Die Winter-Expedition mit FS „Polarstern" in die Antarktis (ANT V/1-3)

The Winter-Expedition of RV "Polarstern" to the Antarctic (ANT V/1-3)

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Ber. Polarforsch. 39 (1987)
ISSN 0176-5027

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Einführung

Vom 6. Mai bis 14. Dezember 1986 hat FS "Polarstern" zum ersten Mal den antarktischen Winter im eisbedeckten Teil des Südpolarmeeres verbracht und auf drei Fahrtabschnitten multidisziplinäre Forschungsarbeiten durchgeführt. Das Schiff legte während dieser Winterexpedition insgesamt 25.638 Seemeilen zurück.

Der erste Fahrtabschnitt begann am 6. Mai 1986 in Punta Arenas und führte in das Seegebiet um Elephant Island in die Bransfield Straße und in das Gebiet westlich der Antarktischen Halbinsel. Die Untersuchungen zur Verbreitung und Zusammensetzung der Krillvorkommen schlossen unmittelbar an laufende Arbeiten der Bundesforschungsanstalt für Fischerei (Hamburg) an. Diese Studien sind ein Beitrag zum internationalen Projekt SIBEX (Second International BIOMASS Experiment), das während dieses Fahrtabschnitts zum ersten Mal im antarktischen Herbst/Frühwinter stattfand. Auch die fischereibiologischen Untersuchungen um Elephant Island zur Abschätzung der Biomasse sowie die Untersuchungen zur Nahrungsmenge und -zusammensetzung der antarktischen Fische gehören zu einer mehrjährigen Studie der Bundesforschungsanstalt für Fischerei. Biochemische Untersuchungen an überwinternden Meerestieren und Aufzuchtexperimente am Krill wurden auf dem ersten Fahrtabschnitt begonnen und auf den beiden folgenden in den Kühlaquarien des Schiffes fortgeführt.

Der zweite Fahrtabschnitt - oder erste Teilabschnitt des Winter-Weddell-See-Projekt 1986 (WWSP'86) - begann am 27. Juni 1986 in Bahia Blanca. Untersuchungen zur Wirkung des Meereises auf die Zirkulation in Ozean und Atmosphäre auf einer meridionalen Traverse durch den Packeisgürtel entlang des Greenwich Meridian standen im Vordergrund des Forschungsprogrammes. Die biologischen Arbeiten konzentrierten sich auf die Erforschung der Lebensgemeinschaften im Meereis.

Der zweite Teilabschnitt von und nach Kapstadt (28. Sept.-14. Dez. 1986) dehnte die ozeanographischen und meteorologischen Arbeiten in den inneren Teil der östlichen Weddell-See aus. Schwerpunkte dieses Abschnittes waren jedoch die biologischen Arbeiten zu den Lebensvorgängen im winterlichen, eisbedeckten Südpolarmeer und während der Frühjahrsentwicklung des Planktons. Die Nahrung und Fortpflanzung der Weddell-Robben und der Kaiserpinguine wurden von der neu errichteten "Drescher-Station" aus in einer eisbedeckten Meeresbucht untersucht. Auch wurden die Robben und Pinguine im östlichen Teil der Weddell-See von den Hubschraubern der "Polarstern" aus gezählt und kartiert.

Kapitän E.P. Greve führte FS "Polarstern" auf ANT V/1, Kapitän L. Suhrmeyer auf ANT V/2 + 3. Den Kapitänen, den Offizieren und der Mannschaft gebührt großer Dank für ihren engagierten Einsatz und für die allezeit bewiesene Unterstützung, die zum Erfolg der wissenchaftlichen Arbeit wesentlich beigetragen haben.

Herzlicher Dank gebührt auch D. Burhop, G. Dansauer, M. Gomez, G. Kühn, H.-P. Marschall, S. Marschall, C. Schwake und L. Schwidernoch für ihre unermüdliche Hilfe bei der Fertigstellung dieses Fahrtberichtes.

Introduction

For the first time RV "Polarstern" has spent the winter in the pack-ice zone of the Antarctic starting on 6 May and ending on 14 December 1986. The cruise consisted of three legs (V/1, 2, 3) on which different multidisciplinary research programmes were carried out. "Polarstern" passed a total of 25,638 nautical miles during the cruise.

The first leg started in Punta Arenas on 6 May 1986, and led to Elephant Island, the Bransfield Strait and the region west of the Antarctic Peninsula. The studies on the distribution and composition of krill were a direct follow-up of ongoing investigations of the Federal Institute for Fisheries, in Hamburg. They were part of the Second International BIOMASS Experiment (SIBEX) which for the first time during this leg extended into the Antarctic fall/ early winter season. The fisheries research which was executed around Elephant Island to estimate biomass as well as to examine food consumption and composition for Antarctic fish, was also part of a long-term study of above-mentioned Fisheries Institute. Biochemical studies on overwintering marine animals and growth experiments with krill started during the first leg and were continued during the two following legs in the cooling laboratories of the vessel.

The second leg being the first part of the Winter Weddell Sea Project (WWSP'86) started on 27 June 1987 in Bahia Blanca. Studies on the interaction of sea ice on the oceanic and atmospheric circulation along a transect following the Greenwich Meridian through the pack-ice to the Antarctic coast, formed a central part of the research programme. The parallel biological work concentrated on the investigation of sea ice biota.

The third leg being the second part of WWSP'86 from Cape Town to Cape Town (28. Sept.-14. Dec. 1986) extended the oceanographical and meteorological work into the inner part of the eastern Weddell Sea. Main emphasis, however, was put on studies of biological processes in the ice covered Weddell Sea during winter and the beginning of spring bloom. Feeding and reproduction of Weddell seals and Emperor penguins in an ice covered bay were investigated from the newly constructed "Drescher Station". Aerial counts of seals and penguins along the eastern coast of the Weddell Sea were carried out with helicopters from "Polarstern".

Captain E.P. Greve was master of "Polarstern" on leg ANT V/1, Captain L. Suhrmeyer on legs ANT V/2 + 3. We are grateful to them, the officers and the crew for their excellent work done and their close co-operation which contributed to the scientific success of the cruise.

Thanks are due to D. Burhop, G. Dansauer, M. Gomez, G. Kühn, H.-P. Marschall, S. Marschall, C. Schwake and L. Schwidernoch for their unremitting help during the completion of this cruise report.

1. Fahrtabschnitt ANT V/1 (Punta Arenas - Bahia Blanca)

1.1. Zusammenfassung und Fahrtverlauf (D. Sahrhage)

Am 6. Mai 1986 um 14 Uhr Ortszeit verließ FS "Polarstern" mit 29 wissenschaftlichen Fahrtteilnehmern und 44 Besatzungsmitgliedern an Bord den Hafen von Punta Arenas, Chile. Die Abfahrt hatte sich um einen Tag verspätet, da das Eintreffen wichtiger, in der Zollabfertigung verzögerter Geräte abgewartet werden mußte. Das Schiff fuhr durch die Magellan-Straße nach Osten und nahm dann Kurs SSE in Richtung Elephant Island. Starke SSW-Winde, teilweise mit Windstärke 9, und hohe See verlangsamten die Fahrt. Ein geplanter Schnitt mit XBT-Sonden auf jedem vollen Breitenkreis mußte wegen der ungünstigen Wetterbedingungen bereits nach dem Abwerfen der ersten Sonde auf der Position 55°00'S, 63°10'W am 7.5. (St.1) abgebrochen werden. Erst in der Nähe der antarktischen Konvergenz konnte nach Wetterberuhigung am 8.5. auf 57°39'S, 60°08'W wieder eine XBT-Sonde eingesetzt werden. Die Konvergenz wurde auf 57°20'S, 60°31'W überfahren.

Nach einem Versuchshol mit dem Rectangular Midwater Trawl (RMT) (St. 3) begannen am 9.5. mittags fischereibiologische Untersuchungen an den Fischvorkommen um Elephant Island mit dem 140'-Grundschleppnetz. Bis zum 13.5. abends wurden nördlich, westlich und südöstlich dieser Insel auf Tiefen zwischen 80 und 350 m insgesamt 21 Hols mit dem Grundschleppnetz durchgeführt, bei denen etwa 16,7 Tonnen Fisch gefangen wurden. Von diesen Fischen wurde ein Teil in Proben an Bord biologisch bearbeitet, ein anderer Teil für weitere Untersuchungen an Land eingefroren. Die beiden Fischereistationen südlich von Elephant Island zeigten schwierige Bodenverhältnisse und erbrachten neben großen Mengen Beifang (Benthos) nur wenige Fische. Diese Zone sollte daher in Zukunft nicht mehr befischt werden. Hier traten kleinere Netzschäden auf, es ging jedoch kein Fanggerät verloren.

Für ozeanographische Messungen wurden auf den Fischereistationen 15 Einsätze mit Multisonde und Rosettenwasserschöpfer gefahren, wobei das Seewasser für Analysen organischer Spurenstoffe und ATP verwendet wurde. Abendliche Serien mit dem Van Veen-Backengreifer lieferten Proben für Benthosuntersuchungen. Eine Lichtfalle zum Fang von Krill und anderen Tieren wurde erstmals erprobt.

Das Echolot (ELAC-Fischereilot 30 kHz) zeigte neben Fischkonzentrationen am Boden nordwestlich von Elephant Island gelegentlich auch pelagische Vorkommen in Tiefen von 20-40 m, manchmal auch 50 m und tiefer, an, die vermutlich aus Krill bestanden. Sie wurden nicht befischt, weil eine Umrüstung auf RMT zu zeitaufwendig gewesen wäre, doch enthielten die Maschen des Grundschleppnetzes zahlreichen Krill. Fangversuche mit dem Vertikalnetz und dem Apstein-Netz in oberflächennahen Wasserschichten erbrachten reiche Phytoplanktonproben, etliche Male auch Krill-Larven

(Furcilien). Während des Aufenthaltes der "Polarstern" im Gebiet um Elephant Island wurde über längere Zeit in der Nähe ein sowjetisches Fabrikschiff der Atlantik-Klasse beim Fischen beobachtet, meist an der Schelfkante im NW der Insel. Es unterhielt Radiokontakt mit weiter entfernt stehenden sowjetischen Fahrzeugen.

Am 11.5. nachmittags mußten die Forschungsarbeiten bis zum anderen Morgen wegen Sturms (Bft 9-10) bei Lufttemperaturen von -11°C unterbrochen werden. Sonst waren die Untersuchungen durch gutes Wetter begünstigt.

In der Nacht zum 14.5. fuhr die "Polarstern" dann zwischen Elephant Island und Clarence Island hindurch nach Nordosten zur ersten Station (St.25) der Elephant Island Box am Nordende des Schnittes 1.

Auf den Stationen in dieser Box wurde das RMT 1+8 zunächst bis 400 m, dann bis 200 m Tiefe eingesetzt, Multisonde mit Rosettenwasserschöpfer bis zum Boden (maximal 3900 m) gefahren und bei günstigen Wetterbedingungen Plankton mit dem Apstein-Netz und dem Vertikal-Netz gefangen. Auch der Neuston-Schlitten kam gelegentlich zum Einsatz. In der Mitte zwischen den jeweils 15 Seemeilen voneinander entfernten Stationen wurden XBT-Sonden abgeworfen.

Auf dem Wege nach Süden nahm ab 60°15'S das Treibeis rasch zu, und auf 61°00'S wurde es so dicht, daß für den Einsatz des RMT keine ausreichenden offenen Wasserflächen mehr vorhanden waren. Weiter nach Südwesten fand sich jedoch noch eine größere eisarme Zone, in der bei fast windstillem Wetter nicht nur das RMT gefahren, sondern auch eine Erprobung des Unterwasserfahrzeugs (UWE) vorgenommen werden konnte (St.34). Leider erwies sich dieses Gerät als noch nicht einsatzbereit. Ein Schlauchboot wurde auf Station 31 ausgesetzt, um Eisproben zur Untersuchung der Eisalgen und anderer Organismen zu sammeln.

Während der Weiterfahrt nach Süden wurde das Treibeis schließlich so dicht, daß es nicht sinnvoll erschien, die Arbeiten auf Schnitt 1 nach Süden fortzusetzen. So brach sich das Schiff einen Weg durch die Straße zwischen Elephant Island und Clarence Island. Als auch südlich Elephant Island auf 55° westlicher Länge weiter dichtes Packeis beobachtet wurde, mußte auch der Südteil des Schnittes 2 aufgegeben werden. Stattdessen umfuhr die "Polarstern" in der Nacht zum 16.5. Elephant Island auf der Westseite, wo die Eisbedeckung wesentlich geringer war. Der Nordteil des Schnittes 2 auf 55°00'W wurde am 16.5. morgens mit Station 35 begonnen, am 17.5. auf 60°00'S das nördliche Ende erreicht und Schnitt 3 auf 56°00'W nach Süden begonnen. Auf dem Wege nach Süden fuhr das Schiff bei etwa 61°15'S wieder in das Treibeis hinein. Genügend offenes Wasser für eine RMT-Station fand sich nur noch auf Station 58 (61°30'S). Weiter südlich erreichte die Eisbedeckung bald 10/10, sodaß nur einige XBT-Sonden noch hinter dem Schiff abgeworfen werden konnten. Aus diesem Grunde wurde Schnitt 3 abgebrochen und Kurs auf die südlichste Station des Schnittes 4 (56°45'W) genommen. In der Nacht zum 19.5. erreichte das Packeis solche Mächtigkeit, daß sich das Schiff zeitweise nur mit Rammstößen seinen Weg bahnen konnte. So wurden die Arbeiten für Schnitt 4 mit einer XBT-Sonde auf 61°45'S begonnen. Auf etwa 61°20'S verließ die "Polarstern" das Treibeis wieder in nördlicher Richtung, und am 20.5. nachmittags war dieser Schnitt auf 60°00'S und 56°45'W beendet. Insgesamt konnten im nördlichen Teil der Elephant Island Box 25 RMT, 24 Multisonden- und 30 XBT-Stationen durchgeführt werden.

Am 20.5. abends begann der nächste Abschnitt der Reise mit der nördlichsten Station des Schnittes 5 nördlich King George Island. Die letzte Station vor der Insel (St. 80) lag in leichtem Treibeis, und während der Fahrt um das Westende mit Kap Melville war dichteres Packeis (6/10) zu durchqueren. Auf Station 81 im Südosten der Insel war offenes Wasser, doch geriet das Schiff in der Nacht zum 22.5. auf dem Wege nach Süden gleich wieder in dichtes Packeis, und der geplante Schnitt über die Bransfield Straße bis zum Antarctic Sound mußte als undurchführbar aufgegeben werden.

Die "Polarstern" nahm Kurs auf die Position 62°22'S, 57°50'W, um die dort im November 1985 ausgelegte Verankerung von Sedimentfallen zu bergen. Leider war der Ort von dichtem Packeis (9/10) bedeckt, so daß die Aufnahme unmöglich war.

Bei der weiteren Reise durch die Bransfield Straße eben südlich der Süd-Shetland Inseln nach Westen mußte sich das Schiff fast ununterbrochen durch dichtes Packeis (Bedeckung meist 10/10) von einer mittleren Stärke von 1 m brechen, wobei eine dicke Schneedecke auf dem Eis bremsend wirkte, so daß eine Fahrt über weite Strecken nur noch mit Rammstößen möglich war. Es herrschte ruhiges Ostwindwetter, und bei sehr klarer Sicht war zu erkennen, daß die Bransfield Straße in gesamter Breite von den Süd-Shetlands bis zur Antarktischen Halbinsel von dichtem Eis bedeckt war. Die Lufttemperaturen gingen zeitweise bis auf -22°C zurück. Lediglich in einigen Waken mit offenem Wasser, die für den RMT-Einsatz gerade ausreichten, konnten 4 Stationen durchgeführt werden. Auf Station 82 wurden Eisproben zur Untersuchung der Algen gesammelt, auf Station 85 das mobile Unterwasserfahrzeug (UWE) erfolgreich erprobt. Die nach Süden quer über die Bransfield Straße geplanten Schnitte waren nicht möglich. Erst unmittelbar vor Deception Island erreichte die "Polarstern" dann am Abend des 23.5. wieder offenes Wasser. Am folgenden Tage wurden am Eisrand entlang einige Stationen bearbeitet und auf Stat. 91 vor Livingston Island insbesondere Benthosproben mit Bodengreifer und Beyer-Schlitten gesammelt.

Am 25. und 26.5. folgten zwei Schnitte in den ozeanischen Bereich der Drake Passage. Auf fast allen Stationen wurde parallel zum RMT auch der Neuston-Schlitten gefahren, der sich als sehr nützlich zum Fang von Krill-Larven erwies, und neben der Multisonde mit Rosettenwasserschöpfer kam oft das

Apstein-Netz zum Einsatz. An der Station 99 südlich von Smith Island, wo wieder Benthosproben mit Bodengreifer und Beyer-Schlitten gesammelt wurden, traf das Schiff erneut auf den Treibeisgürtel. Die nächsten beiden Stationen südlich von Low Island wurden in offenen Wasserstellen gefahren. Der geplante Schnitt 9 in Richtung auf Hoseason Island erwies sich wegen der Eisbedeckung als nicht durchführbar. Somit war auch der nördliche Zugang zur Gerlache Straße durch die Croker Passage durch Eis blockiert. Die "Polarstern" fuhr daher an der Eiskante entlang nach Südosten auf die südlichste Station des Schnittes 10 (St. 102).

Der anschließende Versuch, die Gerlache Straße durch die Dallmanns Bucht und den Schollaert Kanal zu erreichen, mußte am 27.5. nachmittags wegen einer sehr starken Eisbarriere kurz vor der Einfahrt aufgegeben werden. Überall war Neueisbildung zu beobachten.

Da nach Auskunft der amerikanischen Station "Palmer" in der Bismarck Straße relativ wenig Eis zu sehen war, aber andererseits die Gefahr bestand, daß bei möglichen westlichen Winden auch dieser Zugang zur Gerlache Straße durch Treibeis und Neueis bald versperrt werden könnte, wurde in der Nacht zum 28.5. Anvers Island im Norden umfahren und Kurs auf den südwestlichen Eingang zur Gerlache Straße genommen. Nach Durchqueren eines Eisgürtels, der aus dem Neumayer Kanal heraus die Fahrt hemmte, konnte die Gerlache Straße am 28. und 29.5. bis eben nördlich des Eingangs in den Schollaert Kanal ziemlich ungehindert befahren werden. Dort versperrten Eisbarrieren erneut den Weg. Das Wetter war windarm und neblig-trüb mit zeitweiligen Schneefällen; die Lufttemperaturen betrugen -13 bis -16°C.

In der Gerlache Straße wurden an verschiedenen Stellen, wie erwartet, Krillvorkommen angetroffen, die mit dem Echolot in den oberen Wasserschichten meist bis 80 m Tiefe beobachtet wurden. Auf Station 103 wurde ein gezielter Hol mit dem RMT auf eine solche Lotanzeige durchgeführt, der jedoch nur 0,5 kg adulten Krill erbrachte. Dagegen lieferte ein späterer RMT-Hol (St. 109) ohne erkennbare Lotanzeige knapp 2 kg Krill. Insgesamt wurden in der Gerlache Straße 7 RMT(M)-Einsätze gefahren, die alle Krill erbrachten, von denen jedoch nur einer reibungslos verlief, während bei allen übrigen Schwierigkeiten mit dem Mehrfachauslöser auftraten, die aber vom AWI-Elektroniker, Herrn Dimmler, erfolgreich behoben werden konnten. Nahe dem Eingang des Schollaert Kanals in die Gerlache Straße, wo im April 1985 mit FFS "Walther Herwig" entsprechende Untersuchungen vorgenommen worden waren (Sts. 106 und 108), wurden mit dem RMT(M) Stufenfänge in verschiedenen Tiefenhorizonten von 500 m bis zur Wasseroberfläche durchgeführt. Krill trat in den Fängen nur oberhalb von 200 m auf. Salpen waren im Gegensatz zu anderen Untersuchungsgebieten in der Gerlache Straße nicht zu beobachten.

Das Vorkommen des Krills in der Gerlache Straße wurde auch durch die Anwesenheit einer großen Anzahl von Robben auf

Eisschollen und im Wasser dokumentiert. Neben einigen Krabbenfresserrobben und Seeleoparden waren vor allem Pelzrobben zu beobachten, die in dieser Region in den letzten Jahren offensichtlich stark zugenommen haben. An den Futterplätzen der Robben auf den Eisschollen waren rote Flecke mit Krillresten zu finden. Außer den Robben wurden auch mehrere Gruppen von Adeliepinguinen gesichtet. Wale wurden nicht beobachtet, doch ging aus einem Bericht der britischen Station "Faraday" hervor, daß dort unmittelbar in Landnähe zahlreiche Buckelwale zu sehen waren, woraus auf das Vorkommen von Krill vor der Antarktischen Halbinsel geschlossen werden darf.

Auf Station 104 wurde am 28.5. die Barkasse "Polarfuchs" ausgesetzt, mit der zwei Fahrten zum Sammeln von Benthos mit Bodengreifer und von Plankton mit Bongo unternommen wurden. Gleichzeitig wurde von der "Polarstern" aus mit dem RMT gefischt und Multisonde mit Kranzwasserschöpfer gefahren. Anschließend erfolgte eine weitere Erprobung des Unterwasserfahrzeugs (UWE). Am Abend des gleichen Tages wurde das System auf Station 105 auf eine mit dem Echolot zu beobachtende Krillkonzentration eingesetzt. Dabei konnte Krill in Tiefen zwischen 10 und 70 m mit der Kamera gut beobachtet und auf Video aufgezeichnet werden. Leider mußte der für die gesamte Nacht geplante Versuch noch vor Mitternacht abgebrochen werden, weil die Hydraulik der Winde des UWE-Systems versagte. Auf dem auf das Land zu treibenden Schiff mußte das Unterwasserfahrzeug rasch und mit erheblicher Mühe seitens der Besatzung über die schiffseigene Windenanlage wieder geborgen werden.

Am Morgen des 29.5. ließen Schneegestöber und starker Wind (30 kn) keinen Einsatz der Barkasse "Polarfuchs" zu. Nach Beruhigung des Wetters legte "Polarstern" an einer Eiskante mit Neueisbildung an, und das Schlauchboot wurde zur Sammlung von Eis- und Wasserproben ausgesetzt (St. 107).

Nach Erledigung der Forschungsarbeiten in der Gerlache Straße durchquerte die "Polarstern" abends wieder den Treibeisgürtel vor dem Neumayer Kanal nach Westen. Am Morgen des 30.5. wurde in der Bismarck Straße Station 110 mit Multisonde/Rosette, RMT und Neuston-Schlitten bearbeitet und dann Kurs auf Arthur Harbor genommen.

Ab 11 Uhr Bordzeit begaben sich wissenschaftliche Fahrtteilnehmer und Besatzungsmitglieder mit der "Polarfuchs" zu einem Besuch der "Palmer Station" (USA) an Land. Die Aufnahme durch die 7 Mitglieder der amerikanischen Überwinterungsmannschaft war sehr herzlich, und später waren die Amerikaner auf der "Polarstern" zu Gast. Mit einem amerikanischen Biologen wurden Probleme der Krillforschung, insbesondere die Aufzucht von Krill-Larven, diskutiert.

Mit Einbruch der Dunkelheit um 16 Uhr Bordzeit verließ die "Polarstern" ihre Position vor "Palmer Station", und am gleichen Tage wurden noch zwei Stationen auf Schnitt 11 aus der Bismarck Straße nach Norden bearbeitet. In der Nacht zum

31.5. fuhr das Schiff dann zur Station 113 auf Schnitt 10, die wieder im Treibeis lag. Die Windrichtung änderte sich auf Südwest, und stürmische Winde bis Stärke 9 hemmten die Arbeiten auf den nächsten beiden Stationen dieses Schnittes. Im Nordteil des anschließenden Schnittes 11 konnten am 1.6. vormittags nur zwei Stationen ausgeführt werden, bevor erneut aufbrisende Winde in Stärke 9 mit grober See den Abbruch der Forschungsarbeiten erzwangen. Jedoch beruhigte sich das Wetter in der Nacht zum 2.6. rasch wieder, der Wind kam erneut aus östlichen Richtungen.

In der Nähe des Schelfabhangs auf Station 120 wurden im Neuston-Schlitten große Mengen von Krill-Larven gefunden, und daraufhin wurden mit dem Vertikal-Netz viele Larven zur Hälterung in den Aquarien und für biologische Proben gefangen.

Auf der Station 121 am Schelfrand traf das Schiff unerwartet wieder auf Treibeis, doch konnten am 3.6. die weiteren 4 Stationen auf Schnitt 12 nach Südosten in Richtung auf Renaud Island im offenen Wasser ohne Behinderungen durchgeführt werden. Auf dem Wege nach Südwesten erreichte "Polarstern" bei Station 126 wieder den Eisgürtel. Bis hinter die folgende Station nach Nordwesten (Schnitt 13) war intensive Neueisbildung zu beobachten. An der küstenfernen Station 129 über tiefem Wasser fuhr das Schiff erneut in das Packeis hinein und blieb bis zur Station 135, die am 6.6. morgens bearbeitet wurde, im Eis. Bei Station 132 wurde der südliche Polarkreis überquert. Auf zwei Stationen wurde wieder das Schlauchboot ausgesetzt, um Eisproben zu sammeln. Die Eisbedeckung war großenteils 10/10, und Multisonde, Neuston-Schlitten und andere Geräte konnten nur in wenigen offenen Wasserwaken eingesetzt werden. Für die Station 134 brach sich die "Polarstern" eine Rinne, in der das RMT gefahren wurde. Das Wetter war überwiegend ruhig und trübe mit Lufttemperaturen von -12 bis -15°C.

Nachdem Schnitt 14 nordwestlich von Adelaide Island mit den Stationen 130-132 unter erheblicher Mühe beendet war und sich bei den beiden südlicher gelegenen Stationen herausgestellt hatte, daß die Eisbedingungen in dieser Richtung noch schwieriger waren, wurden die beiden ursprünglich geplanten Schnitte westlich und südwestlich von Adelaide Island aufgegeben. Stattdessen fuhr das Schiff nach Nordosten in das Gebiet vor Lavoisier und Renaud Islands, wo auf der Station 126 im RMT zahlreiche Krill gefangen worden waren. Hier wurden am 6.6. morgens auf Station 135 Stufenhols mit dem RMT von 300 m Tiefe bis zur Oberfläche durchgeführt, die durch Fänge mit dem Multi-Netz und dem Neuston-Schlitten ergänzt wurden. Auf der folgenden Station diente das Schlauchboot wieder zur Gewinnung von Wasser- und Eisproben, und ähnlich wie auf verschiedenen anderen Stationen wurden für die Untersuchung des Benthos Backengreifer und Beyer-Schlitten eingesetzt.

Mit Station 137, bei der mit dem RMT rund 1,5 kg Krill gefangen werden konnten, und wiederum Benthos- und

Sedimentproben gewonnen wurden, waren dann die Arbeiten im Südteil des Untersuchungsgebietes beendet. Am Abend des 6.6. trat die "Polarstern" die Rückreise nach Nordosten zur King George Island und der Bransfield Straße an. Während dieser Fahrt herrschten starke Winde aus nördlichen Richtungen, die zeitweise Stärke 10-11 erreichten, und die See war sehr grob. Nördlich der King George Island, etwa auf 61°50'S und 59°00'W traf das Schiff wieder auf dichtes Treibeis, das bald so stark wurde, daß am Morgen des 8.6. Nord- und später Nordwestkurs eingeschlagen wurde, um aus dem Eisgürtel wieder herauszukommen. Auf der gesamten Strecke von Station 137 bis östlich King George Island konnten auf dem Echolot keinerlei Krillanzeigen festgestellt werden.

Die Einfahrt in die Bransfield Straße um Kap Melville erwies sich als durch sehr starkes Eis blockiert. Aus diesem Grunde mußte leider der Plan, die Verankerung der Sedimentfallen im Seegebiet vor der Admiralty Bay aufzunehmen und eine neue Verankerung auszubringen, für diese Reise endgültig aufgegeben werden.

Die "Polarstern" fuhr nunmehr an der Eiskante entlang nach Nordosten in das Gebiet nordwestlich von Elephant Island. Hier, in einer Zone ausgedehnter Neueisbildung (meist Pfannkucheneis), begann am 9.6. die letzte Etappe der Reise mit Grundschleppnetzfischerei, die mit Einsätzen von Multisonde/Rosettenwasserschöpfern, RMT, Bodengreifer, Beyer-Schlitten und Schlauchboot zur Gewinnung von Eisproben verbunden wurde. Am 9.6. erfolgte auf Station 139 eine ausgedehnte Erprobung des mobilen Unterwasserkamerafahrzeugs (UWE) bei der Untersuchung möglicher Schäden an der Propelleranlage des Schiffes. Nordwestlich Elephant Island wurden wiederum, wie zu Beginn der Reise, Krillanzeigen auf dem Echolot festgestellt.

Insgesamt wurden in der Zeit vom 9. bis 13.6. weitere 17 Hols von je 30 Minuten Dauer mit dem Grundschleppnetz auf Tiefen zwischen 70 und 500 m nördlich und nordwestlich von Elephant Island ausgeführt. Dabei wurden 17,2 t Fische gefangen. Die Fischerei verlief - abgesehen von zwei Hakern - ohne Probleme und Netzverluste. Manche der Hols erfolgten im leichteren Treibeis, andere, im Südwesten geplante, mußten wegen dichter Packeisdecke verlegt werden. Bei schwachwindigem Wetter, das alle Untersuchungen begünstigte, und Lufttemperaturen von -3 bis -6°C wurde am 11.6. erneut die Barkasse "Polarfuchs" für Untersuchungen mit Bodengreifer, Beyer-Schlitten und Bongo sowie zum Sammeln von Eis- und reinen Wasserproben eingesetzt (St. 146).

Bei Auftreten guter Krillanzeigen auf dem Echolot wurde am 12.6. das RMT für 30 Minuten offen in einer Wassertiefe von 20-30 m geschleppt; der Fang betrug rund 20 kg mittelgroßen Krills. In diesem Gebiet waren auch Pelzrobben und einige Adeliepinguine zu beobachten.

Besonders zahlreich waren die Krillanzeigen auf dem Schelf westlich der Robben-Inseln, wo auf dem Flachen in 50 m

Wassertiefe Station 150 für Benthosuntersuchungen mit Bodengreifern und Beyer-Schlitten gefahren wurde. Im dichten Packeis waren hier Pelzrobben zu beobachten. Am 12.6. abends wurde eine mit Bordmitteln verbesserte Ausführung der Lichtfalle zum Fang von Krill und anderen Organismen ausprobiert, allerdings ohne Fangergebnis.

Mit Station 155 waren die Forschungsarbeiten am Abend des 13.6. beendet, und die "Polarstern" trat die Rückreise nach Bahia Blanca an. Am 14.6. abends wurde auf 57°15'S und 58°40'W die Polarfront nach Norden überquert. Stürmische Winde aus Nordwest und sehr hohe See verminderten am 14. und 15.6. die Fahrtgeschwindigkeit. Das Schiff erreichte am 18.6. abends den Lotsen und machte am 19.6. gegen 04:00 Uhr Bordzeit im Hafen von Bahia Blanca fest.

Gastwissenschaftler aus Brasilien, Dänemark, Großbritannien, den Niederlanden, Spanien und Uruguay waren in die wissenschaftlichen Arbeiten integriert. Eine Reihe von Vorträgen und wissenschaftlichen Diskussionen, an denen auch Mitglieder der Besatzung teilnahmen, trugen sehr zur Förderung der Zusammenarbeit bei.

1.2 Summary and itinerary (D. Sahrhage)

Prior to the Winter Weddell Sea Project (WWSP'86), the first leg of the cruise of RV "Polarstern" from 6 May until 19 June 1986 was concerned with biological, ecological and oceanographic investigations in Antarctic waters between Elephant Island and Adelaide Island off the Antarctic Peninsula.

Major components of these research activities were the following:

- investigations of the fish stocks around Elephant Island
- studies on the biology and distribution of Antarctic krill in relation to the oceanographic conditions and to the distribution of phyto- and zooplankton
- research on microplankton and on the respiratory activity and biomass of microorganisms
- chemical and biochemical investigations
- studies on benthos, particularly polychaeta, crustacea and mollusca
- seabird observations.

The investigations during this leg can be considered as an extension into the winter season of the Second International BIOMASS Experiment (SIBEX) in which the Federal Republic of Germany participated in October/November 1983 (RV "Polarstern"), November/December 1984 (RV "Polarstern"), and Feburary to April 1985 (FRV "Walther Herwig"). The same transects and stations as during SIBEX were worked during leg ANT V/1 (see Fig. 1).

"Polarstern" left Punta Arenas (Chile) on 6 May with a research team of 29 and a crew of 44 on board. Rough weather prevented some oceanographic stations originally planned on the way to Elephant Island.
From 9 to 13 May fisheries biological investigations on the fish stocks were carried out with 21 hauls using bottom trawl (140') north, west and southeast of Elephant Island. Fishing stations between 80 and 350 m water depth were supplemented by oceanographic observations and benthos sampling.

On 14 May the programme for sampling of krill with Rectangular Midwater Trawl (RMT 1+8), combined with oceanographic measurements by CTD and plankton sampling, started at the northern end of transect 1, northeast of Elephant Island (see Fig. 1). RMT hauls were made from 200 m to the surface, CTD stations reached mostly down to the bottom. RMT stations werre combined with the deployment of a neuston sledge for sampling krill larvae and other organisms at the sea surface.

Heavy pack-ice was encountered at about 61°S which made it impossible to work on the southern stations of transects 1 and 2. Also transects 3 and 4 could only be worked at the northern halfs because of the heavy ice conditions. Investigations on transect 5, north of King George Island (South Shetlands), were finished successfully on 21 May.
After entering the Bransfield Strait around Cape Melville, it proved that the entire Strait was covered with ice. The original plan to recover a mooring with sediment trap and current meters which had been deployed in November 1985 south of King George Island had to be abandoned due to the heavy ice on that position (coverage 9/10). Furthermore none of the north/south transects in the Bransfield Strait could be carried out.

"Polarstern" went through the Bransfield Strait from east to west near the South Shetlands Islands, breaking and often ramming through the ice (coverage mostly 10/10). Only on a few places it was possible to find some open water for stations with CTD and RMT. The ice, in the average one meter thick, had accumulated as the result of a long-lasting east wind period. The weather was good, air temperature around -20 degrees Celsius. Samples of ice were collected for studies on ice-algae and other organisms.
Only in the waters near Deception Island the water was open, and several CTD/RMT stations were made. On 25 and 26 May oceanic transects with CTD, RMT and neuston sledge were worked in Drake Passage. South of Smith Island, where benthos was collected by bottom sampler, the ship went again into the ice. The northern entry into the Gerlache Strait was covered with heavy pack-ice. It was, therefore, attempted to enter this Strait through Dallmanns Bay and the Schollaert Channel. When it became apparent that also this entrance was blocked, "Polarstern" steamed around Anvers Island to enter the Gerlache Strait from the Southwest. Fortunately this entrance was still open with only some ie barriers near the Georg von Neumayer Channel.

"Polarstern" worked on 28 and 29 May in the Gerlache Strait up to Brabant Island. Krill concentrations were found with the echosounder and krill sampling at various depth levels from 500 m to the surface carried out with the multiple RMT(M). Trials and krill observations were made by a Remotely Operated Vehicle (ROV). The research launch "Polarfuchs" proved very useful for taking samples (benthos, plankton, ice) in in-shore waters.

On 30 May "Polarstern" worked on a station in Bismarck Strait, and later on the same day the station "Palmer" (USA) was visited. The American overwintering team was also welcomed on board.

Further investigations were carried out between 31 May and 6 June in the waters off Anvers Island, off Renaud Island, and north of Adelaide Island. At the southern end of the investigation area "Polarstern" entered again the pack-ice belt originating from the Bellingshausen Sea (Fig. 1). Because of heavy ice conditions the planned southernmost transect was abandoned, and the ship returned to the area north of Lavoisier Island where again hauls with the multipled RMT were made at several depth ranges from 300 m to the surface. Krill sampling was further supplemented by oceanographic measurements, phytoplankton and benthos collection, and a zodiac was used for ice and water sampling.

Later on 6 June, "Polarstern" started the return voyage through the Drake Passage to the area north of King George Island. Strong winds (bft. 10-11) and rough sea delayed the progress to some extent. It was intended to attempt, for the second time, to recover the sediment trap mooring in the Bransfield Strait south of King George Island. However, a very high ice barrier prevented the ship from entering the Bransfield Strait around Cape Melville. Therefore, "Polarstern" went to the area west and north of Elephant Island. Here, further 17 hauls with the bottom trawl (140') were made from 9 to 13 June for the investigation of the fish stocks. Guided by krill indications on the echosounder, sampling of krill with the RMT was continued. Bottom sampler and Beyer sledge were used for collecting benthos.

Late on 13 June the investigations were terminated, and "Polarstern" departed for Bahia Blanca (Argentina) where the ship berthed early on 19 June.

Due to the unexpected difficult ice situation the original plan for this expedition had to be modified substantially during the voyage. However, the investigations, carried out with great enthusiasm and in good harmony between all participants, led nevertheless to a wealth of new information and data on the resources and their environment during the winter period for which extremely little is known so far. Researchers from Brazil, Denmark, Great Britain, the Netherlands, Spain, Uruguay, and the USA worked intergrated into the scientific team on board.

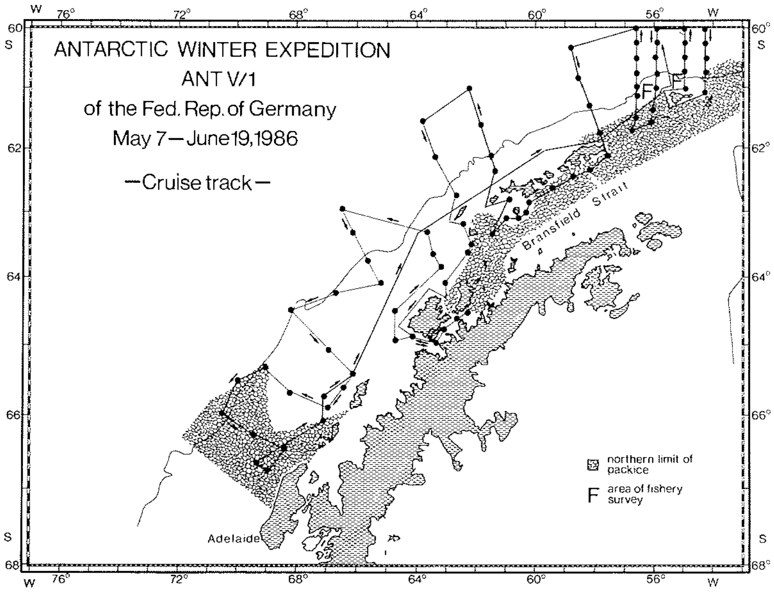

Abb. 1. Fahrtroute während der Reise ANT V/1 des FS "Polarstern".

Fig. 1. Cruise track of RV "Polarstern" during ANT V/1.

1.3. Wetterbedingungen (R.-T. Ochsenhirt, B. Richter)

Am 7. Mai 1986, auf dem Wege nach Elephant Island, geriet FS "Polarstern" in der Drake Passage in die Antarktische Frontalzone. In ihr zog ein Tief von den South Orkneys westwärts und entwickelte sich auf der Vorderseite eines Höhentroges zum Sturmtief; SSW-Winde Bft. 8 bis 9 und grobe See machten Einschränkungen des Forschungsprogrammes notwendig. Bereits in der Folgenacht schwächte sich das Windfeld durch Auffüllung des Tiefs wieder ab.

Am 11.5. baute sich über der Antarktischen Halbinsel ein Hoch auf, dessen Druckanstiegsfeld sich rasch nordwärts in unser Fahrtgebiet ausweitete. Durch die Verschärfung des Druckgradienten stellte sich bei Elephant Island eine südöstliche Strömung mit zeitweise Sturmstärke ein, die auch eine Eisdrift aus der Weddell-See heraus in Gang brachte. Diese wurde durch zyklonale Prozesse im Raume Signy Island - South Georgia unterstützt.

Das stationäre Weddell-See Tief wurde am 20.5. durch Warmluft regeneriert. Diese kühlte sich über dem Larssen-Schelfeis bodennah ab und führte zu einer erheblichen Stabilisierung in der Grenzschicht. Durch den Barriereeffekt der Halbinsel erreichte der Südwind höhere als dem Druckgradienten entsprechende Geschwindigkeiten; die Coriolisablenkung führte dann im Fahrtgebiet vorübergehend zu Oststurm in Bodennähe, während in 1000 m Windstille herrschte.

Am 22.5. setzten sich die südwestlichen Winde auch in Bodennähe durch. Während zunächst kleinraümige Zyklonen, die sich in der Antarktischen Frontalzone bildeten, das Wetter mit überwiegend westlichen Winden der Stärke Bft. 5 bis 6 bestimmten, bildete sich ab dem 25.5. ein Hoch über der südlichen Weddell-See aus, das einen Keil zur Antarktischen Halbinsel aufbaute. Dadurch gelangte das Fahrtgebiet im Raume Anvers Island in eine nordöstliche Strömung mit Winden Stärke Bft. 5 bis 6. Diese Wetterlage hielt mit östlichen Winden im Norden der Halbinsel die Eisdrift in die Bransfield Straße aufrecht, wo vor der King George Island noch eine Verankerung aufgenommen werden sollte.

Diese antizyklonale Phase fand am 29.5. ihren Abschluß durch ein Tief, das sich im Fahrtgebiet entwickelte und vorübergehend zu SW-Winden Stärke Bft. 6 führte. Während dieses Tief die Halbinsel ostwärts überquerte, verlangsamte es sich durch orographische Effekte und wurde dann über der Weddell-See stationär. Von Westen nachfolgender Druckanstieg führte am 31.5. im Fahrtgebiet zu einer erheblichen Gradientverschärfung und SW-Winden der Stärke Bft. 9 bis 10, die eine Unterbrechung der Forschungsarbeiten notwendig machten. Ab dem 2.6. nahm der Wind im Einflußbereich kleinräumiger Zyklonen wieder auf Bft. 5 bis 6 zu.

Während der zweiten Meßkampagne bei Elephant Island gerieten das Schiff am 9.6. kurzzeitig in den Einfluß von Trägheitswinden aus Ost mit Stärke Bft. 8; danach bestimmte eine zyklonale Westlage mit Winden um Bft. 5 das Wetter.

Am 13.6., dem Ablauftag, zog ein Tief von den Falkland Islands südwärts. Es überquerte uns mit seinem Kern und führte zu Nordoststurm Bft. 8 bis 9, so daß nur mit reduzierter Fahrt gedampft werden konnte. Rückseitig flaute der Wind zwar vorübergehend ab, ein Trogtief vertiefte sich jedoch erheblich und führte in seinem Windfeld am 15.6. zu Nordwestwinden Bft. 8. Erst NW-lich der Falklands setzte sich zunehmend Hochdruckeinfluß durch.

Windstatistik:

Windstärke / Bft. :	0	1	2	3	4	5	6	7	8	9	10
rel.Häufigkeit / % :	-	3	5	13	19	17	23	13	7	-	-

1.4 Eisverhältnisse (D. Sahrhage)

Während dieser Winterreise war die Eissituation schwieriger als erwartet. Die Satellitenaufzeichnungen, die bereits seit etlichen Wochen vor Antritt der Reise studiert wurden, hatten vor allem wegen der Wolkenbedeckung keinen Aufschluß über das Eis in der Bransfield Straße und anschließenden Untersuchungsgebieten gegeben. Bei früheren chilenischen und britischen Forschungsreisen im Winter war die Bransfield Straße größtenteils eisfrei. So war die dichte Eisdecke (10/10) über der gesamten Bransfield Straße eine Überraschung (Abb.1). Lediglich ein kleines Gebiet um Deception Island und südlich von Livingston Island erwies sich als eisfrei. Der nördliche und der östliche Eingang zur Gerlache Straße waren durch große Eismassen blockiert.

Zweifellos hat die langanhaltende Ostwindwetterlage zu diesem weiten Vordringen der Eismassen aus der Weddell-See beigetragen.

Im Gebiet nördlich von King George Island und bei Elephant Island war die Ausdehnung der Eisdecke von Mai bis Juni gut zu beobachten. Wo Mitte Mai noch Stationen gefahren worden waren, war im Juni kaum ein Wasserloch zu finden. Die Eisgrenze nördlich von Elephant Island war im Juni entsprechend den Wind- und Strömungsverhältnissen von Tag zu Tag sehr variabel, und darauf mußte bei der Arbeit Rücksicht genomnommen werden. Bei Antritt der Rückreise nach Bahia Blanca am 13.6. wurde festgestellt, daß der Nordrand des Treibeisgürtels auf 56°W bis auf die Breite von 60°20'S vorgeschoben war.

Im Südwesten des Untersuchungsgebietes schob sich erwartungsgemäß Eis aus der Bellingshausen See nach Nordosten vor. Wegen der starken Eisbedeckung waren erhebliche Umstellungen im Forschungsprogramm erforderlich, und es ist bedauerlich, daß weite Strecken der Bransfield Straße nicht untersucht werden konnten. Auf der anderen Seite gelang es trotzdem, interessante Daten aus den eisbedeckten Meeresgebieten zu gewinnen. Die Erfahrung hat gezeigt, daß die Bransfield Straße in manchen Jahren nur mit starken, eisbrechenden Schiffen zu befahren ist, und dies sollte bei der Planung weiterer Forschungsprogramme für die Wintermonate bedacht werden. Ebenso ist zu bedenken, daß in den Eisgebieten Lufttemperaturen bis unter -22°C auftreten. Die wissenschaftlichen Instrumente und die zugehörigen Schiffseinrichtungen müssen, wie auf der "Polarstern", dafür eingerichtet sein.

1.5 Ozeanographische Untersuchungen (E. Balguerias, K.-H. Kock, B. Schillat)

Zur Untersuchung der Struktur und Verteilung der Wassermassen im Untersuchungsgebiet wurde die Multisonde mit Rosettenwasserschöpfer auf 111 Stationen eingesetzt. XBT-Sonden wurden auf 33 Stationen abgeworfen. Zur Wasserversorgung der einzelnen Arbeitsgruppen an Bord war vor Beginn der Arbeiten ein Tiefenstufenplan für die Schöpfer abgesprochen worden, der weitgehend die einzelnen Interessen berücksichtigte.

Der auf dem Anmarsch vorgesehene XBT-Schnitt für ozeanographische Beobachtungen, insbesondere die Lokalisierung der antarktischen Konvergenz, mußte wegen schlechten Wetters abgebrochen werden. Nach Beobachtung der Oberflächentemperaturen und Abwurf eines XBT lag die Konvergenz am 8.5. vermutlich bei 57°20'S, 60°30'W. Zu fast allen Fischerei- und RMT-Stationen wurde eine Begleithydrographie durchgeführt. Zusätzlich wurden bei der Fischerei mittels der Sedimentnetzsonde Bodenproben entnommen, die zur späteren Erstellung einer Bodenbedeckungskarte dienen sollen.

Der Schwerpunkt der ozeanographischen Arbeiten lag, wie immer, in der Elephant Island Box. Hier wurde, soweit es die Eisverhältnisse zuließen, ein sehr dichtes Stationsnetz mit 24 Multisonden-Einsätzen bis zu einer Tiefe von 3960 m und 30 XBT-Stationen gefahren.

Die Daten jeder Station wurden mit Silentschreiberausdruck erfaßt sowie auf Platten gespeichert. Weitergehende Aussagen, wie z.B. über geostrophische Strömungen u.a., sind erst nach Aufarbeitung des Materials möglich.

Für Untersuchungen wurden 945 Wasserschöpferproben zur Verfügung gestellt. Außerdem wurden 200 Referenzproben entnommen und deren Salzgehalt mit dem an Bord befindlichen Autosal 8400 gemessen. Es traten keine Geräteverluste oder Beschädigungen auf.

1.6 Antarktischer Krill

1.6.1 Krill- und Makrozooplankton-Untersuchungen mit dem RMT (W. Dimmler, U. Harm, F. Köster, K.-H. Kock, D. Pietschok, V. Siegel)

Das geplante RMT-Programm zur Untersuchung des Krills und anderer Makrozooplankter schloß sich unmittelbar an das SIBEX Projekt (Second International BIOMASS Experiment) an. Es war daher beabsichtigt, möglichst auf Standardschnitten und -stationen die Erkenntnisse aus anderen Jahreszeiten zu erhärten und zu ergänzen. Dabei sollte die Variabilität der großräumigen Verbreitung des Krills, die Zusammensetzung der Population und eine Biomasseabschätzung das Hauptziel der Analyse sein.

Von den insgesamt 109 geplanten und im Herbst 1984/85 bearbeiteten Standardstationen konnten jedoch nur 66 ausgeführt werden. Wegen der schwierigen Eislage und aus Zeitmangel mußten eine Reihe von Stationen verlegt werden oder ganz entfallen. Ersatzweise wurden 15 RMT-Stationen in anderen Bereichen des Untersuchungsgebietes durchgeführt, so daß zum Ende des Abschnittes V/1 insgesamt 81 Standardschräghols mit dem RMT 1+8 vorliegen.

Der Krill, Euphausia superba, konnte an 42 der 81 Stationen nachgewiesen werden. Die Konzentrationen waren meist jedoch sehr gering. Lohnenswerte Mengen von über 100 Tieren pro Hol wurden nur an 9 der Standardstationen erhalten. Erste Aussagen über die Verbreitung sind bereits hier möglich, da sämtliche Proben des RMT 8 schon an Bord in die Taxa vorsortiert wurden. Die größten Krillmengen wurden in Küstennähe der Halbinsel zwischen Adelaide Island und dem Palmer Archipel gefangen, obwohl dort keinerlei Echolotanzeigen (30 kHz) erkennbar waren. Weiterhin wurde in der Gerlache Straße regelmäßig Krill in den Fängen erhalten. In diesem Gebiet wurden ebenfalls Echolotanzeigen beobachtet und befischt. Nennenswerte Krillfänge stammen zudem aus der Bransfield Straße und aus einem kleinen Gebiet über dem Schelf NW von Elephant Island. Ansonsten konnte im gesamten ozeanischen Bereich der Elephant Island Box kein adulter Krill nachgewiesen werden. Die beschriebenen Krillvorkommen decken sich mit denen aus dem Herbst 1984/85. Ein Vergleich mit dem Hauptvorkommensgebiet in der Bransfield Straße war wegen der Eislage nicht möglich.

Neben den Standardhols wurden zusätzlich 7 Einsätze mit dem RMT 1+8M gefahren. Es wurden Tiefenstufen von 0-50 m, 50-100 m, 100-200 m, 200-300 m, 300-500 m und 500-750 m (Bodennähe) Tiefe befischt. Einsatzorte lagen in der Bransfield und Gerlache Straße. Nach diesen Stufenhols muß davon ausgegangen werden, daß der Krill auch im Frühwinter hauptsächlich in den oberen 100 m lebt, unter 300 m Tiefe wurden nur Einzeltiere gefangen. In den tieferen Schichten dominierten eindeutig Gammariden (Amphipoden) und Mysidacea und an Fischen Pleuragramma antarcticum.

Nach den Erkenntnissen aus den RMT-Fängen scheint die Annahme berechtigt, daß der Krill während des Winters nur selten in großen, dichten Schwärmen lebt und allgemein zerstreuter auftritt als im Sommer. So konnten bei Adelaide Island größere Mengen gefangen werden, ohne daß Krillschwärme im Echolot angedeutet waren. Auch bei Elephant Island fiel auf, daß bei einem 35-minütigen Hol in den oberen 50 m 20 kg Krill mit dem RMT 8 gefangen wurden, während auf dem Echolot keinerlei Anzeigen auf das Vorhandensein von Krill schließen ließen. Mehrere diffuse Anzeigen im ozeanischen Bereich der Elephant Island Box müssen nach den RMT-Fängen als Salpenkonzentrationen gewertet werden. Diese traten vornehmlich um 200 m und tiefer auf und wurden selbst in der Tiefenstufe 500-750 m zahlreich angetroffen.

