SWA Seewetteramt Hamburg
Berhard-Nocht-Straße 76
D-2000 Hamburg 4

UGö-M Universität Göttingen, Institut für Mikrobiologie
D-3400 Göttingen

UM-Z Universität Marburg, Institut für Zellbiologie und Zellpathologie
D- 3550 Marburg

Frankreich/France

COM Centre d'Océanologie de Marseille,
Faculté des Sciences de Luminy, Université d'Aix-Marseille 2
Case 901
F - 13288 Marseille

IOC Intergovernmental Oceanographic Commission - Unesco
Place de Fontenoy
F - 75700 Paris

Italien/Italy

ENEA ENEA, Centro Ricerche Energia Ambiente S. Teresa
Casella Postale
I - 19100 La Spezia

IBMV Instituto di Biologia del Mare
Castello, 1364
I - 30122 Venezia

ISTM Istituto Sperimentale Talassografico di Messina,
Spianata S. Raineri 86
I - 98 122 Messina

ITT Instituto Tallassografico di Trieste Francesco Vercelli
Vivale Romolo Gessi, 2
I - 34123 Trieste

Niederlande/The Netherlands

NIOZ Netherlands Institute of Sea Research
P. O. Box 59
NL - 1790 AB Den Burg, Texel

Norwegen/Norway

UT-F University of Tromsø, Norwegian College of Fishery Science
Dramsveien 201
N - 9000 Tomsø

NPI Norsk Polarinstitutt
Postbaks 158
N-1330 Oslo

Polen/Poland

IOS-PAN Institute of Oceanology of Polish Acad. Sciences
PBox 68
PL- 81 967 SOPOT

Portugal/Portugal

UL-Z Universidade de Lisboa,
Departomento de Zoologia, Facultade de Ciencas C2
Bloco C2 3 Piso
P - 1700 Lisbon

Schweden/Sweden

DQG Department of Quaternary Geology
Lund University
Sölvegatan 13
S - 223 62 Lund

UG-C University of Göteborg,
Department of Analytical & Marine Chemistry
S - 41296 Göteborg

UG-M University of Göteborg,
Dept. of General and Marine Microbiology
S - 41319 Göteborg

Spanien/Spain

CEAB Centro de Estudios Avanzados de Blanes
Camino de Sta. Barbara s/n
E - 17300 Blanes-Gerona

FCM Facultad de Ciencias del Mar, Universidad de Las Palmas
Campus Universitario de Tarifa
E-35017 Las Palmas de Gran Canaria

IEO Instituto Espanol de Oceanografia,
Centro Oceanografico de Canarias
Apartado de Correas 1373
E-38080 Santa Cruz de Tenerife

Türkei /Turkey

UI-M Dokuz Eylül University of Izmir,
Institute of Marine Sciences and Technology
P. O. Box 478
TR - 35260 Konak / IZMIR

Vereinigtes Königreich/United Kingdom

SPRI Scott Polar Research Institute, Univ. Cambridge
Lensfield Road
Cambridge CB2 1ER, England

US-O University of Southampton, Department of Oceanography
GB - Southampton 209 5NH, England

U.S.A.

PMEL NOA Pacific Marine
Environmental Laboratory

WHOI Woods Hole Oceanographic Institution, Biolog. Dept.
Woods Hole, MA 02543

U.d.S.S.R./U.S.S.R.

IBSS Institute of Biology of Southern Seas
37 Pushkinskaya street
Odessa - 270011, Ukraine

IEMR Institute of Ecology and Marine Research
Paldiski Rd. 1,
Tallinn 200001, Estonia

MMBI Murmansk Marine Biological Institute, USSR Acad. Sciences
Vladimirskaya, 17
Murmansk - 183 023, Russia

ZIL Zoological Institute Leningrad, USSR Academy of Sciences
Leningrad - 199 164, Russia

5 Schiffsbesatzung / Ship's Crew

Dienstgrad	ARK VIII/1	ARK VIII/2
Kapitän	I. Suhrmeyer	I. Suhrmeyer
1. Naut. Offizier	H. Götting	H. Götting
Naut. Offizier	N. N.	N. N.
Naut. Offizier	I. Varding	I. Varding
Naut. Offizier zusätzlich	-	S. Schwarze
Arzt	Dr. H. Aschoff	Dr. H. Aschoff
Elektriker	G. Schuster	G. Schuster
Elektroniker	H. Elver	H. Elver
Elektroniker	H. Pabst	H. Pabst
Elektroniker	H. Muhle	H. Muhle
Elektroniker	U. Lembke	U. Lembke
Funkoffizier	H. Geiger	H. Geiger
Funkoffizier	K.H. Wanger	K.H. Wanger
Ltd. Ingenieur	K. Müller	K. Müller
1. Ingenieur	G. Erreth	G. Erreth
2. Ingenieur	R. Fengler	R. Fengler
2. Ingenieur	E. Schuster	E. Schuster
Maschinenwart	E. Carstens	E. Carstens
Maschinenwart	W. Wittfoth	W. Wittfoth
Maschinenwart	U. Husung	U. Husung
Maschinenwart	M. Reitz	M. Reitz
Maschinenwart	G. Dufner	G. Dufner
Lagerhalter	F. Schierl	F. Schierl
Bootsmann	W. Hopp	W. Hopp
Zimmermann	K. Marowsky	K. Marowsky
Matrosen:	Gil Iglesias	Gil Iglesias
	Soage Curra	Soage Curra
	Abreu Dios	Abreu Dios
	Pousada Martinez	Pous. Martinez
	Figueira Lemai	Figueira Lemai
	Iglesias Bermudez	Ig. Bermudez

Dienstgrad	ARK VIII/1	ARK VIII/2
Matrosen	-	N. N.
	-	N. N.
Koch	E. Kubicka	E. Kubicka
Kochsmaat	M. Dutsch	M. Dutsch
Kochsmaat	B. Hünecke	B. Hünecke
1. Steward	N. N.	N. N.
Steward./Krankenschwester	R. Lieboner	R. Lieboner
Stewardess	A. Hopp	A. Hopp
Stewardess	T. Rothmann	T. Rothmann
Stewardess	M. Hoppe	M. Hoppe
2. Steward	Ch. L. Yu	CH. L. Yu
2. Steward	P. L. Wen	P. L. Wen
Wäscher	Ch. Ch. Yang	Ch. Ch. Yang