Salpen waren in nahezu allen Teilen des Gebietes vertreten, sie waren an 75 von 81 Standardstationen nachzuweisen. Besonders häufig fanden sich Salpen in der nördlichen Elephant Island Box und in der Drake Passage vor der Halbinsel. Selten waren sie dagegen in der Bransfield Straße und in Küstennähe vor der Halbinsel. In der Gerlache Straße fehlten sie nahezu vollständig.

Insgesamt war die Artenzusammensetzung des Zooplanktons überraschend vielfältig. Oft traten mehrere Euphausiacea-Arten nebeneinander auf, Krill mit E. triacantha, E. frigida und Thysanoessa macrura. Hyperiiden wurden regelmäßig gefangen, neben Themisto gaudichaudii vor allem die Gattung Cyllopus.

Erstmals wurden in den meisten Hols kleine Tintenfische (squids) angetroffen. Ebenso waren Myctophiden in den oberen 200 m recht häufig. Ob diese Erscheinung in Zusammenhang mit der langen Dunkelphase im Untersuchungsgebiet und der besseren Fängigkeit zu sehen ist oder mit einer jahreszeitlich unterschiedlichen vertikalen Verbreitung dieser Gruppen zusammenhängt, kann nicht beantwortet werden.

1.6.2 Hydroakustische Beobachtungen (D. Sahrhage)

Während der gesamten Fahrtstrecke im Untersuchungsgebiet war das bordeigene ELAC-Fischereilot (30 kHz) im Betrieb, um Anzeigen von Krill, Fischen und anderen Organismen aufzuzeichnen. Das Gerät erwies sich als zuverlässiges Instrument.

Eindeutig identifizierbare Anzeigen von Krillkonzentrationen waren zu dieser Jahreszeit nur in wenigen Gebieten zu beobachten, die aber als Zonen dichterer Krillvorkommen besonders bekannt sind. Gute Krillanzeigen, meist in Tiefen von 20-50 m, gelegentlich auch bis 200 m, waren vom 10.-18.5. und dann wieder beim zweiten Besuch vom 10.-13.6. im Gebiet nördlich und nordwestlich von Elephant Island zu finden. Einige vereinzelte Anzeigen in Tiefen von 30-50 m waren dann am 21.5. nordwestlich von King George Island zu beobachten.

Das zweite Gebiet, in dem Krillkonzentrationen auf dem Echolot zu sehen waren, war die Gerlache Straße. Schon vorher am 27.5. waren in der Dallmanns Bucht einige schwache Anzeigen auf 75-100 m Tiefe festgestellt worden. In der Gerlache Straße fanden sich dann am 28. und 29.5. zahlreiche gute Krillanzeigen meist in Tiefen von 20-100 m. Ebenso wurde vor "Palmer Station" in der Bismarck Straße eine Konzentration beobachtet, die nach der Art der Anzeige aus Krill bestanden haben dürfte.

Nicht selten wurden in größeren Wassertiefen über 100 m diffusere Anzeigen beobachtet. Über deren vermutlichen Ursprung kann erst nach sorgfältigem Vergleich mit Anzeigen aus früheren Untersuchungen eine Aussage gemacht werden.

Die Echolotaufzeichnungen geben Aufschluß darüber, wo dichte Krillkonzentrationen zu finden waren. Sie gestatten aber keinerlei Hinweise auf die Menge des im Gebiet verteilten Krills, wie sie nach den quantitativen Fängen des RMT möglich sind. Mehrfach wurden mit dem RMT erhebliche Mengen von Krill gefangen, ohne daß auf dem Echolot die geringste Anzeige zu sehen war. Das gilt auch für den RMT-Hol nordwestlich Elephant Island, der am 12.6. für 35 Minuten mit offen ausgesetztem Netz in 20-30 m Tiefe gemacht wurde und 20 kg Krill erbrachte, ohne daß der Krill auf dem Echolot zu sehen war. Dies zeigt, daß der Krill in weiten Gebieten vorhanden war, sich aber nicht zu Schwärmen zu konzentrieren schien, die auf dem Echolot zu sehen gewesen wären.

1.6.3 Untersuchungen an Krill-Larven (H.-P. Marschall)

Daten von FRASER (1936), HEMPEL und HEMPEL (1977/78) deuten darauf hin, daß ältere Krill-Larven sehr oberflächennah leben. Um dies zu prüfen, wurde neben dem standartmäßig von 200 bis 0 m benutzten RMT zusammen mit anderen Arbeitsgruppen ein Neuston-Schlitten gefahren, der gleichzeitig zum RMT vom achteren Schiebebalken aus gefahren wurde. Lediglich auf einigen Stationen konnte aufgrund des Seegangs bzw. der Eisbedeckung das Neuston-Netz nicht eingesetzt werden.

Die Zahl der Krill-Larven im Neuston-Netz war fast immer deutlich höher als im RMT, obwohl das filtrierte Volumen des Neuston-Netzes sehr viel geringer ist als das vom RMT. Die Fänge von Neuston- und RMT-Netz sollen im Hinblick auf Häufigkeit und Stadienzusammensetzung der Krill-Larven in Bremerhaven am Alfred-Wegener-Institut untersucht werden.

Auf zwei Stationen konnten zusätzlich mit dem Multi-Netz Stufenfänge von 100-50-30-20-10-0 m durchgeführt werden. Krill-Larven waren in dem Fang von 10-0 m am zahlreichsten. In der Tiefenstufe 20-10 m wurden nur noch einige wenige Krill-Larven gefunden, während darunter keine mehr zu finden waren.

Die Häufigkeit der Krill-Larven schwankte auch zwischen nahe beieinanderliegenden Stationen erheblich. Krillbrut war über das gesamte Untersuchungsgebiet verbreitet, auch wenn auf einzelnen Stationen keine Krill-Larven gefunden wurden. Sehr hohe Konzentrationen wiesen zum einen die Stationen 72, 74 und 76 auf, die nordwestlich von Elephant Island lagen. Hohe Konzentrationen wurden ferner auf den Stationen 84 und 87 in der Bransfield Straße und auf den Stationen 94 und 116 und 117 im ozeanischen Bereich nördlich Livingston - bzw. Anvers Island gefangen. In der Gerlache Straße wurden auf drei von insgesamt 5 Stationen jeweils große Mengen an Krill-Larven gefangen. Auf Station 120, am Kontinentalabhang südwestlich Anvers Island gelegen, wurde die höchste Zahl von Krill-Larven im Verlauf dieser Reise angetroffen. Auch auf den weiter südlich gelegenen Stationen wurden Krill-Larven teilweise in großen Konzentrationen gefangen.

Die Stadienzusammensetzung war im nördlichen Teil des Untersuchungsgebiets relativ einheitlich. Es dominierten 5. und 6. Furcilien. Teilweise wurde auch bereits juveniler Krill gefangen. Im südwestlichen Teil des Untersuchungsgebietes d.h. vom Schnitt nördlich Anvers Island bis zur südlichsten Station wurden neben den weiterhin vorhandenen älteren Furcilien auch eine große Zahl deutlich jüngerer Furcilien und teilweise sogar noch 1. Calyptopen gefunden. Auf diesen Stationen hatte die Stadienhäufigkeit zwei Maxima: zum einen bei den 1. Furcilien und zum anderen bei den 5. bzw 6. Furcilien. Da die Fänge mit den jüngeren Larven zwischen dem 1.6. und dem 6.6. durchgeführt wurden, müssen noch Ende April bis Anfang Mai Krill-Weibchen abgelaicht haben, wenn man annimmt, daß die Entwicklungszeit von der Eiablage bis zur 1. Calyptopis etwa 4-6 Wochen beträgt. Es stellt sich die Frage, ob die vorgefundene Stadienzusammensetzung auf einen zweiten Laichschub oder auf unterschiedliche Laichzeiten in verschiedenen Gebieten zurückzuführen ist.

Der physiologische Zustand der Tiere war in der Regel gut. Die Mitteldarmdrüsen waren haüfig grün, und die Därme waren zumindest teilweise gefüllt. Auf den Stationen mit gehäuftem Auftreten von Krill-Larven wurden jeweils eine Reihe von Larven zur Bestimmung des CHN-Verhältnisses, der chemischen Zusammensetzung und des Chlorophyll a Gehalts eingefroren. Weiterhin wurden Krill-Larven für Hungerexperimente und zur Verfolgung der weiteren Larvalentwicklung in Kultur genommen.

Literatur:

FRASER FS (1936) On the development and distribution of the young stages of krill (Euphausia superba). Discovery Rep 14: 1 - 192.

HEMPEL I, HEMPEL G (1977/78) Larval krill (Euphausia superba) in the plankton and neuston samples of the German Antarctic Expedition 1975/76. Meeresforsch 26: 206 - 216.

1.6.4. **Wechselbeziehungen zwischen Krill-Larven und Mikroplankton** (H. Klöser, H.-P. Marschall)

Die Probennahmen mit dem Neuston-Schlitten erwiesen sich sowohl für den Fang von Krill-Larven als auch von Mikroplankton als unerwartet ergiebig. Während im neritischen Bereich entlang der vorgelagerten Inselkette fädiges Phytoplankton in den Fängen überwog, deutete sich im ozeanischen Bereich der Drake Passage und der nördlichen Bellingshausen See wie auch in den Tiefwassergebieten zwischen Inselkette und antarktischer Halbinsel eine inverse Beziehung zwischen der Häufigkeit des Mikroplanktons und der Krill-Larven an. Möglicherweise liegt die Ursache hierfür in einer Beweidung des Mikroplanktons durch die Krill-Larven.

Es ist daher beabsichtigt, die Proben nach folgenden Gesichtspunkten auszuwerten: Die Krill-Larven werden gezählt und zu der Biomasse des Mikroplanktons in Beziehung gesetzt. Der Mageninhalt der Larven wird auf bestimmbare Reste der aufgenommenen Mikroplankton-Arten untersucht. Die Arten des Mikroplanktons werden bestimmt, wobei ihre Häufigkeit in krillarmen und krillreichen Proben gegenübergestellt werden soll. Erwartet werden Erkenntnisse über die Nahrungswahl der Krill-Larven, über den Umfang der Beweidung und über die Auswirkungen dieser Beweidung auf Biomasse und Artenspektrum des herbstlichen Mikroplanktons.

1.6.5. **Ernährungssituation bei Krill-Larven** (N. Mumm)

Anhand der Aktivität von Verdauungsenzymen (Carbohydrasen, Proteasen) soll die Ernährungssituation einer dominanten Art des antarktischen Zooplanktons im Winter untersucht werden. Aufgrund der reichen Fänge, besonders mit dem Neuston-Schlitten, konnten Krill-Larven als Untersuchungsobjekt gewählt werden. Nach bisherigen Erkenntnissen durchleben junge Individuen von Euphausia superba ihren 1. Winter im letzten Larvenstadium (Furcilia 6).

Über 2000 Tiere verschiedener Larvalstadien (Calyptopis 3 bis Furcilia 6) wurden lebend aus RMT 1- und Neuston-Schlitten-Fängen entnommen und bei -80°C schockgefroren. Dabei entfielen ca. 2/3 des Materials auf RMT-Fänge und 1/3 stammte aus Neuston-Schlitten-Hols. Für Vergleichszwecke wurden erwachsene Tiere von Euphausia superba und auch anderen Euphausiaceen (E. frigida, E. triacantha, Thysanoessa macrura), alle aus RMT-Fängen, ebenfalls bei -80°C schockgefroren. Aufgrund des guten Zustands der Krill-Larven, vor allem aus den Neuston-Schlitten-Hols, konnten sie teilweise für Hunger- und Freß-Experimente verwendet werden. Diese wurden in einem Kühlcontainer an Bord des Schiffes durchgeführt. In Abhängigkeit von Entwicklungsstadium und Ernährungsbedingungen sollen die Überlebensfähigkeit und die Weiterentwicklung der Krill-Larven beobachtet werden. Die Probennahme und auch die Hälterungsexperimente wurden auf ANT V/2 fortgesetzt. Die biochemischen Untersuchungen sind im Anschluß an ANT V/2 in Kiel am Institut für Polarökologie vorgenommen worden.

1.6.6. <u>Underwater observation of krill</u> (M. Bolas, <u>H.-P. Marschall</u>)

In situ observation of krill:
It was planned to use a Remotely Operated Vehicle (ROV) for underwater observations of krill. The Sprint 103 is a commercially available ROV whose primary tasks have been diver support and sub sea inspection for the oil industry. Due to its camera system and small size (61 cm by 61 cm by 68 cm) it is well suited to work as a biological observational platform.

The ROV itself remains within a protective cage during launch and recovery from the ship's side. During a launch, the cage is lowered into the water via a 660 m armored umbilical which is unspooled from a hydraulic winch. Once at the desired operating depth, the cage acts as a Tether Management System (TMS) by releasing the vehicle and then spooling or unspooling up to 120 meters of neutrally bouyant tether as per the operator's instructions. The use of a TMS decouples the vehicle from the ship's motion and eases operations in currents.

The ROV and Cage are controlled via the deck's unit. This unit consists of a joystick style controller, a video monitor and data display unit, and a 5 kW power unit. All pertinent information such as heading and depth are annotated on the video monitor and recorded on U-Matic video tape for later use.

The core of this ROV vehicle is its triplex camera head. This camera head consists of a Silicon Intensified Target (SIT) video camera sensitive to $5 * 10^{-4}$ lux, a color video camera sensitive to 0.6 lux, and a Pentax LX 35 mm SLR camera equipped with a 250 exposure data back, and a 28 mm wide angle lens. Both video cameras share the optics of the SLR camera via a rotating mirror, thus eliminating parallax. The Sprint uses three 250 watt lights and two 150 Joule flash tubes to supply lighting for these cameras. The lighting follows the 180 degree tilt angle of the camera head.

The vehicle is capable of attaining speeds up to 2.5 knots via its' five 1/2 horsepower electric thrusters. Control is made easy due to autoheading and autodepth functions which are capable of holding course to within 2 degrees and depth to within 5 cm.

Data diplayed by the deck's unit includes depth; heading; tether out; time and date; stills exposure counter; focus distance; camera aperture; as well as system status and error messages.

Due to it's relatively small size and easy handling coupled with is high speed and good manouverabiltiy this ROV seems to be useful in marine biological research because it introduces less disturbances into the environment than a larger system and can also be used close to a target. Besides getting in situ observations, also information on behaviour and interactions of marine animals can be obtained.

Specific advantages for Antarctic research especially in winter are that it can obtain information at locations which can not be sampled by normal nets like for example, the cryo pelagic underneath the ice and the hyperbenthos close to the bottom. When compared to a diver, the deployment and recovery of an ROV in the pack-ice is less difficult and dangerous. Additionally the ROV can operate easily between the surface and the maximum operational depth of 600 m for extended periods of time. Due to technical problems only two successful dives with observations of krill could be carried out. In the Gerlache Strait a krill concentration was observed on the echo sounder and by the ROV as well. The krill seemed to occur almost separated from each other although most of them were swimming in the same direction. Distances between individuals were usually greater than 5 to 10 bodylengths up to 1 or 2 meters. The vertical distribution of krill was studied by lowering and hovering the system. At the beginning of the dive (21:30 UTC) there was still some daylight. Krill was found from about 10 to 60 m in various concentrations. It seemed that the krill moved towards the surface when it became darker. The second dive also lasted from dawn to darkness, but the vehicle was only operated at the surface, because the original purpose was to inspect the ship's propeller. During this dive krill was first observed when it was almost completely dark. Once again the krill appeared to be scattered but showed a similar orientation. All observations were recorded on U-matic video for later detailed analysis at home.

1.6.7. Behaviour of krill (H.-P. Marschall)

Laboratory studies on behaviour of krill:
It was intended to study the behaviour of krill in the lab and to investigate to which respect the behaviour differs from specimens caught under summer conditions. Due to the shortage of ship time during the bottom trawling around Elephant Island in the beginning of the cruise almost no krill was available to do the intended studies. Sufficient numbers of krill where first caught at the end of the cruise around Elephant Island. This material is presently used to set up a long-term experiment to establish differences in behaviour of krill under different light regimes. The experiment is planed to last until the end of Ant V/3.

Krill larvae were cultured in the cold lab to study their behaviour as well. Using a low light camera and red light of a wavelength longer than 600 nm which cannot be perceived by krill and low intensities of white light, the behaviour of krill was recorded on video. Later analyses of the tapes will give information on the behaviour, especially on activity, swimming speed , swimming angle and swimming direction of krill larvae under darkness and various light intensities and light directions.

Preliminary results show that under relatively high light intensities activity as well as swimming speed was higher and the larvae showed the tendency to avoid the light. At dark conditions the activity and swimming speed was lower and the larvae showed a strong tendency to the surface.

Electron microscopy of sensory organs:
In order to study behaviour of krill one should also investigate the capabilities of the sensory organs of krill. The first step is to investigate the types of sensory organs and their location. A number of specimens were dissected and parts like e.g. the 1. and 2. antenna preserved for electron microscopy. The internal morphology of the sensory organs should give information on the cues it can perceive. This information will later be used to design experiments to establish the function and capabilities of the sensory organs.

1.7 Fischereiökologische Untersuchungen an Fischen

(E. Balguerias, S. Beeken, H. Berner, U. Harm, F.W. Köster, K.-H. Kock, U. Mühlenhardt-Siegel, N. Mumm, D. Pietschok, D. Sahrhage, V. Siegel)

Die fischereibiologischen Arbeiten hatten im wesentlichen folgende Ziele:

(1) Eine Abschätzung der Biomasse und des Befischungszustandes der seit der Fangsaison 1978/79 durch eine (wenn auch nicht in jedem Jahr stattfindende) kommerzielle Fischerei beeinflußten Bestände von Marmorbarsch (Notothenia rossii marmorata), Grüner Notothenia (N. gibberifrons), Bändereisfisch (Champsocephalus gunnari) und Scotia See - Eisfisch (Chaenocephalus aceratus) zu ermöglichen.
(2) Aufschluß über die zu dieser Jahreszeit laichenden Fischarten zu bekommen und den Aufbau der Laicherpopulationen und ihre Fruchtbarkeit und Laichplätze zu ermitteln (soweit das in der begrenzten Untersuchungszeit möglich war).
(3) Die Nahrungszusammensetzung und die Nahrungsmenge der Fischarten im Spätherbst/Frühwinter zu untersuchen.

Diese Arbeiten sind Teil eines Langzeitpogramms des Instituts für Seefischerei, dessen Ziel die Erfassung der Biologie und Dynamik der Fischbestände um Elephant Island und ihrer trophischen Beziehungen ist. Sie werden z.T. vom BMFT und von der DFG gefördert. Zusätzlich sollten Eier von fließenden Tieren (Reifegrad 4 der Skala von EVERSON, 1977) abgestreift werden, um Möglichkeiten zu untersuchen, in Planktonfängen auftretende Fischeier zu identifizieren. Ferner sollte versucht werden, im RMT gefangene Fischlarven und -postlarven zu bestimmen.

Durchgeführte Arbeiten

Vom 9.-13. Mai und 9.-13. Juni wurden um Elephant Island zwischen 50-500 m Tiefe 21 und 17 Grundschleppnetzhols von jeweils 30 Minuten Dauer durchgeführt. Befischt wurden in erster Linie Schleppstrecken, die von früheren Untersuchungen (1983, 1985) bekannt waren, um Netzverluste so gering wie möglich zu halten. Als Fanggerät diente das 140' Grundschleppnetz, das auch schon 1983 verwendet worden war. Fänge < 1.2 t wurden vollständig sortiert. Von Hols, die mehr als 1.2 t enthielten, konnten aus Platzgründen nur repräsentative Unterproben bearbeitet werden. Von jeder Fischart wurden mindestens Gewicht und Anzahl bestimmt und (bei ausreichendem Material) eine Längenmeßreihe angefertigt. Die kommerziell befischten Arten wurden grundsätzlich auf Länge, Geschlecht und Reife analysiert. Längen- und Reifebestimmungen folgten dabei den von der BIOMASS 'Working Party on Antarctic Fish Biology' und der CCAMLR 'Ad Hoc Working Group on Fish Stock Assessment' gegebenen Empfehlungen. Von Notothenia neglecta, N. gibberifrons, N. larseni, N. nudifrons, Champsocephalus gunnari und Chaenocephalus aceratus wurden Gonaden für Fruchtbarkeitsuntersuchungen gesammelt. Von Notothenia rossii marmorata wurden Schuppen für die Altersbestimmung genommen, die z.T. schon an Bord durchgeführt werden konnte. Einen Überblick über die gesammelten Mägen bzw. die für die Nahrungsanalyse eingefrorenen Ganzfische gibt Tabelle 1. Eier fließender Weibchen konnten von N. coriiceps neglecta, N. larseni, N. nudifrons, Champsocephalus gunnari und Chaenocephalus aceratus konserviert werden.

Für die Sammlungen der Forschungsinstitute auf den Kanarischen Inseln, Spanien, und in Montevideo, Uruguay, konservierten E. Balguerias und C. Aycaguer Proben antarktischer Fische.

Ergebnisse

Fischeier, -larven, -postlarven und Jungfische aus Planktonfängen:
Ausgewertet wurden bisher in erster Linie RMT 8 - Fänge. Die Artbestimmung erfolgte nach den Schlüsseln von NORTH and WHITE (1982) und EFREMENKO (1983). Eine Übersicht über die bisher identifizierten Arten gibt Tabelle 2. Die häufigsten Arten waren Notolepis sp. mit einem Verbreitungsschwerpunkt im Nordteil der Elephant Island Box, Pleuragramma antarcticum mit Konzentrationen von mehreren hundert Postlarven pro Hol in der Bransfield Straße und mit geringeren Dichten von bis zu 16 Larven pro Hol in der Gerlache Straße und westlich der Antarkischen Halbinsel und Notothenia kempi westlich der

Antarktischen Halbinsel. Bemerkenswert war das regelmäßige Auftreten von Fischeiern (Durchmesser 4,5-4,7 mm) in Neuston-Schlittenfängen (Ober- und Unternetz). Die Eier waren meist im 2-16 Zellenstadium der Furchung.

Grundschleppnetzfänge um Elephant Island

Faunistische Zusammensetzung:
Das Spektrum der 37 Arten, wie es Tabelle 3 zeigt, gleicht der faunistischen Zusammensetzung, wie sie frühere Untersuchungen (KOCK, 1982; unveröffentlicht) beschreiben. Die mit Abstand häufigste Art war die Grüne Notothenia (N. gibberifrons). Bemerkenswert ist der Fang zweier Exemplare von Chionobathyscus dewitti (Channichthyidae) auf dem westlichen Teil des Inselschelfs in 147-174 m und 359-401 m Tiefe.

Marmorbarsch (N. rossii marmorata)
Notothenia rossii trat im Mai in fast allen Hols auf, doch überschritten die Fänge selten mehr als 10 kg. Lediglich vor der Nordküste der Insel wurde auf der gleichen Position wie im Februar 1985 ein Fang von 871 kg gemacht. Die Masse der Tiere war 40-50 cm lang (Abb. 2) und gehörte der Altersklasse 6+ an (Tab. 4). Mehr als die Hälfte der Männchen (52,8%) war juvenil, 29,6% war fließend (Reifegrad 4). Von den Weibchen waren 89% juvenil (Reifegrad 1) oder geschlechtsreif ohne sichtbare Oocytenentwicklung (Reifegrad 2), lediglich 4,9% waren reifend (Reifegrad 3). Keines der Weibchen war fließend. Der Anteil der abgelaichten Tiere war mit 4,2 und 6,2% bei Männchen und Weibchen annähernd gleich. Die abgelaichten Weibchen waren alle > 54 cm. Ein fast identisches Bild bot sich im Juni. Zwar wurden mehrfach Konzentrationen angetroffen, die mehrere hundert kg erbrachten, doch glich deren Längenhäufigkeitsverteilung (Abb. 2) der aus dem Mai. Obwohl die Altersbestimmung noch nicht abgeschlossen ist, kann angenommen werden, daß es sich im wesentlichen um Fische der Altersklasse 6+ handelte. Die Reifegradverteilung war der aus dem Mai ähnlich. Lediglich der Anteil abgelaichter Männchen hatte sich erhöht. Die Verteilung der Altersklassen und Reifegrade macht deutlich, daß die Fänge nicht als repräsentativ für den Laicherbestand gelten können, sondern vermutlich den zum Laicherbestand rekrutierenden Teil der Population erfaßten.

Grüne Notothenia (N. gibberifrons)
Notothenia gibberifrons war mit 72,8% (Mai) und 59,2% (Juni) Anteil am Gesamtfang, wie schon 1983 und 1985, die dominierende Fischart. Die Fänge bestanden fast ausschließlich aus Tieren von 20-45 cm Länge (Abb. 3) und erfaßten damit einen ähnlichen Längenbereich wie im Februar 1985. Das Maximum der Längenhäufigkeitsverteilung hatte sich von 28-29 cm im Februar 1985 auf 32-34 cm im Mai und Juni 1986 verschoben. Adulte Tiere wurden ab 30 cm Länge beobachtet. Das Gros der Fische war mit 37-38 cm geschlechtsreif.

Notothenia coriiceps neglecta
Notothenia coriiceps neglecta trat wie N. rossii marmorata in fast allen Hols in wenigen Exemplaren auf. Kleinere Konzentrationen, die 200-600 kg erbrachten, wurden nur gelegentlich angetroffen. Der Großteil der Fische maß 37-50 cm (Abb. 4). Im Mai waren die Männchen fast ausnahmslos in den Reifestadien 3 (65,7 %) und 4 (33,6%), während die Weibchen alle noch im Reifestadium 3 waren. Im Juni waren 40,8% der Männchen fließend (Stadium 4), 57,4% bereits abgelaicht. Mehr als 85% der Weibchen waren abgelaicht und nur noch 11,5% waren fließend. Der Großteil des Laichens scheint also in der 2. Maihälfte und zu Beginn des Juni stattgefunden zu haben.

Bändereisfisch (Champsocephalus gunnari)
Wie schon im Februar 1985 war der Bändereisfisch auch im Mai und Juni 1986 gleichmäßig über den Schelf verteilt. Konzentrationen wurden nicht beobachtet. Die Fänge lagen mit max. 57 kg in der gleichen Größenordnung wie im Februar 1985. Die Längenhäufigkeitsverteilung (Abb. 5) zeigt, daß Fische ab der Altersklasse 1+ (17-20 cm) in den Hols auftraten. Während im Februar 1985 Fische von 25-30 cm mehr als 80% der Fänge stellten, waren im Mai und Juni auch Tiere < 25 cm und > 35 cm in größerer Anzahl im Material vertreten (Abb. 5). Oocyten von ca. 0,5 mm Durchmesser waren bei Weibchen ab 25 cm Länge sichtbar, doch waren erst Fische > 34 cm im Stadium fortgeschrittener Gonadenentwicklung. Vereinzelt wurden fließende Weibchen beobachtet.

Scotia See - Eisfisch (Chaenocephalus aceratus)
Chaenocephalus aceratus war mit 10.1% (Mai) und 16.6% (Juni) Anteil am Gesamtfang die zweithäufigste Art in den Hols. Wie schon im Februar 1985 bildeten auch im Mai und Juni 1986 Fische von 40-60 cm Länge den Großteil der Fänge (Abb. 6). Oocyten von ca. 0,5 mm Durchmesser waren bereits bei einem Teil der Weibchen von 42-50 cm Länge sichtbar, doch waren im Mai - von vereinzelten Exemplaren < 50 cm abgesehen - erst Weibchen > 50 cm im Stadium forgeschrittener Reifeentwicklung. Fließende Männchen wurden nicht gefangen. Der Anteil fließender Weibchen im Mai, die alle > 57 cm waren, lag bei 0,5%; 5,4% der Weibchen war abgelaicht. Im Juni war der Anteil fließender Weibchen 0,1%; 21% der Weibchen waren abgelaicht. Es wurden fast keine Weibchen mehr mit reifenden Gonaden beobachtet. Die adulten Männchen waren fast alle im Reifestadium 2. Nur vereinzelt wurden abgelaichte Männchen beobachtet.

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Tab. 1. Anzahl der pro Art gesammelten Mägen bzw. der für Nahrungsuntersuchungen eingefrorenen Ganzfische.

Zeitraum / Fischart	9.-13. Mai	9.-13. Juni
Dissostichus mawsoni	7	37
Pleuragramma antarcticum	15	60
Notothenia rossii marmorata	62	189
Notothenia gibberifrons	330	291
Notothenia coriiceps neglecta	123	195
Notothenia larseni	182	150
Notothenia kempi	15	119
Notothenia nudifrons	41	11
Trematomus eulepidotus	1	6
Trematomus newnesi	2	-
Trematomus hansoni	-	2
Champsocephalus gunnari	234	243
Chaenocephalus aceratus	151	52
Pseudochaenichthys georgianus	11	3
Chionodraco rastrospinosus	22	24
Chaenodraco wilsoni	-	1
Cryodraco antarcticus	8	19
Neopagetopsis ionah	2	3
Parachaenichthys charcoti	11	-
Gymnodraco acuticeps	-	5
Prionodraco evansii	1	-
Racovitzia glacialis	-	4
Gerlachea australis	1	1
Muraenolepis microps	-	30
Lycodichthys antarcticus	11	37
Zoarcidae sp.	-	29
Bathyraja maccaini	10	18
Bathyraja eatonii	2	1
Bathyraja sp.2	32	31
Macrourus holotrachys	-	4
	1274	1565

Tab. 2. Liste der aus den RMT-Fängen bisher identifizierten Fischpostlarven und Jungfische.

Nototheniidae:
- Notothenia kempi
- Pleuragramma antarcticum
- Nototheniidae sp.

Channichthyidae:
- Chionodraco rastrospinosus
- Chaenocephalus aceratus
- Dacodraco hunteri

Myctophidae:
- Electrona antarctica
- Gymnoscopelus sp.

Paralepididae:
- Notolepis sp.

Liparidae:
- Paraliparis sp.

Tab. 3. Liste der im Grundschleppnetz gefangenen Fischcharten:

Nototheniidae:
- Dissostichus mawsoni
- Pleuragramma antarcticum
- Notothenia rossii marmorata
- Notothenia gibberifrons
- Notothenia coriiceps neglecta
- Notothenia larseni
- Notothenia kempi
- Notothenia nudifrons
- Trematomus eulepidotus
- Trematomus newnesi
- Trematomus hansoni
- Pagothenia sp.

Channichthyidae:
- Champsocephalus gunnari
- Chaenocephalus aceratus
- Pseudochaenichthys georgianus
- Chionodraco rastrospinosus
- Chaenodraco wilsoni
- Cryodraco antarcticus
- Neopagetopsis ionah
- Chionobathyscus dewitti

Harpagiferidae:
- Harpagifer georgianus antarcticus
- Pogonophryne sp.

Bathydraconidae:
- Parachaenichthys charcoti
- Gymnodraco acuticeps
- Prionodraco evansii
- Racovitzia glacialis
- Gerlachea australis

Muraenolepidae:
- Muraenolepis microps

Zoarcidae:
- Lycodichthys antarcticus
- Zoarcidae sp.

Rajidae:
- Bathyraja maccaini
- Bathyraja eatonii
- Bathyraja sp.2

Myctophidae:
- Gymnoscopelus nicholsi
- Electrona sp.

Paralepididae:
- Notolepis coatsi

Macrouridae:
- Macrourus holotrachys

Tab. 4. Alters-Längen-Schlüssel für <u>Notothenia rossii marmorata</u> von Elephant Island, 9.-13. Mai 1986.

Tab. 4. Age Length Key of <u>Notothenia rossii marmorata</u> from Elephant Island, 9 to 13 May 1986.

Age Class

Length (cm)	3+	4+	5+	6+	7+	8+	9+	10+	11+
30	1								
31	1								
32									
33		1							
34									
35		1							
36		1							
37		2							
38				3					
39				7					
40		1	1	8					
41				27	1				
42				19					
43				33					
44				34	1				
45				27	6				
46				14	6				
47				7	1				
48				1	6	2			
49					3				
50					3	1			
51						3			
52					1	1		1	
53					1	1			
54						1	3		
55							3		
56									
57								1	
58							2		
59									1
60								1	
	2	6	1	180	29	9	8	3	1

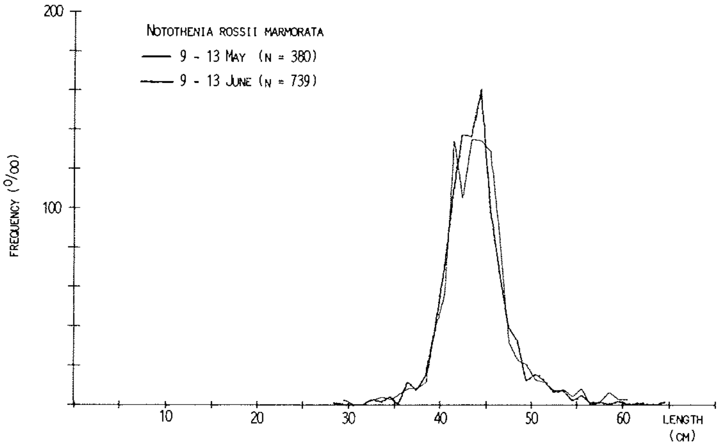

Abb. 2. Längenhäufigkeitsverteilungs von <u>Notothenia rossii marmorata</u> im Mai und Juni 1986 um Elephant Island.

Fig. 2. Length composition of <u>Notothenia rossii marmorata</u> around Elephant Island in May and June 1986.

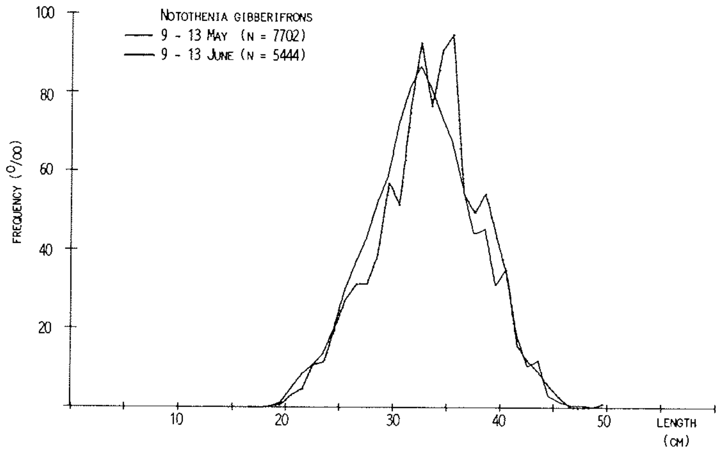

Abb. 3. Längenhäufigkeitsverteilung von <u>Notothenia gibberifrons</u> im Mai und Juni 1986 um Elephant Island.

Fig. 3. Length composition of <u>Notothenia gibberifrons</u> around Elephant Island in May and June 1986.

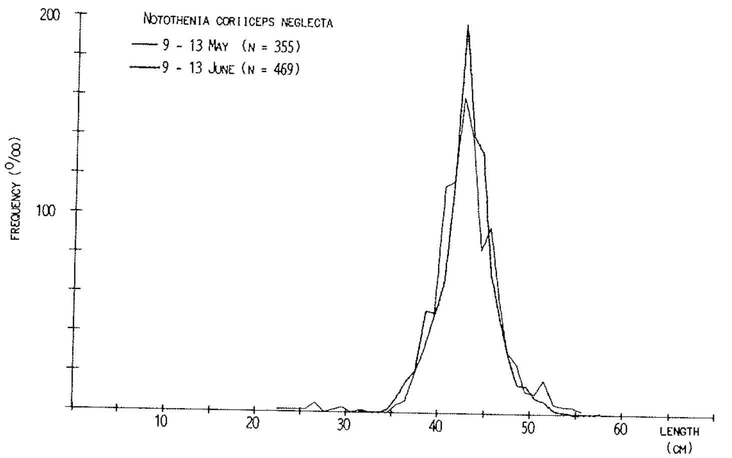

Abb. 4. Längenhäufigkeitsverteilung von Notothenia coriiceps neglecta im Mai und Juni 1986 um Elephant Island.

Fig. 4. Length composition of Notothenia coriiceps neglecta around Elephant Island in May and June 1986.

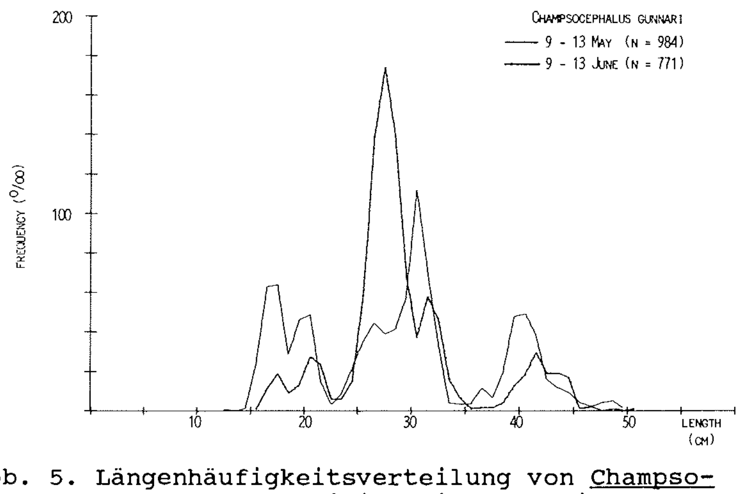

Abb. 5. Längenhäufigkeitsverteilung von Champsocephalus gunnari im Mai und Juni 1986 um Elephant Island.

Fig. 5. Length composition of Champsocephalus gunnari around Elephant Island in May and June 1986.

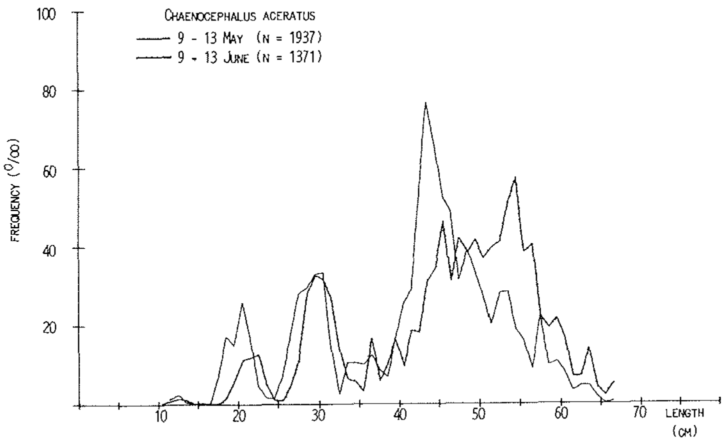

Abb. 6. Längenhäufigkeitsverteilung von _Chaenocephalus aceratus_ im Mai und Juni 1986 um Elephant Island.

Fig. 6. Length composition of _Chaenocephalus aceratus_ around Elephant Island in May and June 1986.

1.8 Histologische Untersuchungen an Fischen und Krill
(Phan Van Ngan)

Während der Reise wurden Proben von Lebern und Retinae von Fischen sowie Hepatopancreas und Gonaden von Krill gesammelt. Die Fischlebern sollen für histopathologische Studien verwendet werden. Die Retinae der Augen werden für eine Untersuchung über die Anpassung der Tiere an jahreszeitliche Veränderungen der Lichtverhältnisse im antarktischen Ozean gebraucht. Die Retinaproben von Myctophiden stammen aus Tiefen bis 700 m und in ihrer horizontalen Verbreitung von 64°48'S bis südlich des Polarkreises. Hepatopancreas und Gonaden des Krills sollen für eine vergleichende Studie über die Histologie dieser Organe im Sommer und im Winter verwendet werden. Alle Proben werden im Laboratorium der Universität Sao Paulo mit optischen und Elektronenmikroskopen untersucht.

1.9 Mikroplankton-Untersuchungen (H. Klöser)

Ziel der Fahrt war die Probennahme für eine Untersuchung des Einflusses der Eisbildung und abnehmender Lichtmengen auf das Mikroplankton im Herbst. Die Bearbeitung der Proben sowie ein darauf aufbauendes experimentelles Programm werden am Alfred-Wegener-Institut in Bremerhaven erfolgen. Die Probennahme wurde in folgender Weise durchgeführt: Auf jeder Station der vorgesehenen Schnitte wurden mit dem Rosettenwasserschöpfer aus jeweils 5, 10, 25 und 50 m Tiefe Wasserproben genommen, außerdem eine Probe des Oberflächenwassers. Von jeder Probe wurden je 1 Liter für die Meßung des Chlorophyll-Gehaltes und des C/N-Verhältnisses filtriert. Die Filter werden bei -30°C Temperatur aufbewahrt. Aus 0, 10 und 50 m Tiefe wurden jeweils je 200 ml Probe mit Lugol'scher Lösung, basischem und saurem Formalin fixiert. Diese Proben sind zur Bestimmung und Zählung der Algen- und Protozoenarten vorgesehen. Um auch seltenere Arten zu erfaßen, wurden diese Proben durch regelmäßig durchgeführte Netzfänge mit Apstein-Netz und Neuston-Schlitten ergänzt. Die Netzfänge wurden geteilt, wobei der eine Teil für spätere Untersuchungen fixiert wurde und der andere für mikroskopische Bearbeitung des lebenden Planktons an Bord benutzt wurde.

Außer dieser routinemäßig durchgeführten Probennahme wurden an geeigneten Stellen mit dem Schlauchboot Meereisproben genommen. Diese umfaßten Stücke mehrjährigen, sichtbar von Algen verfärbten Eises, sich neu bildenden Eisbrei, frisch verfestigten Eisbrei, Stücke jungen Meereises, reinen sowie von Meerwasser durchtränkten Schnee und Wasser aus der eisbildenden Oberflächenschicht. Von jeder dieser Proben wurde jeweils die Hälfte eingefroren, während die andere Hälfte aufgetaut und wie die Wasserproben behandelt wurde.

Vorbehaltlich der noch ausstehenden Bearbeitung lassen sich folgende vorläufige Ergebnisse nennen: Das Mikroplankton besteht hauptsächlich aus Diatomeen und Protozoen. Im Nordwesten des Untersuchungsgebietes kommt ein höherer Anteil Dinoflagellaten hinzu. Die Diatomeenflora ist von hoher Diversität. Ein Streifen höherer Diatomeendichte zieht sich am Nordrand der Inselkette von Adelaide Island bis Elephant Island entlang. Hier sind fädige Formen dominant, die teilweise aus Kolonien von <u>Nitzschia seriata</u> und <u>Rhizosolenia</u>-Arten, überwiegend jedoch aus noch unbestimmten solitären, sehr langgestreckten Diatomeen bestehen. Außerhalb dieses Streifens wird die Diatomeenflora in eisfreien Gebieten von <u>Chaetoceros</u>-Arten geprägt, während in eisreichen Gewässern <u>Corethron criophilum</u> häufiger wird. Unter den Protozoen fällt eine artenreiche Tintinnidenfauna auf. Im nördlichen Teil des Untersuchungsgebietes gibt es Foraminiferen, die im Süden völlig fehlen. Radiolarien treten in wenigen Arten auf, die jedoch im gesamten Gebiet häufig sind.

Insgesamt ist das Plankton durch einen hohen Anteil leerer Diatomeenschalen und teilweise zahlreiche Detritusflocken gekennzeichnet. Südlich von Anvers Island deutet sich eine Verarmung des Mikroplanktons sowohl an Arten als auch an Biomasse an. Außerdem wurde eine Abhängigkeit der Mikroplanktondichte von der Häufigkeit des Krills beobachtet.

1.10 Probennahme für Untersuchungen am Zooplankton
(N. Mumm)

Für ANT V/1 bestand kein selbstständiges Zooplankton-Sammelprogramm. Dennoch bot sich Gelegenheit zur Materialgewinnung. Die Probennahme lehnte sich eng an das RMT-Stationsnetz des Krill-Programms der Bundesforschungsanstalt für Fischerei an.

Fanggeräte

RMT 1
Es stand das gesamte Fangmaterial aus den RMT 1-Fängen (Maschenweite 330 µm) zur Verfügung. Nach Entnahme von lebenden Tieren für physiologische Untersuchungen wurden die Proben konserviert. Sie werden zur weiteren Bearbeitung von Bahia Blanca aus direkt nach Bremerhaven an das AWI verschickt. Das RMT 1 erbrachte als einziges der hier aufgeführten Geräte auch Fänge von adulten Euphausia superba.

Neuston-Schlitten
Soweit Seegang und Eisverhältnisse es zuließen, wurde während der RMT-Hols (RMT über Heck-Slippe) an Steuerbord über einen Schiebebalken der Neustonschlitten eingesetzt. Von insgesamt 4 Netzen stand jeweils 1 (335 µm Netzbecher) für die Zooplankton-Probennahme zur Verfügung. Der Neuston-Schlitten zeigte sich als äußerst seetüchtig (Einsätze bis Windstärke 7 bei starkem Schwell). Lediglich das Aus- und Einbringen wurde bei starkem Wind schwierig. Kleinere Eisschollen stellten keine Probleme für den Schlitten dar. Bei ausgedehnten, dünnen Neueisfeldern ('pancake ice') kam es zu Verstopfungen der Netze und somit zu nicht-quantifizierbaren Fangergebnissen. Ebenso wie bei den RMT 1-Hols wurde das Fangmaterial des Neuston-Schlittens nach Entnahme von Tieren für physiologische Untersuchungen und/oder Hälterungszwecke konserviert und wird im Anschluß an ANT V/1 nach Bremerhaven verschifft. Insgesamt konnten auf 50 Stationen Parallelproben aus RMT 1-Schräghols und Neuston-Schlitten-'Fahrten' genommen werden.

Multi-Netz
Das Multi-Netz wurde auf 10 Stationen eingesetzt. 2 Stationen lagen im Bereich der (wegen Eis nicht aufgenommenen) Verankerung. Sie werden für Sedimentationsuntersuchungen von der Geologie ausgewertet. Auf 6 Stationen, für die schon von Sommerexpeditionen Vergleichsproben vorliegen, konnten

Multi-Netzfänge (200 µm) für S.Schiel (AWI) durchgeführt werden. Außerdem wurde das Multi-Netz zweimal zur Ermittlung der Tiefenverteilung von Krill-Larven eingesetzt. Diese Hols erfolgten unmittelbar im Anschluß an kombinierte RMT-Neuston-Hols.

Vertikal-Netz
Zur schonenden Gewinnung von lebenden Zooplanktern für Hälterungs-Experimente wurde das Vertikal-Netz (335 µm) eingesetzt, wenn RMT- oder Neuston-Hols erfolgversprechende Fänge anzeigten. Auf 12 Stationen wurden jeweils mehrere Vertikalfänge durchgeführt, meist von 20 m (max. 50 m) bis 0 m Tiefe.

Bongo-Netz
Das Bongo-Netz (335 + 500 µm) wurde ausschließlich von Bord der "Polarfuchs" aus gefahren. Einsätze ergaben sich, wenn die "Polarstern" durch langandauernde Stationsarbeit nicht für RMT- oder Neuston-Schlitten-Hols zur Verfügung stand (28.5. und 11.6.). Die Benutzung des Bongo's von "Polarfuchs" aus war problemlos. Durch die Wendigkeit dieses Gespanns konnten Hols unmittelbar entlang der Eiskannte durchgeführt werden. Insgesamt kam das Bongo 5 mal zum Einsatz. Ein oberflächennaher Hol direkt an der Eiskannte erbrachte größere Mengen an Krill-Furcilien (Stat. 09/F08). Hier konnten von Bord der "Polarfuchs" zuvor Krill-Larven beobachtet werden, die auf Eisschollen gespült wurden.

Biochemische Untersuchungen
Im Rahmen der "Untersuchungen zur Lipid-Biochemie des pelagischen Ökosystems" wurde mit der Probennahme begonnen, die auch auf ANT V/2 und ANT V/3 fortgesetzt wurden. Da von Sommerexpeditionen schon Material untersucht wurde, kann so der saisonale Ablauf des Gesamtfettgehalts und der Lipid-Zusammensetzung von Zooplanktonorganismen des Epi- und Mesopelagials verfolgt werden.

Aus dem fangfrischen RMT 1- und Neuston-Schlitten-Material wurden lebende Zooplankter verschiedenster taxonomischer Gruppen entnommen. Nach Arten (und evtl. Größe und Geschlecht) sortierte Proben wurden unmittelbar darauf bei -80°C schockgefroren. Insgesamt konnten ca. 100 Proben, gleichmäßig über das gesamte Stationsnetz verteilt, gesammelt werden. Copepoden, Amphipoden und Euphausiaceen waren in fast allen Fängen (überwiegend RMT-Schräghols 200-0 m, ein RMT(M)-Hol bis 400 m Tiefe und zahlreiche Neuston-Schlitten-Fänge) vertreten. Sie machen den größten Anteil des Probenmaterials aus. Die Aufarbeitung der Proben wird von W. Hagen am Institut für Polarökologie in Kiel durchgeführt.

1.11 Biomass and respiration measurements

1.11.1 Respiratory activity and biomass of microorganisms
(G. Nieuwland, J.H.Vosjan)

The microbial biomass and respiratory activity of several water and a few ice and sediment samples was measured: Biomass as adenosine trifosfate (ATP) and the respiratory activity as electron transport system (ETS) activity. In total more than 2000 analyses were made.

The first set of data were obtained during the fishery stations around Elephant Island. Of 13 rosette sampler stations at 9 depths the ATP and ETS activity were measured. It proved that the biomass decreases from the surface to depth and that the mean concentration over the upper 100 m water column is 77+/- 12 ng ATP/l, integrated over 100 m water column this is 7.7 mg ATP/m^2. Assuming a conversion factor of 250 for calculating to carbon this means a biomass of 1.9 g C/m^2, in wet weight it is 13 * 1.9 = 25 g wet weight/m^2. Integrated over 200 m water column, the biomass is 3.5 g C/m^2.

The respiratory activity over the upper 100 m proved to be, after recalculation to an in-situ temperature of 0°C, about 0.23 g C/m^2/d. This means, assuming a steady state, that in about 1.9: 0.23 = 8 days an amount of organic carbon equal to the existing biomass is respired. In tropical waters we measured a turn-over time of the biomass of 1 day, and in the North Sea of 3 days.

Temperature on the respiratory activity proved to be 14 kcal/Mol. This means a Q10 of 2.6, which is a normal value for biological processes.

After fishing around Elephant Island, a dense net of sampling stations (22 stations analysed) in the Elephant Island Box were studied. The biomass in the upper 100 m proved to be 9.2 +/- 2.3 mg ATP/m^2. Concentrations of ATP in the different water layers were:

0 - 50	m :	108 ng ATP/l
50 - 100	m :	76 "
100 - 300	m :	41 "
300 - 500	m :	12 "
500 - 1000	m :	10 "
1000 - 2000	m :	6.6 "
2000 - 3000	m :	7.2 "

After this Elephant Island Box, a series of tracks to the South, till Adelaide Island were made, 48 rosette stations were studied. So we could make a kind of 'synoptic' map of biomass in the studied area. It proved that the highest biomasses were found in the area around Elephant Island and in a broad band NW of the South Shetland Islands, about

8.1-8.3 mg ATP/m^2 over a column of 100 m. The lowest values were found in the Gerlache Strait, 3 mg ATP/m^2. Also at the Bransfield Strait side of the South Shetland Islands low values of 4.5-6.5 mg ATP/m^2 were observed.

At the end of the cruise, during the fishery stations around Elephant Island, again 10 rosette sampler stations were analysed. The biomass of microorganisms one month later in the season proved to be somewhat lower.

Additionally some ice and 15 sediment samples were studied during this cruise. Ice samples analysed contained often more than 100 times more ATP than the surrounding sea water and the sediment several thousands times more than the bottom water. Also several water samples were fixed with lugol and/or formaline for further study, e.g. counting bacterial numbers at the laboratory in the NIOZ.

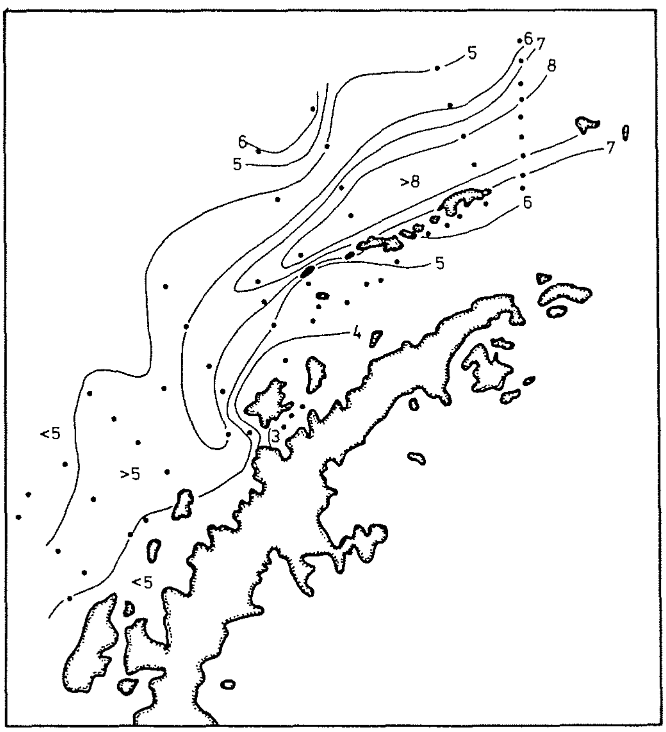

Fig. 7. Horizontal distribution of microbial biomass.
Measured as ATP and integrated over 100 m.
Expressed as mg ATP/m^2.

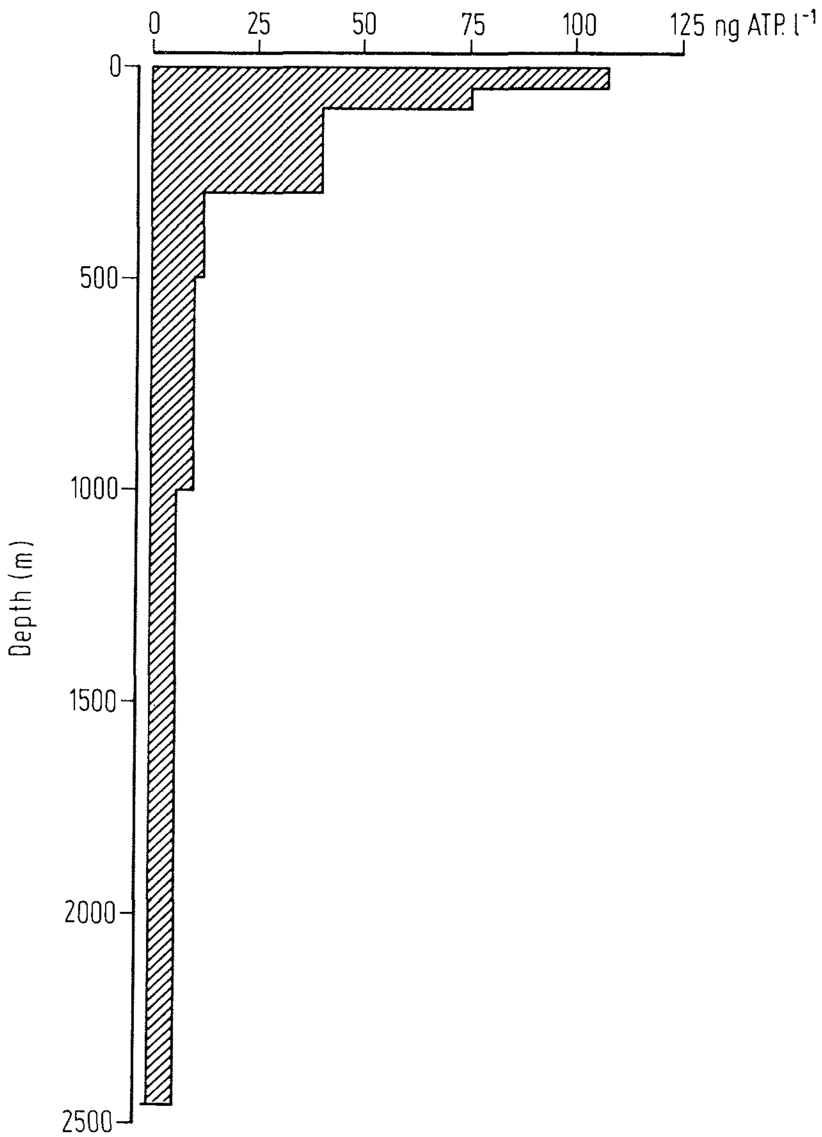

Fig. 8. Vertical distribution of microbial biomass. Mean of 22 profiles of Elephant Island Box, May 1986. Plotted as ng ATP/liter against depth in m.

1.11.2 Intercalibration at sea of two ATP-measuring methods (W. Ernst, G. Nieuwland and J.H. Vosjan)

During ANT V/1 we had the possibility to compare two methods for estimation of ATP. The ATP method followed by Vosjan was adapted for small sample volumes and he followed a cold extraction method especially for the analysis of micro-organisms: the Lumac NRB method. Ernst followed the method of Holm-Hansen with slight modifications and took samples of 500 ml and extracted the whole biomass of his samples in boiling Tris-buffer. Comparing the two methods it proved that there was a good similarity, e.g. for the Elephant Island region Vosjan and Nieuwland found 20 mg C/m3 in the upper water column of 50 m and Ernst found 23 mg C/m3. Because of the patchiness of the biomass and because Ernst used a larger sample volume, he had more chance to collect zooplankton such as copepods on his filters. So his values are a little higher. The results of profiles of stations covered by the two methods have still to be studied.

1.12 Chemische und biochemische Untersuchungen

Die Arbeiten erstreckten sich auf folgende Teilgebiete:
- Untersuchung von Enzymen der Fischleber
- Bestimmung von ATP(Biomasse) in der Wassersäule
- Bestimmung von ATP/Biomasse-Verhältnissen in Zooplankton
- Untersuchung von anthropogenen organischen Spurenstoffen in marinen Organismen
- Untersuchung von organischen Spurenstoffen in Wasserproben

1.12.1 Enzymuntersuchungen

Die Untersuchungen dienten dem Nachweis und der Quantifizierung bestimmter Komponenten des mischfunktionellen Monooxygenase-Systems (MFO-Systems) in Lebermikrosomen antarktischer Fische. Das MFO-System ist für den Abbau und die Biotransformation von körperfremden Stoffen verantwortlich. Durch die Meßung verschiedener Komponenten dieses Systems können eventuell Rückschlüsse auf die Belastung eines Biotops mit systemfremden Stoffen ermöglicht werden. In unbelasteten Meeresgebieten, wie z.B. antarktischen Gewässern dürften somit erhebliche Unterschiede zu den stark belasteten Gebieten der Nordsee zu beobachten sein. Darüber hinaus sollen die Untersuchungen einen Beitrag zu grundlegenden Fragestellungen der enzymatischen Leistungsfähigkeit mariner Organismen unter verschiedenen physiologischen und saisonalen Bedingungen leisten.

Für die Gewinnung der Leberproben wurden vorwiegend Notothenia-Arten herangezogen, die uns aus den Grundschleppnetzfängen des BFA-Fischereibiologie-Teams zur Verfügung gestellt wurden. Insgesamt 42 Leberproben wurden unmittelbar nach dem Einholen des Fanges entnommen. Nach dem Homogenisieren und Zentrifugieren des Homogenates wurde die für die weitere Untersuchung benötigte Mikrosomenfraktion gelchromatographisch abgetrennt. Als zentrale Komponente des MFO-Systems wurde Cytochrom P-450 und b5, sowie Protein spektralphotometrisch bestimmt.

Weiterhin wurde Ethoxycumarindeethylase fluorimetrisch bestimmt. Eine vorläufige Auswertung der Meßergebnisse zeigt, daß auch in Kaltwasserfischen ein MFO-System existiert; jedoch bestehen quantitative Unterschiede zu den mit Fischen der Nordsee erhaltenen Meßergebnissen. Die endgültige Auswertung der Meßergebnisse an Land soll, insbesondere im Vergleich mit anderen Meeresgebieten zeigen, welche Faktoren hierfür verantwortlich sein können.

1.12.2 ATP-Profile (T. Bluszcz, R. Ernst, W. Ernst)

Die vertikale Verteilung der Biomasse (Bakterien, Mikroplankton) wurde an 32 Tiefenprofilen durch Bestimmung von Adenosintriphosphat (ATP) teilweise bis zu einer Tiefe von 3000 m untersucht. Die höchsten Werte wurden in der Oberflächenschicht von 50-100 m gemessen. Die Variabilität der Werte ist bis zu 200 m Wassertiefe teilweise erheblich. In größeren Wassertiefen sind die ATP-Werte relativ konstant und betragen mit ca. 10 ng/l etwa 5-10% der Oberflächenwerte. Aus den gemessenen Daten ergibt sich z.B. für das bei Elephant Island befischte Gebiet eine Biomasse von 2o mg C/m3 bis zu 50 m Wassertiefe und etwa 6 mg C/m3 bei einer Tiefe von 400 m.

Mit der Arbeitsgruppe Vosjan/Nieuwland (NIOZ,Texel) wurden Vergleichsmessungen durchgeführt (Intercalibration at sea, siehe unter 1.11.2).

1.12.3 ATP-Biomasseverhältnisse (T. Bluszcz, R. Ernst, W. Ernst)

Die zur Umrechnung von ATP-Werten in Biomasse erforderlichen Umrechnungsfaktoren wurden für eine Reihe antarktischer Planktonorganismen experimentell ermittelt. Amphipoden, Krill, Krill-Larven und Copepoden wurden noch lebend gewogen und anschließend mit Tris-Puffer und anschließender Homogenisierung aufgeschlossen. In mehr als 80 Einzeluntersuchungen wurden Organismen verschiedener Größe einbezogen. Bei der Mehrzahl der untersuchten Proben liegt der ATP-Gehalt bei guter Konstanz unter 1 µg/mg Frischgewicht. Krill-Larven mit einem Körpergewicht von 0,7-6,4 mg weisen die höchsten ATP-Gehalte auf. Bei den Copepoden konnte nur an einem Exemplar das ATP/Gewichtsverhältnis festgestellt werden, das mit ca. 2 µg/mg extrem hoch lag. Kleinere Copepoden wurden z.T. optisch vermessen und einzeln auf ATP untersucht.

1.12.4 Organische Spurenstoffe im Wasser (T. Bluszcz, W. Ernst, V. Weigelt)

Als Voruntersuchung für künftige spurenstoffchemische Arbeiten wurden Wasserproben verschiedener Herkunft bearbeitet: a) aus dem Querstrahlruderkanal; b) aus 2 verschiedenen bordfesten Pumpsystemen; c) aus dem Rosettenwasserschöpfer und d) vom Schlauchboot aus. Das Probenvolumen betrug 20-150 l; es wurde mit Hexan extrahiert und der Extrakt am Rotationsverdampfer konzentriert. Die anschließende gaschromatographische Untersuchung ergab Unterschiede in der stofflichen Zusammensetzung der einzelnen Proben; eine eingehendere Wertung der Ergebnisse kann erst an Land erfolgen, da die für die weitere Bearbeitung der Proben erforderlichen Reagenzien nach dem Transport erhebliche Verunreinigungen enthielten.

1.12.5 Untersuchungen von organischen anthropogenen Spurenstoffen in marinen Organismen (V. Weigelt)

Die rückstandsanalytischen Arbeiten auf diesem Fahrtabschnitt sollen primär folgenden Fragestellungen unterliegen:

1.) Welche organischen Xenobiotika können in den hiesigen marinen Organismen nachgewiesen werden?
2.) Wie groß ist deren Belastung im Verhältnis zu entsprechenden Organismen, die aus anderen Gebieten, speziell der nördlichen Hemisphäre, stammen?
3.) Gibt es artspezifische Besonderheiten im Schadstoffmuster bei den beprobten Tierspezies?
4.) Lassen sich Nahrungskettenbezüge bei der Anreicherung der Schadstoffe in den Organismen feststellen?

Um hierauf Antworten zu finden, wurden auf diesem Fahrtabschnitt sowohl Phyto- und Zooplanktonproben mit einem Neuston-Schlitten gesammelt, als auch diverse Fischarten (vereinzelt auch adulter Krill) aus den Netzen der Fischereibiologie entnommen und für die weiteren Untersuchungen im AWI konserviert. Die Auswertung soll dort mittels HPLC (High Performance Liquid Chromatography), Kapillargaschromatographie und Massenspektrometrie erfolgen.

Planktonproben:
Parallel zu den RMT-Fängen wurde, wenn es die Wetterbedingungen zuließen, ein Neuston-Schlitten ausgesetzt und Phytosowie Zooplankton in den ca. obersten 20 cm der Wassersäule gesammelt. Die Fangzeit betrug jeweils 15 min, die Schleppgeschwindigkeit des Neuston-Schlitten etwa 3 kn, die Maschenweite des Netzes sowie des Endbeutels 0,047 mm und die Netzöffnung 14,5 cm mal 29,5 cm. Je nach Beprobungsgebiet enthielten die Fänge teilweise eine sehr unterschiedliche Organismenzusammensetzung. Auffallenstes Merkmal war

dabei, daß in der Regel alternierend entweder viele Krill-Larven oder viel Phytoplankton gefunden wurde. Direkt nach dem Fang wurde der Endbeutel abgenommen und der Inhalt unter rückstandsanalytischen Gesichtspunkten quantitativ in eine Edel- stahlschüssel überführt. Anschließend wurde die Probe mittels zweier Prüfsiebe (Durchmesser 10 cm, Maschenweite 1,0 mm und 0,125 mm) vorfraktioniert und teilweise noch mit Pinzette nachsortiert. Die so selektierten Proben, wie z.B. Amphipoden, Salpen, Krill-Larven oder möglichst reines Phytoplankton wurden in vorgewogener Aluminiumfolie verpackt und bei -30°C tiefgefroren.

Fischproben:
Bei den Fischen handelte es sich einerseits um Spezies, die um Elephant Island mit einem Grundschleppnetz gefischt wurden. Sie wurden direkt nach dem Fang vermessen und anschließend die Leber, ein definiertes Stück Filet und das Gehirn herauspräpariert und wie schon beschrieben in vorgewogener Aluminiumfolie eingefroren. Außerdem wurden den Fischlebern auch teilweise Nematoden entnommen, um sie separat rückstandsanalytisch zu untersuchen. Bei den beprobten Fischen handelte es sich überwiegend um Arten der drei Familien Nototheniidae, Channichthyidae sowie Bathydraconidae. Zum anderen wurden Fische gesammelt, die im RMT in Tiefen von normalerweise 200 m bis Wasseroberfläche während des Krillfangs als Beifang enthalten waren. Hierbei handelte es sich fast ausschließlich um Spezies der Familie der Myctophidae. Aufgrund ihrer relativ geringen Größe (normalerweise zwischen 5 und 10 cm) wurden sie vollständig eingefroren.

Alle Geräte, Behältnisse und Verpackungsmaterialien, mit denen die Proben in Kontakt kamen, wurden vor jedem Gebrauch mit destilliertem Wasser, Aceton und n-Hexan gründlichst gesäubert und bestanden aus möglichst inerten Materialien, wie z.B. Edelstahl oder Glas.

1.13. <u>Untersuchungen am antarktischen Benthos</u>

1.13.1 **<u>Allgemeines</u>** (G. Hoepner Petersen)

Diese vorläufige Beurteilung der Bodentierwelt basiert auf Proben aus dem Beifang des Grundschleppnetzes, den 0.1 qm Van Veen Backengreifern und einigen Beyer-Schlitten-Fängen, die alle in Tiefen zwischen 50 und 500 m durchgeführt wurden. Die Sedimente bestanden aus unsortierten Tonen, Sand und Steinen. Steiniger Boden, auf dem die Geräte nicht arbeiten konnten, wurde vermieden.

Im Benthos des Beifangs dominierten große Porifera, Hydroidea, Crinoidea, Echinodermata, Anthozoa und Bryozoa. Dominant in den quantitativen Bodengreiferproben waren

Polychaeta und Amphipoda. Für vergleichende Studien zwischen arktischem und antarktischem Benthos wurden ausgewählte Invertebratenaufsammlungen aus ca. 30 Hols mit dem Grundschleppnetz entnommen. Zusätzlich wurden 25 Greiferproben über ein Sieb der Maschenweite 1 mm sortiert. Alle oben erwähnten Taxa sind in der Arktis vorhanden, aber die folgenden Gruppen sind ausgesprochen selten im antarktischen Benthos vertreten: Krabben, Einsiedlerkrebse und Pectinaria-ähnliche Polychaeten wurden nicht beobachtet. Garnelen, balanomorphe Cirripedier, Muscheln, Prosobranchier und Kalkröhren bewohnende Polychaeten waren kleiner und seltener. Sowohl reguläre als auch irreguläre Seeigel waren präsent. Dagegen fehlen in der Arktis die Irregularia. Im Ganzen gesehen wirken die antarktischen Benthosvertreter evolutionsmäßig älter als die arktischen Tiere. Benthische Larven fehlen ganzjährig, oder sind zumindest selten im Plankton beobachtet worden (V. Siegel, pers. Mitt.). Nur 10% der Nahrung des Fischbestandes besteht aus Bodentieren (K.-H. Kock, pers. Mitt.). So gesehen scheint der Benthos in der Antarktis isoliert vom pelagischen System zu stehen, während in der Arktis ein Austausch zwischen beiden Gemeinschaften regelmäßig vorkommt. Eine vorläufige Aufstellung der Biomasse- und Produktionsraten auf den verschiedenen Stufen des Elephant Island-Ökosystemmodells wurde aus Literaturdaten sowie Ergebnisse der Reise zusammengestellt und zeigt zuverläßige Verknüpfungen zwischen Primär- und Fischproduktion. Es ist vorgesehen, diese Daten auf einem in ca. 6 Monaten folgenden interdisziplinären Workshop abzusichern. Der erste Eindruck stimmt nicht mit der Hypothese überein, daß der antarktische Circumpolarstrom ungefähr 20-30 Millionen Jahre alt ist und die völlige Vereisung initiierte. Die gemachten Beobachtungen passen besser zu einer vorläufigen Arbeitshypothese nach der der Ringstrom bereits vor ca. 200 Millionen Jahren durch die Trennung der Kontinente entstand.

Die Konfiguration der den Strom umgebenden Landmassen konnte in diesem Zeitraum keinen Einfluß auf den Strom nehmen, der als warme Wassermasse enstand und im Tertiär langsam abkühlte. Die Kontinente haben niemals einen ausgedehnten flachen Schelf besessen. So konnte sich mangels Konkurrenz eine dominierende pelagische Fauna entwickeln. Während der Abkühlungsphase stieg die pelagische Produktion noch an. Diese Nahrungsressource wurde von ozeanischen und in der Antarktis endemischen Fischen genutzt. Als spätere Konsumenten erschienen die Vögel und schließlich ab dem Miozän die marinen Säugetiere. Das antarktische Benthos stimulierte nicht eine derartige Produktion und Evolution von Räubern, wie sie im antarktischen Pelagial und wichtiger noch, im arktischen Benthossystem vorkommen.

1.13.2 **Quantitative Untersuchungen am antarktischen Makrozoobenthos** (U. Mühlenhardt-Siegel)

Für die Winterreise der "Polarstern" in das Seegebiet westlich der Antarktischen Halbinsel waren auf den Schelfgebieten quantitative Untersuchungen des Makrozoobenthos geplant. Es sollten ursprünglich an 5 ausgewählten Stationen je 10 Parallelproben gesammelt werden. Aufgrund der Eisverhältnisse war keine der 5 Stationen zu erreichen. Stattdessen wurde eine großräumige Erfassung des Makrobenthos angestrebt. Die quantitative Probennahme erfolgte mit dem 0,1 m^2 Van Veen Backengreifer. Qualitatives Material erbrachte der Beifang der Grundschleppnetzfischerei und der Einsatz des Beyer-Schlittens.

Insgesamt wurde der Van Veen Backengreifer an 39 Stationen von der "Polarstern" (35 Stationen) und vom "Polarfuchs" (4 Stationen) eingesetzt. Pro Station wurden mindestens 2 Parallelproben genommen. Für unsere Arbeitsgruppe wurden insgesamt 92 Greiferproben gesammelt, wovon 58 erfolgreich waren. Die 58 quantitativen Proben wurden an 28 Stationen gesammelt, von denen allein 21 Stationen im Seegebiet NW und W von Elephant Island lagen. Die Benthosproben bei Elephant Island wurden bei dem zweiten Fischereiabschnitt parallel zu jedem Grundschleppnetz-Hol genommen. So ist eine direkte Vergleichbarkeit mit dem Mageninhalt benthosfressender Arten gegeben.

Vom Schelf vor der Antarktischen Halbinsel liegen nur wenige quantitative Proben vor. Von 15 Stationen waren 6 nur qualitativ zu werten und an 3 Stationen enthielt der Greifer keine Fauna. Bedingt durch den steinigen Untergrund konnte der Backengreifer nicht erfolgreich eingesetzt werden. Dredge-Fänge hätten hier sicherlich bessere Ergebnisse gebracht.

Es wurden insgesamt Proben aus den Tiefen von 50-546 m erfaßt. Aus jeder quantitativen Probe wurde Sediment für Korngrößenanalysen eingefroren. Die Greifer-Proben wurden an Bord über einem Sieb der Maschenweite 0,5 mm gespült und in 4% Formaldehyd fixiert. 8 Proben konnten bereits sortiert werden. Es zeigte sich eine hohe Individuendominanz der Polychaeta.

Der Beyer-Schlitten wurde 7 mal eingesetzt. Er erreichte eine hohe Ausbeute an Amphipoda, Mysidacea und Copepoda. Die Probennahme aus dem Beifang des Grundschleppnetzes brachte unter anderem ein umfangreiches Material an Asteroidea (Seesternen), das einer Dissertation am Zoologischen Institut der Universität Hamburg gute Ergänzung geben soll.

1.13.3 Ostracoden (J. Mallwitz)

Während der Forschungsreise Ant V/1 wurden 2533 Ostracoden (Muschelkrebse) an 59 Stationen aufgesammelt. Die Proben von 18 Stationen sind noch nicht ausgewertet. 2270 pelagische Formen (hauptsächlich Halocyprididae) wurden aus RMT-, Multi-Netz-, Beyer-Schlitten- und Neuston-Schlitten-Proben gewonnen. Dem stehen nur 263 benthische Muschelkrebs gegenüber, aus Greifer-Proben mit dem 0,1 m^2 Van Veen Backengreifer (20 Stationen mit insgesamt 54 Greifern), aus Stoßrohrsediment-Proben (1 Station) und Seesternbeifang der Grundschleppnetzfischerei (5 Stationen).

Generell stellen die benthischen Ostracoden nur einen sehr kleinen Teil der Meiofauna. Die größte Ausbeute fand sich in den Greifern aus Tiefen zwischen 96-250 m (Stn. 20, 91, 137) auf tonigen bis grobsandigen Sedimenten. Muschelkrebse der Ordnung Myodocopida dominieren eindeutig vor den Podocopida. Die Meiofauna wird bestimmt durch kleinere Anneliden. Nematoden, Bryozoen und Foraminiferen sind stetig.

Neben der Aufsammlung von Material für eine taxonomische und zoogeographische Bearbeitung wurden ausgewählte Vertreter für elektronenmikroskopische Untersuchungen fixiert. Von verschiedenen Muschelkrebsen wurden Makrofotos angefertigt, um insbesondere Lebendfärbung und Reifestadium (Eigröße und Eizahl) zu dokumentieren. Pelagische Ostracoden wurden im Kühlcontainer gehältert und insbesondere die Bewegungsweise studiert. 4 Seesternarten konnten dort 9 Tage lang gehältert werden, um Aufschluß über den Besatz mit kommensalischen Ostracoden zu erhalten: Schlangenseesterne (Ophiuroidea) wurden nie besetzt. Die Bevorzugung einer Seesternart konnte schließlich fotografisch durch in situ-Aufnahmen dokumentiert werden. Es ist auffallend, daß im antarktischen Frühwinter sowohl pelagische als auch benthische Arten zum überwiegenden Teil Eier tragen.

Die Stationen 123 und 125 erwiesen sich als 'Fundgrube' für subrezentes oder fossiles Ostracodenschalenmaterial, sowie massenhaft auftretende Foraminiferen.

1.14 Partikelfluß in antarktischen Gewässern
(H. Berner)

Am 22. Mai erreichte "Polarstern" die Position der Verankerung vor der Admiralty Bay, King George Island. Dort lag sehr dichtes Eis mit nur wenigen kleinen Waken, so daß an eine sichere Aufnahme nicht zu denken war. Die akustischen Auslöser wurden daher weder angesprochen noch ausgelöst.

In der Nähe der Verankerungsposition wurden die begleitenden Schöpfserien und Multi-Netz-Fänge plangemäß durchgeführt.

Auf dem Rückweg von Adelaide Island nach Elephant Island sollte nochmals versucht werden, die Verankerung aufzunehmen. In der Nacht zum 9. Juni geriet das Schiff westlich von King George Island in dichtes Packeis und mußte nach Norden ausweichen. Auf weiteres Eindringen in das Eis mußte verzichtet werden, da keine Rinnen oder Bereiche mit schwachem Eis zu finden waren.

Die Verankerung ist im November 1986 mit "Polarduke" aufgenommen worden.

1.15 Seabird Observations (M. Whitehouse)

Quantitative seabird observations were made continuously whilst the "Polarstern" was steaming during daylight hours, south of 60°S. The avifauna during the first part of the cruise (the Elephant Island Box) was dominated by Cape Petrels (Daption capense), particularly to the north of the island. During trawling activities, counts of 1,000 were not uncommon, with a maximum count of 15,000 birds on 11 May. Apart from Cape Petrel, modest numbers (10's at most) of 19 other species were observed. Amongst them were a number of birds seemingly at their most southerly range limits for this time of the year, Black-Browed Albatross (Diomedea melanophris), Grey-Headed Albatross (Diomedea chrysostoma), Light-Mantled Sooty Albatross (Phoebetria palpebrata), Antarctic Prion (Pachyptila desolata) and Black-Bellied Storm-Petrel (Fregetta tropica). One 'out-of-season' Wilson's Storm-Petrel (Oceanites oceanicus) and a vagrant Cattle Egret (Bubulcus ibis) were seen. Also 3 fin whales and one humpback whale were sighted.

Further south, Kerguelen Petrels (Pterodroma brevirostris) were seen south to about 62°S. In the offshore waters west of the Peninsula, Blue Petrels (Halobaena caerulea) were evenly but thinly distributed to about 63°S, while Antarctic Fulmars (Fulmarus glacialoides) and Southern Giant Petrels (Macronectes giganteus) were seen in small numbers south to about 64°S and Cape Petrels to 65°S. Antarctic Petrels (Thalassoica antarctica) and Snow Petrels (Pagodroma nivea) were recorded throughout the area.

Inshore, Antarctic Fulmars, Southern Giant, Cape, Antarctic and Snow Petrels were joined by Southern Black-Backed Gulls (Larus dominicanus) and occasional Blue-Eyed Cormorants (Phalacrocorax atriceps), Yellow-Billed Sheathbills (Chionis alba) and Antarctic Terns (Sterna vittata).

In pack-ice, a greater number of Snow Petrels were counted along with four species of penguin. A single Emperor penguin (Aptenodytes forsteri) at 63°S in the Bransfield Strait was of particular interest and modest numbers of Adelie penguins

(Pygoscelis adeliae) were present as well as the occasional Chinstrap (Pygoscelis antarctica) and Gentoo penguins (Pygoscelis papua). One humpback and one minke whale were the only whales sighted. In the Gerlache Strait, many (100's) fur seals were counted but comparatively few crab-eater seals were seen.

On returning north to Elephant Island, with the winter's advancing pack-ice, the large Cape Petrel concentrations of a month previous were not found. However, Snow Petrels were quite widespread throughout the area as were Blue Petrels in open water. Southern Giant and Antarctic Petrels along with Southern Black-Backed Gulls, Sheath- bills and Antarctic Fulmars were present in small numbers, whilst in pack-ice, Adelie penguins, fur and crabeater seals were seen occasionally.

1.16 Stationsliste/Station list

Abkürzungen/Abbreviations

APSN	Apstein-Netz/Apstein net
BG	Backengreifer/Grap sampler
BSL	Beyer-Schlitten/Beyer sledge
CTD	Temperatur-Leitfähigkeitssonde/Conductivity Temperature Depth sonde
GSN	Grundschleppnetz/Bottom trawl
EIS	Eisstation/Ice station
MN	Multi-Netz/Multi net
MS/RO	Multisonde-Rosette
NS	Neuston-Schlitten/Neuston sledge
RMT	Rectangular Midwater Trawl
UWE	Unterwasserfahrzeug/Remotely Operated Vehicle
VN	Vertikal-Netz/Vertical net
XBT	Bathythermograph

Stat No.	Date 1986	Position Start		Depth (m) Start	Time (GMT) Start	Gear
1	07.05.	55°01'S	63°10'W	2133	21:30	XBT
2	08.05.	57°39'S	60°08'W	3410	18:00	XBT
3	09.05.	61°00'S	55°04'W	289	16:00	RMT
4		61°01'S	55°02'W	185	17:38	GSN
					19:10	CTD
5		61°00'S	55°10'W	247	20:07	CTD
					20:29	GSN
					22:03	BG
					22:15	BG
6	10.05.	61°10'S	55°16'W	202	09:40	GSN
7		60°58'S	55°08'W	289	11:35	CTD
					12:27	GSN
8		61°08'S	55°14'W	165	14:31	GSN
					15:50	CTD
9		60°54'S	55°23'W	269	17:32	GSN
					19:19	CTD
10		60°54'S	55°30'W	93	20:29	GSN
					22:00	MS/RO
					22:27	BG
11	11.05.	60°50'S	55°38'W	249	09:20	GSN
					11:01	MS/RO
12		60°51'S	55°39'W	211	12:08	GSN
13		60 50'S	55°38'W	329	14:07	GSN
					15:33	MS/RO
					15:58	VN
14		60°59'S	55°56'W	271	18:22	GSN
15	12.05.	60°58'S	55°53'W	177	09:10	GSN
					10:49	MS/RO
16		61°OO'S	55°51'W	137	11:37	GSN
					12:57	MS/RO
17		61°04'S	55°57'W	253	13:13	GSN
					15:10	MS/RO
18		61°04'S	55°53'W	139	16:08	GSN
					17:38	MS/RO
19		61°06'S	55°51'W	103	18:30	GSN
					19:45	MS/RO
20		61°09'S	55°45'W	78	20:00	GSN
					21:24	BG
					22:18	VN
21	13.05.	61°15'S	55°49'W	139	09:11	GSN
					10:40	MS/R
22		61°17'S	55°50'W	235	11:49	GSN
23		61°14'S	54°53'W	230	15:29	GSN
					16:52	MS/RO
24		61°13'S	54°40'W	260	17:43	GSN
25	14.05.	60°00'S	54°16'W	3100	07:10	MS/RO
					09:34	RMT
					11:02	APSN
					11:50	RMT
					13:22	VN
					14:59	RMT
					16:35	RMT
26		60°08'S	54°15'W	2822	18:10	XBT

Stat No.	Date 1986	Position Start		Depth (m) Start	Time (GMT) Start	Gear
27	14.05.	60°16'S	54°15'W	2870	19:11	MS/RO
					19:27	APSN
					21:08	RMT
28		60°24'S	54°14'W	3199	23:42	XBT
29	15.05.	60°30'S	54°14'W	3140	07:00	MS/RO
					09:15	RMT
					10:14	APSN
30		60°38'S	54°15'W	2934	11:13	XBT
31		60°46'S	54°17'W	3472	12:11	RMT
					13:00	MS/RO
32		60°52'S	54°13'W	794	15:55	XBT
33		61°00'S	54°16'W	820	17:28	MS/RO
					17:32	APSN
34		61°04'S	54°20'W	1120	19:06	UWE
					19:24	RMT
					20:36	XBT
35	16.05.	61°00'S	55°00'W	463	10:35	MS/RO
					11:15	RMT
					13:03	VN
36		60°53'S	55°00'W	793	14:17	XBT
37		60°45'S	55°01'W	3323	15:24	RMT
					16:20	MS/RO
38		60°37'S	55°00'W	3320	19:12	XBT
39		60°30'S	55°00'W	3560	19:52	RMT
					21:00	MS/RO
40		60°20'S	55°00'W	3481	23:45	XBT
41	17.05.	60°15'S	55°01'W	3500	00:27	RMT
					01:29	MS/RO
42		60°07'S	55°00'W	3497	04:45	XBT
43		60°00'S	55°00'W	3597	07:04	MS/RO
					09:25	RMT
44		60°00'S	55°21'W	3535	11:37	XBT
45		60°00'S	55°41'W	3639	12:26	XBT
46		60°02'S	55°59'W	3708	13:34	RMT
					15:03	MS/RO
					17:13	APSN
					17:31	VN
47		60°08'S	56°00'W	3676	18:16	XBT
48		60°15'S	56°00'W	3810	19:00	RMT
					20:00	MS/RO
49		60°24'S	56°01'W	3909	22:56	XBT
50	17./	60°29'S	56°03'W	3935	23:30	RMT
	18.05.				00:24	MS/RO
51	18.05.	60°38'S	56°00'W	3813	05:44	XBT
52		60°44'S	55°55'W	3065	07:00	MS/RO
					09:06	RMZ
53		60°53'S	55°59'W	784	11:09	XBT
54		61°00'S	56°03'W	893	11:55	RMT
					13:00	MS/RO
					13:23	VN
					14:00	RMT
55		61°10'S	56°02'W	305	15:44	XBT

Stat No.	Date 1986	Position Start		Depth (m) Start	Time (GMT) Start	Gear
56	18.05.	61°46'S	56°03'W	165	16:16	RMT
					17:05	MS/RO
					17:11	APSN
					17:32	NS
57		61°22'S	56°07'W	317	18:37	XBT
					19:04	RMT
58		61°29'S	56°08'W	368	20:18	RMT
					21:04	MS/RO
59		61°35'S	56°01'W	603	23:18	XBT
60	19.05.	61°45'S	56°01'W	703	00:18	XBT
61		61°53'S	56°45'W	448	04:52	XBT
62		61°45'S	56°45'W	433	05:42	XBT
63		61°42'S	56°44'W	493	09:02	MS/RO
					09:38	RMT
64		61°37'S	56°45'W	502	10:50	XBT
65		61°30'S	56°42'W	487	11:59	RMT
					12:39	MS/RO
66		61°22'S	56°47'W	970	14:07	XBT
67		61°07'S	56°37'W	1944	15:07	RMT
					15:25	XBT
					15:51	APSN
					15:57	MS/RO
68		60°59'S	56°45'W	2675	18:04	RMT
					18:46	MR/RO
					18:46	APSN
					20:30	NS
69	19.05.	60°52'S	56°43'W	2950	21:37	XBT
70	19./	60°46'S	56°46'W	3130	22:15	RMT
	20.05.				22:52	MS/RO
					00:03	APSN
71	20.05.	60°38'S	56°45'W	2318	03:25	XBT
72		60°30'S	56°45'W	3887	07:00	MS/RO
					09:32	RMT
73		60°23'S	56°45'W	4324	10:41	XBT
74		60°16'S	56°46'W	3300	11:26	RMT
					11:59	MS/RO
					14:49	NS
75		60°07'S	56°45'W	3627	15:23	XBT
76		60°00'S	56°46'W	3605	16:13	RMT
					16:56	MS/RO
					18:58	NS
77	21.05.	60°19'S	58°51'W	3564	00:04	RMT
					00:44	MS/RO
					01:11	APSN
78		60°47'S	58°38'W	4770	08:06	MS/RO
					09:05	RMT
					09:13	NS
79		61°17'S	58°19'W	4282	12:22	RMT
					13:19	MS/RO
80		61°45'S	57°53'W	303	16:29	RMT
					17:21	MS/RO

Stat No.	Date 1986	Position Start		Depth (m) Start	Time (GMT) Start	Gear
81	21.05.	62°06'S	57°34'W	390	22:17	RMT
					22:20	NS
					23:00	MS/RO
					23:26	MN
82	22.05.	62°22'S	58°03'W	1971	13:30	EIS
83		62°22'S	58°15'W	1696	14:49	MS/RO
					15:42	MS/RO
					16:07	MN
					16:52	VN
					17:31	MS/RO
					18:40	RMT
					18:51	NS
84		62°24'S	58°36'W	1310	21:24	MS/RO
					22:21	RMT
					23:00	MN
					23:23	RMT
					23:57	VN
85	23.05.	62°40'S	59°20'W	1447	11:08	RMT
					11:15	NS
					11:47	MS/RO
					12:58	RMT
					13:41	MN
					14:50	UWE
					16:30	MN
86		62°49'S	60°17'W	835	23:25	RMT
					23:57	MS/RO
87	24.05	63°00'S	60°23'W	750	08:47	MS/RO
					09:25	RMT
					09:28	NS
88		63°05'S	60°38'W	554	11:09	RMT
					11:09	NS
					11:44	MS/RO
					11:52	APSN
89		63°06'S	60°58'W	751	13:00	RMT
					13:03	NS
					13:40	MS/RO
					14:00	APSN
					14:18	MN
90		63°23'S	61°23'W	1048	16:47	RMT
					16:49	NS
					17:21	MS/RO
					18:11	MN
					19:28	RMT
91	25.05.	62°49'S	60°56'W	187	00:08	RMT
					00:10	NS
					00:33	MS/RO
					00:35	APSN
					00:55	MN
					01:23	BG
					02:40	BSL
92		62°23'S	61°23'W	401	11:06	MS/RO
					11:34	RMT
					11:37	NS
					12:18	RMT

Stat No.	Date 1986	Position Start		Depth (m) Start	Time (GMT) Start	Gear
93	25.05.	62°07'S	61°34'W	1930	14:20	RMT
					14:22	NS
					14:55	MS/RO
					14:57	APSN
94		61°34'S	61°56'W	4140	18:23	RMT
					18:26	NS
					18:59	MS/RO
					19:14	APSN
					19:40	VN
95		61°02'S	62°18'W	3560	22:45	RMT
					22:50	NS
					23:22	MS/RO
					23:28	APSN
96	26.05.	61°30'S	63°52'W	3560	08:33	MS/RO
					09:30	RMT
97		62°09'S	63°20'W	4667	13:47	RMT
					14:31	MS/RO
98		62°46'S	62°40'W	416	18:32	MS/RO
					19:00	RMT
99		63°12'S	62°36'W	202	22:12	RMT
					22:30	NS
					22:44	MS/RO
					23:05	BG
					23:46	BSL
100	27.05.	63°30'S	62°08'W	132	08:34	MS/RO
					09:01	RMT
					09:01	NS
					09:33	BG
					10:11	BSL
101		63°35'S	62°19'W	303	12:24	RMT
					12:25	NS
					12:48	RMT
					13:21	MS/RO
					13:25	APSN
102		64°05'S	63°05'W	646	17:16	RMT
					17:18	NS
					18:00	MS/RO
103	28.05.	64°49'S	63°11'W	359	12:54	RMT
					12:55	NS
104		64°42'S	63°00'W	317	15:28	RMT
					15:33	NS
					16:03	MS/RO
					16:36	UWE
105		64°38'S	62°54'W	634	18:35	RMT
					18:39	NS
					19:17	APSN
					19:18	CTD
					21:28	UWE
106	29.05.	64°33'S	62°37'W	689	09:06	RMT
					09:09	NS
					10:13	CTD
					11:17	RMT
					11:26	NS

Stat No.	Date 1986	Position Start		Depth (m) Start	Time (GMT) Start	Gear
107	29.05.	64°30'S	62°23'W	667	13:35	VN
108		64°34'S	62°38'W	701	15:48	NS
					15:49	RMT
109		64°53'S	63°15'W	387	21:21	CTD
					21:21	APSN
					21:46	NS
					21:48	RMT
110		64°52'S	64°11'W	607	10:11	RMT
					10:14	NS
					11:06	MS/RO
111		64°55'S	64°42'W	693	21:17	NS
					21:18	RMT
					22:00	CTD
					22:00	APSN
112		64°31'S	64°45'W	533	00:37	RMT
					00:37	NS
					01:13	MS/RO
					01:15	APSN
113	31.05.	63°51'S	63°14'W	528	08:32	CTD
					09:23	RMT
					10:10	MS
114		63°38'S	63°27'W	398	12:11	RMT
					12:46	MS/RO
					13:11	MN
115		63°18'S	63°43'W	305	15:28	MS/RO
					15:51	MN
					16:14	BG
					21:34	RMR
116	01.06.	63°00'S	66°29'W	3359	08:30	CTD
					09:17	RMT
					09:20	NS
117		63°20'S	66°11'W	3270	12:32	RMT
					13:08	MS/RO
118	02.06.	63°45'S	65°39'W	428	09:01	MS/RO
					09:25	BG
					10:00	RMT
					10:02	NS
119		64°06'S	65°16'W	524	12:30	RMT
					12:32	NS
					13:12	MS/RO
					13:14	APSN
					13:38	BG
120		64°17'S	66°46'W	399	18:09	RMT
					18:10	NS
					18:44	VN
					18:54	MS/RO
					18:55	APSN
121		64°28'S	68°15'W	2826	22:50	RMT
					22:52	NS
					23:20	MS/RO
					23:31	APSN

Stat No.	Date 1986	Position Start		Depth (m) Start	Time (GMT) Start	Gear
122	03.06.	64°46'S	67°37'W	361	08:25	CTD
					08:55	RMT
					08:59	NS
123		65°03'S	67°02'W	273	11:47	RMT
					11:47	NS
					12:40	MS/RO
					12:43	APSN
					12:59	BG
					14:20	BSL
124		65°23'S	66°08'W	439	17:48	RMT
					17:52	NS
					18:21	MS/RO
125		65°53'S	66°49'W	125	22:15	RMT
					22:16	NS
					22:49	CTD
					22:49	APSN
					23:04	BG
126	04.06.	66°08'S	67°16'W	259	01:18	RMT
					01:20	NS
					01:54	MS/RO
					01:59	APSN
					02:20	BG
127		65°43'S	68°12'W	446	09:01	CTD
					09:30	NS
					09:31	RMT
128		65°21'S	68°59'W	383	13:08	RMT
					13:09	NS
					13:35	MS/RO
					13:51	APSN
					14:06	MN
129		65°32'S	70°00'W	2968	17:38	RMT
					17:39	NS
					18:11	MS/RO
130		65°58'S	70°27'W	400	21:45	RMT
					22:20	CTD
					22:20	APSN
131	05.06.	66°15'S	69°16'W	401	01:52	MS/RO
132		66°31'S	68°25'W	499	09:00	CTD
					09:31	BG
					10:18	RMT
					10:18	NS
133		66°47'S	68°58'W	197	13:39	RMT
					14:07	MS/RO
					14:11	APSN
					14:27	BG
134		66°39'S	69°27'W	365	18:15	MS/RO
					18:53	MS/RO
					19:17	BG

Stat No.	Date 1986	Position Start		Depth (m) Start	Time (GMT) Start	Gear
135	06.06.	66°04'S	67°04'W	386	09:08	MS/RO
					09:28	NS
					09:29	RMT
					10:59	RMT
					11:46	RMT
					12:28	MN
					12:43	BG
136		65°43'S	67°07'W	160	15:43	NS
					15:44	RMT
					16:23	MS/RO
					16:37	BG
					17:33	BSL
137		65°34'S	66°33'W	228	20:20	NS
					20:20	RMT
					20:44	MS/RO
					21:02	BG
					21:45	RMT
138	09.06.	60°57'S	55°46'W	209	09:55	GSN
					11:30	MS/RO
					11:56	BG
139		60°51'S	55°46'W	236	13:00	GSN
					15:27	MS/RO
					15:52	BG
					18:07	UWE
140		60°50'S	55°44'W	294	20:09	GSN
					21:58	MS/RO
					22:44	BG
141	10.06.	60°57'S	55°16'W	344	09:12	GSN
					10:45	MS/RO
					11:07	BG
142		60°52'S	55°27'W	332	12:38	GSN
					14:08	MS/RO
					14:08	APSN
					14:33	BG
143		60°56'S	55°01'W	351	16:31	GSN
					18:16	MS/RO
					18:40	BG
144		60°56'S	55°09'W	362	19:42	GSN
					21:26	MS/RO
					21:51	BG
145	11.06.	61°07'S	56°00'W	134	09:06	GSN
					10:45	MS/RO
					11:01	BG
146		61°07'S	55°52'W	111	13:26	GSN
					14:46	MS/RO
147		61°05'S	55°55'W	151	16:37	GSN
					18:09	MS/RO
					19:00	BG
148	12.06.	60°52'S	55°24'W	311	09:06	GSN
					10:52	MS/RO
					11:09	BG

Stat No.	Date 1986	Position Start		Depth (m) Start	Time (GMT) Start	Gear
149	12.06.	60°50'S	55°34'W	473	12:10	GSN
					13:50	MS/RO
					13:52	APSN
					14:16	BG
					15:28	RMZ
150		60°58'S	55°37'W	53	17:39	BG
					18:19	BSL
151		60°50'S	55°45'W	373	21:02	GSN
					22:45	MS/RO
					23:03	BG
152	13.06.	61°08'S	56°09'W	300	09:09	GSN
					10:59	MS/RO
					11:19	BG
153		61°05'S	56°08'W	199	12:44	GSN
					14:05	MS/RO
					14:16	BG
154		61°05'S	56°03'W	271	15:28	GSN
					17:32	MS/RO
					17:49	BG
155		61°03'S	55°58'W	330	18:38	GSN
					20:33	BG

2. Fahrtabschnitt ANT V/2 (Bahia Blanca - Kapstadt)

2.1 Zusammenfassung und Fahrtverlauf (E. Augstein)

Das Arbeitsgebiet der "Polarstern" während des ersten Abschnitts des Winter-Weddell-See-Projekts 1986 lag zwischen dem Meereisrand und der Schelfeiskante entlang des Greenwich-Meridians (siehe Abb. 9 und 10 im englischen Text). Auf zwei meridionalen Traversen und in einem verdichteten Meßnetz über dem Maud-Rücken wurden ozeanische und atmosphärische Strukturen aufgezeichnet und groß- sowie mesoskalige Prozesse untersucht, eisphysikalische Vorgänge erfaßt und die pflanzlichen wie tierischen Lebensformen im Eis und in der Wassersäule studiert. Dabei standen folgende Forschungsziele im Vordergrund:

- Analyse der Kristallstruktur, der physikalischen Eigenschaften und der zeitlichen und räumlichen Entwicklung des Meereises sowie seines dynamischen Verhaltens unter der Einwirkung atmosphärischer und ozeanischer Antriebsmechanismen.

- Berechnung des Wärme- und Impulsaustauschs zwischen Atmosphäre und Eis/Ozean und Bestimmung der großräumigen Verdriftung des Packeises anhand der Luftdruck- und Bodenwindfelder.

- Erfassung der horizontalen und vertikalen Verteilung thermohaliner Zustandsgrößen, chemischer Substanzen und verschiedener Spurenstoffe zur Ableitung der mittleren Zirkulation, mesoskaliger Transportvorgänge und signifikanter Vermischungsprozesse im östlichen Bereich des ozeanischen Weddell-Wirbels.

- Erkundung der biologischen Entwicklung im und unter dem Meereis bei geringem Lichtangebot, dichter Eisbedeckung und starken Schwankungen der Temperatur und des Salzgehaltes im Eis.

Die Messungen und Beobachtungen wurden von integrierten Arbeitsgruppen durchgeführt, die sich aus Wissenschaftlern und Technikern deutscher (30), amerikanischer (12), britischer (5), schweizer (1), österreichischer (1) und argentinischer (1) Institute zusammensetzten. In einigen Teilprogrammen arbeiteten Vertreter verschiedener Disziplinen eng zusammen. Letzteres gilt vor allem für die Meereisuntersuchungen und die Ozeanographie. Die schon bei der Expeditionsplanung begonnene gemeinsame Arbeit soll bis zur Veröffentlichung der Ergebnisse fortgesetzt werden.

Die Seereise begann am 27. Juni 1986 in Bahia Blanca, Argentinien. "Polarstern" konnte wegen windbedingten niedrigen Wasserstandes erst einen Tag später als vorgesehen auslaufen. Das Schiff war zu dieser Zeit mit 44 Besatzungsmitgliedern, 47 Wissenschaftlern und Technikern und einer vierköpfigen Hubschraubermannschaft besetzt. Eine Woche nach dem Verlassen von Bahia Blanca erkrankte ein Wissenschaftler so schwer, daß wir am 5. Juli - kurz vor dem Eintreffen im Arbeitsgebiet - Kurs auf Kapstadt nehmen mußten. Am Scheitelpunkt der Kurslinie wurde die erste ARGOS Boje zur Bodenwerterfassung im offenen Wasser ausgesetzt. Nach sechstätiger Fahrt mit aller Kraft erreichte das Schiff am 11. Juli abends Kapstadt. Der Kranke war in Begleitung des Bordarztes schon am Morgen mit dem Hubschrauber an Land gebracht worden, wo er sofort ärztlich versorgt werden konnte. In der Nacht wurde Treibstoff nachgebunkert und am 12. Juli morgens lief "Polarstern" erneut in die Antarktis aus.

Auf der gesamten Anreise von Kapstadt begünstigten Wind und Wetter die Fahrt des Schiffes, so daß wir schon am 17. Juli auf 58°30'S, 01°00'W die erste ozeanographische Station durchführten. Diese bildete den Ausgangspunkt einer meridionalen Traverse auf dem Längengrad 01°W in das Packeis hinein. Statt auf einen wohldefinierten Eisrand trafen wir zunächst auf Eisgrieß, der sich weiter südwärts zu kleinen und mit zunehmender Breite zu immer größeren und dickeren Pfannkuchen zusammengeschlossen hatte. Erkennbar aus Pfannkucheneis gebildete Schollen prägten das Meereis noch in 300 sm Abstand vom Eisrand, wo es Dicken von 30 bis 50 cm erreichte. Aufgrund dieser Gegebenheiten waren Probennahmen und Bohrungen erst nach zwei Tagen zügiger Fahrt durchs Eis möglich und die zweite ARGOS Boje, die nahe am Rand des Packeisgürtels messen sollte, mußte bei 61°S zwischen kleinen Schollen ins Wasser statt aufs Eis gesetzt werden.

Folgende Messungen bildeten die Grundlage des Expeditionsprogramms:

Während der gesamten Eisfahrt wurden im 30 sm Abstand Temperatur-und Salzgehaltsprofile mit der CTD-Sonde im Ozean gemessen und mit Hilfe von jeweils 24 10-Liter Schöpfern Wasserproben aus unterschiedlichen Tiefen genommen. Letztere wurden ständig zur Analyse des Salzgehalts, des Sauerstoffs, weiterer chemischer und biologischer Größen sowie verschiedener Spurenstoffe im Meerwasser genutzt. In größeren Abständen wurden auch Profile mit 300-Liter Schöpfern zum Nachweis von Stoffen mit besonders geringer Konzentration eingesetzt. Das vertikale Profil des Stromvektors in den oberen 150 bis 300 m der Wassersäule wurde während der Stationsaufenthalte des Schiffes regelmäßig mit einem Doppler SONAR aufgezeichnet. Zur Untersuchung des Zooplanktons in der Wassersäule unter dem Eis diente täglich ein Hol mit dem Multi-Netz.

Einmal am Tag, möglichst in Verbindung mit einer CTD-Station, arbeitete eine interdisziplinäre Mannschaft für 2 bis 4 Stunden auf dem Eis, um Kerne zu ziehen, in einem festen Raster Bohrungen zur Eisdickenverteilung vorzunehmen, die Oberflächenspannungen des Eises aufzunehmen und die Albedo der kurzwelligen Strahlung zu messen. Die Eiskerne wurden hinsichtlich der biologischen Einschlüsse (Diatomeen, Foraminiferen, Bakterien), der Nährstoffe und des Salzgehaltes analysiert und ferner zur Bestimmung der Temperatur-, Dichte- und Wärmeleitfähigkeitsprofile sowie zur Erforschung des kristallinen Aufbaus des Eises verwandt.

In enger Anlehnung an die Arbeiten auf dem Eis wurden fast kontinuierlich, besonders aber während der Stationsaufenthalte auf fünf Kanälen die Mikrowellenstrahlung der Eis- oder Schneeoberfläche registriert. Aus den Ergebnissen werden verbesserte Algorithmen zur Interpretation der Satellitenfernerkundungssignale für das Meereis abgeleitet.

Zur ständigen Erfassung der atmosphärischen Felder nahe der Meeresoberfläche wurde ein ARGOS Bojennetz ausgelegt, das den Meereisgürtel bis zur Schelfeiskante überdeckte. Sondierungen des Windvektors, der Temperatur und des Wasserdampfgehalts bis zu 20000 m Höhe erfolgten viermal täglich während der gesamten Eisfahrt durch Radiosondenaufstiege. Ferner wurden Bodenwerte auf dem Schiff kontinuierlich als 10-Minutenmittel registriert. Die turbulenten Flüsse der Wärme und des Impulses und das Windprofil der Grenzschicht wurden mit einer SONIC- bzw. einer Doppler-SODAR-Anlage auf allen längeren Schiffsstationen gemessen.

Die Arbeiten vom Schiff wurden - wenn die Wetterbedingungen es zuließen - durch Radareisdickenmessungen, flächendeckende Fotografie und CTD-Profile von Eisschollen aus mit Hilfe von Hubschraubern erweitert.

Im Bereich des Maud-Rückens, dem Hauptarbeitsgebiet dieses Fahrtabschnitts, wurde das ozeanographische Meßnetz auf 10 sm Abstand verdichtet. Außerdem wurde der geplante gerade Südkurs auf 02°W durch eine Zickzacklinie ersetzt, um die wegen schlechten Wetters verhinderten Hubschraubermessungen wenigstens teilweise zu kompensieren. Diese zusätzliche Leistung der "Polarstern" war wegen der bis dahin schnellen Fahrt durchs Eis möglich. Entgegen geltender Annahmen trafen wir auf dem ganzen Schnitt westlich des Rückens relativ warmes Tiefenwasser mit Maximalwerten $> 1.1°C$ an. Dagegen waren weder hier noch im weiteren Verlauf der Reise warme Zellen zu finden, die auf eine tiefreichende vertikale Vermischung im Ozean hingewiesen hätten.

Am 23. Juli erreichte uns etwa bei 65°S, bereits 500 km im Eis, völlig unerwartet eine ausgeprägte Dünung mit Wellenhöhen bis zu 2 m und Perioden um 18 s. Dieses etwa 2 bis 3 Stunden anhaltende Ereignis, das von einem Sturmtief mit dem Kern nördlich des Eisrandes erzeugt wurde, zerlegte die vorher feste Eisdecke vollständig in Schollen von maximal 200 m Durchmesser.

Die Meridionaltraverse westlich des Maud-Gebirges endete bei 66°40'S, 02°W. Von dort aus überquerte "Polarstern" den Rücken mit Nordostkurs. Dieser Schnitt wurde im Zentrum des Plateaus vom 28. Juli bis zum 4. August durch eine Driftstation mit Eisdeformationsmessungen unterbrochen. Mit kontinuierlichen Einpeilungen von Radartranspondern und Omegasonden, die ein 20 km weites Gitter aufspannten, wurde 4 Tage lang die horizontale Verformung der Eisdecke registriert. Diese Untersuchungen wurden begleitet von Analysen der Eisstruktur, der Eisdickenverteilung, des Wärmeflusses durch das Eis sowie Foto- und Radaraufnahmen vom Hubschrauber aus.

Auf dem letzten Teil der Traverse über den Maudrücken wurden beide Hubschrauber am 2. August bei CTD-Messungen von einer rasch aufziehenden Schneefront überrascht und konnten nicht mehr zum Schiff zurückkehen. Da nur unter ständiger Radarkontrolle geflogen wurde, waren die Landepositionen genau bekannt, so daß "Polarstern" beide Maschinen abholen und nach einigen Stunden heil an Bord nehmen konnte.

Die bisherigen und die nachfolgenden Messungen im Bereich des Maud-Rückens zeigten übereinstimmend, daß relativ kaltes ($T_{max} < 0.5°C$) Tiefenwasser über dem Plateau von einem wärmeren ($T_{max} > 1.1°C$) Gürtel umschlossen ist. Die Front zwischen beiden Wassermassen verläuft entlang des Gebirgshanges. Um abzusichern, daß das warme Tiefenwasser auch im Osten lateral weit ausgedehnt ist, wurde der östlich des Rückens gelegene Schnitt von 64°S, 05°E nach 66°S, 05°E in Form eines Winkels mit dem Scheitelpunkt bei 65°S, 08°E gefahren. Auch hier wurde das warme Tiefenwasser auf der ganzen Strecke angetroffen. Es wurde erst weiter südlich von einer bis zur antarktischen Küste reichenden kälteren Wassermasse abgelöst.

Südlich von 66°S erschwerten an Zahl und Mächtigkeit zunehmende Preßeisrücken das Vorankommen des Schiffes. In kurzen Abständen mußten mehrere Meter dicke Pressungen immer wieder durch Rammen überwunden werden. Schlechte Sicht bei starkem Schneetreiben trug zusätzlich zur Fahrtbehinderung bei. Dennoch hatte "Polarstern" sich am 8. August bis zum nördlichen Rand des Antarktischen Küstenstroms durchgeboxt, wo bei 68°30'S, 01°E vom 8. bis zum 13. August die 2. Eisdeformationsmessung stattfand. Sie war offenbar von besonderem Wert, weil leichte Windgeschwindigkeiten der Anfangphase von einem Sturmtag am Ende abgelöst wurden. Letzterer bewirkte markante Verformungen und Pressungen, die zumindest durch einen Teil der Transponder und Omegasonden erfaßt werden konnten. Leider gingen in den Preßrücken zwei auf Eisschollen ausgelegte Strommesser, eine Wärmeflußanlage und eine ARGOS Boje verloren. Letztere konnte nach Aufbrechen des Eises mit dem Schiff später zwar beschädigt aber noch reparaturfähig geborgen werden.

Auf dem weiteren Weg zur Schelfeiskante wurden die Eispressungen immer stärker und verlegten dem Schiff etwa 15 sm vor der Küste den Weg völlig. Aufklärungsflüge zeigten eine bis zur Schelfeiskante ausgedehnte, nahezu ausschließlich mit gepreßtem Eis bedeckte Zone, die nur unmittelbar an der Küste von schmalen Rinnen durchbrochen wurde. Einer der Erkundungsflüge wurde bis über die südafrikanische Überwinterungsstation "Sanae" ausgedehnt. Da die Station weder durch Funk erreicht noch jemand auf dem Gelände gesichtet werden konnte, mußte auf eine Landung verzichtet werden. Später vorgesehene, mit der Station abgesprochene Besuche fielen dem dann folgenden schlechten Wetter zum Opfer.

Wachsender Eisdruck auf das Schiff und Aussichten auf erneute starke Nordwinde nötigen das Schiff am 15. August von der südlichsten Position dieser Reise (69°31'S) auf 69°S nach Norden auszuweichen. Entlang dieser Breite machte "Polarstern" parallel zur Schelfeiskante bei schwerem Sturm und schlechter Sicht langsame Fahrt nach Westen, um die Messungen unmittelbar an der Küste noch nachholen und die "Georg-von-Neumayer-Station" wenigstens mit dem Hubschrauber besuchen zu können. Als dann am 18. August noch immer keine kurzfristige Wetterbesserung in Aussicht stand, mußte schließlich die Rückreise nach Norden angetreten werden. Mit abnehmender Breite verringerten sich die Eispressungen, Flächen mit dünnem Neueis und sogar offenes Wasser wurden erkennbar. Weiter nördlich über dem Maudrücken wurde die fast geschlossene Eisdecke wieder aus älterem Material gebildet. Demnach könnte die Massenflußkonvergenz vor der Küste bereits durch die ihr nördlich angelagerte etwa gleich große Divergenzzone kompensiert worden sein.

Der Rückweg in Süd-Richtung über den Maud-Rücken führte nahe an vier der inzwischen ostwärts verdrifteten ARGOS Bojen vorbei. Diese Gelegenheit wurde zur Identifikation des schon vor 4 bis 5 Wochen beprobten Eises benutzt, von dem erneut Kerne gezogen wurden. Die so ermöglichten Vergleiche sind für eisphysikalische Untersuchungen und mehr noch zum Studium biologischer Entwicklungen von Nutzen.

Nördlich des Maud-Rückens wurde das CTD-Netz noch einmal auf einer Strecke von 60 sm verdichtet, und zwar in dem Gebiet, wo die amerikanisch-russische Expedition 1981 sogenannte warme Zellen beobachtete. Wir haben solche Phänomene nicht, wohl aber eine weitausschwingende maeanderfärmige Front zwischen dem äußeren warmen und dem inneren kalten Tiefenwasser des Weddell-Wirbels festgestellt. Die dabei angeschnittenen warmen Ausbuchtungen können leicht als isolierte Wirbel verkannt werden. Unsere Messungen bestätigen hingegen bei 61°30'S, 07°O das in in dieser Breite weit nach Osten reichende relativ kalte Tiefenwasser (Tmax < 0.4°C) des inneren Weddell-Wirbels.

Hier im Übergangsbereich von der kompakten inneren zur lockeren äußeren Zone des Packeisgürtels erfolgte bei 61°30'S, 07°O vom 30. August bis zum 3. September die dritte Eisdeformationsmessung. Trotz wechselnder Windrichtung und -stärke und markanter Variationen der Eisdrift blieben die Verformungen des Eises recht klein. Aufgrund dieses, nach einigen Tagen gut dokumentierten Sachverhalts, wurde die Driftstation um einen Tag verkürzt, um Zeit für das umfangreiche Eisrandprogramm zu gewinnen.

Letzteres begann unmittelbar nach dem Einsammeln der Transponder, mit denen die Eisbewegungen gemssen wurden. Auf der Fahrt nach Norden stoppte "Polarstern" in 15 sm Abständen, um Eisprobennahmen, Bohrungen zur Dickenmessung und Spannungsmessungen zu ermöglichen. Ferner zeichnete eine auf der Brücke montierte Videokamera ständig die Eisverhältnisse auf. Arbeiten auf dem Eis waren bei 58°15'S zum letztenmal durchführbar, weiter nördlich waren die Schollen von Menschen nicht mehr begehbar. Hier bildeten zunehmend Pfannkuchen und griesförmiges Neueis die Eisdecke. Mit abnehmender Breite vergrößerten sich die offenen Wasserflächen und bei starkem Südwestwind ordneten Pfannkuchen und Gries sich steifenartig vornehmlich parallel zum Bodenwind an. Der auf offenen Wasserflächen laufend neu entstehende Eisschlamm driftete ebenfalls in die bereits vorhandenen Eisstraßen hinein. Diese Verhältnisse änderten sich bis zum, trotz des Südwindes scharf gezogenen, Eisrand bei 55°50'S höchstens graduell etwas, wie man sicher der ausführlichen Photodokumentation vom Hubschrauber aus später entnehmen kann.

Zwanzig Seemeilen außerhalb des Eises änderte "Polarstern" den Kurs wieder auf Süd, um für atmosphärische Grenzschichtuntersuchungen und Seegangsmessungen noch einmal die äußere Eisrandzone zu durchqueren. Auf einer 90 sm langen Strecke senkrecht zum Eisrand wurden auf dem Hin- und Rückweg die turbulenten vertikalen Impuls- und Wärmeflüsse und der vertikale Aufbau der unteren Troposphäre auf einem engen Meßgitter erfaßt, das Seegangsspektrum bestimmt und die Struktur der oberen Wassersäule mit Hilfe von CTD-Sonden aufgenommen. Auf der Ausfahrt aus dem Eis nach Norden mußten die Arbeiten 10 sm vor dem Erreichen des Eisrandes wegen zu hoher Dünung abgebrochen werden, die ein stürmischer Nordwestwind angefacht hatte. Weiter anhaltende Windstärken von mehr als 25 m/s verhinderten auch die bei 55°S und 52°S geplanten ozeanographischen Stationen, so daß der erste Abschnitt des WWSP'86 schon am 10. September etwas abrupt zu Ende ging.

Auf der Marschfahrt nach Kapstadt, die am 17. September mit dem Einlaufen des Schiffes in dem südafrikanischen Hafen endete, wurden Absprachen über den Fortgang der Datenaufbereitung und -analyse getroffen. Die Expeditionsteilnehmer bekundeten ihren Willen, auch die kommenden Arbeiten gemeinsam fortzusetzen. Um eine zügige Auswertung der Messungen zu sichern, wurde folgende Arbeitsteilung vereinbart:

1. Physik des Ozeans:

Meßwert/Gerät	Institution	Verantwortl. Wissenschaftler	Zeit	Datenträger
CTD, XBT, Wasserproben, Strommesser	LDGO	A.Gordon, B.Huber	Ende 87	Magnetb.,Bericht
Nährstoffe	OSU/LDGO	J.Jennings	Ende 87	" , "
Thermosalinogr.	AWI	E.Fahrbach	Ende 87	" , -
Doppler SONAR	AWI	G.Flenner	Ende 87	" ,Bericht

2. Meereschemie/Spurenstoffe:

CO_2	LDGO	D.Chipman	Ende 87	- ,Bericht
CO_2	SIO	D.Keeling	Ende 87	- , "
Nährstoffe	OSU	L.Gordon, J.Jennings	Mitte 87	Magnetb.,Bericht
Freone, CO_2,N-20 He, H-3, C-14	SIO	R.Weiss	Anfg. 87	" , "
Ra-226,stab.Isot.	IUP	P.Schlosser,W.Roether	1988/89	- , "
Ar-99	PIUB	H.Loosli	1988/89	- , "
Ra-228	USC	D.Moore	1988/89	- , "
Kr-85	LDGO	W.Smethy	1988/89	- , "
Stab.Isotope	SIO	H.Craig	1987/88	- , "
Ba	LSU	C.H.Chan	1987/88	- , "

3. Physik der Atmosphäre:

WMO-3 stündl.	SWA/AWI	V.Wagner, M.Gube-Lenh.	Mitte 87	Magnetb., -
Radiosonden	AWI	M.Gube-Lenhardt	Mitte 87	" ,Bericht
Turb. Flüsse	AWI	C.Wamser	1988	" , "
SODAR-Profile	AWI	C.Wamser	Ende 87	" , "
Auslegerdaten	AWI	C.Wamser	Mitte 87	Magnetb., "
ARGOS Bojen	AWI/MIH	H.Hoeber	Mitte 87	" , "
Druckbojen	SPRI/BAS	P.Wadhams	Mitte 87	" , "
Albedo	UI	E.Schlosser	Mitte 87	- , "
Wetterkarten	SWA	W.Rabe	Mitte 87	- , "

4. Meereis:

Stündl.Beob.	CRREL/SPRI	S.Ackley/P.Wadhams	Mitte 87	- ,Bericht
Eiskerne, phys.	AWI	M.Lange	Ende 87	- ,Bericht
Eiskerne, biol.	AWI	G.Dieckmann	Ende 87	- , "
Dickenprofile	AWI	M.Lange	Ende 87	- , "

Eisoberfläche	AWI	M.Lange	Ende 87	-	, "
Eisdicke (Radar)	SPRI	P.Wadhams	Ende 87	-	, "
Fotografie	SPRI	P.Wadhams	Anf. 87	-	, "
Rasterkamera	AWI	S.ElNaggar	Mitte 87	-	, "
Passive Mikrow.	NASA/UW	J.Comiso/T.Grenfell	Ende 87	Magnetb.	, "
Seegang	SPRI	V.Squire	Mitte 87	"	, "
Eisdeformation	CRREL/AWI	S.Ackley/H.Tüg	Mitte 87	-	, "

5. Biologie:

Bakterien	AWI	H.Weyland	1988	-	, "
Phytoplankton	AWI	G.Dieckmann	Mitte 87	-	, "
Zooplankton	AWI	G.Dieckmann	Ende 87	-	, "
Tierzählungen	AWI	J.Plötz	Mitte 87	-	, "

6. Schiffsdaten:

GPS	AWI	H.W.Schenke	Mitte 87	Magnetb.	,Bericht
Satellitennav.	AWI	C.Wamser/M.Gube-Lenh.	Mitte 87	"	, "
Infodaten	AWI	M.Gube-Lenhardt	Ende 87	"	, "
Stationslisten	AWI	E.Augstein	Mitte 87	-	, "

Die jeweils zuständigen Institute und verantwortlichen Wissenschaftler haben dafür zu sorgen, daß die von ihnen betreuten Proben, Messungen und Beobachtungen möglichst zu den angegebenen Zeiten allen Expeditionsteilnehmern in geeigneter Form zugänglich sind. Die Verwendung von Daten anderer in Veröffentlichungen bedarf stets deren Zustimmung. Vorrangig sollen gemeinsame Aufsätze unter der Mitautorschaft der an den Arbeiten beteiligten Wissenschaftler verfaßt werden.

2.2 Summary and itinerary (E. Augstein)

During the first phase of WWSP'86 RV "Polarstern" operated in the Weddell Sea along the Greenwich Meridian between the ice edge and the Antarctic coast. Oceanic and atmospheric large scale and mesoscale processes, sea ice structures and marine biological features were investigated on two meridional transects and by a rather dense network over Maud Rise. The entire cruise track and an enhancement of the working area are portrayed on Figures 9 and 10, respectively. The experimental work was focussed primarily on the following topics:

- Analysis of the crystal structure, the physical properties, the spatial and temporal development of sea ice as well as its dynamics under atmospheric and oceanic forcing.

- Determination of the air- sea heat and momentum exchanges and of the atmospheric impact on ice drift and ice deformation.

- Investigation of the large scale oceanic circulation, meso-scale transports and vertical as well as lateral mixing in the eastern part of the Weddell Gyre on the basis of horizontal and vertical distributions of temperature, salinity, chemical properties and trace substances.

- The measurements and observations were carried out by working groups composed of members from German (30), USA (12), British (5) Swiss (1), Austrian (1) and Argentine (1) institutions. The sea ice and oceanographic programmes in particular have been conducted by scientists of various disciplines. The close cooperation among the participants of the expedition which started already during the planning of the WWSP'86 is intended to continue until the analyses of the gathered data are finished.

The cruise leg ANT V/2 of RV "Polarstern", started on 27 June 1986 at Bahia Blanca, Argentina. The ship left port with a delay of one day because of a wind-induced low water level in the bay. She was manned by 44 crew members, 47 scientists and technicians and 4 helicopter crew. The ship was already close to the ice edge when on 5 July a medical emergency case made it necessary to change course for Cape Town, South Africa. At the apex of the track line the first ARGOS buoy was launched to provide open water surface values of air pressure, air temperature and water temperature during the following months.

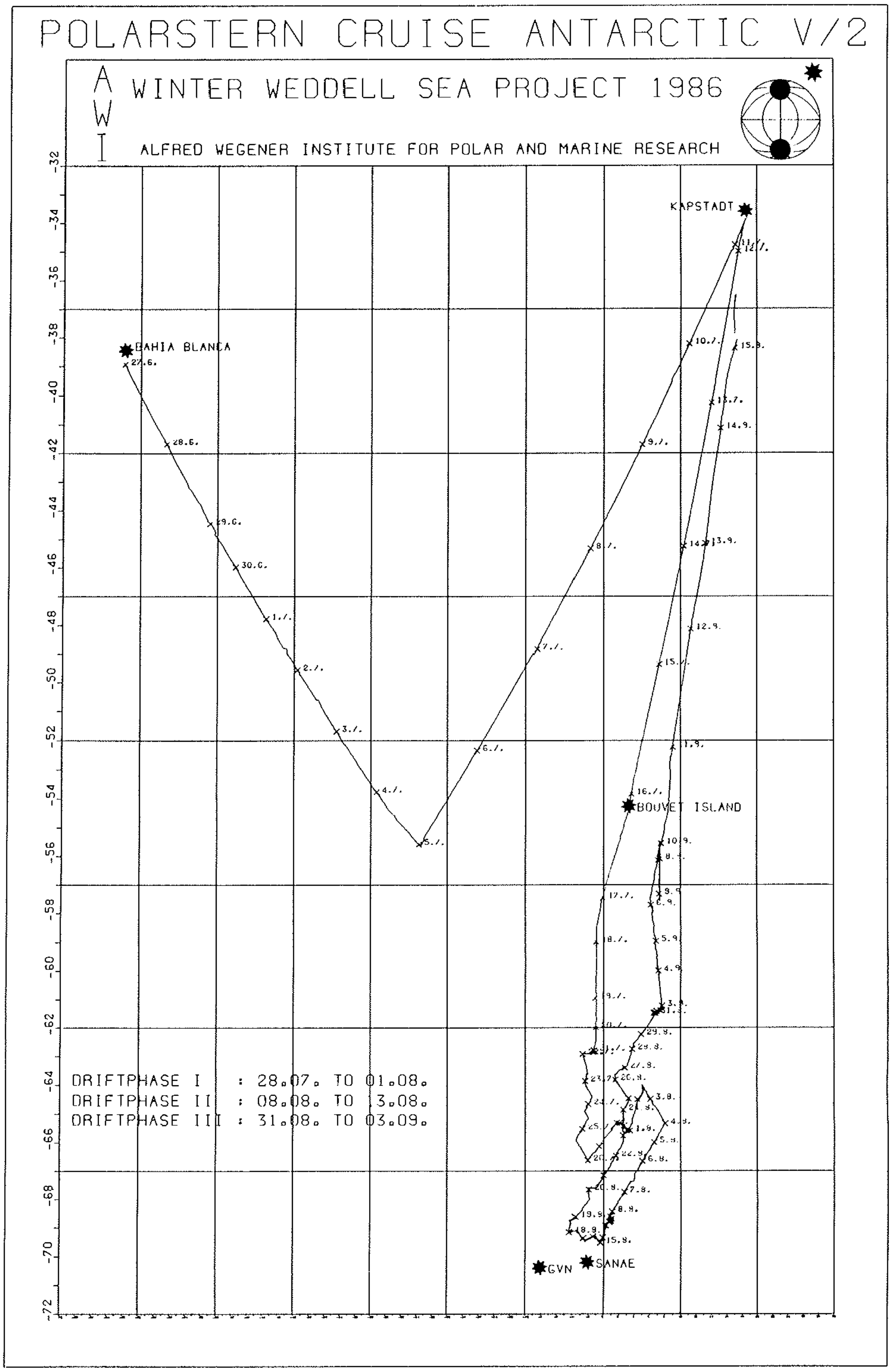

Abb. 9. Fahrtroute der "Polarstern" während des gesamten Abschnittes ANT V/2.

Fig. 9. The ship's track of the entire cruise leg ANT V/2.

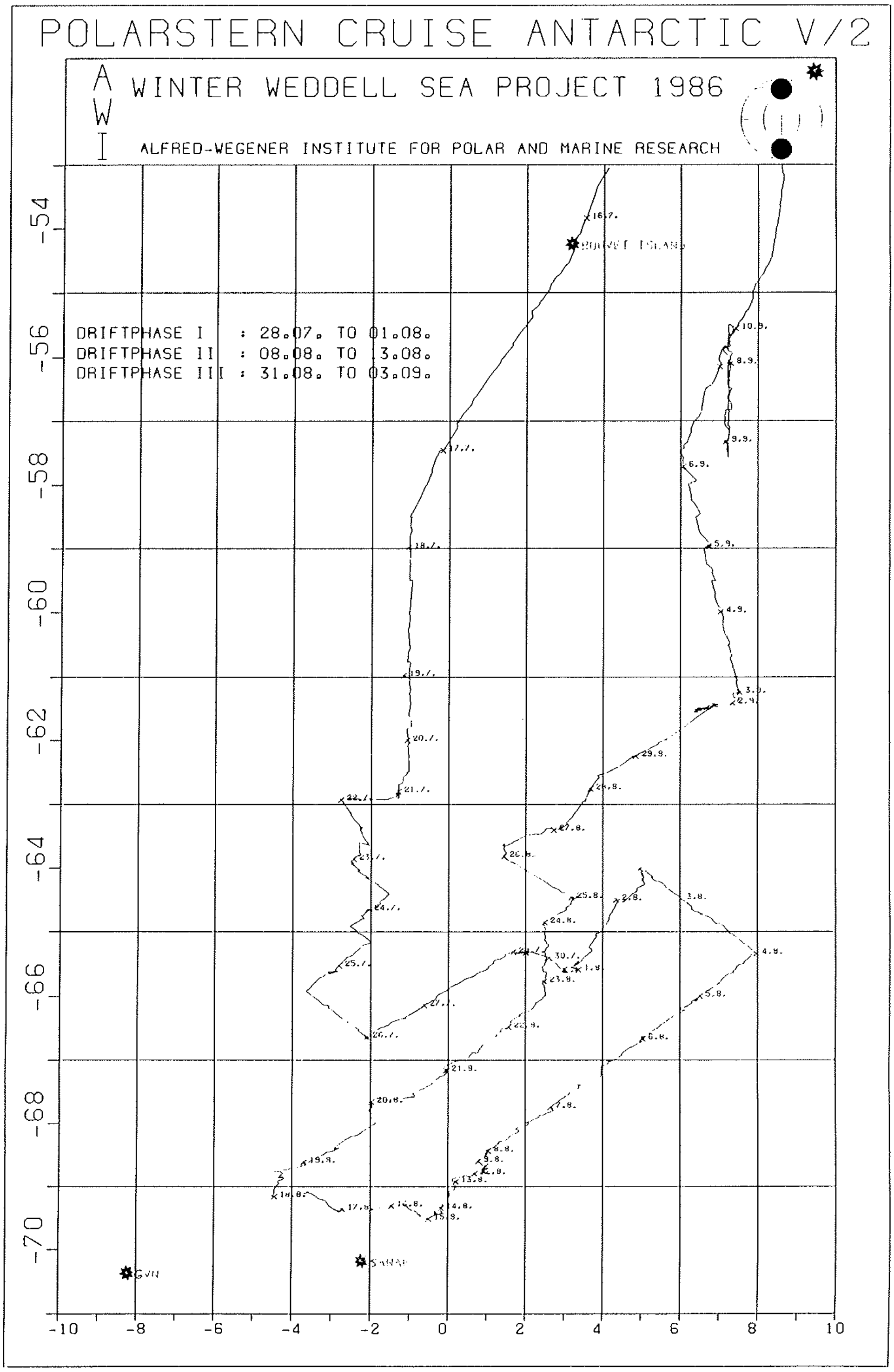

Abb. 10. Fahrtroute der "Polarstern" im Bereich des antarktischen Meereisgürtels.

Fig. 10. The ship's track within the Antarctic sea ice belt during ANT V/2.

On the evening of 11 July, "Polarstern" arrived at the harbour of Cape Town. The patient accompanied by the ship's doctor had been disembarked already in the early morning by one of our helicopters to enable the required surgery to be done as soon as possible. During the night the ship was refuelled so that it could depart again for Antarctica in the morning of 12 July 1986.

The extended time period of three weeks between the departure from Bahia Blanca and the arrival at the ice edge was favourably filled with seminars and lectures on e.g. 'Sea Ice Dynamics' and 'Physical Processes in Atmosphere and Ocean' as well as language courses, notably 'German' for foreigners. These activities have fruitfully supported the cooperative efforts among the various groups and individuals.

Due to favourable winds during the entire passage to the south we arrived at 58°30'S, 01°00'W, the position of the first oceanographic station on 17 July. There the southward meridional section along the 01°W-meridian commenced. At about 58°45'S we encountered the first grease sea ice which gradually changed over to pancakes growing in size with increasing latitude. Even 300 nm inside of the ice nearly the entire ice cover recognizably originated from pancake floes of 30 to 50 cm thickness. Because of small floe sizes in the marginal ice zone ice core sampling could not begin until the third day in the ice belt. Even the second ARGOS buoy which was assigned to measure surface properties near the ice edge had to be deployed into the open water among pancake floes at latitude 61°S.

During the whole expedition the following measurements formed the routine background of the scientific programme:

Oceanographic stations including CTD and rosette water sampler with twenty-four 10-liter Niskin bottles were conducted along the cruise track on a 30 nm spacing. The water samples were analysed with respect to salinity, oxygen and various other chemical and trace substances as well as biological properties. For tracers of a rather low concentration 14 casts with 300-liter Gerard cylinders were carried out more or less equally spaced between 58°30'S and 69°30'S latitude. The ocean currents in the upper 150 to 300 m layer were measured during CTD stations with a Doppler SONAR. Zooplankton was caught in the upper 500 to 700 m of the water column with the aid of a Multi net once daily.

Sea ice work occurred generally during one station per day for two to four hours. In a joint effort ice and remonte sensing physicists together with biologists measured the ice thickness disribution, the surface strain variations, the short wave albedo of snow and ice surfaces and took several ice cores. The latter serve for investigations of physical ice properties, the ice texture, and biological specimens such as diatoms, foraminifera, bacteria and nutrients.

Closely related to the in situ studies passive microwave measurements of the ice and snow surfaces were executed from the ship. The applied remote sensing device was operated on five frequency channels continuously and additional observations were made on stations where ground truth could be provided.

The meteorological programme consisted firstly of a network of eleven ARGOS buoys which was built up during the cruise between the ice edge and the Antarctic continent. All of these systems besides the one in the open water had sensors the measure air pressure and temperature, the wind vector and the ice surface temperature and seven were equipped also with an acoustic current meter at 10 m depth. Secondly 10 minute averages of routine deck level quantities were continuously recorded on the ship where also radiosondes were launched at six hourly intervals. Finally turbulent fluxes of heat and momentum and low level wind profiles were obtained mostly on stations by means of a SONIC device mounted on the bow crane and a Doppler SODAR, respectively.

The ship based work was extended by two helicopters in suitable weather conditions. They enabled us to achieve aearial photography, floe size observations and open water to ice ratio estimates with a line scan camera as well as ice thickness measurements with a microwave impulseradar. They furthermore enabled an intensification of the CTD profiling by transporting specially designed instruments to ice floes in the environment of the ship.

Over Maud Rise the mesh width of the oceanographyic grid was reduced to 10 nm in order to resolve features of smaller scales. An important contribution to this programme was expected from the helicopters. But unfortunately bad visibility conditions reduced their working capabilities drastically. To at least partly fill these gaps "Polarstern" steamed on a zigzag-course southwards instead of straight along the latitude 02°W. The additional time required for this pattern was available since the light ice cover so far had allowed for a higher cruising speed than assumed in the planning. An impressive event happened on 23 July when the ship was positioned near 65°S about 500 km inside the pack ice. A strong swell with wave amplitudes of 1 m and periods of 18 s moved in from the north and disintegrated the solid ice cover into numerous floes with sizes smaller than 200 m in diameter within two to three hours. This process was generated by an atmospheric cyclone the centre of which migrated from west to east slightly north of the ice edge.

From the southernmost position of the first meridional transect at 66°40'S, 02'W "Polarstern" headed northeast to cross Maud Rise. The traverse was interrupt over the summit from 28 July to 1 August for an ice deformation study. During this period of time microwave transponders and Omega radiosondes, deployed within a 20 km array on the ice around the ship were tracked continuously in order to determine the horizontal ice deformation. The experiment was completed by helicopter aerial photography and radar ice thickness measurements as well as by intensive coring and drilling.

While the ship proceeded further to the northeast and the helicopters supported CTD profiling from ice floes a rapidly moving snow front trapped the helicopters on the ice. Since the flight operations were always controlled by radar the ship could approach both accurtely documented landing positions within a few hours to pick the helicopters up.

The obvious oceanographic result of all Maud Rise transects is that relatively cold deep water over the plateau ($T_{max} < 0.5°C$) is surrounded by a warmer water mass ($T_{max} > 1.1°C$) the front of which follows more or less the contours of the slope. In order to clearly identify the lateral extent of the warmer water to the east the straight southward leg east of Maud Rise along 05°E longitude was modified to an angle with the apex at 65°S, 08°E. The warm deep water was consistently present on the track line to 66°S, 05°E. Colder water was found further to the south spreading all over the coastal current to the Antarctic ice shelf.

South of 66°S the ice was more rafted and ridges increased in number and size. Consequently the ship's speed was reduced considerably, in particular when ridges of several meters in thickness had to be broken in a ramming mode. Low visibility caused by blowing snow made manoeuvring of the ship even more difficult. In spite of such limitations "Polarstern" arrived at the northern fringes of the coastal current at about 68°30'S on 8 August.

Here the second deformation study took place until 13 August. This investigation gained a particular value since rather light wind conditions at the beginning were followed by a storm with wind speeds up to 30 m/s. Fortunately some of the transponders and of the radiosondes could be tracked through the full time period so that one should be able to document the observed strong ridging and tremendous shear motions quantitatively. A negative effect of the storm was the loss of two current meters and a thermistor chain exposed on the ice near the ship. An ARGOS buoy which was also captured under a newly formed ridge could be recovered.

On the last 90 nm to the ice shelf the compactness of the ice still increased and when about 15 nm from the coast at 69°31'S "Polarstern" was not able to proceed any further. Reconnaissance flights with the helicopter made obvious that compressed ice covered the entire area between the ship and the coast with small openings only along the ice shelf front. One of the observation flights was extended to the South African Antarctic Station "Sanae". But since the station could not be contacted by radio and no person was to be seen outside of the buildings the helicopter did not land. Another visit planned for the next day was prevented by bad weather.

Increasing ice pressure on the ship's hull and the forecast of heavy northerly winds for the following day forced us to retreat to a more manageable environment at 69°S on 15 August. In order to keep up the possibility of completing the CTD cross-section to the coast and of visiting the German Antarctic Station "Georg von Neumayer" "Polarstern" sailed slowly to the west on 69°S latitude. Since the strong northerlies continued on 18 August and no improvement of the weather could be expected for the next day we began the northward transect across Maud Rise to the ice edge.

With decreasing latitude the ridging of the ice diminished and patches of new ice and even of open water occured to a greater extent in the 68° to 66°S latitude belt. Farther north over Maud Rise more compact older ice dominated again so that one might speculate that the mass flow convergence in the coastal zone is largely compensated by a divergence in the area adjacent to it. The northward leg of "Polarstern" passed near four of the earlier deployed ARGOS buoys so that these sites could be visited again and ice cores could be taken from floes which had been sampled already 4 weeks ago. An intercomparison of these samples is useful for physical investigations and of even greater importance for studying biological developments.

North of Maud Rise in the region where the so called warm features were detected during the 1981 USA-USSR winter cruise the CTD measurements were again intensified. This year we could find only a strong meandering of the front which separates the outer warm and the inner cold Weddell Gyre deep water but no isolated warm cells. One might speculate that a more coarse spacing of CTD stations in our case could have misled us to identify warm frontal bulges as eddies.

In the transition zone between the compact inner and the more loose outer parts of the pack ice belt, at 61°30'S, 07°E the third ice deformation investigation took place from 30 August to 3 September. In spite of variable winds and drift motions of the ice only small deformations seemed to occur. Therefore, it was reasonable to stop this work one day earlier as planned in favour of an extension of the ice edge programme.

The latter began immediately when the radar transponders of the deformation array had been recovered. "Polarstern" on her course to the north stopped at 15 nm intervals for extensive ice work. A video camera, mounted on the bridge, continuously documented the ice conditions along the path of the ship. The last position at which ice cores could be taken was at 58°15'S. Further to the north the floe sizes were too small for a person to work on. Here the ice cover was composed of pancakes and newly formed grease ice. The open water areas increased with decreasing latitude and pancake floes together with the frazil ice aligned in bands mostly parallel to the strong surface wind. These conditions changed only gradually until the ice edge at 55°50'S. In spite of the southerly wind direction the transition from ice to open water was defined by a sharp line. Details of the outermost ice conditions were observed during helicopter photo flights over that area.

After steaming 20 nm into the open water to recover an earlier deployed ARGOS buoy "Polarstern" turned to the south again for a meteorological and oceangraphic marginal ice zone study. On a 90 nm transect perpendicular to the ice edge enhanced measurements at the air-sea-interface and in both the atmospheric and oceanic boundary layers were conducted. Special attention was paid to surface wave observations. All investigations were stopped on the way out of the ice 10 nm before crossing the edge by a strong sea swell, resulting from northwesterly winds of about 25 m/s speed. Two oceanographic stations planned at 55°S and 52°S had also to be sacrificed to the unfavourable weather. Thus, the first half of the WWSP'86 abruptly ended at 10 September 1986.

On the way to Cape Town, where the ship arrived on 17 September 1986, the data processing and analyses procedures were discussed among the participants. All of them agreed that the fruitful cooperation of the planning and field phases should continue during the forthcoming scientific application of the results. In order to assure that all measurements and observations will be made available to all interested participants as early as possible the data processing tasks have been assigned as indicated in the table of the preceeding German Summary.

The indicated institutions and scientists are supposed to take care that the availability of the data at the deadlines marked in the table will be met. It was understood that usage of data from other groups in or for publications requires the endorsement of the contributors. Joint publications of all scientists having taken part in a certain study are particularly encouraged.

More detailed information on the field work is to be found in the subsequent paragraphs of the various working groups on board "Polarstern". Tables of the cruise participants and the contributing institutions as well as a station list form the final part of this report.

2.3 Physical and chemical oceanography

2.3.1 Physical oceanography (LDGO, AWI)

The measurements of this programme consisted of CTD profiles, XBTs, underway measurement of surface temperature and salinity, measurements of current shear via doppler sonar and acoustic current meter, and CTD profiles from ice floes with the aid of helicopter.

155 CTD profiles were obtained, with water samples collected during more than 70% of the casts. More than 2500 salinity samples were taken for calibration of the CTD. Analysis of the water samples for dissolved oxygen, nutrients and various tracer chemicals was performed by others.

Supplementary CTD profiles were obtained occasionally with portable units carried by helicopter. These 'helo casts' were used for filling in the ship's survey, and for mesoscale surveys in an attempt to map mesoscale thermohaline features. A total of 102 casts were obtained, including 17 intercalibration casts, 3 time series and 14 shipboard casts.

The investigations focused on four major areas, namely

- the ice edge zone
- Maud Rise region
- the continental margin
- the interior pack ice.

High resolution surveys were obtained in all but the continental margin areas, with 30 mile station spacing in between the region of intense study. We were unable to reach the margin due to unfavorable wind and ice conditions.

The most complete part of the programme was a comprehensive survey of the Maud Rise region. Four sections were carried out: one each along the western and eastern flanks and two across the rise. Three of the four sections consisted of 7.5 to 15 mile station spacing, supplemented by helo CTD casts when weather permitted. Preliminary analysis of the data suggest that the rise is surrounded by waters with a rather high temperature maximum ($T_{max} \sim 1,2°C$) which originate presumably from the warm regime to the east, fed by circumpolar waters. On top of the rise is an isolated pocket of much colder water ($T_{max} < 0.5°C$), with characteristics more like those of the interior Weddell Gyre to the west. Since no isolated mesoscale features were observed, it is evident that the boundary between warm and cold waters is highly convoluted and abrupt. The warm water influence extends at least to 3.5°W, approximately 150 km further west than indicated by past observations.

One day was devoted to an intense survey northeast of Maud Rise which ran roughly parallel to the front separating the Weddell Cold and Warm regimes. It was just to the west of this zone where a series of warm features were observed during the "Somov" cruise of 1981 but our measurements revealed no such activities.

The ice edge study at the end of the cruise consisted of three subsequent transects perpendicular to the ice edge, with closely spaced CTD casts during the first two. During the third, high winds and heavy swell prevented further over-the-side-work . The ice edge occurred at approximately 55°50'S, coinciding roughly with a transition from Weddell interior to warmer circumpolar water.

Mixed layer temperatures were everywhere above freezing, even when active frazil ice formation could be observed during a station. The temperatures were not uniform, however, ranging from -1.87° to -1.75° C in the ice covered regions.

In conjunction with ongoing efforts to model the Weddell Gyre, 3 buoys with meteorological sensors and pressure, temperature, salinity chains were to be deployed within the pack ice. Since the first one malfunctioned deployment due to manufactural failures the two others were kept on board for later improvements. They are planned to be deployed during the next summer season.

Expendable Bathythermographs (XBT) were used before, during and after the pack ice work to supplement the temperature profiles obtained by the CTD. Lines from Bahia Blanca to Cape Town and from the ice back to Cape Town extend the data coverage well beyond the pack ice. Over 200 probes have been applied.

Profiles of current shear were obtained at intervals throughout the cruise. Whenever possible, the doppler current profiling system was activated. In the ice, this was confined to stations longer than one hour. Results await further processing of the data. It is clear from inspection of the preliminary data, however, that sufficient scatterers in the water column to yield good data were mostly restrictet to the upper 150 m. Four current proviles were obtained with a pair of Neil Brown Smart Acoustic current meters. The most reliable data were obtained by lowering a single meter to several depths and taking a 5 minute average at each level. The meters were finally deployed as a 2 unit mooring during the first and second ice deformation arrays in order to obtain series of shear across the pycnocline. Both meters failed to record useful data during the first experiment due to faulty low battery detection. The entire mooring was lost during the second deployment when a severe storm caused heavy ice ridging on top of the mooring site. Floatation bodies attached to the mooring was torn from the mooring line by the ice movement.

Some equipment difficulties hampered our programme. Most notable among these was repeated failure of conductivity cells on the CTD. The cause of this effect is suspected to be thermal shock when the sondes were lowered from a - 20°C air into the -1.8°C water environment. Several methods for preventing such thermal influences were tried to no avail. In all, 4 cells were used, with the last, while not failing completely, giving less than satisfactory data which will require special processing to correct. Two oxygen sensors also failed due to effects of the cold air temperatures. A third sensor was installed only after the sensor receptacle was modified, and continued to work well.

Prof. Arnold Gordon (LDGO), the principal investigator for the USA Physical Oceanography programme was forced to leave the ship at Cape Town for medical reasons, but kept contact to his group through frequent communication.

Tab. 5. CTD-Stations.

CTD	STA #	LAT	LONG	DATE	TIME	COMMENTS
0	156	44 26.0S	057 01.0W	29/6	1130	G,MN
1	156	44 25.2	050 58.4	29/6	1911	ODEC TEST
2	234	58 29.0	000 59.4	17/7	1819	S
3	234	58 30.5	000 56.5	17/7	2224	D,G
4	238	59 00.0	001 00.0	18/7	1004	D
5	241	59 30.3	001 00.7	18/7	1820	D
6	247	60 30.8	001 00.2	19/7	0418	S(1500)
7	251	60 57.7	001 09.6	19/7	1203	D
8	254	61 30.1	001 00.1	20/7	0033	D
9	255	62 02.2	001 00.4	20/7	1358	S,ODEC
10	255	62 02.2	001 02.3	20/7	1525	D
11	256	62 29.6	001 02.6	20/7	2229	D,
12	256	62 33.8	001 08.9	21/7	0640	S
13	257	62 37.0	001 09.7	21/7	0850	S
14	258	62 45.3	001 16.2	21/7	1040	S
15	259	62 49.8	001 14.8	21/7	1405	D,I,H-B
16	260	62 54.3	002 00.6	21/7	2212	D
17	263	62 54.7	002 45.9	22/7	0616	D,CM
18	264	63 07.0	002 28.8	22/7	1334	S
19	265	63 19.2	002 13.3	22/7	1539	S
20	266	63 39.2	002 02.0	22/7	1934	S
21	266	63 37.1	002 08.2	23/7	0105	D,G
22	267	63 47.4	002 14.4	23/7	1018	SNB
23	268	63 55.9	002 24.9	23/7	1236	SNB,CM
24	269	64 02.4	002 24.7	23/7	1705	SNB
25	270	64 10.2	002 19.0	23/7	2031	D
26	271	64 17.4	001 45.4	24/7	0215	SNB
27	272	64 25.3	001 30.5	24/7	0416	SNB
28	273	64 33.9	001 43.0	24/7	0608	SNB
29	274	64 40.3	001 59.4	24/7	0820	D
30	275	64 47.6	002 09.8	24/7	1655	SNB
31	276	64 55.3	002 30.9	24/7	1905	SNB
32	277	65 02.4	002 13.0	24/7	2121	SNB
33	278	65 11.6	002 06.3	25/7	0230	D,G
34	279	65 23.3	002 30.7	25/7	0926	SNB
35	280	65 34.0	002 51.0	25/7	1218	D
36	281	65 54.2	003 35.7	25/7	2158	SNB
37	282	66 08.9	003 02.3	26/7	0258	SNB
38	283	66 23.0	002 34.0	26/7	0650	SNB
39	284	66 40.0	002 00.0	26/7	1733	D,G2
40	285	66 20.1	001 03.3	27/7	0548	D
41	286	66 00.3	000 17.1	27/7	1402	D,O,I
42	287	65 40.2	000 44.3E	27/7	2138	D
43	291	65 21.8	001 30.8	28/7	0529	D,DEF ARRAY
44	291	65 33.5	003 16.7	01/8	1230	D,G,end DEF ARRAY
45	292	65 03.6	003 51.8	02/8	0355	D
46	293	64 29.9	004 24.0	02/8	1200	D
47	294	64 00.7	004 58.0	02/8	2208	D,H-B,MN end Mrise, begin mesoscale 2
48	295	64 09.2	005 19.2	03/8	0347	SNB
49	296	64 17.2	005 38.1	03/8	0553	SNB
50	297	64 26.4	005 58.6	03/8	0751	D
51	298	64 35.0	006 17.3	03/8	1341	SNB
52	299	64 43.6	006 37.0	03/8	1733	SNB,O(CAL)
53	300	64 52.0	006 56.4	03/8	2046	D
54	301	65 02.0	007 18.3	04/8	0208	SNB
55	302	65 11.2	007 39.2	04/8	0525	SNB
56	303	65 20.4	008 00.0	04/8	1210	D,G2,MN,CM
57	304	65 29.0	007 40.8	04/8	2218	SNB
58	305	65 37.3	007 23.9	05/8	0120	SNB
59	306	65 48.5	007 00.0	05/8	0434	D
60	307	65 55.6	006 41.5	05/8	1007	SNB
61	308	66 04.1	006 25.4	05/8	1300	SNB,I,CM
62	309	66 12.5	006 02.4	05/8	1930	D
63	310	66 22.3	005 41.0	06/8	0233	SNB
64	311	66 30.8	005 21.4	06/8	0523	SNB
65	312	66 40.0	005 00.1	06/8	0834	D,MN,G
66	313	67 02.1	004 13.1	06/8	2016	HB,D
67	314	67 22.9	003 23.3	07/8	0418	D
68	315	67 46.5	002 39.5	07/8	1218	D,MN
69	316	67 44.7	002 45.0	07/8	2249	D
70	317	68 27.1	001 04.7	08/8	1427	D,G,MN,DEF,CM

CTD	STA #	LAT	LONG	DATE	TIME	COMMENTS
71	317	68 55.0	000 13.1	13/8	1800	D
72	318	69 06.8	000 02.6	14/8	0053	S,HB
73	319	69 20.5	000 09.8	14/8	1342	D,G
74	320	69 28.8	000 22.3W	14/8	2030	D
75	321	69 18.4	001 03.7	16/8	0052	D
76	322	69 05.8	003 33.8	17/8	1827	D
77	323	69 07.6	004 02.2	18/8	0446	D
78	324	68 47.5	004 12.9	19/8	0005	D
79	326	68 23.7	002 46.4	19/8	1852	S,ODCAL,PSI,MN
80	326	68 23.8	002 46.6	19/8	2046	D
81	327	67 59.9	001 49.4	20/8	0432	D
82	329	67 33.3	000 51.3	21/8	0110	D,G
83	330	67 23.1	000 23.7	21/8	0740	S
84	331	67 11.0	000 01.1	21/8	1115	D,G
85	332	66 59.8	000 25.9E	21/8	2010	S,MN
86	333	66 52.5	000 39.5	21/8	2253	S
87	334	66 47.6	000 52.0	22/8	0048	D
88	335	66 41.8	001 04.5	22/8	0556	S
89	336	66 35.5	001 16.8	22/8	0802	S
90	337	66 29.0	001 30.4	22/8	1026	S
91	338	66 23.1	001 37.5	22/8	1302	D
92	339	66 18.0	001 54.8	22/8	1806	S,PSI,MN
93	340	66 12.3	002 06.1	22/8	2020	S
94	341	66 05.4	002 16.9	22/8	2245	S
95	342	66 00.0	002 30.0	23/8	0050	D
96	343	65 51.4	002 31.8	23/8	0500	S,MN
97	344	65 45.5	002 31.5	23/8	0826	S,I
98	345	65 36.8	002 33.7	23/8	1550	S
99	346	65 31.1	002 31.8	23/8	1741	D
100	347	65 22.9	002 33.3	23/8	2153	S
101	348	65 14.7	002 33.9	24/8	0013	S
102	349	65 07.3	002 30.7	24/8	0218	S
103	350	65 00.6	002 30.6	24/8	0438	D
104	351	64 53.5	002 29.7	24/8	0819	S,I
105	352	64 46.2	002 46.8	24/8	1613	D
106	353	64 35.8	003 06.0	25/8	0600	S
107	354	64 28.6	003 13.1	25/8	1045	S,I
108	355	64 23.4	002 59.7	25/8	1518	S
109	356	64 18.3	002 46.6	25/8	1730	D
110	357	64 13.6	002 33.9	25/8	2220	S,MN
111	358	64 09.0	002 20.0	26/8	0049	S
112	359	64 03.9	002 07.3	26/8	0230	S
113	360	63 58.1	001 54.2	26/8	0450	D
114	361	63 54.9	001 39.3	26/8	0920	S
115	362	63 49.3	001 27.4	26/8	1124	S
116	363	63 38.5	001 27.3	26/8	2000	D
117	364	63 32.2	001 52.1	27/8	0151	S
118	365	63 27.6	002 19.2	27/8	0522	S
119	366	63 24.2	002 44.3	27/8	1115	S
120	367	63 18.0	003 06.8	27/8	1347	D
121	368	63 07.2	003 17.7	27/8	1744	S,MN
122	369	62 57.5	003 33.4	28/8	0200	S
123	370	62 45.0	003 43.6	28/8	0749	S
124	371	62 34.0	003 54.5	28/8	1708	D,mesoscale beg.
125	372	62 30.5	004 06.8	28/8	2214	S
126	373	62 25.8	004 23.5	29/8	0126	S
127	374	62 21.8	004 33.1	29/8	0334	S
128	375	62 15.8	004 48.1	29/8	0608	D
129	376	62 11.6	005 00.0	29/8	1232	S
130	377	62 07.7	005 12.8	29/8	1439	S
131	378	62 03.7	005 25.9	29/8	1647	S
132	379	61 58.7	005 38.5	29/8	1911	D
133	380	61 25.8	006 25.8	30/8	0818	S,HB
134	381	61 30.9	006 33.9	30/8	1920	D,G,MN,DEF BEG.
135	381	61 22.0	007 31.7	03/9	0000	D,G,MN,DEF END
136	383	61 00.7	007 30.9	03/9	1548	D
137	384	60 30.1	007 15.3	03/9	2358	D
138	386	59 59.0	007 06.3	04/9	1033	D
139	389	59 29.8	006 50.1	04/9	2039	D
140	391	58 58.2	006 41.8	05/9	0855	D
141	392	58 30.0	006 25.0	05/9	1842	D
142	394	58 00.4	006 13.4	06/9	0423	D
143	396	57 27.6	006 00.4	06/9	1455	D,PR BUOY,MN
144	398	56 57.4	006 26.6	07/9	0015	D
145	400	56 27.7	006 43.3	07/9	0852	S
146	404	55 29.8	007 15.3	07/9	2009	D

CTD	STA #	LAT	LONG	DATE	TIME	COMMENTS
147	406	55 44.7	007 16.3	08/9	0143	S
148	408	55 54.8	007 17.4	08/9	0644	S,WAWI,PR
149	410	56 05.1	007 15.6	08/9	1036	S,PR,WAWI,O,PSI
150	411	56 22.2	007 16.8	08/9	1430	S,PR,WAWI,O
151	413	56 28.2	007 15.6	08/9	1654	S,PR,WAWI,O
152	416	56 49.9	007 15.9	08/9	2036	S,WAWI
153	418	57 05.2	007 17.0	08/9	2337	S,WAWI
154	420	57 19.8	007 13.3	09/9	0258	S,WAWI
155	422	57 34.1	007 15.9	09/9	0619	S,WAWI,PR,PSI

Key of comments:

D	=	Deep Station
S	=	Shallow Station
O	=	ODEC CTD Cast
H-B	=	Met Buoy
DEF	=	Ice Deformation Array
PSI	=	Particulate Silicate
WAWI	=	Boundary Layer and SODAR Measurements
G	=	Gerard
SNB	=	Shallow, No bottles
I	=	Ice Work
CM	=	Current Meter(s)
PR	=	SPRI Pitch/Roll Buoy
MN	=	Multi net

2.3.2 Ocean tracer sampling (IUP, PIUB)

Samples for the analysis of several geochemical ocean tracers were taken throughout the whole cruise leg (see Tab. 6). The analysis will be carried out after the cruise in the laboratories which are listed in Table 6. The data will be available about to two years after the cruise.

Large volumes of water were sampled with the aid of Gerard bottles (270 liters volume) while all other samples were drawn from rosette Niskin bottles on nearly all oceanographic ship stations. A gas extraction unit was operated to process the samples for C-14, Ar-39 and Kr-85, and those for Ra-228 were concentrated by chemical absorption. Table 6 indicates the number of samples taken for each of the properties. Our samples represent a detailed meridional section across the Weddell Sea near to the Greenwich meridian with some zonal extension in the Maud Rise area. Special emphasis was laid on shallow (< 700 m) sampling across the ice edge. The tracer and chemistry programmes were closely coordinated in order to obtain coherent data sets for all properties involved. The main purpose of the joint tracer project is to study deep water formation, upwelling, mixing and spreading. The geochemical approach supplements the physical oceanography studies of the cruise by providing information on larger time scales (months to decades).

The sampling within the Weddell Sea was successfull, however, two open water stations planned for both the inbound and outbound tracks to determine tracer concentrations in waters flowing into and out of the Weddell Sea, had to be cancelled because of bad wheather conditions. The winter pack ice zone proved to be a more favourable working environment than the adjacent open ocean. The continental margin area was covered as planned since the ship could not proceed totally to the ice shelf front. The coverage of this part is left to the following cruise leg. Gerard casts with 8 to 10 sampling bottles were carried out without any problems even at air temperature below -20°C. The gas extraction units had some minor problems with the seawater supply when the ship was moving through ice. The gas extracted from the water samples (240 liters) was led through pretreated NaOH for CO_2 capture and then compressed into pressurized gas bottles for collection of the remaining gas. The water was then pumped into plastic barrels and - after pH adjustment - drained through fiber cartridges for Ra-228 absorption.

Together with the Gerard samples, water temperature was measured by means of reversing thermometers. Salinity and nutrients were determined from the water samples. The depths are computed by fitting the length of the cable to the thermometric depths. Some minor inconsistencies in the thermometer readings were rectified by means of a careful comparison with CTD temperature data for the same station.

This procedure led to temperature data with a standard precision of about 0.01°C. The salinity and nutrient data of the Gerard and Rosette casts appeared to be satisfactorily consistent. This finding means that tracer data from Gerard samples may be related to those of Rosette samples without significant ambiguity.

Tab. 6. Tracer sampling during ANT V/2.

Property	LV	Processing	Total no. of samples	Investigator/ institution
He-3/4, Ne	no	no	656	IUP
H-3,0-18	no	no	656	IUP
H-2,0-18	no	no	168	H.Craig/SIO
Ba	no	no	137	L.H.Chan/LS
C-14 1)	yes	gas extrac.	152 2)	IUP
Ar-39 3)	yes	gas extrac.	16	H.H. Loosli/ Univ.Berne
Kr-85	yes	gas extrac.	110	W.M.Smethie/LDGO
Ra-226	yes	no	129	IUP
Ra-228	yes	chem.adsorp.	166 4)	W.Moore/USC

1) 56 small-volume samples for AMS analysis and some DIC samples were taken additionally (IUP)

2) includes 12 surface water samples from Cape Town to Sta. 234

3) 3 air samples were taken additionally

4) includes 37 surface water samples along entire cruise track

2.3.3 Trace gases (SIO)

Chlorofluoromethanes, also called freons, (F-11, F-12) were analysed at approximately 76 hydrographic stations totaling about 1750 samples taken from a rosette sampler. The freon samples were always drawn from the Niskin bottles first. Normally all bottles, spaced throughout the water column, were used. The data set provides detailed sections of the two freons along the track line of the cruise. A freon deficit relative to a solubility equilibrium with atmospheric air in the surface layer and various layers exhibiting relative concentration extrema further down related to the various subsurface water masses is apparant in the data. In addition, atmospheric freon concentrations were measured approximately twice per day throughout the cruise.

An automatic gas chromatograph system analysed, twice per hour and again throughout the cruise, atmospheric air for CO_2 and N_2O and an air/water equilibrating apparatus measured pCO_2 and pN_2O from surface water. In addition, 24 discrete air samples were collected for later anaysis at home for CO_2 and N_2O. The air for the automatic measurement was directed into the aft chemical laboratory via a plastic coated metal tube from the bow of the ship. The equilibrator was mounted in the Rosette room. Water intake was by a direct line from the pump in the enginge hall fed directly from the sea chest beneath it. This intake procedure caused problems when the ship moved through the ice and had to be modified to using the portside intake of the cooling system for the ship's engines. This way imposed a longer delay between water intake and measurement as well as certain variations in water temperature in the equilibrator.

Finally dissolved inorganic carbon samples were collected from surface water throughout the cruise as well as on one hydrographic station for later analysis. These results will then be compared to the shipboard measurements of LDGO.

2.3.4 Discrete sampling and analysis of carbon dioxide (LDGO)

Water samples for the analysis of partial pressure of CO_2 (pCO_2) and total dissolved inorganic carbonate (Total CO_2, or TCO_2) were drawn from roughly 3/4 of the bottles on roughly 1/2 of the deep CTD casts, with the sampling concentrating on the upper part of the water column. A total of 757 samples were analyzed on the ship for pCO_2 and TCO_2. All of the pCO_2 analyses were made in duplicate (re-equilibration of the same water) and showed an analytical precision of approximately 0.15% (one common deviation). Some of the TCO_2 analyses which were duplicated, indicated that the combined sampling and analytical uncertainty (one standard deviation) was better than 0.04% of the value (+/- 0.8 µmoles/kg in sample of approximately 2200 µmoles/kg).

In the open water at the ice edge, both at the start and end of the main part of the cruise, the pCO_2 of the surfacewater was found to be very nearly in equilibrium with the CO_2 of the atmosphere, with values of between 345 and 350 µatm, while the atmospheric VCO_2 observed was 344 µatm. Everywhere under the ice cover, higher surface water pCO_2 values were observed, as had been predicted on the basis of out samples taken under the ice from the "Somov" (WEPOLEX Expedition, 1981). On the present cruise these values ranged from about 350 µatm near the ice edge to as high as 400 µatm near the continent. Although it may be coincidental, there appears to be a correlation between chlorophyll concentration and pCO_2 in the sub-ice surface water, such that values of pCO_2 below approximately 360 µatm were associated with chlorophyll concentrations of greater than 0.1 µg/l.

In addition to the samples analyzed within the main study area, surface water samples were drawn from the underway pumping system during the transit cruises to and from the study area, with a spacing of roughly 1° of latitude. A total of approximately 65 samples, from Bahia Blanca to near the ice edge to Cape Town and back to the ice edge were taken in late June and early to mid July, and another 14 were obtained in early September between the ice edge and 41°S latitude on the way to Cape Town. All of these samples were analyzed for pCO_2 and TCO_2, and with the co-operation of other groups, analyses were made respectively for nutrients and salinity. The pCO_2 analyses demonstrated the continued existence of the CO_2 sink zone (region of low pCO_2s) southwest of Cape Town, which had been observed during the austral spring and summer (GEOSECS and AJAX cruises) and postulated by us to be a year-round feature. During the September transit cruise, it was observed that this feature had retreated somewhat to the north, with the 320, 330 and 340 µatm isobars being found approximately 2 to 3 degrees further north than during the mid July period. Unfortunately, samples could not be taken close enough to Cape Town to determine whether the minimum pCO_2 observed in the earlier period (297 µatm) had changed as well.

Both of the analytical systems used during the cruise were new and had not been previously operated at sea. The pCO_2 analyses were made using a gas chromatograph system similar to that which we have operated in the past but using a much smaller gas chromatograph and integrator than the earlier system. No significant problems were encountered with the operation of this system, although the Shimadzu Mini-2 DC may be more sensitive to shipm motion than was the earlier-used Perkin-Elmer Sigma 4 DC. Total CO_2 analyses were made using a new technique, CO_2 coulometry, which proved itself to be highly stable and reliable under the shipboard conditions, including the periods in the open water when the ship motion restricted the functioning of the operator. The analytical instrument (from Coulometrics. Inc.) showed no malfunctioning due to ship motion, ship's power or interference from radio communications, etc. In order to attain the highest precision, it is necessary to maintain the titration cell at constant temperature, which we normally do through use of a Peltier thermoelectric unit to counter the heat produced during the titration. Rapid changes in the ambient temperature, which were not observed on "Polarstern" but are often observed on other ships, would cause a loss of precision and will need to be prevented on other cruise. All things considered, the coulometer operated in the laboratory as well as on land, and showed great promise for use at sea in the future.

2.3.5 Nutrient and oxygen chemistry (OSU)

A Technicon Autoanalyzer was used for the simultaneous nutrient analysis of phospate, nitrate plus nitrite, silicate, and nitrite. The methods used were essentially those developed for the GEOSECS and ISOS programs and which have become relatively standard for oceanographic investigations. The dissolved oxygen determined by the Carpenter-Winkler technique (Limnol. Oceanogr. 10: 141, 1965), with the actual titration performed by a Radiometer autotitrator (model TTT80) which utilizes a platinum/platinum electrode and monitors the endpoint amperometrically. This cruise is the first extensive at sea use of the Oregon State autotitrator and the first major use of a amperometric oxygen autotitrator of which we are aware. This system performed extremely well throughout the cruise, and except for sampling it operates semi-automatically.

Of the 155 CTD casts made during this leg, just over half were sampled for dissolved oxygen and nutrients. With the exception of a few shallow casts, 24 rosette bottles were sampled on all stations. Additional nutrient analyses were performed on surface samples during the transect to and from the study area, on Gerard bottle samples, on culture media and on ice core samples. In total, nearly 2000 oxygen titrations were run and over 2500 determinations of the four nutrients.

Within the seasonal pack ice, the surface mixed layer was observed to be nearly homogeneous from station to station with high but varying nutrient concentration vertically. The undersaturation of dissolved oxygen observed on the 1981 "Somov" cruise was again found and it increased as the "Polarstern" proceeded southward. The lowest mixed layer oxygen values (< 6.40 ml/l) were observed just prior to encountering the coastal current and were much lower than those determined on the "Somov" cruise.

In a separate but complementary effort, samples were taken for particulate silica, carbon, and nitrogen at 10 stations during the final northward transect. These were accompanied by chlorophyll and nutrient determinations. Four of these particulate stations were occupied in the broad marginal ice zone encountered at the end of the cruise. Filters from the mixed layer at these stations were visibly discolored, indicating a substantial increase in the amount of particulate material present.

2.4. Sea ice investigations

2.4.1 Introduction

The sea ice programme was a multidisciplinary effort to define the relationships that govern ice behaviour in the winter period in the Southern Hemisphere. The contributions of the different disciplines are described in more detail in the following sections. These consisted of ice deformation experiments, ice thickness measurements by coring and drilling, surface wave investigations, aerial photography, radar ice thickness measurements, microwave emission studies, and joint physical-biological ice property studies to characterize the sea ice as a habitat.

Several of the studies suggest the relative importance of an ice advance process controlled by wave and swell action during the freeze-up period.The resulting ice formation gives rough surface pancake ice that feedsback to modify the incoming wave field. The ice structure is dominated by frazil ice textures that are a direct result of the formation process that builds up pancake ice. The ice thickness variations are more controlled by the initial pancake thickness and subsequent rafting and ridging of these structures than by other dynamic or thermodynamic processes, with the possible exception of the far South where coastal effects dominate. The rafting and ridging of these ice types ultimately controll the rheological response to wind and current induced divergence and convergence as the season processes. We also found that biological features have links with ice textures and since these are dominated by frazil ice formed in panckes, the habitat is also controlled by the freeze-up process.

Our preliminary findings have established a context for interpreting the analyses. Future work will continue to quantify and extend these findings in substantive detail.

2.4.2 Ice deformation experiments (CRREL, AWI)

a) With Radar transponders:

During three separate five day periods, ice deformation experiments were conducted. The experiments were performed by the deployment of microwave range finding transponders at 5 locations and using master units on board the ship to initiate range measurements from the remote sites. The transponders were located at distance up to 11 km from the ship which was drifting with the ice during the experimental period. A control sequence initiated by the units on the ship caused the remote transponders to be ranged at 15 minute intervals throughout the experimental period.

b) With modified OMEGA radiosondes

Modifications of the Vaisala-Mini-Cora radio sonde system provide an inexpensive means to measure the deformation of ice fields. An array of eight with a mean distance of 15 km transmitted every two hours for 15 minute periods to the data aquisition system on the ship.

The OMEGA sonde array supplemented the transponder measurements. Although the OMEGA situation in the Antarctic area is generally poor the transmitter stations of Argentina, Liberia and Reunion provided satisfactory field strengths. The position error lies in the range from 10 to 60 m, depending on the quality of the OMEGA signals.

Three sites were chosen as possibly different in the ice properties at 61°30'S, 65°30'S and 68°30'S. These measurements will undergo complete analysis in the near future. Based on a preliminary look, however, there are apparently three somewhat distinct regimes for interior pack deformation inside the limits of usual swell penetration. These are:

I. North of Maud Rise (60° to 63°S). This region showed relatively modest convergence and divergence despite sizable wind amplitude and direction changes during the experiment. Ice surface topography was consistent with the observed deformation, showing slight lead and ridge formation prior to and after the experiment. The region was dominated by consolidated pancake ice with small areas of newer lead ice.

II. Over Maud Rise (63° to 66°S). The deformation array showed a strong divergence (~10%) during the 5 day period. Ice topography reflects this characteristics with substantial amounts of ice formed in leads after the ice edge advance (up to 50%). Ridging activity was also higher than further north.

III. South of Maud Rise to the Antarctic Coast (66° to 69°S). This area showed a strong shear and mean drift to the west as opposed to the eastward drift of the northern stations. Ridges higher than 2 m and at intervals of 100 m or so, were commonly encountered, suggesting a coastal shear zone type formation. While we were there, the coast was also closed off because of the strong convergence although coastal polynyas are quite often seen on the satellite imagery suggesting synoptic weather control over the quantity of open water that can appear at the coast.

2.4.3 Ice thickness (CRELL, SPRI, AWI)

Ice drilling

The combination of data from the triad of complementary interdependent techniques for assessing ice thickness distribution (drilling, radar, photography) requires considerable care.

The most direct measurement is of course drilling. During daily ice stations a total of some 4450 holes was drilled. With typical 50-200 holes at 1 m spacing drilled on each station in an L-shaped pattern. At each hole the ice draft, ice thickness and snow depth were measured. The distribution of ice thicknesses derived from a single line of this kind is very informative about the thickness characteristics of single floes. Of necessity the ship drew alongside undeformed floes for the daily stations. And so most lines of holes represent the variability of thickness expected across relatively underformed ice. Rafting was often encountered during these transects, but major ridges were only sampled if a deliberate decision was made to seek out a nearby ridge and profile across it. A number of such ridge transects was performed, although no ridge of more than 4 m maximum draft was profiled. The cores taken at each station will be most helpful in allowing the floe to be assigned to a given category of ice type, especially categories 3 and 4 (smooth ice versus stony fields) as described in the aerial photography section. In this way composite thickness distributions and mean thicknesses of undeformed floes of visually distinguishable ice types can be built.

Analysis of drilled lines thus has two aspects. The first is an internal investigation of each line of holes to generate statistics of the following kinds:

- Ice thickness distribution and mean, median and modal thickness (similarly for draft and snow depth)
- Length scales over which isostatic imbalance occurs near ridges and rafting
- Spectral characteristics of the ice bottom and surface, yielding roughness parameters and the length scales of bottom irregularities such as rafting
- Occurrence of flooded ice (draft greater than ice thickness) and whether this is taking place in isolated instances or in coherent tracts which can be seen visuallay from the air as grey 'slush pools'.

An example of this kind of analysis is the accompanying Figure 11 which shows the mean ice thickness derived from each ice station as a function of latitude for the inward and outward runs. On the inward run of "Polarstern" the mean ice thickness are scattered about typical values of 50-55 cm which appear to grow only slowly with latitude until 67° is passed, when a rapid growth to beyond 1.2 m occurs. This is simply because ice stations in the higher latitude sampled more ridging and rafting, since deformed ice occupied a large fraction of the ice cover. On the outward run the mean thickness in the region 62-67°S is again fairly steady, but at about 65 cm, indicating that thermodynamic growth of 10-15 cm has occured during the intervening period. North of 62°S a linear decrease of mean ice thickness with decreasing latitude occurs at a rate of about 8 cm per degree, until the last consolidated ice had a thickness of 33 cm.

The second aspect is the combination of these single lines into composite probability densitiy functions for visually distinguishable undeformed ice types. At this stage the contribution of aerial photography becomes important, since

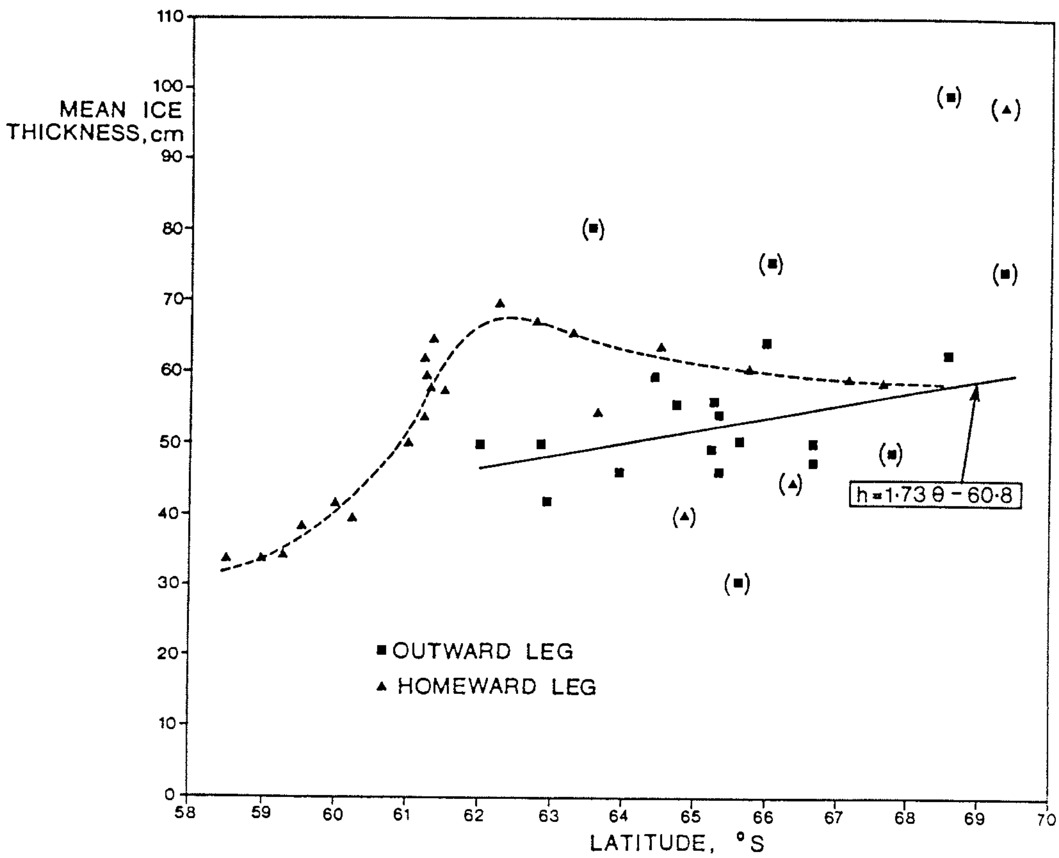

Fig. 11. Mean ice thickness from outward and homeward legs, using sections composed mainly of undeformed consolidated pancake ice.

it enables the relative areas of surface occupied by these different ice types to be assessed (see topic 2.4.7). Thus by convolving the composite thickness distributions from the drilling with area estimates from the photography an area-averaged composite ice thickness distribution can in principle be derived.

The contribution of impulse radar becomes important at this point. Firstly, it may be possible to estimate the area of deformed ice from photographs but the assessment of its likely thickness distribution is very uncertain based on drilling alone. For instance, in higher latitudes we encountered at times an ice type dubbed 'mysterious islands', rounded floes of 20-50 m diameter with high freeboard, ridged around the edges, but with superficially smooth ice of great thickness (8-11 m were measured) in the centre. Aerial photography would not suggest such a thickness, whereas such thick consolidated ice shows up clearly in radar profiles (this was probably multiyear ice). Radar does not succeed in seeing all deformed ice, since where rafting comprises a loose unconsolidated pile-up of blocks the radar is stopped by the firt aqueous horizon. It is hoped that the extensive set of lines in which radar and drilling are compared will enable us to determine the radar's performance over deformed ice and thus its value in generating this part of the ice thickness distribution. Secondly, in a given region it is by no means certain that the undeformed ice has a thickness distribution identical to the composite of the drilling data, and radar profiling will give the thickness distribution of the undeformed floes with some reliability.

Thus it is by a careful blending of the data from these three sources that final area-averaged thickness distributions will be generated. The data density is such that separate distributions can probaply be produced for 1° latitude bins. This will show quantitatively the effect of deformation and thermodynamics on the morphology of the ice cover.

Impulse radar ice thickness profiling

The distribution of ice thickness along extended profile lines was measured during the voyage using the 'Hoverfly' 100 MHz impulse radar system developed by Cambridge Consultans Ltd, (CCL), Science Park, Cambridge. The transmit and receive antennas were mounted on a frame across the skids of the Aerospatiale Ecureuil helicopter. The preferred technique was to fly slowly upwind at a ground speed of 3-5 m/s and a height of 7-15 m, with tracking of the helicopter's radar transponder from the bridge radar to give exact speed and course. At times when there was no wind the helicopter had to fly faster in order to retain stability, in which case the quality of the data over rough ice is somewhat degraded. In addition, the pilot had an unexpected degree of difficulty in detecting surface contrast in other than perfectly sunny conditions, so that flying opportunities were rather few relative to the good flying conditions which prevailed for much of the experimental period.

Wherever possible a calibration was carried out against a line of holes drilled across the ice. At a daily ice station a line of 50-200 holes was drilled at 1 m intervals, four cores were taken and snow samples retrieved. The ends of the line were flagged and the helicopter flew slowly along the line in addition to carrying out its normal longer profile. The results of the core analysis give a dielectric constant suitable for use in scaling the pulse time lags on the radar reflection to provide ice thickness. The data were recorded on high density digital cassette and played back into a thermal visicorder for inspection. Table 7 summarises the data obtained.

Tab. 7. Impulse radar measurements.

Date	No. flights	Km profile data	Calibration againt holes	Ship's Position
July 21	1	0	Y	63°00'S 1°W
July 22	2	57	Y	63°01'S 2°36'W
July 27	2	39	Y	66°00'S 0°17'W
July 29	3	99	Y	65°20'S 2°00'E
July 31	1	7	Y	65°36'S 3°30'E
August 1	2	60	Y	65°37'S 3°13'E
August 2	2	66	N	64°33'S 4°24'E
August 10	2	51	N	68°41'S 1°00'E
August 15	1	24	N	69°30'S 0°32'W
August 20	2	42	Y	67°40'S 2°00'W
August 21	2	20	Y	67°07'S 0°04'W
August 22	2	24	Y	66°23'S 1°41'E
August 23	1	0	Y	65°45'S 2°32'E
August 24	1	3	Y	64°51'S 2°32'E
August 25	1	0	Y	64°29'S 3°13'E
August 26	3	91	Y	63°48'S 1°28'E
August 28	1	12	Y	62°45'S 3°42'E
	--	---	--	
	29	595	14	

To generate a statistically valid probability density function of ice thickness from submarine sonar data requires about 50 km of profile. Therefore 50 km of profile constitutes one 'station' from which an area-averaged ice thickness distribution may be derived. Neglecting the August 10 data (of degraded quality through a radar fault), there are therefore nine full or almost full stations in the above list (on July 22, 27, 29 (two), August 1, 2, 20, 26 (two)). However, where the contribution of deformed ice to the overall ice thickness distribution is slight, it is probable that a shorter track length will yield a good approximation to the ice thickness distribution. In any case, the data will be merged with estimates from the drilling lines themselves and from analysis of relative concentrations of different ice types done from aerial photography.

The calibrations against drilled lines showed that over undeformed ice the radar gave an accurate value for (ice and snow) thickness, while over deformed ice the radar either saw bottom or else was stopped by the first aqueous void encountered (see Fig. 12). Thus loosely consolidated or unconsulidated heaps of rafting are unlikely to be recorded with their true depths. Since ice thicknesses were so small, often lying in the range 40-80 cm, the surface and bottom echoes were partially merged. It was possible from the geometry of the composite pulse to recover the ice thickness, however. On return to Cambridge further processing to deconvolve the two returns can be done to improve the resolution still further.

2.4.4 <u>Sea ice property investigations</u> (CRREL, AWI)

From July 19, 1986 to September 7, 1986 i.e. from entering the ice edge to leaving the sea ice zone, a total of 60 ice stations were carried out. Each station, with few exceptions consisted of a standard procedure, which included

- Drilling of two 4" cores for the joint textural, chemical and biological investigations and for archiving, respectively
- Drilling of three 3" cores basically for biological investigations (species enumeration and cultures) and for archiving
- Measurement of air and snow temperatures at the sampling site
- Obtaining a temperature profile through one of the cores at a spacing of 0.05 m and a profile of light intensity through the bore hole and the underlying water column to a depth of 10 m
- Drilling of one or two sections of 2 1/2" thickness holes at 1 m spacing for a total of 70 to 100 m at each site. Measurements of snow and ice thickness as well as freeboard were taken at each hole
- Surface sampling in the footprint of the ship-borne radiometer which consisted of snow and ice samples along a 25 m section at a spacing of 5 m, measurements of snow surface and temperatures at the snow ice interface at the drill holes and measurements of the snow thickness along the same section with a spacing at 1 m.

We obtained a total of 214 cores, which totaled 156 m of ice, we drilled 75 ice thickness profiles and carried out surface sampling at 32 sites. One of the 4" cores was used for obtaining the textural characteristics at each site. Based on ice texture the spacing of sampling for chemical and biological investigations was chosen such that each textural unit was sampled separately. We performed measure-

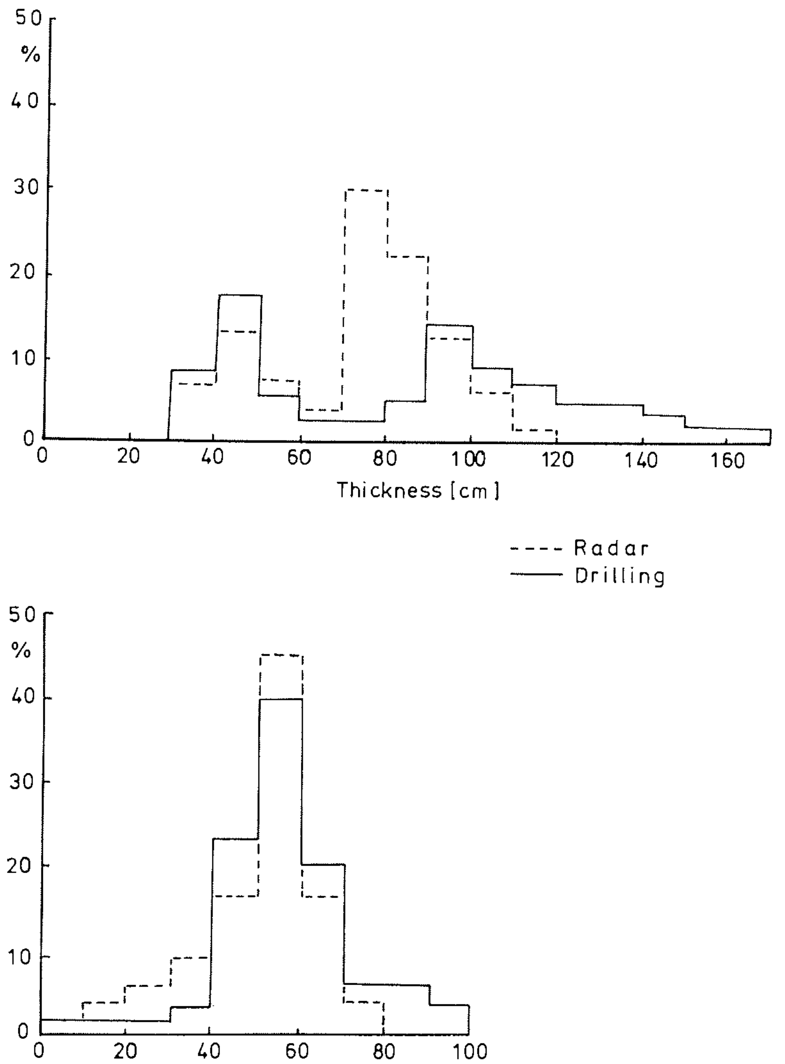

Fig. 12. Sea ice thickness distribution based on drilling (full lines) and radar (broken lines) measurements.

ments of salinity, chlorophyll a, SiO_2, NO_2, NO_3, and PO_4 and counted the number of foraminiferes in each section of the core thus obtained. This procedure enabled us to relate textural characteristics of the ice, which reflect its growth history, to the chemical and biological properties of the sampled cores.

In our textural analysis, we distinguished four textural classes: snow ice, frazil ice, columnar ice, and mixed frazil/columnar ice where the last class includes ice of transition zones as well as ice which results from irregular frazil/columnar growth and or rafting of ice floes. The cores analysed lead to the following distribution of these textural classes for the sampled ice:

snow ice	9,4%
frazil ice	50,8%
columnar ice	27,1%
mixed frazil/columnar	11,9%

The relative amount of frazil and columnar ice found in a single core was used to classify the sampled ice sheet according to the following definitions:

Fraction of columnar or frazil ice	Ice class
(a) 80% columnar	pure columnar
(b) 60% columnar	predominantly columnar
(c) 80% frazil	pure frazil
(d) 50% frazil	predominantly frazil
(e) 30-50% frazil/columnar	combined or mixed frazil/columnar

Each ice class can be related to a specific growth history of the ice.

(a) Pure columnar- refrozen leads of space between pancake ice floes grown under quiet conditions (i.e. absence of wind and wave motion)
(b) Predominantly columnar- either refrozen leads with initial frazil growth and or snow ice or rafted pieces of type (a) ice when the space between the rafted pieces consists of frazil and/or snow ice
(c) Pure frazil-consolidated pancake ice floes
(d) Mixed frazil/columnar- either pancake ice floes with substantial growth of columnar ice at the bottom of the floe or rafted pancake and refrozen lead ice.

The cores analyzed fall into these classes with the following proportions:

(1) Pure Columnar	13,7%
(2) Predominantly columnar	15,7%
(3) Pure Frazil	27,5%
(4) Predominantly frazil	23,5%
(5) Mixed Frazil/Columnar	19,6%

First analyses of chlorophyll a and foraminifer concentrations show that specific concentration limits can be ascribed to each of these classes. Also, it is apparant that the distribution of biogenic material in each core is texturally controlled. The exact nature and the predominant process, which give rise to the observed distribution is one of the major goals of the future ice core studies.

2.4.5 Passive microwave radiometer measurements (NASA, UW)

The objectives of this project are to understand the physics of the microwave emission of the Antarctic sea ice cover and to evaluate the variability of the emission characteristics of the different ice types as they undergo different stages of development. Results fromthis project will be used to improve the interpretation of satellite sensor data including those from the Scanning Multichannel Microwave Radiometer (SMMR) now on board the Nimbus 7 satellite, and the Special Scanning Microwave Imager (SSMI) which is scheduled to be launched soon on board a DMSP satellite. To meet the objectives, five radiometers at various frequencies, namely 6, 10, 18, 37, and 90 GHz, which matches most of those from SMMR and SSMI, were utilized. The measurements made during the cruise can be categorized into a) angular measurements from the ship, (b) transect measurements from the ship and c) ground based measurements. The angular measurements were done at 18-20 deg from nadir and were made mainly when the ship was stopped for ice stations. This enabled measurements at both horizontal and vertical polarizations at approximately the same area. Also, it made it possible to do physical characterization of the ice over the same region where the measurements have been made. The physical characterization included measurements of temperature of the snow cover and the snow ice interface, the thickness of the snow cover and the density and salinity of the snow and ice. The transect measurements were done while the ship was in motion. This enabled a more comprehensive sampling of the different types of ice surfaces and allowed measurements of areas comparable to those of satellite footprints. Many times, when weather permits, video coverage over the same surface was taken during the radiometer measurements. Ground based measurements were taken only during the ice deformation stations when time allowed for switching mode from the ship based to the surface based mode. The ground measurements allowed for a more precise matching of the radiometer measurement and the ice physical characterization and will be used to better interpret the ship based measurements.

About 300 different measurements were taken during the second leg of the cruise. Preliminary analysis of the data, strongly shows the potential utility of the 90 Ghz channel, which will be on board the SSMI, for ice study. The 90 GHz data in combination with those of lower frequency channels, seem to have the capability to detect thin ice, especially on newly frozen leads or polynyas. Also, as later confirmed from ground measurements, the 90 GHz is found to be sensitive to the thickness of the snow cover. Because of scattering within the snow layer, the brightness temperature at 90 GHz decreases as thickness of the snow increases. Thus in combination with another frequency, the statistics of the snow cover can be approximately quantified. Preliminary analysis also shows that there are two main peaks in the frequency distributions over consolidated ice for all frequencies except 90 GHz.

For the latter, the peak is smeared out by the effects of snow. The double peak suggests two main thicknesses in some consolidated ice regions, perhaps corresponding to the thicknesses of the pancake ice component and those of the generally thinner glue between the pancakes. Overall, the data accumulated are comprehensive, limited only by weather, and encompasses the marginal ice zone, the central and innter regions, and areas of leads and polynyas, during the austral winter.

2.4.6 Surface wave experiments (SPRI)

During WWSP a series of surface gravity wave experiments were carried out from "Polarstern" to study the effect of the winter Weddell Sea pack ice on incoming waves and swell from the South Atlantic, and conversely, to study the effect of waves on the pack ice. Very few data are available from Antarctica in this area of research, and none during the Antarctic winter. By analogy with summer data from the Antarctic, we expected: (1) waves entering the ice field to be attenuated systematically with distance from the ice edge, with short periods being damped more effectively than long; (2) the ice edge floe size distribution (extending up to say 200 km into the pack) to be controlled principally by incoming waves and swell - ice floes of too large a size for a particular wave height and length being destroyed by fracture; (3) the directional character of the incoming wave spectrum to be marked altered by the ice encountered.

Various instruments were used to measure the incoming waves and swell. These included an Institute of Oceanographic Science (IOS) pitch-roll buoy, and instrument of similar sensors manufactured by Scott Polar Research Institute (SPRI) for use directly on the sea ice surface, an ARGOS waverider buoy, and rosettes of SPRI strainmeters. The pirch-roll buoy is a free-floating, surface-following wave buoy which has a gyro to provide vertical reference. An accelerometer is mounted within the gyro to give heave, and two tiltmeters measure the pitch and roll of the buoy relative to vertical. A compass is also included to reference the tilts to north. The SPRI pitch-roll unit is similar to the buoy but uses gimbals to provide vertical rather than a gyro. The ARGOS waverider buoy was also constructed by IOS. This buoy was deployed on the way south to the ice edges and was intended to provide position, significant wave height, zero upcross period, and spectral peakedness, routinely throughout our time in the pack ice. Unfortunately the buoy failed to give the wave parameters required. It did transmit position effectively, however, which enabled "Polarstern" to recover the buoy on the way out of the ice. When the wave energy had been diminished by the ice sufficiently that its magnitude was too small to be measured by concentional open-water instrumentation, the SPRI strainmeter was used. This is a well-tested instrument for the measurement of wave-induced deflections in sea ice (and icebergs). The strainmeter detects the very small extension or contraction seen at the ice surface due to flexure induced by a passing wave. Strains of 1 in 100 million can be resolved by the instrument, which is usually deployed in a set of three located at 120 degrees to one another so that the principal strains and their direction may be found.

Ice conditions up to 500 km inside the ice edge were determined by incoming waves and swell for both our passage in, and our passage out of the Weddell Sea pack ice. In both cases we experienced pancake ice across a zone of some 100 km at the ice edge. Pancake diameter and thickness gradually increased with penetration into the pack and eventually at some distances in, determined by the incoming waves, the pancakes consolidated to form ice floes. Up to this point on the way in, the pancakes appeared to collect into patches separated by open water; on the way out a definite banded structure to the ice morphology was seen from the helicopter and was recorded on aerial photography. All of the pitch-roll buoy, experiments were done in this zone, because of the need for open water in the deployment. A total of fifteen such deployments were done as three transects, viz, 3-4 stations in a line during a single day, and a band experiment where the buoy was deployed on either side of a 2,5 km wide band of pancake ice to study the effect that the band had on the incident wave spectrum. In this latter experiment it was found that even though the band was narrow and the sea was running obliquely into the band, the significant wave height was diminished from 4.5 m to 3.6 m, the zero upcross period was increased from 9.6 s to 12.1 s, and the directional nature of the wave energy was changed in such a way that the long period waves became fully isotropic (from all directions). A similar change to isotropy in directional characteristics was seen as the waves entered the area in the ice where consolidated floes began to form from the previously separate pancakes. This is believed to be due to each floe's new found ability to generate waves travelling in all directions as they are brought into motion by the incoming sea.

Thirty-five strainmeter sites were set out where heave, pitch and roll were also measured using the SPRI unit. These sites extend from the point where floes first consolidated, throughout to near the Antarctic coast, and then back to within 200 km of the ice edge again. Waves were detected and measured at all sites with a gradual increase in 'average' period from about 12-13 s in the north to about 18-20 s in the south. Wave height gradually diminished with penetration from the ice edge. The strainmeters also enabled internal waves to be studied. On three occasions, during a deformation experiment, long oscillations were observed in the data which had a period between 6 and 8 minutes. These oscillations are believed to be a surface manifestation of internal waves in the pycnocline, which are seen by the strainmeter as a tensile or compressive strain in the ice (depending on direction). The internal wave hypothesis, which is based on similar data observed in the Arctic, was checked by deployment of an ODEC CTD unit simultaneously with the strainmeters.

A single event of extreme swell penetration, sufficient to cause ice breakup deep within the pack, was observed some 600 km from the ice edge, when a swell of 18-19 s period and 1,5 m peak-to-through heigh passed through for several hours. Wavefronts during this event, and during pitch-roll buoy stations done near the ice edge, were of sufficient amplitude to be clearly observable on the ship's x-band radar.

2.4.7 Aerial Photography (SPRI)

The aerial photography programme was carried out using a Vinten F95 70 mm aerial reconnaissance camera controlled by an intervalometer inside the helicopter. A full magazine contains 500 frames, and a single frame covers an area of 1 km^2, if the helicopter flies at 1500 m heigh. Special camera frames were constructed for both helicopters, although most of the photography was done from the Ecureuil.

Three main types of mission were flown:

- Contextual photography, to define ice conditions in a region around the ship, involving square or triangular patterns flown at 500 to 1300 m height so as not to lose detail of surface topography

- Photography along north-south axes, to define meridional changes in ice conditions (e.g. the transitions near the ice edge from loose pancake to partly cemented floes to vast consolidated floes)

- Aerial photomosaics of the ice deformation arrays, flown at 2000 m elevation with parallel lines 1 km apart in an attempt to provide complete coverage of the aera enclosed by the Del Norte transponders.

The accompanying Table 8 shows the flights carried out, the height of the helicopter, the purpose of the mission (C = contextual, NS = meridional transects, M = mosaics), the position of the ship and the number of frames obtained.

Tab. 8: Aerial photo flights.

Date	Type	Height (m)	Frames	Ship's position
July 19	NS	100	500	60°59'S 1°08'W
July 22	C	500	500	63°13'S 2°27'W
July 24	C	500	200	64°40'S 2°01'W
July 28	M	1000	500	65°18'S 1°43'E
July 28	M	2000	300	65°18'S 1°43'E
July 29	M	300	500	65°19'S 2°05'E
July 31	M	2000	400	65°35'S 3°02'E
August 1	M	2000	270	65°34'S 3°19'E
August 2	C	2000	200	64°31'S 4°22'E
August 4	C	2000	100	65°20'S 8°00'E
August 5	C	300	130	66°04'S 6°25'E
August 10	M	2000	500	68°41'S 1°00'E
August 13	M	2000	500	68°55'S 0°16'E
August 15	NS	600	340	69°31'S 0°29'W
August 20	C	500	400	67°38'S 2°03'W
August 21	C	2000	290	67°09'S 0°02'W
August 22	C	300	500	66°32'S 1°24'E
August 25	C	1300	500	64°28'S 3°13'E
August 26	C	1300	500	63°55'S 1°40'E
August 30	M	2000	260	61°31'S 6°33'E
September 1	M	500	70	61°30'S 6°53'E
September 3	M	2000	170	61°15'S 7°34'E
September 3	M	250	440	61°15'S 7°34'E
September 7	NS	600	500	56°05'S 6°59'E
September 7	C	500	250	55°50'S 7°09'E
September 9	NS	500	500	57°23'S 7°14'E
September 9	NS	300	500	57°15'S 7°16'E

Total flights 27, 9980 frames

The immediate application of the photography is to the ice thickness programmes, although the results find application to many other study. The overall purpose of the ice thickness measurements is to determine the probability density function of ice thickness, P(h), averaged over areas which are sufficiently large to contain a statistically valid sample of ice types but sufficiently small to reveal genuine variations in the ice conditions. Inputs from ice drilling, impulse radar and aerial photography will be combined in 1° latitude steps for the inward and outward cruise legs to obtain a series of P(h) values for varying latitude and advancing season. The role of the aerial photographs in this blending of data will be to yield the relative areas covered by distinct ice types which can be distinguished reliably on the photographs and whichs have their own characteristic thickness distribution deduced from drilling and radar profiles. The categories are:

- Open water
- Recently refrozen leads, i.e. nilas with differing grey tones
- Young ice, formed from leads which refroze at an earlier date than those of the former category and which is characterised by a smooth white surface
- The 'stony field' ice type (the most common ice type across the entire Antarctic pack), comprising vast fields of ice generated by the cementation of pancakes which formed at the ice edge. This ice type has a characteristic local point roughness comprising up-ended blocks and the raised edges of the original pancakes, forming nuclei for sastrugi and drifting snow. The resulting appearance is of a stony field
- Deformed ice, in particular ridges and rubble fields.

Each frame is analysed for the fractional area occupied by each of the above ice types, and the results are used to generate P(h).

Other applications of the aerial photographs are to

- Interpretation of the results of the ice deformation experiments, where photomosaics done at the beginning and end of the experiments show how much, and what type of, divergence, shear and pressure ridging have taken place during the experimental period
- Interpretation of boundary layer measurements, where aerial photographs augment the data on ice conditions upwind of the ship derived from flights with the line scan camera
- Interpretation of data on large-scale ice deformation obtained from the ARGOS buoy network. For example, if the network shows net divergence over a region, this should be reflected both qualitatively and quantitatively in the opening up of fresh leads seen in aerial photographs.

2.4.8 Meteorology

Air-sea heat and momentum exchanges and atmospheric boundary layer processes (AWI)

The main purpose of this programme was to measure the momentum and heat transfers between the atmosphere and the underlying ice or water under various surface and large scale flow conditions. Four different instrument systems were installed on the ship:

- A radiosonde device with OMEGA-windfinding
- A three component Doppler-SODAR for low level wind profiles
- A sonic turbulence system which was exposed on a boom at the bow crane together with sensors which supplemented the deck level measurements

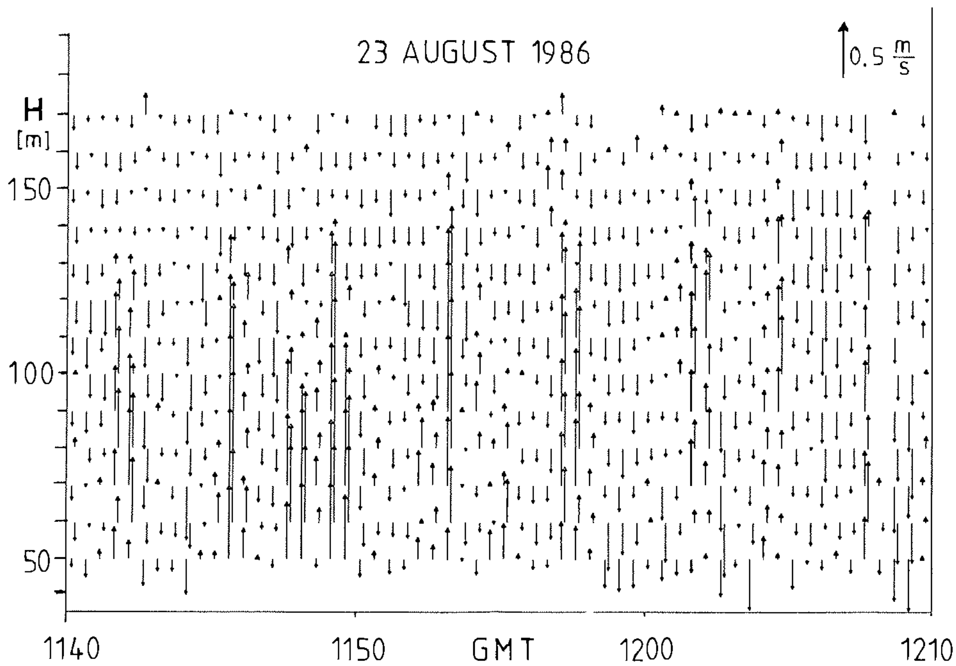

Fig. 13. Time series of vertical motions in the atmospheric boundary layer as derived from SODAR measurements.

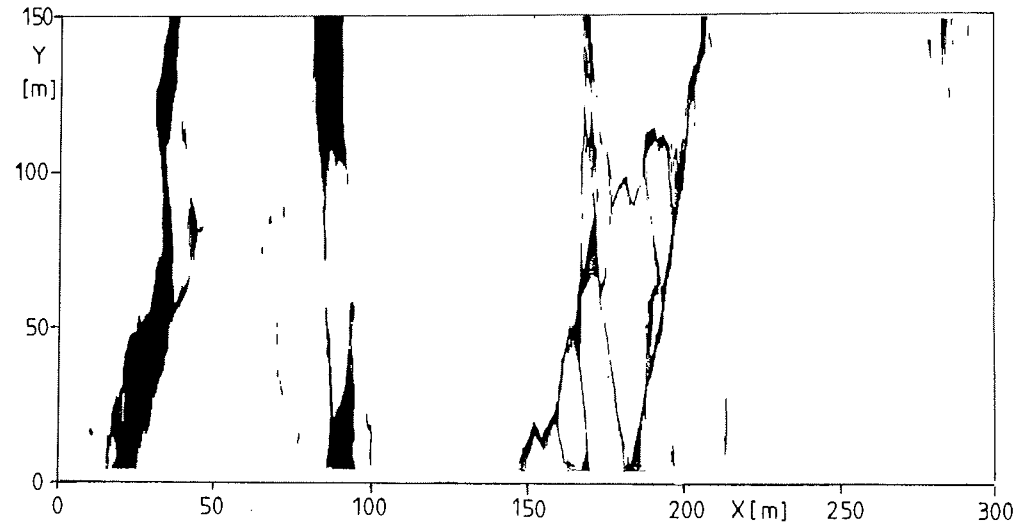

Fig. 14. Line scan camera observations. Black areas indicate open water or thin ice, white areas represent sea ice.

- A PRT-5 radiation thermometer, which continuously recorded the radiation temperatures of ice and water surfaces.

Information of the ice concentration and the floe size distribution was gained by the means of a line scan camera which was operated from a helicopter.

257 radiosondes were launched, several hundreds of Doppler-SODAR profiles were measured and more than 100 MByte of surface data were recorded on tape. During 18 flights the line scan camera surveyed a track line of nearly 600 km length.

The radiosonde temperature profiles indicate the following structures of the atmospheric boundary layer over ice:

No inversion below 1000 m height	50%
Ground based inversion	18%
Low level inversion	32%

An example of a height-time cross section of the vertical wind component measured with the Doppler-SODAR is displayed in Figure 13. Thermally driven motions seem to be the dominating feature within the 'mixed layer' below a strong low level inverson. Figure 14 shows a line scan camera picture in the vicinity of the ship. The dark areas represent nearly frozen leads or open water while the white areas indicate snow covered pack-ice.

Surface **buoy network** (MIH, AWI)

Between 19 July and 19 August 1986 a network with nine surface stations on the ice and one buoy in the open water was installed; an eleventh station followed on 30 August to fill a gap in the northern part. Using the ARGOS system of positioning and data transmission, the buoys collect data of air pressure, air temperature, ice temperature, wind speed and direction and buoy heading. Five of the stations, in addition, measure current speed and direction at 10 m depth. During the time of the cruise three buoys were lost, probably due to ice ridging during periods of strong winds. The rest of the stations, with a nominal battery life time of nine month, is expected to report through spring and the summer melting period.

With a few exceptions, the data quality is good. Ice temperature sensors turned out to be vulnerable and were lost on five of the stations. Wind direction abviously failed on three stations possibly due to an internal data processing error. Wind speed sensors, at times, are suspectible to icing and riming; disturbed periods can, however, be separated from undisturbed, by using a suitable geostrophic to actual wind relation ship. Pressure data appear to be free of errors as can be verified from intensive intercalibration prior to the deployment, from continuous meso-scale pressure analyses and through the network. Figure 15 shows the station distribution on 19 August, the first day of the completed deployment, and on 8 September 1986.

The main purpose of the programme is to derive the surface pressure field and the geostrophic wind in the Maud-Rise area, to give an estimate of the curl of the windstress using, for instance, the resistance law of the atmospheric boundary layer, and to investigate the relation between geostrophic wind, actual wind, and ice drift velocity on the scale of 100-600 km and on time scales of 6 hours to several weeks. The observations show that the ice movement responds rapidly to the atmospheric forcing. Consequently, the scale of the ice movement corresponds to a large extent to the scale of atmospheric wind systems which was observed to vary considerably with time. The observed fields of ice convergence and divergence vary closely with the wind velocity.

Stations with current meters permit to measure the angle α between wind and water stresses and the relation between the current and the wind vectors. Under conditions of free drift, i.e. without internal ice stress and with negligable acceleration of the ice flow, the momentum budget - using the bulk parameterization for wind stress - is balanced if

$$\sin \alpha = \frac{\alpha i}{\alpha a} \, hi \, f \, \frac{1}{Ca} \, \frac{u}{U^2}$$

holds U = wind speed and u = relative current speed. Taking the drag coefficient Ca to be 0.002 and average conditions for ice and air density, di and da, and for the ice thickness hi, the relationship $\sin \alpha = 25u/u^2$ should hold for a latitude of 65 degrees. Deviations from this relation are an indication of the presence of internal ice stresses and/or inertia forces during high winds events. Figure 16 shows the time series of the sum of internal ice stresses and the acceleration term, R, scaled by the wind stress (negative values indicating this sum pointing to the left of the wind stress and vice versa). Periods with small values at all stations - such as the first nine days of August - can clearly be separated from days with large excursions which are related to major storms passing through the area. After 17 August, meridional differences become obvious, with internal ice stresses similar to the wind stress, in particular at the southern station. A more detailed investigation will concentrate on the components of the momentum budget and, especially, on the internal ice stress and its relation to ice properties and atmospheric forcing. The results shall be compared with the meo-scale ice deformation investigations described in section 2.4.2.

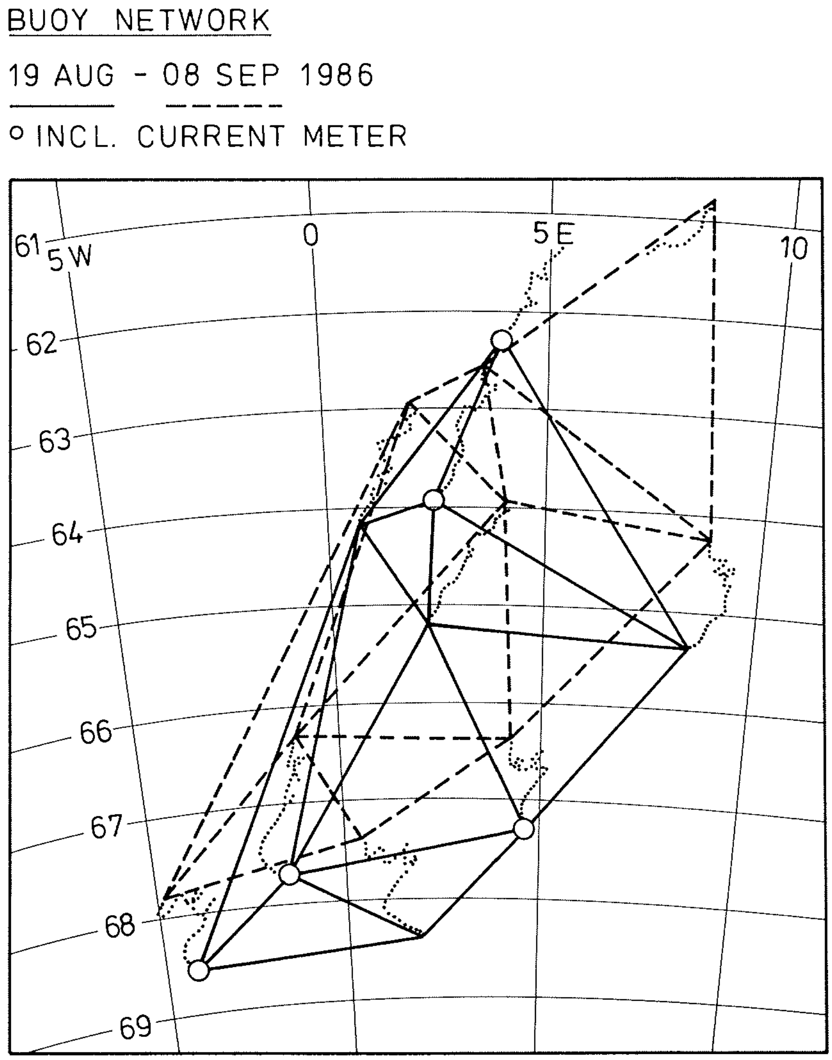

Fig. 15. Buoy network on 19 August (first day of completed network) and 8 September 1986 (when "Polarstern" left the area). Circles denote stations with current meters; other stations are at the corners of triangle. Dotted lines are trajectories from daily positions.

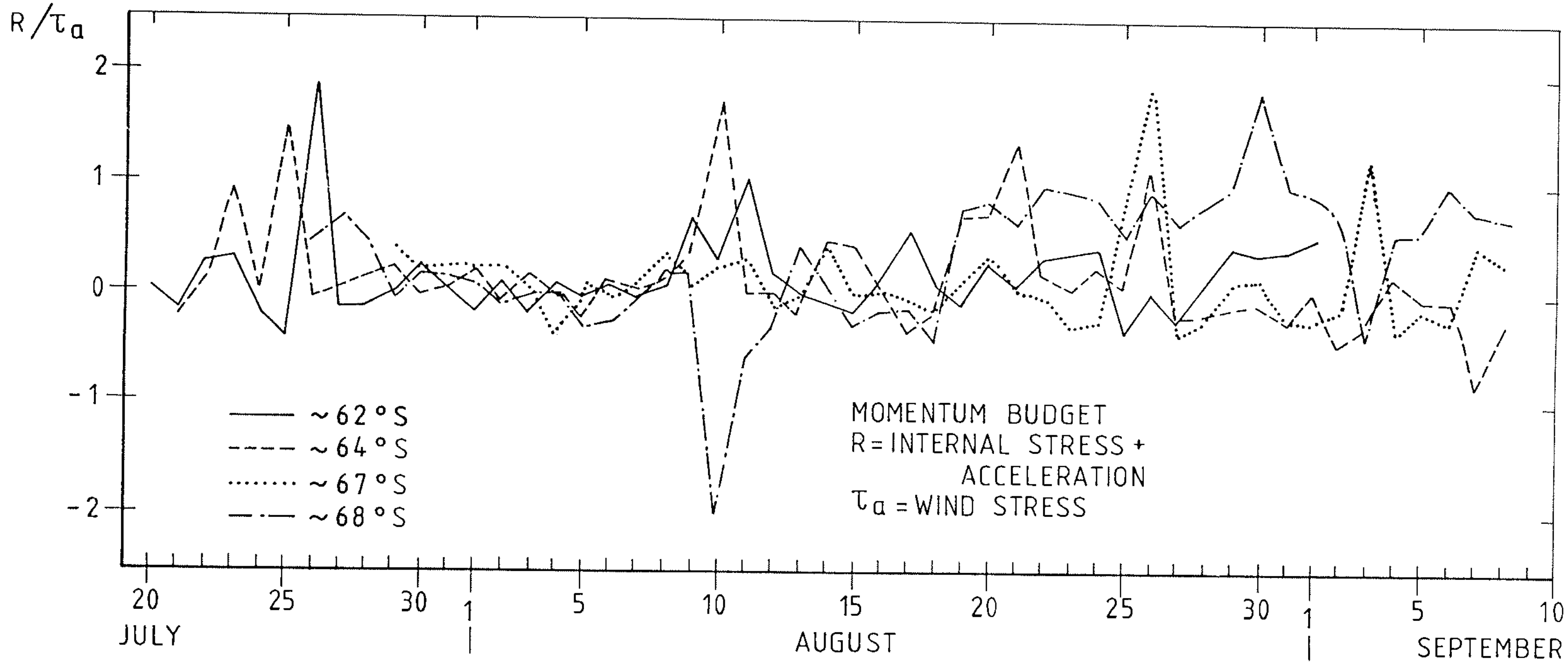

Fig. 16. Sum of internal stress and ice floe acceleration (R) relative to wind stress (τ_a) for four stations between 62°S and 68°S. R is the deviation from free-drift conditions. Note increasing non-free-drift conditions in the second half of the periods.

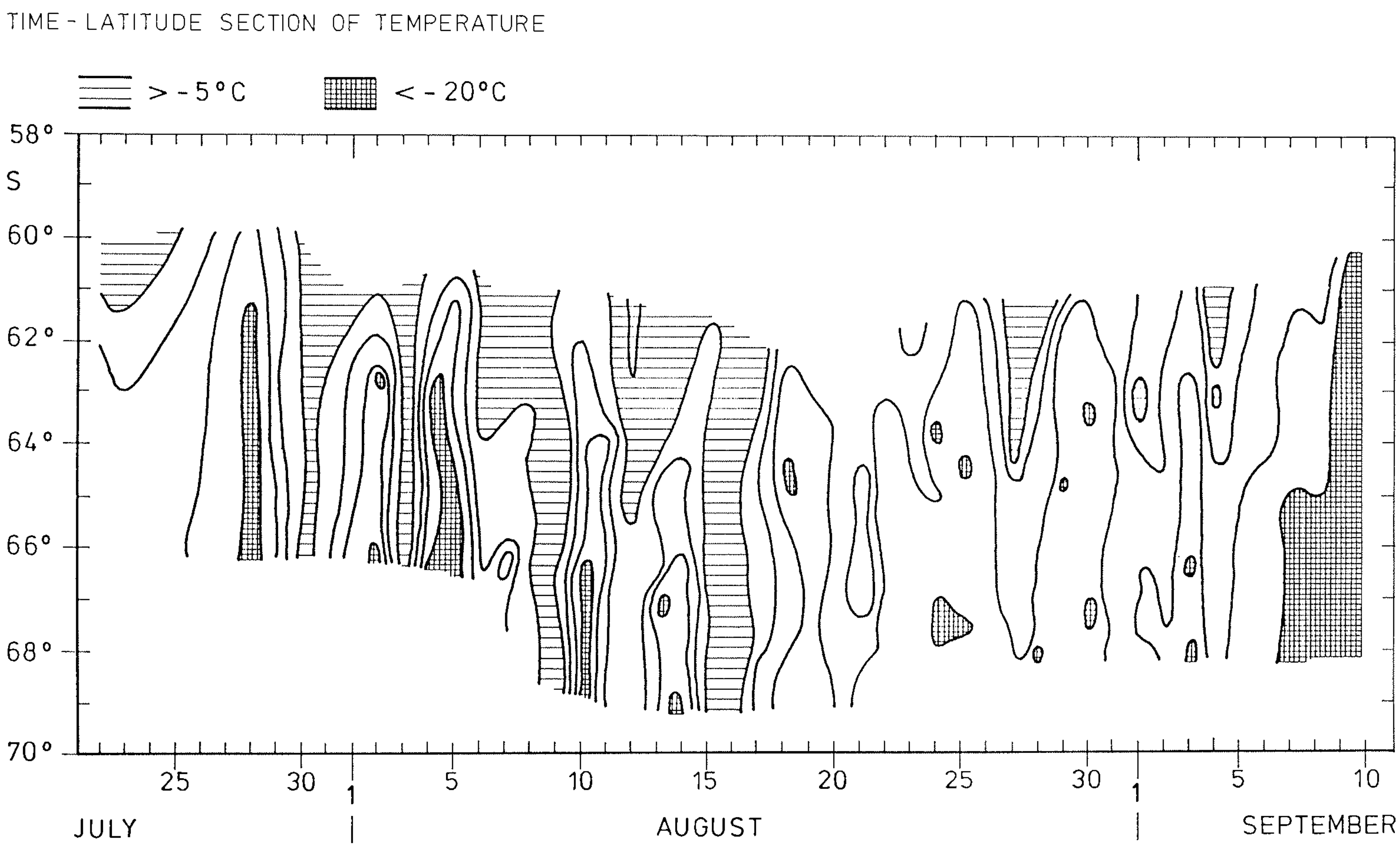

Fig. 17. Time-latitude section of temperature from up to nine stations between 60°S and 69°S. Isotherms are in 5 K intervals. Note the periodic change between warm southward intrusions and cold northward outbreaks and the change of behaviour after 17 August 1986

Meridional temperature profiles between latitudes 60° and 69°S (Fig. 17) derived from the buoy network reveal the regime to be governed by a synoptic-scale pattern with large intrusions of warm air from the north being replaced by periods of cold air flow from the south. A typical time scale of this periodically changing pattern is four days; it prevails in July and in the first half of August. Meridional temperature gradients during warm periods are negligeable; temperatures are uniformly -3° to -5°C, almost down to the ice shelf front. Concurrent with ice surface temperatures being of the same order, this indicates very small sensible heat fluxes. In contrast, southerly winds, causing divergent ice flow and formation of leads, increase the heat flux from the surface. This flux - typically of order 30 Watts per sq.meter - is increases the heat content of the atmospheric boundary layer from temperatures around -20°C at 65°S to -15°C at 61°S. The north-south contrast south of 65°C remains small. Most of the air mass modification appears to take place in the marginal ice zone in the north, causing periodical sea ice formation events.

However, paralleling the dynamic situation described in Figure 16, also the thermal conditions change after 17 August. Warm air intrusions no longer occur at the same scale as before and temperatures remain below -15°C most of the time (but never fall below -25°C). It appears that the Weddell Sea ice is now densely packed, with large internal ice stresses and small heat fluxes. A strong baroclinic zone in the north (58° to 56°S) seems to control the atmospheric forcing.

Reflectivity of sea ice (UI)

Spectral albedo
The spectral albedo of both snow-covered and bare sea ice was measured over the wavelength range 400 to 1350 nm in steps of 50 nm.

The instrument used was an ISCO spectrometer of 15 nm half width in the visible and 30 nm in the near infrared part of the spectrum. The wavelength could be chosen by use of an interference filter. The spectrometer was equipped with a 2Pi diffuser disc which was mounted on a 0.8 m light pipe so that the receiver could be set up at the end of an aluminum support at a height of about 40 cm above the ground. To avoid uncertainties in wavelength adjustment, at a given wavelength the incoming radiation from both the upper and the lower hemisphere was measured. Then the process was repeated with another wavelength. This procedure reduced uncertainties due to a change of the solar radiation between the measurements of the downward and upward components.

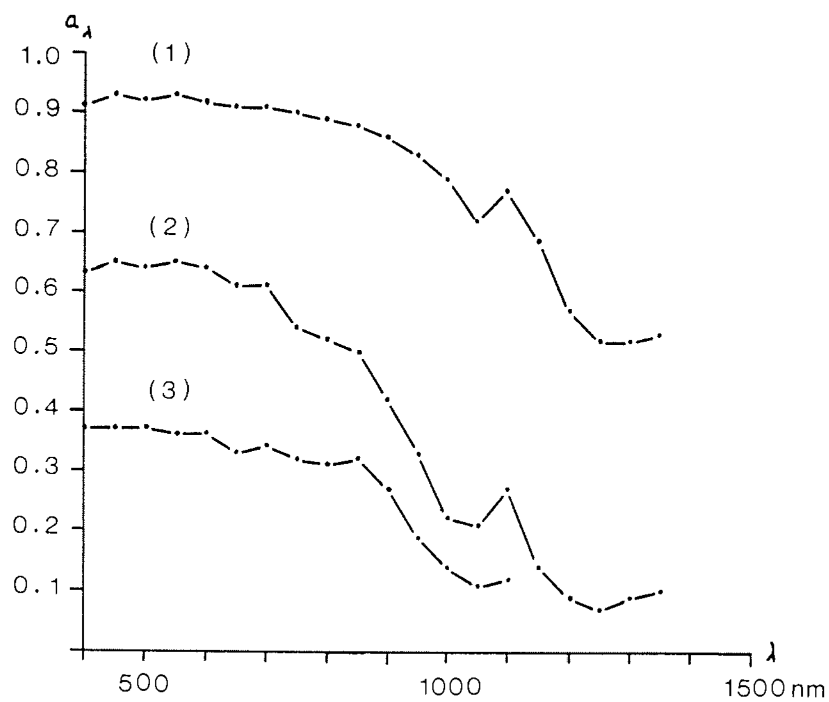

Fig. 18. Spectral albedos observed over (1) windblown snow, (2) slush, and (3) nilas (5 cm thickness).

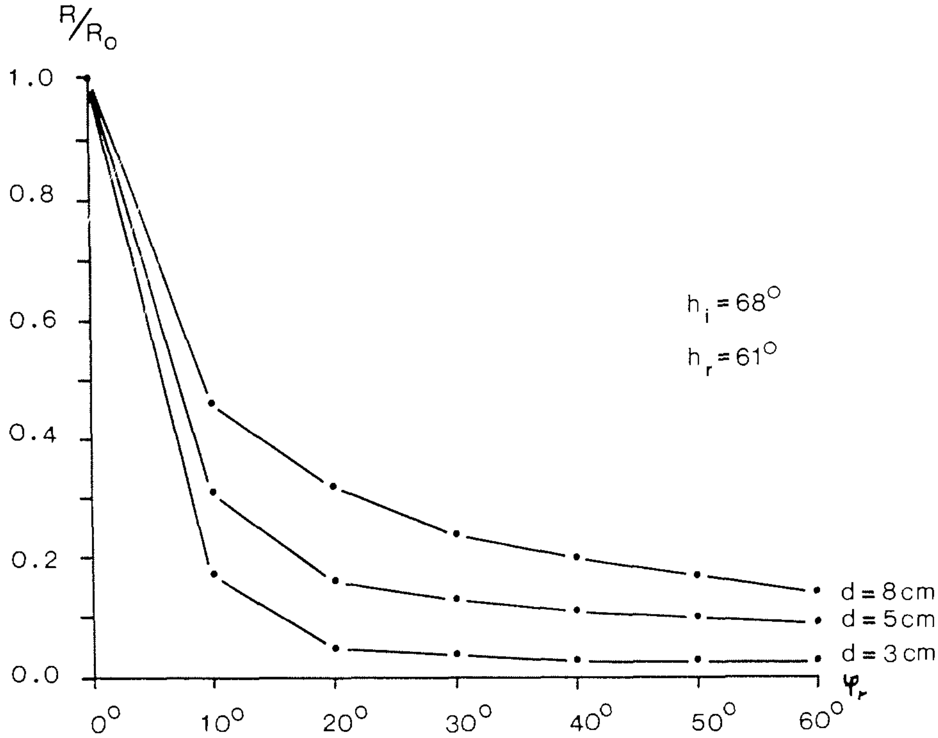

Fig. 19. Reflected radiance as a function of azimuth angle φ_r for different ice thicknesses. Values are normalized by $R(h_r, \varphi_r)/R(h_r, 0)$. ($h_i$, h_r zenith angle of incident and reflected ray, respectively).

Most of the cases show a maximum albedo between 500 and 700 nm. Beyond 700 nm the albedo decreases with increasing wavelength. A second maximum occurs at about 1100 nm due to a minimum in ice and water absorption. Figure 18 shows spectral albedos observed over windblown snow, slush, and nilas of 5 cm thickness. Since the intensity of the incoming radiation was very low in the IR wavelengths because of the high latitude and the time of the year, it was not always possible to measure the whole wavelength range. For the same reason the uncertainties in this part of the spectrum are higher than in the visible range. Special attention was given to the albedo of thin ice. In recently refrozen leads the ice thickness varied between a few millimeters and about 30 cm. The albedo shows a strong dependence on the ice thickness (e.g. ice of 6 mm thickness has an albedo of about 11-14% in the visible range, an increase of ice thickness to ~5 cm corresponds to an increase of the albedo to 37%).

Bidirectional reflectivity
The radiation reflected by snow and ice surfaces is not isotropic. This can lead to significant errors in albedo measurements. Therefore, it was also planned to study the bidirectional reflectance of sea ice. Because of logistic difficulties it was impossible to do these observations in the field.

However, a series of measurements was done with ice created from sea water in one of the cold rooms of the ship. The reflected radiance R was measured as a function of zenith angle h_i of the incident ray (which came from an artificial light source) and zenith and azimuth angles of the reflected ray h_r and Ψ_r, respectively.

For thin ice (thickness < 1cm) the reflectance is nearly specular. When the ice grows, more scattering within the ice occurs. The reflectance distribution shows a peak in the direction of the light source, which is less developed with thicker ice. Figure 19 shows the reflected radiance for different ice thicknesses. The values are normalized by the nadir quantities of the reflected radiation R $(h_r,0)$. Thin sections and salinity profiles of the artificial ice show that it is rather similar to thin ice on refrozen leads.

2.5 Marine Biology

2.5.1 Phytoplankton (AWI)

Phytoplankton investigationes were carried out primarily to supplement the sea ice studies, but also to establish the composition of the phytoplankton in the Weddell Sea during winter. Water samples were drawn from the CTD-rosette at 32 stations from depths between 2 and 300 m. Chlorophyll-a was determined fluorometrically in 1 l subsamples while 200 ml samples were preserved with 0,5% formaldehyde for later species enumeration. Samples for particulate carbon and silicate were collected at 11 stations by filtering 2.8 l through GFF and millipore filters respectively. Analyses of the samples will be done in conjunction with nutrient determination. Apstein net (20 µm) hauls were performed at 32 stations to obtain samples for quantitative species enumeration, while the photosynthetic active radiation to a depth of 30 m was measured at 25 stations.

Chlorophyll a values in the mixed layer ranged between 0.01 and 1.24 mg/m^3, the highest values being recorded near the ice edge on the return leg. The composition of the phytoplankton varied considerably from that in the sea ice since it was primarily comprised of centric diatoms while the sea ice contained mainly pennate forms. Furthermore, the diatoms appeared healthy and growing. Very few spores were found.

2.5.2 Culturing experiments (AWI)

Experiments were performed to study aspects of the overwintering strategy of sea ice diatoms:

Salinity and temperature tolerance
Phytoplankton from the water column is incorporated into sea ice during its formation and growth. The algae live in brine pockets which have salinities and temperatures which are in thermodynamic equilibrium with the ice. Thus, organisms may be subjected to temperatures below -10°C and corresponding salinities above 145 ppm as verified by field studies. In order to test the growth of sea ice algae under adverse conditions, the following salinities and temperatures were selected for growth experiments: 34, 70, 115 and 145 ppm at -1.5, -3.7, -6.7 and -9.7°C. Growth of the dominant species, Nitzschia cylindrus occurred up to a salinity of 70 ppm, but was slower than at 34 ppm. No increase in cell numbers was recorded at higher salinities. However, cells still appeared healthy. Tests will be carried out to establish their viability by gradually returning them to ambient temperatures and salinities.

Viability of sea ice diatoms upon ice melting
To examine the viability of diatoms enclosed in the sea ice for most of the winter, the following procedure was applied: Ice cores were cut into 10 cm sections and halved horizontally. One half was preserved in 0.5% formalin, while the other was melted in 8 liters of filtered seawater at -1°C. Subsequent growth of algae was monitored by measuring chlorophyll a daily at 2 intervals and enumerating subsamples 3 times during the experiment. Incubations were done under blue filtered daylight bulbs (30 µ Einstein/m^2/sec) for 12 hours daily. Preliminary results indicate that

several algal species throughout the core were viable and had begun to grow in culture. Most of the species belong to the genus Nitzschia. Thus specially adapted algae are capable of surviving the adverse winter conditions.

2.5.3 Zooplankton (AWI)

A total of 30 successful Multi net hauls were made along the cruise track in the ice (Fig. 10). The net was closed at depths of 600-400 m, 400-200 m, 200-100 m, 100-50 m and from 50 m to the surface. The net was deployed during various times of day and night and the space resolution ranged between 30 and 60 nm. Plankton catches were fixed in 4% Formaldehyde buffered with Borax. Part of the catch was removed for biochemical analyses prior to fixation. Specimens were identified as far as possible, counted and frozen at -80°C for further analysis in home laboratories. Euphausia superba were also caught occasionally and transferred to aquaria for physiological experiments. Foraminifer numbers of the upper water column were determined from the Multi net as well in order to supplement the biological sea ice work.

A close association of E. superba with sea ice was observed during the entire track through the ice. Larger numbers of small adult krill were swept on to the ice by overturning ice chunks during ice breaking. Several samples were collected. Krill (adult and Furcilia larvae) were also collected during coring operations. We believe that they were living in voids between rafted ice floes. These observations suggest that E. superba graze on the sea ice algae and possibly also use the voids in the ice for protection.

2.5.4 Mammal and seabird observations (AWI)

Counts of warm blooded animals were made during the entire cruise. A helicopterflight around Bouvet Island yielded the following approximate numbers:

1000	Fur Seals	(Arctocephalus gazelle)
50	Elephant Seals	(Mirounga leonina)
1000	Southern Giant Petrels	(Macronectes giganteus)
50 000	Southern Fulmars	(Fulmar glacialoides)

No penguins were seen.

Beginning at the ice edge, countings were done daily for 8 hours. Species observed in the ice were:

- Antarctic Petrel (Thalassoica antarcticus)
- Snow Petrel (Pagadroma nivea)
- Chinstrip penguin (Pygoscelis antarctica)
- Adelie penguin (Pygoscelis adeliae)

- Emperor penguin	(Aptenodytes forsteri)
- Crabeater seal	(Labodon carcinophagus)
- Ross seal	(Ommatophoca rossi)
- Weddell seal	(Leptonychotes weddelli)
- Minke whale	(Balaenoptera acutorostrata)
- Orca whale	(Orcinus orca)

A total of 650 Chinstrip penguins was seen at the ice edge. They were not observed in the heavier pancake-ice or in the pack-ice. A large number of Antarctic Petrels and Snow Petrels (up to 1000 individuals per day) were counted. The numbers decreased rapidly further to the south where the consolidated ice covered the sea surface. However, scattered individuals of both species were seen throughout the cruise. The southern Giant Petrel, the Southern Fulmar, and the Cape Pigeon (Daption capense) practical stopped to appear south of the ice edge. Adelie penguins first occured in the consolidated pancake ice. They were limited to the zone between 58°S and 66°S. A maximum number of 236 Adelies out of a total of 503 were seen at 63° within a period of 4 days.

The distribution of Emperor penguins was probably determined by the breeding season. A total number of 96 was seen between 63°S and 69°S near the breeding colonies.

Two maxima occurred, one at 65°S (29 individuals) and one at 69°S (27 individuals). Only one juvenile Emperor was seen at 61°S.

Emperor penguins not observed further to the north. Eleven skatsamples showed that the Emperors had eaten mainly krill. Crabeater seals were scattered between 61°S and 68°S. A total of 129 individuals were counted during the cruise. Eightyfour crabeater seals were observed at 63°S preferably in ridged pack-ice.

One Ross seal was seen at 59°S while one Weddell seal at 69°S. Six seals which could not be identified in more detail were lying on large pancakes at the ice edge. Twenty nine minke whales were observed during the entire cruise leg. A maximum number of 15 appeared near 63°S. An enhanced number of several bird and mammal species occupied the area near 63°S. Actually no explanation is available for this observational fact.

2.5.5 Sea ice bacteria (AWI)

The main objective of this investigation was to study the distribution, abundance, diversity, and activity of the bacterial population of the sea ice biota during winter. With regard to the diminished primary production of the algae causing nutrient deficiency, together with low temperatures, causing for example high salinities in the brine channels of the sea ice, our interest was focussed on the formation of bacterial populations during this season in the micro-habitat. Additionally, we wanted to clarify to what extent the heterotrophic activity of the bacteria will be affected. Therefore, efforts were mainly directed towards cultivation and isolation of these microbes by applying various culture conditions as well as to prove bacterial activity within the ice or of the bacterial population of the sea ice.

In some cases samples of brown ice layers caused by an enrichment of diatoms could be collected. Generally ice core samples were collected with the aid of auger at 22 stations distributed between 56°S and 69°20'S. For the bacteriological processing of the cores with lengths between 30 and 110 cm, vertical sections of ice were preserved for determinations of total counts and bacterial biomass. Additionally, immediate cultivations were done by applying solid and fluid media for viable counts in order to compare the ratios of these counts later on.

Similar to the ice studies we have treated water samples from immediately under the ice. Attempts to prove the activity stage of the bacterial population within the sea ice were carried out as well as determinations of uptake rates of 14C-Glucose and 3H-Leucine.

Preliminary results indicate low activity of ice bacteria in most cases. However, at the ice edge, the uptake rates of the ice population per volume exceeded those of the water. Raised activity was observed in ice layers with distinct diatom colouration. Similar results were obtained for the activity of the extracellular enzymes (phosphatases, proteases, glucosidases) by applying methylumbelliferyl derivates and flourophotometry.

In order to characterize the biomass of the whole community extractions of adenosinetriphosphate (ATP) were performed from ice and water samples. Growth experiments suggested that the predominant proportion of the ice bacteria is optimally growing under normal water conditions. Therefore, they seem not to be adapted to the high salinities of the brine pockets. Slight growth, however, was obtained in a brine of 105 $^{o}/oo$ salinity.

The bacteriological processing with respect to the ecophysiological and taxonomical characterization of representative isolates of most of the cultures performed during the cruise provide information on the extent of the adaptation to the ice habitat.

To investigate the low temperature adaptation of Antarctic ice bacteria and the fate of the ice organisms during melting in spring and summer, experiments were conducted to determine the tolerance or adaptation of the bacteria to increased hydrostatic pressure.

2.6 The Ship's Meteorological Office

The ship's meteorological office provided six surface observations and three upper air soundings daily for transmission into the Global Telecommunication System (GTS). These observations from an area of low data density are of great importance for forecast models of the southern hemisphere.

The surface analysis of this office formed the basis of the daily weather forecast on board and of the meteorological service to the helicopter pilots. In total 69 flights weather reports were issued. The surface analyses and daily forecasts gained in accuracy and reliability when the networkof surface buoys considerably improved the data basis. A daily data set from about 10 buoy stations covering the entire pack-ice belt, frequent satellite images, several radiosonde launches per day and data from antarctic stations provide a reasonable data set. Daily maps from the global modell of the British Meteorological Office, Bracknell, and from the European Centre for Medium Range Weather Forecasts, Reading were used as an additional valuable data source.

The daily weather maps will be made available to all participants of the cruise.

2.7 Stationsliste/Station list

Date Datum 1986	Stat. No.	Time Uhrzeit (GMT)	Position		Depth Lottiefe (m)	Heading Kurs	Speed Geschwindig-keit	Station work/ Equipment applied Arbeiten/Geräte
29.06.	156	11.30-19.47	44°26.0'S	51°04.4'W	5662	320°	stop	CTD deep *), MN
01.07.	157	10.52	47°27.6'S	44°24.9'W	5686	125°	7.13	XBT
	158	13.44	47°42.4'S	43°52.7'W	5814	128°	8.23	XBT
	159	16.40	47°56.4'S	43°18.5'W	5712	128°	7.10	XBT
	160	19.45	48°09.3'S	42°43.7'W	5714	136°	9.10	XBT
	161	21.44	48°19.8'S	42°21.2'W	5884	143°	10.2	XBT
	162	22.46	48°27.2'S	42°11.0'W	5600	129°	9.42	XBT
02.07.	163	00.45	48°38.3'S	41°46.7'W	5717	120°	6.54	XBT
	164	02.42	48°47.3'S	41°27.0'W	5722	118°	6.85	XBT
	165	04.42	48°57.4'S	41°01.8'W	5496	120°	7.31	XBT
	166	06.47	49°07.8'S	40°33.5'W	5152	130°	7.2	XBT
	167	08.46	49°19.5'S	40°07.6'W	5469	135°	9,8	XBT
	168	10.43	49°29.3'S	39°46.9'W	3262	130°	6.81	XBT
	169	12.46	49°38.8'S	39°24.8'W	4174	130	7.22	XBT
	170	14.46	49°50'S	39°01'W	4620	123	8.50	XBT
	171	17.50	50°07.2'S	38°19.8'W	5061	117	5.8	XBT
	172	20.48	50°23.4'S	37°40.3'W	5059	114°	6,5	XBT
	173	23.44	50°36.2'S	36°53.6'W	5008	130°	8.88	XBT
	174	02.45	50°54'S	36°22'W	4941	130°	7.20	XBT
	175	05.45	51°11.4'S	35°44.1'W	4900	125°	7.2	XBT
	176	08.45	51°26.9'S	37°07.7'W	4838	119°	5.1	
	177	11.43	51°40.7'S	34°33.0'W	4708	123°	7.57	XBT
	178	14.43	51°57'S	33°58'W	2632	123°	7.56	XBT
03.07.	179	17.45	50°10.5'S	33°18.2'W	1816	125°	6.90	XBT
	180	20.42	52°27.3'S	32°38.1'W	2360	125°	9.1	XBT
	181	23.42	52°41.6'S	32°00.3'W	3518	130°	9.86	XBT
04.07.	182	02.56	52°58.2'S	31°20.3'W	3577	120°	9.84	XBT
	183	05.45	53°13.0'S	30°42.6'W	3769	124°	9.8	XBT
	184	08.45	53°29.5'S	29°59.6'W	3926	130°	9.6	XBT
	185	15.20	55°15.5'S	22°53'W	5440	260°	stop	1. Met. buoy deployed
06.07.	186	11.03	52°27.2'S	16°27.8'W	4145	54°	15.0	XBT
	187	13.46	52°03'S	15°34'W	4142	54°	14.6	XBT
	188	16.45	51°36.2'S	14°35.9'W	3538	50°	14,3	XBT
	189	19.45	51°08.6'S	13°36.2'W	3662	50°	14,7	XBT
	190	22.44	50°41.4'S	12°37.3'W	3115	50°	14.7	XBT
07.07.	191	01.57	50°11.4'S	11°33.9'W	3497	53°	15.0	XBT
	192	04.45	49°46.1'S	10°40.9'W	34,94	57°	15.1	XBT
	193	07.44	49°19.7'S	09°45.7'W	3055	60°	15.3	XBT
	194	10.46	48°57.9'S	08°48.4'W	2374	50°	13.0	XBT
	195	13.55	48°32'S	08°03'W	3593	50°	13.5	XBT
	196	16.52	48°07.8'S	07°16.4'W	3497	50°	13.6	XBT
	197	19.45	47°43.9'S	06°30.9'W	3332	55°	14.7	XBT
	198	22.45	47°17,5'S	05°36.5'W	3612	53°	15.4	XBT
08.07.	199	01.42	46°52.5'S	04°45.8'W	3971	50°	15.2	XBT
	200	04.48	46°24.0'S	03°51.3'W	4153	53°	15.3	XBT
	201	07.40	45°57.8'S	02°59.3'W	4282	52°	15,2	XBT
	202	10.43	45°29.9'S	02°05.5'W	3646	54°	15.3	XBT
	203	13.45	45°03'S	01°13' W	4234	50°	15.2	XBT
10.07.	204	10.05	38°27'S	10°45.3'E	5229	50	14.7	XBT

Date Datum 1986	Stat. No.	Time Uhrzeit (GMT)	Position	Depth Lottiefe (m)	Heading Kurs	Speed Geschwindig-keit	Station work/ Equipment applied Arbeiten/Geräte
10.07.	205	11.49	38°15.4'S 11°05.6'E	5211	52°	14.7	XBT
	206	15.02	37°44'S 11°58'E	5070	52°	14.7	XBT
	207	18.00	37°19.6'S 12°39.9'E	5030	52°	15.2	XBT
	208	20.58	36°52.8'S 13°22.0'E	4928	55°	14.5	XBT
	209	23.55	36°27'S 14°07'E	4869	59°	14.5	XBT
11.07.	210	03.00	36°02'S 14°50'E	4811	59°	14.5	XBT
	211	05.56	35°38.3'S 15°30.0'E	4675	59°	15.1	XBT
	212	08.58	35°11.4'S 16°14.9'E	4224	55°	15.0	XBT
	213	12.00	34°42'S 17°10'E	2708	47°	15.0	XBT
	214	15.00	34°18'S 17°47'E	3570	48°	15.0	XBT
16.07.	215	18.00	55°02.3'S 02°29.7'E	3569	215°	13.4	XBT
	216	19.24	55°14.2'S 02°14.3'E	3239	213°	10.7	XBT
	217	21.03	55°30.2'S 02°00.2'E	3744	215°	10.8	XBT
	218	22.50	55°46.1'S 01°40.8'E	3949	212°	10.7	XBT
17.07.	219	00.06	55°56.5'S 01°29.3'S	3827	216°	10.7	XBT
	220	01.32	56°10'S 01°14'E	4151	217	11.0	XBT
	221	03.00	56°23'S 00°57'E	3837	210°	11.0	XBT
	222	04.30	56°36.0'S 00°42.8'E	4555	212°	8.4	XBT
	223	05.59	56°47.1'S 00°32.0'E	4668	216°	8.7	XBT
	224	07.32	56°58.0'S 17.7'E	3873	216	8.0	XBT
	225	08.00-09.30	56°59.9'S 00°15.0'E	3850	215°	stop	2. Met. buoy deployed, Pitch- and Rollbuoy
	226	10.16	57°09.3'S 00°10.5'E	4234	212°	10.35	XBT
	227	10.33	57°12.9'S 00°06.7'E	4299	212°	10.35	XBT
	228	11.29	57°24.3'S 00°05.1'W	3917	205°	13.3	XBT
	229	12.30	57°34'S 00°18'W	4457	201°	13.0	XBT
	230	13.29	57°45'S 00°26'W	4261	200°	13.0	XBT
	231	14.20	57°56'S 00°32'W	4139	203°	13.3	XBT
	232	15.08	58°06'S 00°40'W	4507	200°	13.3	XBT
	233	16.04	58°17.8'S 00°49.0'W	4776	203°	13.4	XBT
17.07.- 18.07.	234	17.09-05.12	58°30.0'S 00°59.9'W	4750	252°	stop	CTD, shallow 2 GERARD-SERIES, CTD, deep, MN
	235	06.27	58°41.0'S 00°57.5'W	4152	183°	9.8	XBT
	236	07.24	58°50.3'S 00°59.8'W	4772	185°	9,4	XBT
	237	08.22	59°00.2 S 00°59.9'W	5264	181°	12.9	XBT
	238	10.11-14.51	59°00.0'S 01°00.4'W	5280	180°	stop	CTD,deep,MN,Pitch- and rollbuoy
	239	15.19	59°10.3'S 01°00.1'W	5050	181°	10,4	XBT
	240	17.12	59°19.9'S 00°59.8'W	5032	184°	10.5	XBT
	241	18.20-21.51	59°29.9'S 00°59.7'W	4709	262°	stop	CTD, deep, "Dieckmann-Net"
	242	23.01	59°40.0'S 00°57.7'W	5392	186°	10.6	XBT
	243	23.54	59°49.7'S 00°58.8'W	5380	186°	10.6	XBT
19.07.	244	01.23	60°01'S 01°01'W	5381	181°	10.5	XBT
	245	02.34	60°11.1'S 01°00.1'W	5349	180°	11.0	XBT
	246	03.13	60°20.5'S 01°01.6'W	5378	175°	11.0	XBT
	247	04.26	60°30.1'S 00°59.9'W	5369	65°	stop	CTD, shallow
	248	06.53	60°40.4'S 01°00.0'W	4885	179°	11.1	XBT
	249	07.24	60°45.0'S 00°59.9'W	5221	234	stop	Pitch- and Rollbuoy
	250	10.00	60°56.5'S 01°00.9'W	5382	180°	10.5	XBT
	251	10.32-12.34	60°59.7'S 00°59.9'W	5376	170°	2.4	3. Met. buoy deployed, CTD, deep APSN, Pitch- and Rollbuoy
	252	17.18	60°13.6'S 01°00.2'W	5300	186°	8.1	XBT

Date Datum 1986	Stat. No.	Time Uhrzeit (GMT)	Position	Depth Lottiefe (m)	Heading Kurs	Speed Geschwindig-keit	Station work/ Equipment applied Arbeiten/Geräte
19.07.	253	17.36	61°15.1'S 01°00.1'W	5293	180°	stop	Pitch- and rollbuoy
19.07.- 20.07.	254	20.30-08.24	61°29.5'S 00°58.5'W	5342	0°	stop	2 Gerard-Series, MN, CTD, de
	255	11.04-19.03	61°59.1'S 01°00.8'W	5342	153°	stop	"Martinson-buoy", Incestatic CTD, deep, CTD shallow, APSN
-21.07.	256	21.48-07.26	62°29.1'S 01°01.0'W	5321	60°	stop	Gerard-Series, MN CTD, deep, CTD, shallow
	257	09.02	62°39.8'S 01°12.1'W	5314	243°	stop	CTD, shallow
	258	10.46	62°45.4'S 01°16.3'W	5313	220°	stop	CTD, shallow
	259	13.30-17.45	62°53.7'S 01°16.1'W	5301	175°	stop	Icestation, CTD, deep, LSM, 4. Met. buoy deployed
-22.07.	260	21.33-03.28	62°55.2'S 02°01.3'W	5279	195°	stop	MN, CTD, deep, current meter
	261	04.29	62°54.3'S 02°14.7'W	5280	271°	6.1	XBT
	262	05.10	62°54.2'S 02°27.2'W	5278	271°	6.9	XBT
	263	06.17-11.24	62°55.0'S 02°43.2'W	5276	321°	stop	CTD, deep, current meter
	264	13.33	63°07.1'S 02°28.8'W	5261	125°	stop	CTD, shallow
	265	16.36	63°23.4'S 02°14.6'W	5232	95°	stop	CTD, shallow
-23.07.	266	19.36-07.13	63°39.2'S 02°01.9'W	5215	148°	stop	CTD, shallow, CTD, deep 2. Gerard-Series, MN
	267	09.12-10.47	63°47.4'S 02°14.4'W	5187	163°	stop	5. Met. buoy depl., CTD, sha
	268	12.41-15.00	63°56.3'S 02°25.5'W	5184	115°	stop	APSN, Icestation, LSM, CTD
	269	17.02	64°02.5'S 02°16.3'W	5166	186°	stop	CTD, shallow
-24.07.	270	20.29	64°10.2'S 02°01.2'W	5169	56°	stop	CTD, deep
	271	02.16	64°18'S 01°46'W	5145	175°	stop	CTD, shallow
	272	04.10-04.20	64°24.9'S 01°29.9'W	5127	128	stop	CTD, shallow
	273	06.07	64°33.9'S 01°43.1'W	5118	120°	stop	CTD, shallow
	274	07.50-12.56	64°41.1'S 01°56.6'W	5123	125°	stop	MN, CTD, deep, Pitch- and Rollbuoy, BO
	275	14.00-17.34	64°45.9'S 02°11.4'W	5056	145°	stop	Work on a floe, CTD,shallow,
	276	19.06	64°55.3'S 02°31.0'W	5049	119°	stop	CTD, shallow
	277	21.23	65°02.4'S 02°12.9'W	4997	161°	stop	CTD, shallow
-25.07.	278	23.44-07.01	65°11.6'S 02°02.7'W	4984	60°	stop	Gerard-Series,CTD,deep,DCP,M
	279	09.34	65°23.2'S 02°32.6'W	4973	317°	stop	CTD, shallow
	280	14.11-16.00	65°36.9'S 02°59.9'W	4894	110°	stop	CTD, deep, Icestation, "Apstein-Net", LSM
	281	21.00-23.11	65°54.4'S 03°36.8'W	4867	251°	stop	6.Met. buoy depl., CTD, shal
26.07.	282	03.09	66°09.7'S 03°03.7'W	4617	113°	stop	CTD, shallow
	283	07.20	66°23.4'S 02°34.2'W	4575	141°	stop	CTD, shallow
	284	12.00-23.54	66°38.0'S 02°04.2'W	4787	162	stop	2 Ger.Series, APSN,MN CTD,de lightmeasurement, Icestation
27.07.	285	05.51	66°19.8'S 01°05.0'W	4540	173°	stop	CTD, deep
	286	13.53-16.38	66°00.2'S 00°16.6'W	3870	210°	stop	CTD, deep, LSM, Icestation,A
-28.07.	287	21.37	65°40.2'S 00°44.6'W	3209	114°	stop	CTD, deep
28.07.	288	02.41	65°27.9'S 01°11.4'E	3093	48°	stop	OMEGA-Sonde
	289	03.45	65°25.7'S 01°21'E	3069	480°	stop	OMEAGA-Sonde
	290	04.45	65°22.3'S 01°30'E	2968	48°	stop	OMEGA-Sonde
-01.08.	291	05.30-22.45	65°21.9'S 01°30.9'E	2954	88°	stop	Drift station with: 2.CTD,de Transponderarray, MN, APSN, 3 Smart-CTD's, Icestation Gerard Series, 7. Met. buoy deployed
02.08.	292	04.10	65°01.9'S 03°53.2'E	2798	220°	stop	CTD, deep,

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02.08.	293	11.59-14.30	64°30.0'S	04°22.6'E	2890	320°	stop	CTD, deep, DCP, APSN, LSM, Icestation
-03.08.	294	21.29-01.48	64°0.8'S	04°59.2'E	3817	354°	stop	8. Met. buoy deployment, CTD, deep, MN
	295	03.47	64°09'S	05°19'E	3710	180°	stop	CTD, shallow
	296	05.51	64°17.3'S	05°38.1 E	4044	201°	stop	CTD, shallow
	297	08.06-11.25	64°24.6'S	05°53.4'E	4059	300°	stop	CTD, deep, Icestation
	298	14.55	64°36.6'S	06°18.8'E	2599	243°	stop	CTD, shallow
	299	17.36	64°43.4'S	06°36.8'E	2867	265°	stop	CTD, shallow
	300	20.43	64°52.0'S	06°56.4'E	4861	310°	stop	CTD, deep
04.08.	301	02.10	65°01.9'S	07°18.3'E	4852	235°	stop	CTD, shallow
	302	05.30	65°11.2'S	07°39.2'E	4807	187°	stop	CTD, shallow
	303	09.00-19.38	65°19.9'S	07°56.7'E	4789	281°	stop	Icestation, CTD, deep, MN 2 Gerard Series, APSN Current meter
	304	22.10	65°29.1'S	07°40.0'E	4767	210°	stop	CTD, shallow
05.08.	305	01.21	65°37.0'S	07°23.9'E	4643	330°	stop	CTD, shallow
	306	04.43	65°48.5'S	07°00.0'E	4571	221°	stop	CTD, deep
	307	10.12	65°55.3'S	06°41.5'E	4309	263°	stop	CTD, shallow
	308	13.24-15.50	66°03.9'S	06°26.0'E	4125	245°	stop	CTD, shallow, APSN, Icestation Current meter
	309	19.40	66°12.5'S	06°05.5'E	3954	201	stop	CTD, deep
06.08.	310	02.35	66°22.2'S	05°41.3'E	4233	235°	stop	CTD, shallow
	311	05.32	66°30.8'S	05°22.1'E	4236	241°	stop	CTD, shallow
	312	08.30-14.04	66°39.4'S	04°59.6'E	4137	283°	stop	CTD, deep, APSN, LSM, MN Icestation Gerard Series
	313	19.06-22.44	67°02.1'S	04°13.1'E	3815	231°	stop	9. Met. buoy deployed, CTD, deep
07.08.	314	04.21	67°22.9'S	03°23.4'E	3286	244°	stop	CTD, deep
	315	12.18-15.50	67°46.8'S	02°39.2'E	4534	225°	stop	Icestation, CTD deep, APSN, MN
	316	22.45	68°07.3'S	01°50.1'E	4496	294°	stop	CTD, deep
08.08.-13.08.	317	11.00-19.10	68°26.2'S	01°04.3'E	4361	306°	stop	Driftstation with: Icestations Transponderarray, OMEGA-Sonde, Radio-Sonde, 2 CTD, deep, MN 2 Gerard Series 10. Met. buoy deployed
14.08.	318	00.08-02.05	69°06.9'S	00°04.3'E	3261	185°	stop	11. Met buoy deployed, CTD, shallow
	319	10.51	69°20.0'S	00°07.3'W	2158	328°	stop	Gerard Series, Icestation, CTD, deep, LSM, MN
-15.08.	320	20.41-11.00	69°28.8'S	00°22.3'W	1858	240°	stop	CTD, deep, Icestation
16.08.	321	00.58-11.30	69°18.4'S	01°03.7'W	2250	340°	stop	CTD, deep, Icestation 12. Met. bouy deployed
17.08.	322	17.40	69°04.9'S	03°31'W	3506	19°	stop	CTD, deep
18.08.	323	05.06.	69°08.2'S	04°03.9'W	3455	18°	stop	CTD, deep
19.08.	324	00.45	68°46.5'S	04°15.3'W	3241	16°	stop	CTD, deep
	325	10.25	68°39.2'S	03°37.4'W	3766	66°	stop	13. Met. buoy deployed, CTD, shallow, MN, CTD, deep
	326	19.03-23.47	68°23.6'S	02°46.8'W	4204	80°	stop	CTD, shallow, CTD, deep, MN
20.08.	327	04.48	67°59.8'S	01°50.5'W	4418	73	stop	CTD, deep
	328	12.30	67°40.3'S	02°01.0'W	4454	180°	stop	Work on a floe

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-21.08.	329	21.45-04.20	67°35.5'S 00°51.4'W	4596	148°	stop	Gerard Series, CTD, deep
	330	07.40	67°23.1'S 00°23.7'W	4655	78°	stop	CTD, shallow
	331	11.05-17.00	67°11.1'S 00°01.0'W	4677	151°	stop	CTD, deep, Icestation, LSM Gerard Series
	332	20.11-21.14	66°59.8'S 00°25.8'E	4657	128°	stop	CTD, shallow, MN
	333	22.56	66°52.5'S 00°39.6'E	4651	165°	stop	CTD, shallow
22.08.	334	00.49-04.17	66°47.8'S 00°51.8'E	4633	132°	stop	CTD, deep, VN
	335	05.43	66°41.8'S 01°04.9'E	4476	172°	stop	CTD, shallow
	336	08.10	66°36.2'S 01°16.6'E	4321	215°	stop	CTD, shallow
	337	10.31	66°29.1'S 01°29.1'E	4113	107°	stop	CTD, shallow
	338	13.04-14.30	66°23.1'S 01°37.5'E	4022	278°	stop	CTD, deep; Icestation, APSN
	339	17.18-18.43	66°18.0'S 01°54.7'E	3737	135°	stop	MN, LSM, CTD, shallow
	340	20.44	66°13.4'S 02°05.7'E	3445	146°	stop	CTD, shallow
	341	22.51	66°05.4'S 02°16.9'E	3057	213°	stop	CTD, shallow
23.08.	342	01.00	65°59.7'S 02°30.4'E	3147	200°	stop	CTD, deep
	343	04.38-05.15	65°52.3'S 02°31.3'E	3304	198°	stop	MN, CTD, shallow,
	344	08.30-12.00	65°45.5'S 02°31.5'S	3081	322°	stop	CTD, shallow, LSM, Icestatic
	345	15.55	65°36.8'S 02°34.7'E	2709	330°	stop	CTD, shallow
	346	17.42	65°31.2'S 02°31.8'E	2525	44°	stop	CTD, deep
	347	21.19-22.25	65°22.6'S 02°31.5'E	2141	101°	stop	MN, CTD, shallow
	348	00.06	65°14.7'S 02°33.1'E	1308	45°	stop	CTD, shallow
	349	02.40	65°07.3'S 02°31.3'E	1714	60°	stop	CTD, shallow
24.08.	350	04.50	65°09'S 02°31'E	1436	220°	stop	CTD, deep
	351	08.15-14.40	64°53.6'S 02°29.6'E	1753	221°	stop	MN,Icestation,CTD,shallow,AF
	352	16.16	64°46.2'S 02°46.7'E	2265	202°	stop	CTD, deep
25.08.	353	06.28	64°36.2'S 03°06.4'E	2211	133°	stop	CTD, shallow
	354	10.10-13.27	64°28.4'S 03°14.3'E	2178	336°	stop	CTD, shallow,Icestation,APSN
	355	15.21	64°23.5'S 02°59.4'E	2260	319°	stop	CTD, shallow
	356	17.42	64°18.2'S 02°46.5'E	2520	306°	stop	CTD, deep
	357	21.51	64°13.8'S 02°34.1'E	2392	333°	stop	MN, CTD, shallow
26.08.	358	00.36	64°08.6'S 02°19.7'E	2405	360°	stop	CTD, shallow
	359	02.35	64°04.2'S 02°07.2 E	2605	20°	stop	CTD, shallow, CTD, deep
	360	04.43	63°58.9'S 01°53.3'E	3014	50°	stop	CTD, deep
	361	08.45-09.45	63°54.9'S 01°39.3'E	3746	153°	stop	MN, CTD, shallow
	362	11.19	63°49.3'S 01°27.3'E	4620	23°	stop	CTD, shallow
	363	14.29-23.31	63°37.3'S 01°28.4'E	5239	175°	stop	Icestation, LSM, CTD, deep
27.08.	364	01.50-03.00	63°32.2'S 01°52.1'E	5120	240°	stop	MN, CTD, shallow, APSN
	365	05.18	63°27.3'S 02°18.1'E	4960	200°	stop	CTD, deep
	366	10.52-11.44	63°21.8'S 02°41.8'E	4841	51°	stop	VN, CTD, shallow
	367	14.00-17.14	63°18.3'S 03°07.4'E	5000	290°	stop	Icestation,CTD,deep,LSM,APSN
	368	19.45-21.07	63°07.0'S 03°18.7'E	5249	250	stop	MN, CTD, shallow
-28.08.	369	23.30-05.31	62°56.5'S 03°34.7'E	5349	180°	stop	CTD, deep, ETA-Station
	370	08.09-13.20	62°46.3'S 03°43.0'E	5349	186°	stop	CTD, shallow, MN, Icestatior
	371	17.14	62°33.9'S 03°54.5'E	5344	70°	stop	CTD, deep
	372	23.00	62°30.5'S 04°07.3'E	5346	132°	stop	CTD, shallow
29.08.	373	01.30	62°25.8'S 04°23.5'E	5353	140°	stop	CTD, shallow
	374	03.31	62°21.8'S 04°33.2'E	5344	88°	stop	CTD, shallow
	375	06.08-11.05	62°15.8'S 04°48.1'E	5333	184°	stop	CTD, deep, APSN, Icestation, MN, LSM
	376	12.36	62°11.6'S 05°0.1'E	5336	154	stop	CTD, shallow
	377	14.45	62°07.7'S 05°12.7'E	5350	150°	stop	CTD, shallow

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29.08.	378	16.54	62°03.7'S 05°25.1'E	5356	83°	stop	CTD, shallow
	379	19.15-23.10	61°58.6'S 05°38.4'E	5262	227°	stop	CTD, deep, MN
30.08.	380	07.01-08.49	61°25.5'S 06°59.4'E	5343	62°	stop	14. Met. buoy deployed, CTD, shallow
-03.09.	381	11.00-07.20	61°29.9'S 06°31.9'E	5350	167°	stop	Driftstation with: APSN, 2 MN 2 Gerard Series, 2 CTD, deep Icestations Transponderarray (incl. 1 OMEGA-Sonde)
	382	08.25-03.30	61°18.6'S 07°27.9'E	5330	284°	stop	Icestation
	383	16.04-17.48	61°07.7'S 07°27.9'E	5346	115°	stop	CTD, deep, Icestation
04.09.	384	00.09-04.36	60°00.0'S 07°15.7'E	5380	162°	stop	CTD, deep, Icestation, MN
	385	06.51	60°14.8'S 07°08.0'E	5366	348°	stop	Icestation
	386	10.48-14.11	59°59.8'S 07°02.4'E	5336	241°	stop	Icestation, CTD deep, APSN
	387	15.09	59°55.8'S 07°03.6'E	5066	150°	stop	
	388	17.50	59°45'S 6°55'E	5095	344°	stop	Icestation
05.09.	389	20.45-01.04	59°29.7'S 6°50.1'E	5354	188°	stop	Icestation, CTD, deep, MN
	390	06.24	59°15.1'S 6°43.3'E	5313	310°	stop	Icestation
	391	10.17-14.16	58°58.2'S 06°42.3'E	5380	162°	stop	CTD, deep, Icestation, APSN
	392	19.28-23.24	58°29.9'S 06°26.1'E	5328	144°	stop	CTD, deep, Icestation, MN
06.09.	393	02.15-02.22	58°14'S 06°18'E	5070	340°	stop	Icestation
	394	04.44-08.59	57°59.6'S 06°13.1'E	2327	241°	stop	CTD, deep, IOS-buoy
	395	11.00	57°44.6'S 06°06.2'E	5210	117°	stop	IOS-buoy
	396	13.33-20.05	57°29.8'S 06°01.1'E	4969	118°	stop	IOS-buoy, CTD, deep; APSN, MN
	397	21.39	57°07.6'S 06°18.8'E	5327	13°	8.5	XBT
07.09.	398	23.02-04.47	56°59.3'S 06°24.4'E	5006	100	stop	MN, CTD, deep
	399	06.13	56°40.0'S 06°35.2'E	4978	005°	8,7	XBT
	400	07.30-09.48	56°29.2'S 06°40.6'E	4906	91°	stop	MN, CTD, shallow, 2 APSN
	401	13.45-14.04	55°50.1'S 07°08.9'E	4526	250°	stop	Wave rider buoy
	402	14.51-17.23	55°50.3'S 07°09.9'E	4502	170°	stop	2 Wave rider buoy
	403	18.42	55°40.5'S 07°15.2'E	4291	356°	8,4	XBT
	404	20.09	55°29.8'S 07°15.2'E	4826	276°	stop	CTD, deep
08.09.	405	00.33	55°38.0'S 07°16.2'E	4961	200°	7.3	XBT
	406	01.54	55°44.0'S 07°15.0'E	4430	270	stop	CTD, shallow,
	407	03.55	55°49.9'S 07°17.3'E	4547	265	5.2	XBT
	408	04.12	55°50.1'S 07°15.3'E	4476	274	stop	SODAR station, DCP
	409	06.05-08.34	55°54.8'S 07°16.7'E	4707	271°	stop	CTD, shallow,Wave riderbuoy
	410	10.25-11.46	56°05.1'S 07°15.8'E	5083	270°	stop	Wave rider buoy, CTD, shallow
	411	12.59	56°13.0'S 07°17.2'E	3880	195°	8.5	XBT
	412	14.14-15.34	56°21.3'S 07°15.2'E	4166	270°	stop	Wave rider buoy, CTD, shallow
	413	16.44-18.03	56°28.2'S 07°15.3'E	4773	280°	stop	Wave rider buoy, CTD, shallow, APSN, XBT
08.09.	414	18.51	56°35.3'S 07°16.5'E	3454	196°	8.9	XBT
	415	19.22	56°39.3'S 07°16.5'E	4427	185°	8.5	XBT
	416	20.46	56°49.9'S 07°15.4'E	5132	161°	stop	CTD, shallow
	417	22.30	56°58.0'S 07°15.8'E	4617	187°	7.9	XBT
	418	23.41	57°05.2'S 07°16.9'E	5155	200°	stop	CTD, shallow
09.09.	419	01.40	57°11.9'S 07.16.6'E	4976	190°	6.5	XBT
	420	03.00	57°19.7'S 07°13.3'E	4919	196°	stop	CTD, shallow
	421	05.02	57°27.8'S 07°13.8'E	5066	169°	8.2	XBT
	422	06.09-07.33	57°34.3'S 07°14.7'E	5680	200°	stop	Wave rider buoy, CTD, shallow
	423	09.38	57°19.9'S 07°08.9'E	5003	221°	stop	Wave rider buoy

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09.09.	424	11.48	57°19.5'S 07°12.0'E	4898	008°	5.1	XBT
	425	12.59	57°10.1'S 07°15.9'E	4184	347°	9.0	XBT
	426	13.45-14.45	57°03.3'S 07°10.4'E	5246	265°	stop	Wave rider buoy, MN
	427	15.15	56°58.0'S 07°11.0'E		360	8.5	XBT
	428	16.33-17.33	56°49.7'S 07°10.3'E	5178	236°	stop	Wave rider buoy, XBT
	429	18.51	56°39.3'S 07°14.3'E	4215	139.6°	11	XBT
	430	19.30	56°34.8'S 07°14.0'E	3589	4215	11	MN
	431	21.38	56°29.6'S 07°15.9'E	4984	358°	5.7	XBT
	432	22.50-23.52	56°19.9'S 07.15.4'E	3875	355°	stop	XBT
	433	01.32	56°09.6'S 07°14.8'E	5025	2°	5,8	XBT
	434	02.06	56°06.5'S 07°14.7'E	5081	16°	stop	MN
11.09.	435	08.25	52°48.0'S 08°35.3'E	2957		8.5	XBT
	436	10.21	52°29.8'S 08°47.6'E	3416	20°	11.1	XBT
	437	11.21	52°19.5'S 08°54.1'E	3766	18°	11.6	XBT
	438	12.11	52°10.0'S 09°00.3'E	3946	18°	11.1	XBT
	439	14.08	51°48.0'S 09°11.0'E	3934	20°	11.1	XBT
	440	15.00	51°37.9'S 09°17.2'E	3972	20°	11.0	XBT
	441	16.10	51°25.4'S 09°24.8'E	4164	20°	11.1	XBT
	442	17.05	51°15.5'S 09°30.9'E	4297	20°	11.5	XBT
	443	18.05	51°06.1'S 09°37.2'E	4080	18°	11.4	XBT
	444	19.00	50°56.4'S 09°42.3'E	4002	15°	11.3	XBT
	445	20.25	50°40.2'S 09°50.9'E	4305	20°	11.7	XBT
	446	21.03	50°33.2'S 09°54.8'E	4106	20°	12.1	XBT
	447	22.33	50°20.6'S 10°02.1'E	4359	20°	11.1	XBT
	448	23.29	50°10.7'S 10°08.2'E	3864	20°	11.1	XBT
12.09.	449	00.06	50°01.3'S 10°14.4'E	4084	20°	11.0	XBT
	450	01.08	49°49.3'S 10°21.1'E	3981	20°	11.1	XBT
	451	02.00	49°41.9'S 10°25.1'E	4033	20°	11.1	XBT
	452	03.05	49°30.6'S 10°31.9'E	4259	20°	10.7	XBT
	453	04.03	49°20.8'S 10°36.8'E	4000	16°	10.9	XBT
	454	05.03	49°11.1'S 10°41.9'E	3728	17°	10.5	XBT
	455	06.02	49°01.5'S 10°47.3'E	3833	19°	10.3	XBT
	456	07.03	48°51.6'S 10°53.1'E	3592	18°	10.3	XBT
	457	08.15	48°39.7'S 10°58.5'E	3779	20°	10.1	XBT
	458	10.48	48°08.9'S 11°16.8'E	4297	20°	8.5	XBT
	456	16.14	47°49.4'S 11°27.4'E	4550	17°	4.0	XBT

CTD (Rosette incl.)
Smart-CTD = Hand-CTD (ODEC-CTD)
MN = Multi net
BO = Bongo
VN = Vertical net
APSN = Apstein net
LSM = Light sonde measurement
DCP = Doppler current profiler

3. Fahrtabschnitt ANT V/3 (Kapstadt - Kapstadt)

3.1 Zusammenfassung und Fahrtverlauf (G. Hempel)

Das Arbeitsgebiet von FS "Polarstern" während des zweiten Teiles des WWSP'86 war weit gesteckt, von der Nordgrenze des winterlichen Packeisgürtels in der Westwind-Drift bei 59°S bis in die südöstliche Weddell-See bei 77°S. Anfang Oktober und Anfang Dezember wurde auf zwei Meridionalschnitten durch den Packeisgürtel vom Meereisrand bis zur Schelfeiskante gearbeitet. Während der Hauptphase der Untersuchungen von Mitte Oktober bis Ende November konzentrierten sich die Arbeiten auf den Bereich des Schelfrandes mit der Küstenpolynya vor Vestkapp (72°S). Sie wurden unterbrochen durch zwei Exkursionen Ende Oktober und Mitte November in die südliche Weddell-See.

Die Expedition diente der Erfassung von

- Zusammensetzung und Produktivität des Phyto- und Zooplanktons sowie des Benthos und der Fischfauna unter winterlichen Eisbedingungen
- Verteilung und physikalischem Zustand des Meereises, seiner Besiedlung durch tierische und pflanzliche Organismen im Verlaufe des Spätwinters und Frühlings
- Fortpflanzungs- und Nahrungsbiologie von Weddell-Robben und Kaiserpinguinen
- Wassermassenverteilung und Struktur des antarktischen Küstenstromes
- thermischen und dynamischen Wechselwirkungen zwischen Wind, Eis- und Meeresoberfläche.

Über den ursprünglichen Plan hinaus bot die Expedition Gelegenheit zu interdisziplinären Untersuchungen im Packeisgürtel am Ostrand des Weddell-Wirbels und in der Grenzschicht zwischen Wassersäule und Meereis sowie zu einer großräumigen Zählung der Weddell-Robben und Kaiserpinguinen entlang der Küste der östlichen Weddell-See.

Die Aufklärung der Lage der neu entstandenen Filchner-Eisinseln und die Bergung von Strommesserketten auf dem Maud-Rücken verbunden mit ozeanographischen Stationen im gleichen Gebiet konnten angesichts der günstigen Eissituation als zusätzliche Aufgaben übernommen werden. Während 11 Wochen arbeiteten Wissenschaftler und Techniker aus deutschen (39 Personen) und ausländischen - insbesondere US-amerikanischen und niederländischen - Instituten (12 Personen) eng zusammen. Eine deutsch-niederländische Gruppe war 6 Wochen lang in der neuerrichteten "Drescher-Station" auf 72°S, 19°W mit biologischen und meteorologischen Untersuchungen beschäftigt.

Zwei auf dem Schiff stationierte Hubschrauber wurden für den Transport von Personen und Geräten zur "Georg-von-Neumayer-Station" und "Drescher-Station" für das Ausbringen von ARGOS

Bojen, zur Eisaufklärung, zur Vermessung der Filchner-Eisinseln und in besonders großen Umfange für die Zählung von Robben und Pinguinen eingesetzt.

Am 29. September verließ "Polarstern" Kapstadt, Südafrika, und nahm Kurs auf die "Georg-von-Neumayer-Station". Das Wetter verschlechterte sich schnell, ein Sturm verhinderte wiederum die schon auf dem vorigen Fahrtabschnitt geplante ozeanographische Station an der antarktischen Konvergenz (50°45'S, 9°20'O). Das erste Pfannkucheneis wurde am 4.10. bei 58°S erreicht, ab 60°S fuhr das Schiff durch eine anfangs noch von hoher Dünung stark bewegte Eisdecke. Selbst 200 Seemeilen südlich der Eisgrenze war die Dünung noch spürbar und die Eisdecke zu Schollen sehr unterschiedlicher Größe und Dicke zerborsten. Durch die Eisrandzone wurde ein planktologisch-ozeanographischer Schnitt mit 5 Stationen gelegt, die unterschiedliche Eisbedeckung vom freien Wasser bis zur ca. 50 cm dicken Eisdecke erfaßten. In seiner Verlängerung folgten in ca. 100 sm Abstand weitere Stationen durch den gesamten Packeisgürtel bis zur Atka-Bucht. Auf diesen Stationen wurden jeweils Eiskerne erbohrt, Phyto- und Zooplankton gesammelt und die vertikale Wassermassenverteilung untersucht.

Die Eisverhältnisse erlaubten meist eine kontinuierliche Fahrt von durchschnittlich 6 kn mit 3-4 Maschinen. Im zentralen Teil der Packeiszone querte "Polarstern" ein Feld Ost-West verlaufender Waken mit reger Neueisbildung. Weiter im Süden waren die freien Flächen mehr nord-südlich ausgerichtet und erleichterten das Vorankommen bis zur Küstenpolynya. Das Wetter war bei dieser ersten vollständigen Querung des winterlichen Packeisgürtels meist stürmisch mit Lufttemperaturen um -20°C.

Die Atka-Bucht wurde am 12.10. erreicht und die "Georg-von-Neumayer-Station" besucht. Durch eine bis zu 25 sm breite Küstenpolynya fuhr "Polarstern" anschließend zum Vestkapp. Acht meteorologische ARGOS-Bojen, von denen 7 während der ganzen Reise arbeiteten, wurden vom Schiff oder Hubschrauber auf großen driftenden Eisschollen in einem breiten küstenparallelen Streifen ausgebracht. Ferner konnten programmgemäß vier Strommesserketten im Küstenstrom südlich Vestkapp auf unterschiedlichen Tiefenstufen eines Schnittes senkrecht zur Schelfeiskante verankert werden. Zwei der Ketten wurden am Schluß der Reise bereits wieder geborgen. Eine Kette scheint verloren.

Bevor die systematische Bearbeitung des Vestkapp-Gebietes beginnen konnte, mußte die "Drescher-Station" am Nordufer des Drescher-Inlets auf dem Riiser-Larsen Schelfeis errichtet werden. Nach 36 Stunden regen Hubschrauber-Transports und intensiver Aufbauarbeit, an der Mitglieder der Schiffsbesatzung beteiligt waren, konnten die drei aus Fertigteilen zusammengesetzten Hütten von 5 (zeitweilig 6) Biologen und 2 Meteorologen bezogen werden. Sechs Wochen lang hat die Gruppe weitgehend unabhängig vom Schiff brut- und ernährungsbiologische Arbeiten an den Fortpflanzungsgemeinschaften der Weddell-Robben und Kaiserpinguine des Drescher-Inlets durchgeführt. Die Beobachtungen der Meteorologen lieferten Meßwerte über Aufbau und Dynamik der planetarischen Grenzschicht über dem Schelfeisrand und ergänzten die gleichzeitig durchgeführten Messungen vom Schiff und von den ARGOS-Bojen. Am Schluß der Arbeiten wurden die Hütten in funktionsfähigem Zustand und mit einem Vorrat an Generator-Treibstoff und Flugbenzin als Zwischenstation für Flugoperationen und als Basislager für weitere wissenschaftliche Arbeiten hinterlassen.

An den Aufbau der "Drescher-Station" schloß sich 16.-25.10. die erste Meßphase vor Vestkapp an. Sie bestand vor allem aus einer intensiven Bearbeitung des bis 38 sm langen Drescher-Schnitts, der vom Drescher-Inlet küstennormal von der Schelfeiskante über den Kontinentalhang bis auf ca. 3500 m Wasertiefe führte. Dabei wurde die Küstenpolynya, deren Bedeckung mit Neueis und alten Driftschollen von Tag zu Tag stark schwankte, gequert und in das Scholleneis der zentralen Weddell-See vorgedrungen. Ferner wurde auf einem langen Schnitt in der Polynya entlang der Schelfeiskante der Küstenstrom eingehend untersucht. Eisbohrungen und ozeanographisch-geochemische Stationen wechselten mit mageren Planktonfängen und reichen Bodentieraufsammlungen mit Grundschleppnetz und Agassiz-Trawl. Die Arbeiten des Schiffes wurden ergänzt durch wiederholte systematische Aufklärungsflüge zur Erfassung der variablen Eisverhältnisse in einem küstennormalen Streifen und der seewärtigen Verbreitung der Pinguine vor dem Drescher-Inlet.

Während dieser Phase der Expedition traten mit -32°C die niedrigsten Temperaturen der Reise auf. Sie bereiteten bei ozeanographischen Meßeinrichtungen z.T. erhebliche Schwierigkeiten.

Mit dem Weltrekord einer Secchi-Sichttiefe von 79 m und extrem niedrigen Chlorophyllwerten herrschte in der Wassersäule trotz günstiger Nährstoff- und Beleuchtungsverhältnisse tiefster Winter.

Um die Zeit bis zum biologischen Frühlingsanfang zu nutzen, wurde der für die Ozeanographen geplante Vorstoß des Schiffes nach Südwesten vorgezogen. Auf dem Wege wurden sehr unterschiedliche Eisverhältnisse angetroffen. Offene Polynyen wechselten mit Preßeisfeldern vor Küstenvorsprüngen. Immerhin gelangte "Polarstern" überraschend schnell bis vor den Dawson-Lambton-Gletscher. Dann verlor sich die Küstenpolynya und die Fahrt wurde immer stärker gehemmt, bis südlich von 76°30' das dicke Packeis ein weiteres Vordringen in den Filchnergraben unmöglich machte.

Am Nordostrande des Filchnergrabens wurde das Weddell-See Bodenwasser am Boden angetroffen. Es gab aber auch hier keinen Hinweis auf lokale Bildung von antarktischem Bodenwasser. So lieferte die Südexkursion nur allgemeine Beiträge zur winterlichen Ozeanographie und Biologie dieser von uns seit 1979 im Sommer regelmäßig besuchten Region.

Die Gelegenheit des weiten Vordringens nach Süden wurde genutzt, um auf zwei Hubschrauberflügen die kürzlich vom Filchner-Schelfeis abgelösten Eisinseln zu befliegen und der sowjetischen Bitte um Aufklärung des Schicksals der Sommerstation "Drushnaya" zu entsprechen. Zeitweilig schlechte Sichtverhältnisse und der beschränkte Aktionsradius der Hubschrauber verhinderten eine gründliche Aufnahme der Lage der Inseln und eine Rekonstruktion des Verlaufs der alten Schelfeiskante. Wir hatten den Eindruck, daß Drushnaya bei dem Zerbrechen des Schelfeises verloren gegangen sei.

Die Rückfahrt aus der südlichen Weddell-See verlief unter erheblich günstigeren Wetter- und Eisbedingungen als die Hinfahrt. Vor dem Dawson-Lambton-Gletscher wurden unter großen Eisschollen die an Diatomeen reichen Eisplättchen untersucht und damit der Anfang für eine neue Arbeitsrichtung dieser Reise gelegt. Die Rückfahrt zum Drescher-Inlet erfolgte in Etappen, die sich über eine Woche hinzogen. Am 29. Oktober wurde die britische Station "Halley" besucht. Ein meteorologischer Schnitt von der Schelfeiskante quer über die Polynya ins Packeis war gekoppelt mit Radiosonden-Aufstiegen an der "Halley-Station". Ähnliche Profile wurden im Laufe der Reise mehrmals südlich Vestkapp in Verbindung mit Messungen der "Drescher-Station" durchgeführt. Der Halley-Schnitt auf dem Schelf der südlichen Weddell-See wurde auch ozeanographisch-biologisch bearbeitet. Ihm folgte in zwei Anläufen ein Schnitt durch die Halley-Divergenz in der Südost-Ecke der tiefen Weddell-See, wo der Kontinentalhang scharf nach Westen umbiegt. Das Gebiet südlich von Vestkapp wurde am 3. November wieder erreicht. Nun wechselten biologisch-ozeanographische Schnitte vor dem Drescher-Inlet und 30 sm südlich davon (Neptuns Schnitt) mit - wenig erfolgreichen - pelagischen Fischerei-Arbeiten am Meeresboden und Einsatz des Unterwasserfahrzeugs UWE. Die Küstenpolynya veränderte täglich ihre Weite und Eisbedeckung und das Wetter war meist milde (-6°C bis -10°C), trübe und stürmisch. Die biologischen und ozeanographischen Untersuchungen ergaben immer noch keine Frühlingszeichen in Form einer Planktonblüte und Bildung einer Deckschicht.

Da sich am 8. November im Satellitenbild eine fast durchgehende schmale Küstenpolynya bis zum Filchnergraben abzeichnete, nahmen wir nach Erledigung der Fischereiprogramme mit Krillnetz und Grundschleppnetz noch einmal Kurs nach Süden, um uns über die Eisverhältnisse im Bereich der Filchner-Eisinseln und über das Schicksal der "Drushnaya-Station" Klarheit zu verschaffen und für unsere nächste Sommerkampagne Planungshilfen zu liefern. In anfangs sehr schwieriger, dann aber zügiger, eintägiger Fahrt erreichte "Polarstern" auf 77°10'S die Ausgangsposition für das Flugunternehmen zu den Filchner-Inseln. An der ehemaligen Station "Belgrano" wurde per Lufttransport ein Treibstoffdepot angelegt, mit dessen Hilfe ein sechstündiger Aufklärungsflug in der Nacht 9./10. November möglich wurde. Dabei fanden wir bei Mitternachtssonne die Station "Drushnaya", erkundeten den Weg zum Filchner-Schelfeis im Hinblick auf die nächste Sommerkampagne und sichteten die neue Schelfeiskante.

Eine gleichzeitig durchgeführte ozeanographische Station lieferte ähnliche Ergebnisse wie die 40 sm nordöstlich gelegene Südstation vom 27. Oktober. Wie damals verhinderte Preßeis das Vordingen des Schiffes zur Achse des Filchner-Grabens. Da wir aufgrund der Wettervorhersage fürchten mußten, daß schweres Packeis vom Filchner-Graben her die schmalen Waken der Küstenpolynya schließen würde, drehte "Polarstern" nach Rückkehr des Hubschraubers sofort nach Nordosten ab. Auf dem Rückweg besuchten Besatzungsmitglieder und Wissenschaftler die Kaiserpinguin-Kolonie am Dawson-Lambton-Gletscher, die wir auf dem ersten Ausflug nach Süden, Ende Oktober entdeckt und ausgezählt hatten. Auch wurden erneut Krill-Netz, RMT und Bongo-Netz gefahren und UWE eingesetzt. Als Abschluß der Arbeiten südlich 73°S fand am 15. November auf dem Festeis einer Robbenbucht (Neptun's Point) die traditionelle Polartaufe statt.

Die verbleibenden zehn Arbeitstage im Vestkapp-Gebiet waren u.a. mit ein bzw. zwei Wiederholungen des Neptun-Schnittes und des Drescher-Schnittes gefüllt. Die Meteorologen und Ozeanographen führten Serienmessungen in der Küstenpolynya durch und für die Untersuchung der Grenzschicht zwischen der freien Wassersäule und dem Meereis bildeten sich verschiedene interdisziplinäre Arbeitsgruppen, denen auf driftenden Eisschollen sehr unterschiedlicher Struktur und Genese und auf mehreren Festeis-Stationen Gelegenheit für Messungen und Probennahmen gegeben wurde. Von den Strommesserketten, die Anfang Oktober ausgelegt worden waren, wurden die beiden flachsten geborgen. Die dritte Kette ließ sich trotz mehrfacher Versuche an drei Tagen weder orten noch auslösen. Sie muß daher als verloren gelten. Die westlichste Kette lag unzugänglich unter einer geschlossenen Packeisdecke. Sie wurde auf dem nächsten Fahrtabschnitt geborgen.

Am 24.11. wurde die "Drescher-Station" ausgeräumt und die deutsch-holländische Arbeitsgruppe wohlbehalten wieder an Bord genommen. Das Unternehmen hat gute biologische und meteorologische Ergebnisse erbracht und verlief ohne wesentliche technische Schwierigkeiten. Um die Lastentransporte von der "Drescher-Station" zu erleichtern und um einzelnen Arbeitsgruppen freie Hand bei ihren vielfältigen Untersuchungen unter dem Festeis zu geben, lag "Polarstern" vom 22. bis 24.11. im Festeis des Drescher-Inlets, wo jedermann freien Auslauf hatte.

Bei der letzten Wiederholung des Drescher-Schnittes und auf mehreren Stationen südlich und nördlich von Kap Norvegia in den folgenden Tagen machte sich endlich der Frühling in der Wassersäule bemerkbar. Seit 10. November hatte fast durchweg mildes, windarmes, sonniges Wetter geherrscht, was zu einer Aufweichung des Meereises und langsam zur Ausbildung einer Deckschicht führte. Damit stellte sich eine merkliche Vermehrung des Phytoplanktons in der Wassersäule ein.

In der Atka-Bucht traf "Polarstern" am 28.11. noch einmal sehr schwierige Packeisverhältnisse an. Preßeis hatte sich zwischen den gestrandeten Eisbergen gestaut und verwehrte den Zugang zum Festeis, das der Schelfeiskante breit vorgelagert ist. Da außerdem Schneetreiben und stürmische Winde den Hubschraubereinsatz stark einschränkten, konnte nur ein kleiner Teil des für die Atka-Bucht vorgesehenen Forschungs- und Transportprogramms durchgeführt werden. Eine kurze Wetterbesserung vor Ablaufen des Schiffes aus der Atka-Bucht nutzten wir für Flugaufnahmen der beiden Kaiserpinguin-Kolonien im Bereich der Atka-Bucht. Damit war das umfangreiche Flugprogramm dieser Reise abgeschlossen, mit dem der gesamte Schelfeisbereich von der Luitpold-Küste bis zur Atka-Bucht nach Ansammlungen von Weddell-Robben und Kaiserpinguinen systematisch mit Hubschraubern abgesucht worden war. Die Pinguinkolonien wurden aus der Luft photographiert, außerdem wurden die Tiere am Boden gezählt. Die Anzahl der Robben wurde vom Hubschrauber aus jeweils doppelt bestimmt.

Die heimwärts gerichtete Passage durch den antarktischen Packeisgürtel von der Atka-Bucht über den Maud-Rücken zur Bouvet-Insel war viel leichter als erwartet. Die Meereisdecke war überall in Auflösung begriffen und in Stücke unterschiedlicher Größe zerbrochen. Daher konnte "Polarstern" überall zügig fahren. Die so eingesparte Zeit wurde in den Versuch gesteckt, möglichst viele der fünf von "Polarstern" im April d. J. am Rande des Maud-Rückens ausgelegten Strommesserketten zu bergen. Bei zwei Ketten verlief die Aufnahme problemlos, die dritte lag in einem dichten Treibeisfeld, konnte aber unbeschädigt geborgen werden. Die Position der vierten und wahrscheinlich auch der fünften Kette befand sich unter starkem Scholleneis. Hier wäre die Auslösung besonders bei den herrschenden ungünstigen Wetterbedingungen zu riskant gewesen. So begnügten wir uns mit drei vollständig geborgenen Ketten und überließen die letzten beiden dem nächsten Fahrtabschnitt, Anfang Januar, wo sie ohne Beschädigung aufgenommen wurden.

Die Querung der Packeiszone und der nördlichen Eisrandzone sollte Vergleichsdaten über die ozeanographische und biologische Situation zehn Wochen nach der ersten Querung liefern. Zusätzlich wurden ein ozeanographischer Schnitt über den Maud-Rücken gelegt, geochemische Proben aus großen Tiefen genommen und in der nördlichen Eisrandzone fünf biologische Stationen gefahren. Dabei konnte auch das sich auflösende Meereis noch ein letztes Mal beprobt werden. Die nördliche Eisgrenze wurde auf dem Greenwich-Meridian auf 58°40'S passiert und anschließend die letzte ozeanographisch-biologische Station auf 58°00'S durchgeführt. Bei trübem und stürmischem Wetter besuchte "Polarstern" am 7.12. die Spiess Kuppe, die von "Meteor" 1926 entdeckt, als spitzer Vulkankegel aus der Tiefsee bis 300 m unter die Meeresoberfäche aufragt. Das Schiff legte mehrere Lotprofile über die Kuppe und setzte zweimal das Agassiz-Trawl ein, das Lavabrocken und etwas Tiermaterial an Deck brachte. Der folgende Tag war für einen Besuch der Insel Bouvet eingeplant, wo in Absprache mit dem norwegischen Polarinstitut biologische Zählungen an den Pelzrobben- und Vogelkolonien durchgeführt werden sollten. Leider verhinderte schlechtes Wetter den Flugbetrieb fast gänzlich, sodaß nur eine kurze

Stipvisite und eine Inselrundfahrt möglich waren. Das Warten auf Wetterbesserung wurde am 9.12. morgens abgebrochen und die Heimreise nach Kapstadt bei anfangs stürmischem später freundlichem Sommerwetter angetreten. Die Antarktische Konvergenz wurde bei 51°55'S, 5°20'O, d.h. 70 sm weiter südlich als auf der Hinreise angetroffen.

Etwa 100 sm südlich von Kapstadt brach am 13. Dezember abends im Hauptmaschinenraum Feuer aus, das schnell gelöscht werden konnte, ohne daß Personen zu Schaden kamen. Am 14. Dezember vormittags machte "Polarstern" in Kapstadt fest. Damit war das Winter-Weddell-See-Projekt 1986 erfolgreich und unfallfrei beendet. Die eingeschifften Wissenschaftler und Techniker verließen das Schiff am 16. und 17. Dezember 1986, gleichzeitig begannen die Reparaturen im Hauptmaschinenraum.

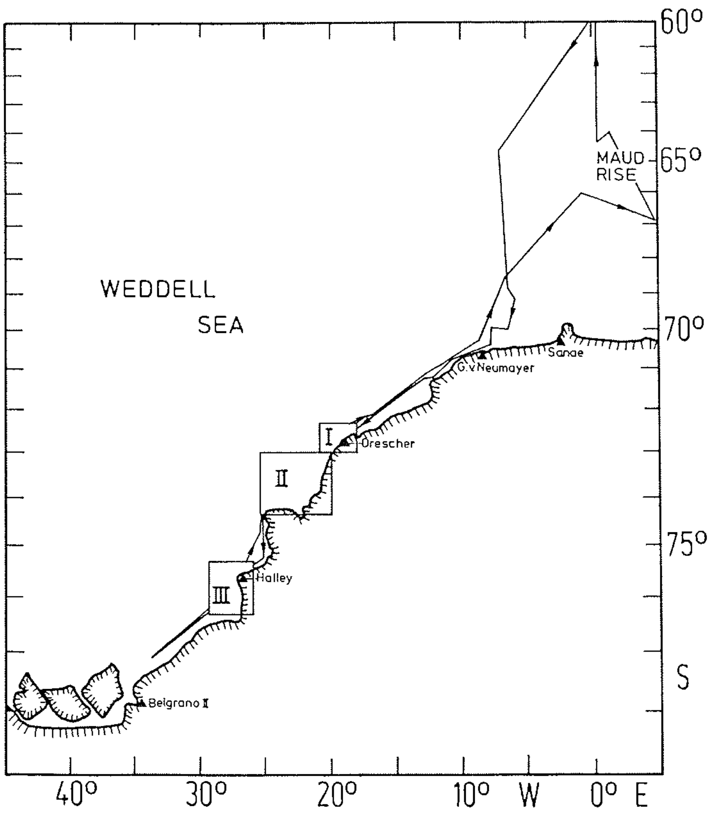


Abb. 20. Fahrtroute während der Reise ANT V/3 des FS "Polarstern".

Fig. 20. Cruise track of RV "Polarstern" during ANT V/3.

3.2 Summary and itinerary (G. Hempel)

During the second leg of the WWSP'86, RV "Polarstern" operated in a large area from the northern boundary of the winter pack-ice belt in the Westwind Drift at 59°S to the southeastern Weddell Sea at 77°S. At the beginning of October, and again in December, two meridional transects were worked through the pack-ice belt from the northern border of the sea ice to the edge of the shelf ice. The main phase of the investigations focused on the coastal polynya at Vestkapp (72°S), interrupted by two excursions to the southern Weddell Sea.

The expedition served a variety of research goals.

- Composition and productivity of phyto- and zooplankton as well as benthos and fish fauna under winter-ice conditions
- Distribution and physical state of the sea ice, its population of plant and animal life during the course of late winter and spring
- Reproduction and feeding biology of Weddell seals and Emperor penguins
- Distribution of water masses within the pack-ice belt and the structure of the Antarctic coastal current
- Detailed structure of the water masses by means of tracer oceanography
- Thermal and dynamic interactions between wind, ice- and sea surface.

In addition, the expedition provided opportunities for interdisciplinary investigations on the water column /sea ice boundary layer, and for a large-scale survey of the breeding colonies of Weddell seals and Emperor penguins along the coast of the eastern Weddell Sea.

Favourable ice conditions permitted exploration of the recently emerged Filchner ice islands, and the retrieval of current meter moorings in connection with oceanographic work in the area.

During 11 weeks, scientists and technicians from Germany (39) and foreign institutions (12) (particularly the United States of America and the Netherlands) worked in close cooperation. For six weeks a group of six persons from Germany and the Netherlands undertook biological and meteorological investigations at the newly-erected "Drescher Station" at 72°52'S, 19°25'W.

On-board research was supported by two helicopters which were used for transporting persons and equipment to "Georg von Neumayer Station" and "Drescher Station", to the fast ice, deployment of ARGOS buoys, reconnaissance flights, exploration of the Filchner ice islands and, on a particularly large scale, for the stock assessment of seals and penguins.

Itinerary

"Polarstern" left Capetown, South Africa, on 28 September heading for "Georg von Neumayer Station". Because the weather situation worsened rapidly, an oceanographic station at 58°S which had been planned already for the previous leg again could not be completed. The first pancake ice was reached on 4.10. at 58°S, from 60°S onwards the ship proceeded through closed ice cover. Swell apparent at the ice edge could still be felt as much as 200 nautical miles into the ice, and the ice cover was broken into floes of varying size and thickness.

A planktological and oceanographic transect incorporating five stations located in different types of ice cover - from open water to closed ice of 50 cm thickness - was laid through this border zone. With more stations, following in distances of approximately 100 nautical miles, this transect was then extended throughout the entire pack-ice belt to Atka Bay. Ice cores were drilled, phyto- and zooplankton collected, and the vertical structure of the water column was investigated.

Ice conditions generally allowed continuous steaming at 6 knots using 3 or 4 engines. The central part of the pack-ice zone was characterized by leads with an east/west orientation; further south these changed to a north/south direction and thus facilitated the ship's progress towards the coastal polynya. High windspeeds and air temperatures around -20°C were experienced most of the time during this first complete transit through the pack-ice belt in winter.

Atka Bay was reached on 12 October and "Georg von Neumayer Station" was visited briefly. "Polarstern" then headed for Vestkapp, proceeding through the coastal polynya which at times had a width of up to 25 nautical miles. Eight meteorological ARGOS buoys were put on large drifting floes either from the vessel or by helicopter, seven of them were functioning during the entire leg of this expedition. Further, as planned, four current meter moorings were laid out in the coastal current south of Vestkapp. They were positioned at different depths on a transect normal to the edge of the shelf ice. Two of the mooring were retrieved at the end of this leg.

Before "Polarstern" could start any comprehensive investigation in the Vestkapp area, "Drescher Station" had to be erected at 72°52'S, 19°25'W. It took 36 hours of busy helicopter flights and construction work until the five (at times six) biologists and two meteorologists were able to move in. Members of the ships crew also participated in the erection of the three prefabricated huts. For six weeks this group operated as an independent unit, investigating the breeding and feeding biology of Weddell seals and Emperor penguins in the Drescher Inlet. The meteorological observations yielded valuable data on the structure and dynamics of the planetary boundary layer over the edge of the shelf ice and supplemented simultaneous measurements made on board of research vessel and by the ARGOS buoys. At the end of the stay, the huts were left at the site together with a supply of petrol and kerosene for future scientific activities and as a refuelling basis for flight operations.

After the completion of the "Drescher Station" a first phase of scientific measurements in the Vestkapp area commenced on the 16 October and lasted until the 25 October. Intensive probing took place on this Drescher transect,leading normal to the coast over a distance of 38 nautical miles from the edge of the shelf ice across the continental slope to water depths of c.3500 meters. The coastal polynya which exhibited a daily changing cover of newly formed ice and old drifting floes was crossed and the floe ice of the central Weddell Sea was penetrated. Furthermore, on a long transect parallel to the edge of the shelf ice the coastal current was investigated. Ice drilling and oceanographic/geochemical stations changed with meagre plankton catches, and rich benthos collections from Agassiz- and Bottom trawls. Work on board was repeatedly supplemented with systematic reconnaissance flights for assessing the variable ice cover on a strip normal to the coast and the distribution of penguins off the Drescher Inlet.

The lowest air temperatures (-32°C) of the expedition were experienced during this phase causing considerable problems with some oceanographic equipment. A world record of a Secchi depth of 79 meters, extremely low chlorophyll values despite favourable conditions of nutrients and light, indicated that high winter was still prevalent in the water column.

To use the time until spring came, "Polarstern" made an advance to the Southwest to serve the interests of the oceanographers. En route quite variable sea ice conditions were met. Open polynyas alternated with pack-ice in the vicinity of capes. Nevertheless, "Polarstern" advanced surprisingly rapidly to a position off the Dawson-Lambton glacier. Then the polynya petered out and it became more and more difficult to progress until finally south of 76°30'S thick pack-ice prevented any further advance towards the Filchner trough.

On the turning point, at the north-easterly edge of the Filchner trough, Weddell Sea Bottom Water was encountered. Though here too no indication of the instantaneous creation of Antarctic Bottom Water was found. Thus, the excursion to the South yielded only a general contribution to our knowledge of the oceanography and biology of this region during winter. Since 1979 this area has been regularly visited by us in summer.

The southern position of the vessel provided the opportunity to explore three ice islands that had probably separated in July from the Filchner shelf ice, and following a request from the Russians to investigate the fate of the summer station "Drushnaya" on two helicopter flights. Poor visibility and the limited flying range of the helicopters prevented us from a thorough survey of the position of the ice islands and a reconstruction of the original edge of the shelf ice. We left with the impression that "Drushnaya" got lost when the shelf ice broke up.

Our return from the southern Weddell Sea was favoured by good weather and ice conditions. Off the Dawson-Lambton glacier, ice platelets, enriched with diatoms, from the underside of large floes were investigated, and a new field of research was thereby opened. The return to the Drescher Inlet was done in stages spread out over one week. The British station "Halley" was visited on 29. October. A meteorological transect from the edge of the shelf ice across the polynya was combined with radio sonde ascents by the "Halley Station". During the course of the journey similar profiles were done south of Vestkapp in conjunction with mesurements of the "Drescher Station". Oceanographic and biological work was also performed on this Halley transect on the shelf of the southern Weddell Sea. It was followed by a transect across the Halley Divergence in the southeast corner of the deep Weddell Sea where the continental slope turns sharply towards the west. The area south of Vestkapp was reached again on 3. November. Biological/oceanographic transects off the Drescher Inlet and 30 nautical miles to the South, alternated with a - not particularly successful - pelagic fishery. The underwater vehicle UWE also came into action here. Width and ice cover of the coastal polynya changed from day to day, and the weather was mostly mild (-6°C to -10°C), foggy and stormy. Biological and oceanographic investigations still failed to detect signs of the advancing spring neither in form of a spring bloom nor in a stratified surface layer.

As the satellite images for the 8 November indicated a continuous narrow polynya right through to the Filchner trough and our fishery with Krill net and Bottom trawl had been dealt with, "Polarstern" proceeded once more to the South to gain insight into the ice conditions around the Filchner ice islands and the fate of the "Drushnaya Station". Within one day, first hampered by ice then advancing rapidly, the vessel reached at 77°10'S the starting point for the flight operations. By means of helicopter a kerosene depot was dumped next to the former station "Belgrano". This served as backup for a six-hour reconnaissance flight during the night of 9 to 10 November On this flight we found "Drushnaya", explored the way to the Filchner shelf ice in view of the next summer campaign, and sighted the new edge of the shelf ice.

The results of the oceanographic station of this day were similar to those of the south-station from 27 October which was situated 40 nautical miles to the Northeast. As on our first visit, pack-ice prevented the advance to the center of the Filchner trough. The weather forecast made us fear that heavy pack-ice might close the narrow leads of the coastal polynya. "Polarstern" therefore immediately proceeded to the Northeast as soon as the helicopter returned. On our way back members of the crew and scientists visited a Emperor penguin rookery on the Dawson-Lambton glacier which we had discovered and censused during our first visit of the South at the end of October.

Sampling with Krill net, RMT, and Bongo was also done, and UWE took underwater videos. To mark the end of our activities south of 73°S, the traditional celebrations for crossing the polar circle took place on the fast ice at Neptun's Point.

The remaining ten working days in the Vestkapp area were filled with a singular repetition of the Neptun transect and a double repetition of the Drescher transect. Meteorologists and oceanographers performed serial mesurements in the coastal polynya, and interdisciplinary working groups investigated on drifting ice floes of variable origin and structure as well as on fast ice, the boundary layer between the water column and the sea ice. The two shallowest current meter moorings laid out at the beginning of October were retrieved. Despite several attempts over the course of three days no acoustic contact could be established with a third mooring. It was possible neither to locate nor to release it from the sea floor. We therefore consider it lost. The most westerly chain was found inaccessible under closed pack-ice. It has to be retrieved on the next leg.

"Drescher Station" was cleared on 24 November, and the field party from Germany and Netherland returned back on board. The exercise yielded good biological and meteorological results. No substantial technical difficulties were encountered. "Polarstern" then stopped from 22 to 24 November in the ice of the Drescher Inlet to facilitate the loading of cargo from the "Drescher Station", and to allow the various working groups to perform their investigations of the fast ice.

During the last repetition of the Drescher transect and on several stations to the north and south of Kap Norvegia, spring conditions became finally noticable in the water column. The period from 10. November on was characterized by mild, calm and sunny weather which aided in melting of the sea ice and the development of a stratification of the surface layers. Under these conditions phytoplankton multiplied in the water column.

On 28 November in Atka Bay, once more very difficult ice conditions were met. Pack-ice had jammed between stranded icebergs and prevented access to the fast ice which was lying in a broad girdle in front of the shelf ice. Because drift and gales were severely hampering the flight operations of the helicopters only a small part of the research and transport program could be completed. Before the ship finally departed from Atka Bay a brief improvement of the weather situation allowed to take aerial photographs of both Emperor penguin rookeries at Atka Bay; thus marking the end point of a comprehensive and almost uninterrupted aerial survey of seal and penguin colonies along the coast, from the Luitpold Coast to Atka Bay. The penguin colonies were photographed from the air and censused by ground counts. Seals were counted from the helicopter by two observers.

The homeward passage through the Antarctic pack-ice belt from Atka Bay over the Maud Rise to Bouvet Island was easier than expected. The ice cover of the sea had disintegrated into floes of variable size. "Polarstern" was able to advance rapidly all the time. This timesaving progress allowed us to try to retrieve as many as possible of the five current meter moorings that were deployed in April next to the Maud Rise. Two moorings were recovered without any problems; a third one was also taken on board without any damage despite considerable ice cover at its position. The fourth and fifth mooring were inaccessible under extensive ice floes. Releasing them appeared too risky under the unfavourable weather conditions prevailing at this time. They will have to be retrieved on the next leg.

As the ship was proceeding north, comparative data of the oceanographic and biological situation in the pack-ice zone and the northerly border of the sea ice were obtained ten weeks after the first transit. In addition, an oceanographic transect was carried out across the Maud Rise, geochemical samples were taken at great depths, and five biological stations were completed. The disintegrating sea ice was thus sampled for the last time on this leg.

The northern ice limit was passed at 58°40'S on the Greenwich meridian followed by a final oceanographic/biological station at 58°00'S. On 7 December in foggy and stormy weather "Polarstern" visited the Spiess sea-mount. This vulcanic cone rising from the deep sea floor to 300 m under the sea surface was discovered by RV "Meteor" in 1926. We carried out several echo sounder profiles across the area and fished twice with the Agassiz trawl. But only pieces of lava and few animals were found in the codend.

A visit to Bouvet Island was planned for the next day where in agreement with the norvegian polar institute censuses of seals and penguins should be done. But bad weather hampered flight operations so that only one brief visit by helicopter and a circumnavigation was possible. Since the weather did not improve on 9 December further attempts to land were abandoned and "Polarstern" departed for Capetown. On her way

the Antarctic convergence was encountered at 51°55'S, 5°20'E, 70 nautical miles farther to the South than on the outward passage.
"Polarstern" berthed in Capetown in the morning of 14 December, and with this the Winter Weddell Sea Project '86 had come to a successful end. Scientists and technicians left the ship on 16 and 17 December 1986.

3.3 Die "Drescher-Station" auf 72°52'S, 19°25'W (J. Plötz)

Die "Drescher-Station" wurde auf dem Riiser-Larsen Schelfeis südlich Vestkapp etwa einen Kilometer nördlich der Mündung des Drescher-Inlets errichtet. Eine natürliche Rampe ermöglichte den Zugang vom Schelfeis zum Inlet.

Die zerlegbare Station mußte in 15 Holzkisten mit Gewichten zwischen 600-800 kg von zwei Helikoptern in das Gebiet geflogen werden, da ein Transport über das Meereis nicht möglich war. Die übersichtliche Anordnung der Boden-, Wand- und Deckensegmente sowie deren Leichtbauweise ermöglichten einen zügigen Aufbau innerhalb von zwei Tagen.

Zwei Wohncontainer und ein Gerätestore mit den Abmessungen 6,5 x 2,5 x 2,5 m dienten 5-6 Biologen und 2 Meteorologen über 6 Wochen hinweg als Wohn- und Arbeitsplatz.

Die Container wurden parallel zueinander im Abstand von 35 m angeordnet, mit dem Store in der Mitte. Jeder Wohncontainer ist ausgestattet mit 4 Betten im Hinterraum, einem kombinierten Koch-, Eß- und Arbeitsbereich in der Mitte sowie einem abgetrennten Vorraum mit Waschbecken und Schneeschmelze. Zwei große Seitenfenster und ein Türfenster geben ausreichend Helligkeit.

Gekocht wurde mit Propangas. Tiefgefrorenes Frischfleisch und andere Frostvorräte wurden außerhalb der Container in Holzkisten aufbewahrt. Der Gerätestore ist mit stabilen Regalwänden ausgerüstet, die Stauplatz für Gerätschaften und Lebensmittel bieten. Außerdem gibt es ausreichend Stellfläche für empfindliche Registriergeräte.

Für die Stromversorgung wurden 3 Benzingeneratoren (4,5 kW-Wechselstrom) unter Dauerbetrieb eingesetzt. Hauptabnehmer waren 5 Heizlüfter und 2 Schneeschmelzen. Drei Registriergeräte, 1 Funkgerät und 1 Computer wurden über einen Netzstabilisator betrieben. Die nur 10 cm starken Containerwände hatten eine vorzügliche Wärmedämmung. Trotz heftiger Stürme und Temperaturen bis zu -32°C gab es keine starke Auskühlung, auch wenn die Generatoren nachts einmal ausfielen.

Für den Stationsbetrieb und für Arbeiten auf dem Eis wurden 2 große und 2 kleine Ski-Doos mit Schalen- und Nansenschlitten eingesetzt. Zur Sicherheit für Personen und Unterbringung von Geräten wurde je 1 Scottzelt in 2 und 6 km Entfernung von der Station aufgestellt. Im Vorgelände der Station wurden ein Lagerplatz für Treibstoff und ein Helikopterlandeplatz angelegt.

3.3.1 "Drescher-Station" at 72°52'S, 19°25'W (J. Plötz)

"Drescher Station" was erected on the Riiser-Larsen Shelfice south of Vestkapp approximately one kilometer north of the mouth of the Drescher Inlet. The building material had to be transported by two helicopters in crates of 600 to 800 kg because ground transport over the sea ice was impossible. The clear and lightweight design of wall, floor and ceiling segments enabled quick assembly within two days. Two living containers and one store measuring 6.5 x 2.5 x 2.5 m served five to six biologists and two meteorologists for six weeks as living quarters and work place.

The containers were erected parallel to each other in a distance of 35 m; the store located between them. Each living container is furnished with four bunks in the back section, a combined cooking and work area in the middle, and a separate entrance with sink and snow melting apparatus. Two large windows on each side and one in the door provide ample light.

Cooking is done with propane. Frozen meat and other frozen supplies are kept outside in wooden boxes. The store is fitted out with sturdy shelves for supplies and equipment. Further, there is ample space for sensitive registration devices. Electricity is provided by three petrol generators of 4.5 kW AC each. Main consumers were the five electric heaters and two snow melting appartuses. Three registration devices, one short wave radio and one computer were supplied with stabilized current.

Although only ten centimeters thick the walls had excellent insulation properties. Despite strong gales and temperatures down to -32°C they kept the station warm even when generators were not running at nighttime.

Two big and two small skidoos each with Nansen sledges were used for transport of persons and goods across the inlet. As safety measure Scott tents in distances of two and six kilometers from the base were erected. A helipad was marked in the vicinity of the station and a petrol depot was established in safe distance from the huts.

3.4 Underwater observations with a remotely operated vehicle (H.-P. Marschall, F.-P. Rapp)

Objectives

The Remotely Operated Vehicle (ROV) called UWE recently acquired by the AWI was used under the sea ice, in the water column and on the sea bottom not only to show the presence of organisms but also to estimate their abundance and to study their behaviour as well as their interactions and relationships between organisms and the environment.

Technical description

The Sprint system is a commercially available ROV, whose primary tasks have been diver support and sub sea inspection for the oil industry.

The system can be used in two configurations. For shallow dives under calm conditions, like in the ice, down to a maximum of some 50 m the vehicle is operated using a neutrally buoyant, Kevlar reinforced tether cable. When used for observations in greater depth the ROV itself remains within a protective cage during launch and recovery from the ship's side. The cage is lowered into the water via a 660 m steel armoured umbilical which is unspooled from its own hydraulic winch. Once at the desired operating depth, the cage acts as a Tether Management System (TMS) by releasing the vehicle and then spooling or unspooling up to 120 m of neutrally buoyant tether as per the operator's instructions. The use of a TMS decouples the vehicle from the ship's motion and eases operations in currents.

The vehicle itself is relatively small (61 x 61 x 68 cm) and unlike other small ROV's not a pressurised sphere or cylinder. The non-pressurised hull consists of two major components (Fig. 21). The upper part is mostly filled with pressure resistant buoyant material, while the lower part houses the triplex camera head and the electronics in two pressurised aluminium bottles. Due to this design the vehicle stabilises itself like a damped pendulum while in other ROV's motors have to be used for stabilisation and by that introducing more disturbance into the environment and providing a less stable platform for observations.

The core of this ROV is its triplex camera head. This camera head consists of a low light level b/w video camera sensitive to $5*10^{-4}$ lux, a colour video camera sensitive to 0.6 lux, and a 35 mm SLR camera equipped with a 250 exposure data back, and a water corrected 28 mm wide angle lens. Both video cameras share the optics of the SLR camera via a rotating mirror, thus eliminating parallax errors. The Sprint uses three 250 watt lights and two 150 Joule flash tubes to supply lighting for these cameras. The lighting follows the 180 degree tilt angle of the camera head.

The vehicle is capable of attaining speeds up to 2.5 knots via its four 1/2 horsepower electric vertical thrusters. Control is made easy due to autoheading and autodepth servos which are capable of holding course to within 2 degrees and depth to within 5 cm.

The ROV and cage are controlled via the deck's unit. This unit consists of a joystick style controller, a video moni-

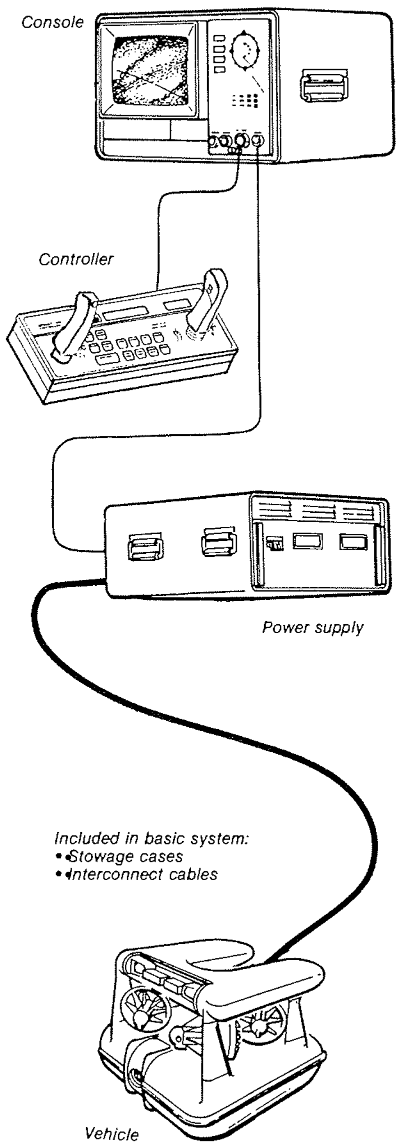


Fig. 21. Schematic drawing of the system configuration used for observations of the bottom surface of the ice.

tor and data display unit, and a 5 kW power unit. All pertainent information such as heading and depth are annotated on the video monitor and recorded with the video signal on a U-matic video recorder for later analysis.

Data displayed by the deck's unit include depth, heading, tether out in meters, time and date, stills exposure counter, focus distance, camera aperture, as well as system status and error messages.

Specific advantages for polar research especially in winter are that it can obtain information at locations which cannot be sampled by normal nets like for example, the cryopelagic underneath the ice and the hyperbenthos close to the bottom. When compared to a diver, the deployment and recovery of an ROV in the pack-ice is less difficult and is not dangerous for men. Additionally the ROV can operate easily between the surface and the maximum operational depth of 600 m for extended periods of time.

Work at sea

During this cruise a total of 39 dives, 27 under the ice and 12 to the bottom were undertaken. The maximum depth reached was 425 m.

The ROV was mainly used to study presence and behaviour of animals under the sea ice. It also showed different structures of the sea ice. During ice stations these informations were used by other groups working on the ice for planning their activities. Different under ice activities like ice drilling, water sampling and CTD measurements in the under ice water layer were watched to get information on actual sampling site and procedure and on the surrounding area.

When the system was lowered to the sea bed, particle concentration and vertical distribution of organisms in the water column were monitored on the descent. The camera focussed to 40 cm and was tilted downwards with bottom light on. Normally the low light level b/w camera was used for observations, which were also recorded on video. Every 15 m the descent was briefly stopped and a still picture taken.

At the bottom, the vehicle remained in the cage, because of technical problems with the tether management system. Usually the ship drifted with 10-30 cm per sec. Therefore over a certain distance information on abundance and interrelationships of epibenthic organisms could be recorded on video. Still pictures on colour slide film providing a much better resolution than the video were taken to document objects of certain interest.

Preliminary results

The great number of observations carried out with the ROV was useful for a variety of disciplines on the vessel.

Especially interesting are the observations made underneath the sea ice. On video tapes and still pictures different structures of the bottom of the ice were recorded for later analysis. These observations also revealed that the cryopelagic system is used by krill as a feeding and hiding ground during winter. The observations of the under ice activites helped to see conditions of the surrounding area of the sampling site.

In the water column different concentrations of particles were recorded. It could repeatedly be shown that the upper layer was extremely low in regard to particles and that there was a tremendous increase of particles towards the bottom.

At the sea bottom the abundance of the epibenthic fauna and interspecific relationships could be seen in detail. Sponges, one of the major component of the benthic communities in the Antarctic were commonly used by different organisms like crinoids and holothurians as substrates. Some organisms which never showed up in Bottom trawls were properly documented.

Detailed results are given in the relevant sections of this report.

3.5 Brief description of the sea ice conditions along the cruise track (H. Eicken, T.C. Grenfell, B. Stonehouse)

Approach to the continent (4 to 11 October):
The ice edge, first encountered at 58°07'S, 02°19'E with air temperatures around 0°C, consisted of strips of brash ice and fragments of floes which had been rounded by erosion to resemble pancakes. Ice concentration increased from 0 to 90-100% over a distance of about 150 km between 57°49'S and 59°30'S; during this two major transverse bands were crossed, the first centered in about 58°00'S and the second about 59°00'S. Winds were NW, T_a about -1°C and there were light flurries of snow. At 07:00 next morning in 59°53'S, the wind direction changed to SW and by 16:00 (air temperature) T_a was down to -13.1°C. Ocean swell penetrated some 330 km into the pack-ice to approximately 60°50'S. Typical floe diameter increased from 3-10 m at the edge to over 50 m well into the close pack south of 63°. Snow depth also increased over the same interval from 0 to 10 cm near the ice edge to 20-30 cm.

From early on 6 October until 11 October T_a remained below -18°C almost continously. The ice was mostly large floes and unbroken sheets 50 to 100 cm thick covering 60-90% of the visible area, ridged to 1 m high and covered with drifted snow; leads formed by movement between the floes were often extensive (up to 32 km long, 3-8 km wide) but quickly became covered with rafted nilas up to 10 cm thick overnight. On 11

October off Atka Bay after cutting through consolidated pack with ridged floes up to 2 m thick, the ship broke into a polynya recently formed by strong offshore winds.

The polynya in early spring (12 October to 14 November): During this period RV "Polarstern" worked within an area of about 1300 km^2, mostly between Drescher Inlet (72°53'S, 19°11'W) and 77°S within a few miles off the shelf ice coast. The amount of ice within sight of the ship ranged from almost nil to almost complete coverage, in a recognisable sequence of events that was repeated several times.

On October 12 (noon position 70°30'S, 8°04'W) continued SW in a polynya at least 24 km wide extending parallel to the coast. Rapid cooling (T_a -18°C, winds SE more than 15 m sec^2) led to formation of grease and pancake strips up to 100 m wide and 16 km long parallel to the wind. Winds lessened overnight, and by morning a sheet of dark nilas had formed. This gradually broke into floes about 100 m in diameter, reduced in area by finger-rafting. Concentrations of frost flowers formed along cracks and zones of weakness. Between 13 and 15 October the nilas thickened to 20 cm by accretion. On the 15th winds near the inlet increased to 15 m/s, and renewed rafting produced smaller floes (20 m diameter) with ice up to 50 cm thick. By this time the polynya, some 24 km wide, was covered with light nilas except for a few leads of open water up to 100 m wide and several km long.

Air temperatures around -20°C and light offshore winds of 5-10 m/s persisted for a further week. Under this regime a narrow coastal lead was continually being formed along the fast ice edge, and covered with light nilas which was then driven westward and replaced. Thickened both thermally and by rafting, the new ice was driven against the pack some 16 to 30 km from the fast ice edge, by this time both rafted and ridged to thicknesses of about 50 cm. At the junction ridging up to 2 m high was observed over 50% of the boundry zone. Floes were between 3 m and 30 m diameter, often with raised brash rims; within the pack they were generally larger, up to 100 m across.

About 20 October onshore winds carried all the ice eastward, narrowing the polynya to a few hundred m and bringing the junction between pack and new ice to within 8 km of the coastal fast ice. A day later SW winds of 15 m/s reopened the polynya to a width of over 3 km. Grease ice formed immediately on the open water in bands up to 30 m broad, quickly solidifying into black nilas. Plentiful sea smoke indicated a considerable latent heat flux, and frost flowers formed abundantly at points of high porosity on the nilas. Heavy snowfall overnight filled remaining patches of open water with grease ice. After 23 October the wind dropped and nilas formation began again.

This pattern was varied after 25 October when NE winds gusting to 25 m/s broke the nearshore ice cover, first creating deformational pancakes in a narrow lead, then reopening the lead to form a polynya 18 km wide. Persistent line missing lining the coast and causing over 75% rafting and ridging. Headlands in the shelf ice, for example those of Halley Bay and the Stancomb-Wills Promontory, cause the ice pressed against them to be ridged up to 3 m. During the night of 27-28 October a wind-shift to SE reopened the costal lead to a width of 200 m, and the pack-ice itself contained parallel leads of similar size.

On 4 November (noon position 74°S, 24°52'W) air pressure fell to 955 mb, the wind rose to 18 m/s and T_a to -4°C. Leads up to 1.5 km long and 10 m wide appeared in the ice cover, though at the same time compression was generating pressure ridges up to 2 m high. On 4 November, with weather conditions unchanged, a polynya 10 km wide developed, which was rapidly covered with grease and pancake ice. To reach 77°S, the southernmost point of the cruise, "Polarstern" took advantage of easterly winds that allowed relatively free progress through narrow leads, encountering pressure only on the windward side of headlands. During the following week T_a ranged between -4°C in daytime and -12°C at night; winds remained light, and the return journey to Drescher Inlet was made along a coastal polynya about 8 km wide, thinly covered with unbroken nilas that did not exceed 10 cm thick and remained almost completely unrafted. Throughout early spring Emperor penguins _Aptnodytes forsteri_ were observed frequently on the fast ice, expecially near their colonies, on nearby inshore pack-ice, and on the ice of the polynya when it was strong enough to bear their weight. They were feeding through holes and leads, and using the ice as a platform for resting.

The polynya in late spring (14 to 28 November):
During the evening of 15 November winds shifted from NNW to NE and increased to 10 m/s, bringing the pack-ice in toward the coast and crushing the thin nilas of the polynya. The ship worked through a mixture of heavily-ridged white ice over 0.5 m thick and rafted nilas floes less than 20 m across, with brash and larger fragments lining leads and pools of open water. During the next three days the wind decreased and veered to E; by 18 November off Drescher Inlet a polynya 8 km wide had again formed. Continuous sunshine, radiation fluxes of up to 700 W/m^2 and daytime T_a as high as -1.5°C inhibited further ice growth. Only streaks of thin frazil appeared overnight, when T_a fell to -8°C, to disperse during the following day. During the very calm night of 20 November nilas less than 5 cm thick formed, but was broken next morning by light winds and dispersed to SW. These conditions prevailed until 27 November when E winds at 15 m/s increased the width of the polynya to 16 km and produced a swell with waves 1 m high. Brash ice with fragments up to 2 m long spread from the pack-ice margin to

gather in strips and patches on the polynya surface; with T_a -6°C no grease ice formed.

Transects that took the ship more than 16 km NW into the pack on 15 and 25 November showed it to consist of floes with over half their area ridged from 0.5 to 2.5 m high. These were angular, 3-25 m across, and separated by narrow brash-filled leads; only about 10% of the area was open water.

In late November brown ice and brown water was often seen in the ship's wake. Both Emperor penguins and Weddell seals Leptonychotes weddelli were plentiful on nearshore ice. Seals were observed to enter the water through holes and leads, and punch breathing holes through thin nilas as required. Southern bottlenose whales Hyperoodon planifrons, killer whales Orca orca and minke whales Balaenoptera acutorostrata, all of which depend on ice-free water for breathing, were present in the polynya and shore leads thoughout spring.

Transect to the ice edge (28 November to 6 December):
During this phase the early ice decay pattern was clearly evident. Near the coast just north of the polynya, the ice cover was nearly continuous with floe sizes greater than 50 m across. Proceeding north, floe sizes decreased and the fraction of open water increased. These changes were not smooth, however, because the ice tended to form aggregates of floes or floe bands, and abrupt changes in the vicinity of the ship from full ice cover to mostly open water were encountered almost all the way to the ice edge. The decrease in ice concentration was characterized by the change in the relative widths of the bands of ice and open water such that the pack apperared to be experiencing differential divergence increasing northward from the coast. Brown algae were present in the ice over the entire traverse.

Floes consisted almost entirely of white ice 30-60 cm thick and the snow cover was thicker than on the ice near the polynya. Formation of grease ice and nilas was seen only within 60 km of the coast during a final period of colder clear weather. Freezing was due to long-wave radiation losses and consequent surface cooling during hours when the sun was low. Otherwise, even though air temperatures remained below freezing, the continuous incident solar radiation raised the ice temperature contributing substantially to the weakening and decay of the pack.

Close to the coast, between Atka Bay and about 66°S, 1°W, ice concentration was generally near 90%, and the ice sheet was broken into floes from 10 to about 70 m across. Three distinct bands of low concentration were present with characteristic widths of 10 to 30 km. Between 69°S and 66°S a zone of icebergs was encountred, extending from at least 5°E to 5°W. From 66°S, 1°W to 67°S, 5°E and then NNW to 66°S was a large area of very little pack-ice, with concentrations between 0 and 30%. Satellite photographs show that this area was a continuous wide channel extending out of the pack to NE; to NW the pack increased in density.

From 64°S to the ice edge the ship proceeded almost due north, and floe size along the track decreasing from typical values of 30 m to diameters of 3 to 5 m, and T_a rose from -5°C to the freezing point. Near the southern end of this stretch the pack consisted of closed areas typically 100 km in extent separated by zones of low concentration (10 to 20%) 20 to 40 km across. Further to the North the width of the high concentration areas decreased steadily to between 5 and 10 km finally fading to individual band like structures. A total of seven concentrated, perhaps banded, zones were observed over this part of the traverse. Another region of high iceberg density was found between 62°S and 59°S.

3.6 Microwave emission from polar surfaces

(T.C. Grenfell)

Objectives

(A) To obtain ship-based microwave frequency spectra and the angular distribution of radiation emitted by the prevalent types of sea ice in the Weddell Sea during the spring and early summer in support of remote sensing microwave imagery by the NIMBUS series satellites.
(B) To measure the physical properties of the ice which determine its microwave emissivity in order to understand the physics of microwave emission with the help of theoretical models.
(C) To investigate the spatial and temporal distribution of ice types in the Weddell Sea over the scales resolvable by presently available satellite sensors (25-100 km).

This work is a continuation of the project begun during the winter cruise (V/2). During V/2, temporal stability and spatial variations in microwave emissivities were investigated over the central part of the Antarctic sea ice pack in the northeastern Weddell Sea during the winter maximum. During V/3, the investigation was extended into the late winter and spring, and spatial coverage was expanded to include the thin ice types of the coastal polynya system as well as the southern rim of the heavy pack. The two data sets, thus, complement each other both in seasonal and areal coverage.

Work at sea

Brightness (Radiation) temperatures have been obtained for the full range of ice types encountered by the ship along the transects to and from the antarctic continent as well as during the traverses through the Weddell Sea coastal polynya system. Observations were made at 5 frequencies from 6 to 90

GHz (including the set used by the NIMBUS-7 SMMR satellite) in vertical (V) and horizontal (H) polarization. Two modes of operation were employed. (1) At each ice coring station, scans over angle of incidence were obtained in both polarizations together with low and high temperature calibrations of each instrument. Angular scans of the sky radiation were obtained to determine the contribution of the atmosphere to total microwave radiation which would reach satellite altitudes. (2) When the ship was in transit, scans at a fixed nadir angle of 50 deg., the SMMR nadir angle, were carried out in both V- and H-polarization to obtain spatial distributions and to investigate the thin ice types which were not observable at the coring stations.

A vital part of the microwave study was to characterize the different varieties of ice type, their spatial distribution, and their temporal variations; thus the present work is closely linked with the ice watch observations and resultant organization and analysis.

To carry out objective B, I relied heavily on the efforts and cooperation of the ice coring team which has collected and is studying the necessary sea ice and snow samples. The data required for the present study include depth profiles of temperature, salinity, and crystal size through both the snow and the ice. In addition, snow density and bubble size distribution in the ice are also needed. In order to make a visual comparison of the ice at the different stations and to record spatial variations in snow thickness and ice ridging, we have obtained a video taped record at each station of the surfaces we observed.

Preliminary results

The emmissivity spectrum of growing sea ice increased rapidly from relatively low open water values to near unity (blackbody) when the ice reached a thickness of about 10-15 cm. This corresponds to grey/white nilas. The spectral gradient of new ice was initially rather steep and flattened out as the ice grew thicker. The degree of polarization decreased continually during the same interval, and may provide a good measure of thickness for 0-15 cm thick sea ice. Subsequent changes which were observed appeared to depend on the snow thickness, on desalination, and on melt/freeze cycling in the surface layers. As long as the air temperature remained below -10°C and the snow conditions did not change much, however, the signatures for ice types thicker than about 20 cm appear to have been quite stable. Thick layers of coarse grained snow observed in the main part of the ice pack resulted in a depression of the emissivities at higher frequencies.

3.7 Ice watch (H. Eicken, T. Grenfell, B. Stonehouse)

Objectives

The ice watch was instituted to provide sampling of the observed ice concentration and ice type distribution on a regular basis throughout the cruise. Percent of surface coverage and the spatial distribution of sea ice types are needed for almost all the major activities on the cruise. The ice conditions play an important role in the surface heat exchange and the dynamic interactions betweeen the ocean and the atmosphere. They also determine the mesoscale microwave emission signatures and the observations are needed to relate the measurements from the ship to larger distance scales. The ice also plays an important role in biological processes especially in the near surface layers where the ice provides a favourable habitat for a wide variety of organisms.

Work at sea

The ice watch was carried out from the bridge of the ship by a team of 21 interested scientists. The data include a systematic record of ship's position, environmental conditions such as temperature, surface pressure, wind speed and direction which are related to the formation of sea ice and its subsequent development. The description of the ice includes in tabular form (1) the percent of the total area covered by ice, (2) range in floe size, (3) typical snow thickness, and (4) number of icebergs present within about 12 sea miles of the ship. In addition, a more detailed description is provided for each distinct ice type consisting of typical dimensions and percent area covered, snow depth, degree of rafting, and amount of ridging. Peripheral observations such as horizontal visibility, distance from the coastal cliffs, impressions of the degree of ice compression, and the presence of ice algae are also included. A series of 35 mm black and white photographs was taken concurrently with the visual observations, and a set of contact prints are an integral part of the report. Hourly observations were recorded on the transects from the ice edge to Atka Bay and three hourly readings were taken during the polynya traverses.

Preliminary results

The data have been transcribed onto microcomputer diskettes as the observations were gathered and have been printed out and made available to all interested parties before the termination of the cruise. The original observation file together with the photographic negatives will be stored at AWI under the protection of M. Lange. To obtain a set of photographic prints, arrangements must be made with AWI. A synthesized description of the development of ice conditions on the north/south transects and of polynya related ice dynamical processes is currently in preparation for publication. A brief summary of the log book of the ice watch is given earlier in this cruise report.

3.8 Biology and structure of sea ice (A. Bartsch, K. Beyer, H. Eicken, M. Elbrächter, K. Schaumann, M. Spindler, R. Steinmetz)

Objectives

To study distributional patterns, on both large geographical and small scales, of the thickness of different types of sea ice in late winter and early spring. Patterns are related to structural, physical and chemical properties of sea ice, and compared with summer data obtained during ANT III/3 in the same region. In addition the physiology of selected ice organisms (diatoms, bacteria, fungi, foraminifers) has been investigated.

Work at sea

Two hundred and six cores were taken from 35 fast ice and floe stations along the shelf ice edge in the eastern Weddell Sea and along the cruise track from the outer edge of the pack-ice to the continent and back (see list of ice core stations).

At each station several replicate cores were taken: 2 cores with 4 inch diameter and 3 to 6 cores with 3 inch diameter.

The first 4 inch core was archived. In the -25°C cold laboratory one third of the second was cut away vertically covering the whole length. From thin sections of this slice the stratigraphy of the ice core, brine layer spacing, distribution of inclusions and c-axes distributions were determined. The remaining two thirds of the core were cut according to ice texture and melted to measure volume, salinity, chlorophyll a concentration, nutrients and foraminifers.

The temperature of each first 3 inch ice core was recorded immediately after removal, in holes drilled at 5 cm intervals. The additional cores were cut into 10 cm sections and thawed in larger volumes of seawater or in smaller volumes of concentrated brine both at +2°C for a) enumeration of living specimens such as flagellates, ciliates, copepods, bacteria, fungi and foraminifers, and b) obtaining live diatoms, dinoflagellates and foraminifers for physiological experiments.

Preliminary results

Thickness of ice cores ranged from 20 cm to 220 cm with snow covers of various thickness (0 to 50 cm) (see list of ice core stations).

The structural and textural studies showed types of sea ice unaccounted for by the conventional two-fold classification into frazil and columnar ice. One was the occurrence of loose single-crystal platelets (up to 20 cm in diameter, < 2 mm thick) in layers several meters thick underneath the solid ice cover. This platelet layer consolidated from the top down and was thus contributing as much as 30% to the thickness of the sea ice cover. Another type of sea ice that constituted about half of the total length of cores drilled consisted of indented, interlocked grains with random to ordered c-axis distributions, in which gradual transitions to columnar ice were observed. Samples of new sheet ice, mostly grown overnight, displayed clearly the sequence of frazil, transitional and columnar ice typical for growth under quiet conditions.

Diatoms were distributed throughout the cores. In winter they were concentrated in the lower sections of the ice; upper sections were inhabited mainly by a variety of heterotrophic and phototrophic flagellates and dinoflagellates. The highest chlorophyll a content measured was 450 µg/l. Most of the diatoms were active, especially in lower sections, although resting spores were found as well. The dominant diatom species belonged to genera well known from ice: Nitzschia, Amphiprora, Tropidoneis and Pleurosigma. In some cores very high numbers of live specimens belonging to the planktonic diatom genera Thalassiosira, Coscinodiscus and Actinocyclus were present. Species of planktonic diatom genera present in the water column were also found alive in the ice. These algae may serve as a seeding population for the plankton community during melting of the ice. Several dinoflagellates seem to be restricted to the ice, including some new species. In summer (during ANT III/3) diatoms were concentrated also in upper layers of the ice, and chlorophyll contents were much higher than in winter with values up to 2200 µg/l.

The lower abundance of diatoms during late winter may account for less numerous heterotrophic consumers (foraminifers, ciliates, calanoid and harpacticoid copepods). In the cores from ice floes taken close to the ice edge, and in those taken towards the end of this leg (end of November), numbers of diatom-consuming microherbivores increased.

Bacteria were most numerous in upper and lower sections of the ice. Total colony counts of saprophytic bacteria ranged from 0 to 4 x 10^7 cfu (colony forming units) per liter. Marine fungi, recorded for the first time in sea ice, are regarded as a permanent constituent of the sea ice community. In most samples mycelia-forming higher fungi (mainly Deuteromycetes) occurred, also yeasts and lower fungi (Phycomycetes). Among the higher fungi several species are known as 'terrestrial' forms whereas among the yeasts and lower fungi aquatic species dominate.

The growth experiments with diatoms started on ANT V/2 were continued and showed similar results (reduced growth of cells from upper layers, high growth rates by those from the bottom layers). In experiments involving variant temperature and salinity regimes diatom species were able to grow in salinity of 70°/oo and a temperature of -4°C. At 115°/oo at -7°C and 145°/oo at -10°C algae remained alive but no increase of cell numbers and chlorophyll was observed. Growth was reduced also under low light conditions where centric diatom species tended to form resting spores.

The planktonic foraminifer Neogloboquadrina pachyderma shows a remarkable adaptation to the environment in the sea ice. While other species of planktonic foraminifers stop growing at high salinities (> 42°/oo) N. pachyderma was still forming chambers at 46°/oo and was actively feeding in seawater of 55°/oo. Experiments with higher salinities are still in progress and will be continued together with those on the ice algae.

Tab. 9. Ice core stations.

Station No.	Position	Date	Core length and snow cover in brackets		No. of cores drilled
532780	60°36.5 S 0°43.2 W	05 Oct	55	(-)	7
532800	63°24.6 S 4°49.9 W	07 Oct	80	(15)	8
532810	65°06.4 S 7°10.3 W	08 Oct	84	(7)	8
532820	67°09.9 S 6°55.0 W	09 Oct	72	(15)	9
532830	68°59.5 S 6°11.1 W	10 Oct	184	(-)	2
532850	70°40.6 S 10°16.2 W	12 Oct	44	(3)	7
532860	71°24.6 S 15°06.3 W	13 Oct	46	(5)	7
532870	72°43.4 S 19°50.8 W	14 Oct	39	(4)	7
532871	72°49.3 S 19°24.9 W	14 Oct	42	(-)	5
532880	72°53.5 S 19°10.9 W	15 Oct	83	(-)	7
532881	72°52.0 S 19°23.0 S	15 Oct	175	(-)	3

Station No.	Position	Date	Core length and snow cover in brackets		No. of cores drilled
532900	72°25.1 S 20°55.5 W	17 Oct	128	(3)	7
533000	76°32.9 S 32°39.o W	27 Oct	53	(2)	7
533010	76°04.6 S 27°53.8 W	28 Oct	105	(6)	8
533020	75°28.2 S 27°04.5 W	29 Oct	52	(3)	3
533030	75°46.8'S 29°09.8 W	30 Oct	82	(5)	7
533050	74°03.2 S 25°08.2 W	01 Nov	20	(2)	7
533070	72°50.7 S 19°40.6 W	03 Nov	28	(4)	3
533110	72°51.7 S 19°56.8 W	07 Nov	37	(5)	8
533120	72°46.9 S 20°10.1 W	08 Nov	31	(-)	6
533140	76°06.2 S 28°23.5 W	10 Nov	118	(20)	6
533150	75°59.5 S 28°16.9 W	11 Nov	107	(5)	6
533160	76°02.6 S 27°59.3 W	12 Nov	18	(1)	2
533170	74°53.7 S 25°59.4 W	13 Nov	25	(2)	4
533180	73°56.4 S 23°07.2 W	14 Nov	44	(10)	6
533190	73°42.5 S 21°59.8 W	15 Nov	22	(-)	5
533210	72°52.0 S 19°21.0 W	17 Nov	65	(-)	7
533220	72°52.6 S 19°20.8 W	18 Nov	178	(50)	6

Station No.	Position	Date	Core length and snow cover in brackets		No. of cores drilled
533240	72°52.8 S 19°06.7 W	20 Nov	220	(22)	6
533270	72°51.9 S 19°22.8 W	23 Nov	47	(10)	2
533300	72°02.9 S 15°26.7 W	26 Nov	125	(20)	7
533330	69°02.1 S 7°34.9 W	29 Nov	63	(20)	7
533340	67°31.7 S 3°55.5 W	30 Nov	37	(10)	7
533380	62°54.1 S 0°27.7 E	04 Dec	40	(10)	7
533390	59°57.7 S 0°25.2 E	05 Dec	50	(15)	3

3.9 Physical oceanography (E. Fahrbach, H. Klindt, D. Muus, G. Rohardt, P. Salameh)

The work carried out by the physical oceanography group concentrated on four major topics:

- A large scale survey of the eastern boundary between the Weddell gyre and the open ocean.
- A large scale survey of the Antarctic Coastal Current along the eastern Weddell shelf area.
- A mesoscale survey of the time variation of the Antarctic Coastal Current off Drescher Inlet.
- A small scale survey of the hydrographic conditions under the sea ice.

A. A large scale survey of the eastern boundary between the Weddell gyre and the open ocean

Objectives

1. To describe the transition from the winter to summer conditions.
2. To find possible relationships between the gyre circulation and topographic features as Maud Rise.
3. To find indications of possible open ocean deep convection.

Work at sea

On the way to the coastal polynya in early October 12 CTD stations were carried out between 54°30'S, 6°E and 70°30'S, 8°W. Another set of 16 stations was obtained in early December on the way back north. During this transsect three current meter moorings were recovered at Maud Rise. The path between the current meter arrays was used to run an additional section to the NNE across the top of Maud Rise.

Preliminary results

The section to the South began at 54°30'S where a temperature minimum layer of -0.7°C at a depth of about 100 m indicated the onset of spring conditions. South of 58°S clear winter conditions were found with a surface Winter Water layer whose temperature was less than -1.8°C. In the area west of Maud Rise the deph of this layer decreased to less than 50 m from values of about 150 m to the North and 250 m to the South.

The observed structures in the underlaying Warm Deep Water (WDW) were found to be related to the topographical constraints on the gyre circulation. Above the flank of the Mid-Ocean-Ridge at 58°S the temperature maximum of the WDW dropped within a few miles to the South from 0.9°C to 0.3°C corresponding to the northern eastward flowing boundary current of the gyre. In the area west of Maud Rise the temperature maximum increased again to 1.08°C. This is consistent with a south westward inflow north of Maud Rise.

The inflow pattern was investigated in more detail during the journey north. A pronounced WDW-temperature maximum of more than 1.2°C was found in 150 to 250 m depth above the north-western flank of Maud Rise (Fig. 22). On the top it dropped to about 0.3°C and reintensified further to the South to more than 0.6°C. West of Maud Rise temperatures of more than 1.0°C occurred between 69°S and 63°S. This horizontal spreading of the temperature maximum is presented in Figure 23. In this figure stations from both crossings are used. The observed density field (Fig. 22) is consistent with an anticyclonic flow advecting the WDW- tongue around the north-western flank of Maud Rise.

With the exception of the area above Maud Rise the near surface layers show the onset of the summer stratification by warming and freshening. The warming increases to the North. Below the summer layer in 50 to 100 m depth the remnant Winter Water generates a temperature minimum layer. Over Maud Rise the Winter Water layer is broken up and the WDW temperature maximum drops which leads to a significant weakening of the stratification. However, during this time of the year the mixed layer salinity is not high enough to allow deep convection.

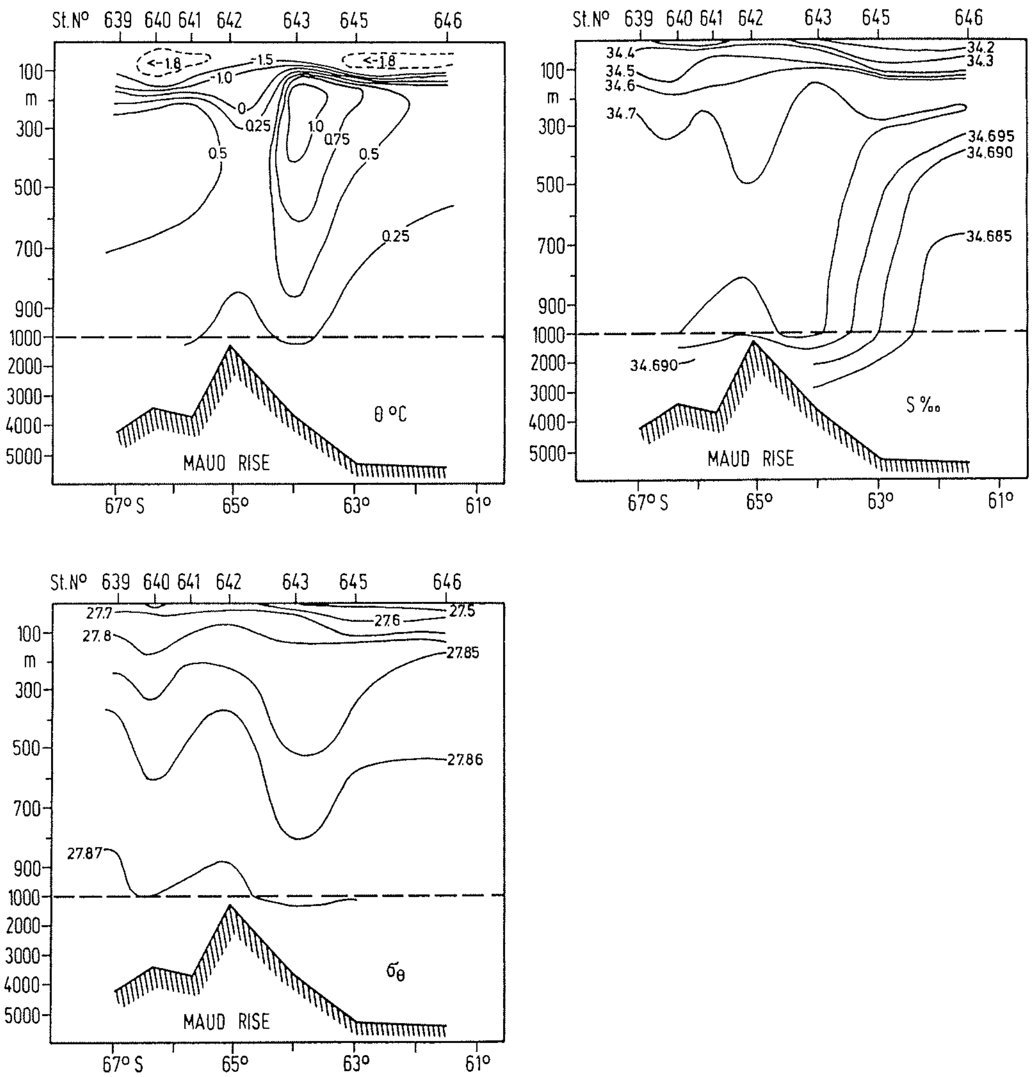


Fig. 22. A hydrographic section across Maud Rise carried out from 2 to 6 December 1986 representing a potential temperature θ , salinity S and density σ_θ . The location of the stations is indicated in Figure 23.

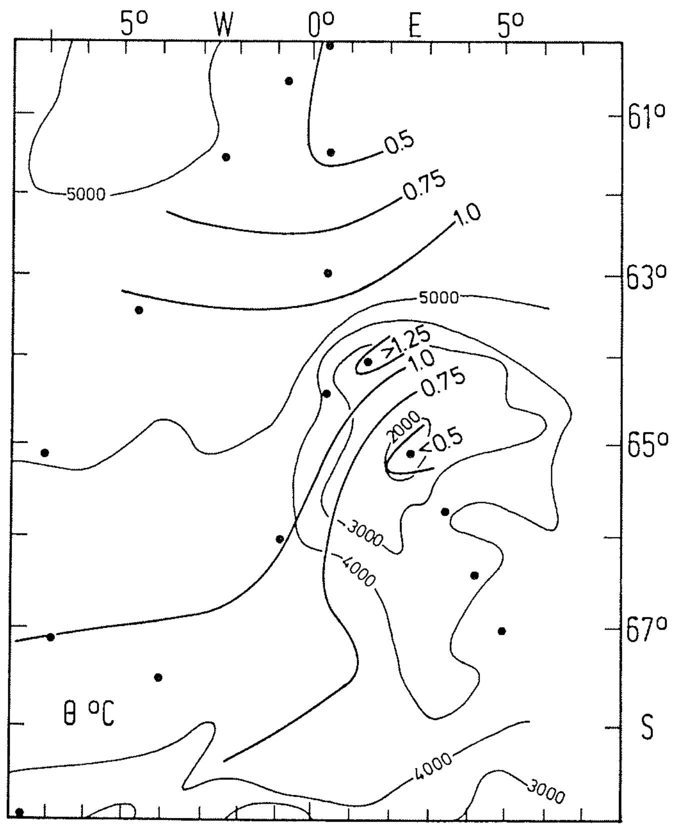


Fig. 23. A horizontal map of the potential temperature in the level of the temperature maximum related to the Warm Deep Water. The stations are carried out from 5 to 10 October and from 30 November to 4 December 1986.

B. A large scale survey of the Antarctic Coastal Current along the eastern shelf area

Objectives

1. To find indications of water mass transformation along the path of the Coastal Current along the eastern shelf in the sense of a preconditioning for Antarctic Bottom Water formation.
2. To observe the transition from winter to summer conditions along the coast.

Work at sea

To obtain the water mass characteristics along the eastern Weddell shelf 36 CTD stations were carried out between Atka Bay and the Filchner Trench. Most of the stations were located on the shelf. Cross shelf sections were obtained both near Drescher Inlet and off Halley Bay, in the divergence area of the Coastal Current where the continental slope turns to the west and south of Vestkapp at Neptune's Point. A longshore section over 120 km was run north of Vestkapp.

Preliminary results

In most sections an offshore increase of salinity from slightly below 34.3 to more than 34.4 was observed in the surface mixed layer indicating the transition from the Eastern Shelf Water to the Winter Water. On the way south to the Filchner Trench in early November the increase of salintity over 750 km did not exceed this level. The highest mixed layer salinity was observed at 77°10'S amounting to 34.42. Therefore one has to assume that even in winter the interaction with the ice shelf leads to a freshening of the shelf water which is strong enough to compensate in a large extent for the salt gain within the polynya due to freezing. Consequently no indication on essential preconditioning to Antarctic Bottom Water formation was found.

The transition from winter to summer conditions was first encountered at the last Drescher section. It increased in intensity on the way north to Atka. There, however, pure winter stratification was found which shows that the onset of spring is obviously intermittent and is interrupted by advective events.

C. A mesoscale survey of the Antarctic Coastal Current off Drescher Inlet

Objectives

1. To identify time and space scales of the variability of the Antarctic Coastal Current.
2. To separate local and remote forcing.
3. To discriminate between thermohaline and wind forcing.

4. To study the response on different type of wind forcing.
5. To study the modification of the wind forcing due to variations in the ice cover.
6. To observe the transition from winter to summer conditions.

Work at sea

The experimental work consisted of 37 CTD-stations and direct current measurements. The CTD-profiles were grouped into seven sections perpendicular to the coast line off Drescher Inlet extending once over 70 km but normally over 35 km. The profile depth ranged from 300 m on one section to the complete water column at two sections. Most sections consist of five stations providing highest resolution over the upper continental slope with offshore increasing spacing. The stations were chosen to represent the shelf (450 m), the shelf break (800 m), the upper slope (1600 m), the lower slope (2400 m) and the transition to the abyssal plain (3400 m). Rough topography and difficult ice conditions made it impossible to meet those requirements in all cases.

To obtain direct current information current meter arrays were moored, an acoustic current meter was lowered from the ship and a Doppler SONAR Profiling Current Meter (DCP) was used.

Four current meter arrays were moored on the section, Adelie in 445 m, Goldschopf in 838 m (Fig. 24), Zügel in 2614 m and Kaiser in 3454 m depth. A short term mooring, Sturmvogel, was laid for 42 hours under the fast ice of Drescher Inlet in 398 m depth. Adelie and Goldschopf were recovered at the end of the observation period. We obtained 35 day long time series of one water level recorder, one thermistor cable, two acoustic NB current meters and five Savonius rotor Aanderaa current meters. Zügel could not be interrogated for recovery either before or after the release. A helicopter survey with a battery powered release unit was not able to contact the underwater unit. In the present situation it can not be decided whether the failure was due to a damage of the release or if the mooring was carried away by deep reaching ice ridges. A search during a future cruise possibly with the LODAR would be desirable. As for the deepest mooring, Kaiser, recovery was not attempted, because the area was completely ice covered. Locations and records length of the moorings are summarized in Table 10.

On 46 stations the DCP was used to measure 20 min averages of current profiles down to 350 m. The data were primarily recorded as profiles on a printer. Extensive data processing is still needed for the drift correction. The ships drift is determined accuratly enough only during times when GPS was available.

Tab. 10. Mooring instruments.

Mooring No.	Position	Waterdepth	Date
AWI 201-1	72°51.7'S 19°32.5'W	415 m	16.10.-19.11.1986
AWI 101	72°49.4'S 19°36.1'W	815 m	15.10.-18.11.1986
AWI 103	72°33.4'S 20°35.7'W	3415 m	17.10.-22.02.1987 (ANT V/4)
AWI 104	72°51.9'S 19°22.8'W	393 m	22.11.-24.11.1986

Preliminary results

As the current meter data have to be processed in Bremerhaven no results of the direct current measurements can be presented here.

The hydrographic sections show a series of possible responses of the water column to an highly variable wind and thermohaline forcing. The variability of the wind can be demonstrated by means of the weather observations on board. Figure 25 gives a time series of daily means of wind speed and direction and a histogram including all three hourly observations of the shipborne weather station between 71°S and 76°S. One can see that ENE winds dominate with an average speed of 19 m/s. However from the time series it appears that during the first part of the cruise S to SW winds contribute significantly, whereas later NE winds are dominant. A typical time scale of the variations lies between 2 and 5 days. Consequently we can not expect to find a steady state in our sections but only transient features. As it took one to two days to run a section, even when the profile depth was reduced to 1000 m depth, it has to be taken into account that the sections were not measured on a synoptic time scale.

The seasonal variation can be seen by comparing the data with those obtained in summer 1985. The variations are primarily restricted to the upper layers. Two major seasonal changes in the forcing functions have to be taken into account to explain the differences:

1. The thermohaline forcing leads to the formation of cold (<-1.8°C) and relatively saline (>34.3) Winter Water layer of about 200 m thickness at the offshore end of the sections with a significant deepening towards the coast. During summer this layer is covered by a shallow relatively warm and low saline summer layer. Figure 26 shows as an example the last Drescher section carried out on 25 November. The Winter Water is shaded.

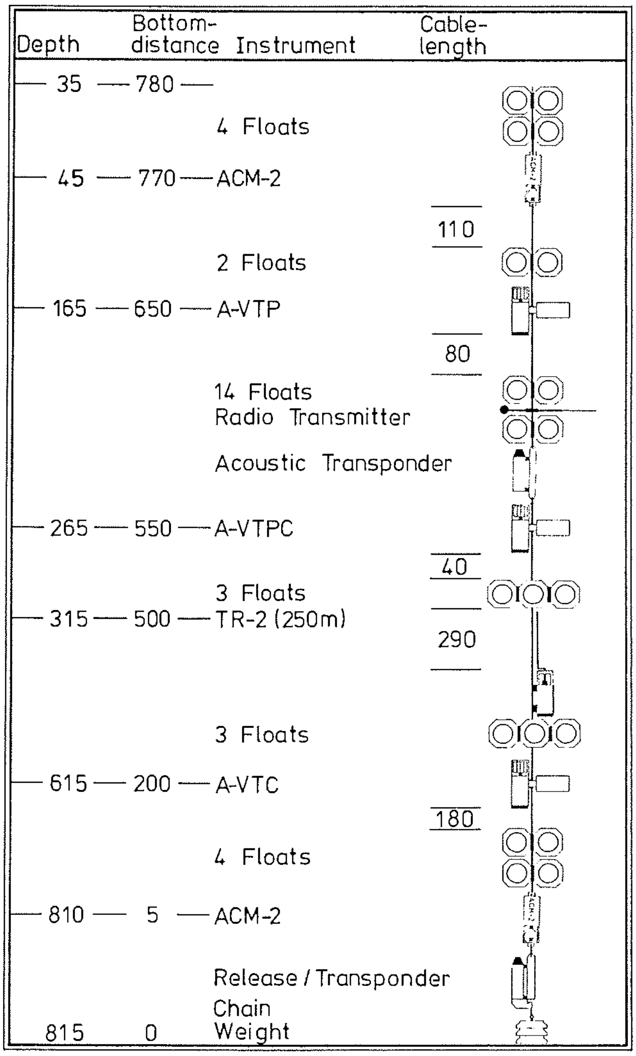
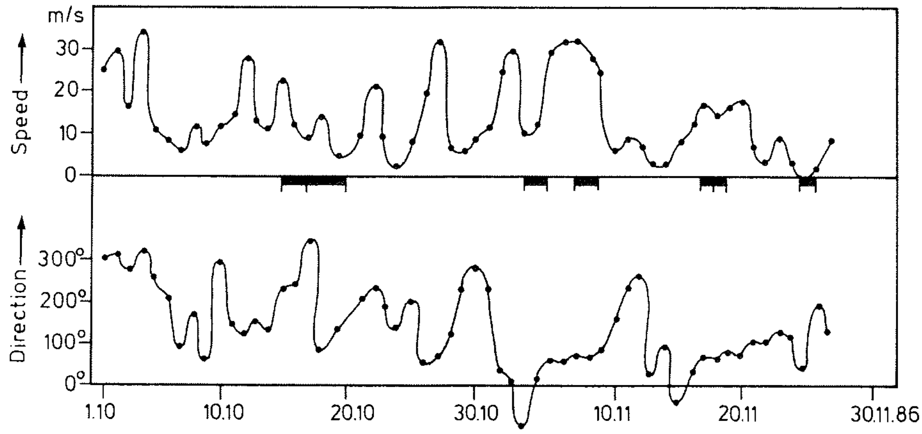


Fig. 24. A schematical representation of mooring Goldschopf laid and recovered during the present leg at 72°49'S, 19°35'W.



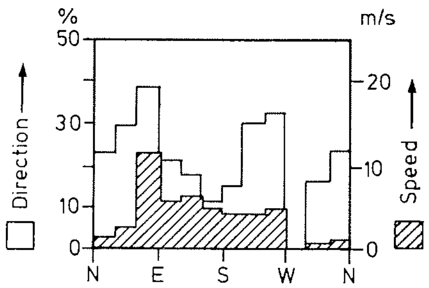


Fig. 25. Time series of the daily means of wind speed and direction observed by the weather station on board RV "Polarstern".
The bars indicate periods when sections were carried out off Drescher Inlet. The histogram gives the percentage of observed winds in a 30° sector and their average speed.

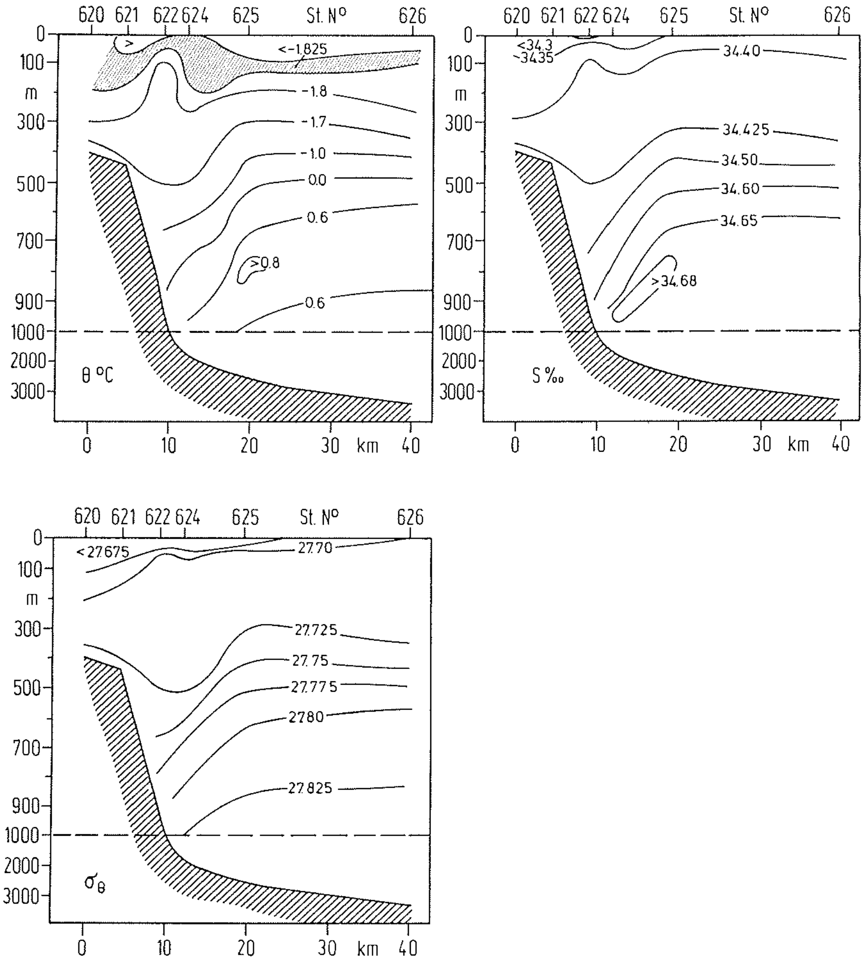


Fig. 26. A hydrographic section off Drescher Inlet carried out on 24 and 25 November 1986 representing potential temperature θ , salinity S and density σ_θ . The hatched area in the temperature section indicates the temperature minimum due to the reminents of winter water.

2. The dynamic forcing by the wind is modified during the winter by the presence of variable sea ice. In a wide continously ice free summer polynya only the direct variation of the wind generates upwelling or downwelling conditions. These are visible in the sections as ridges or troughs. In winter the variable ice cover modifies the mometum transfer from the wind to the ocean. Large ice sheets are no longer influenced by the local winds, but by large scale or distant wind fields. Consequently the ice decouples the ocean from the local wind. Freely moving ice floes amplify the momentum transfer to the ocean in comparison to ice free conditions. Since the ice cover varies over rather short distances within the polynya additional up- and downwelling is generated with length scales of 10 to 20 km. An example is given in Figure 26.

The stratification below 300 m is dominated by the density gradient which is in geostrophic balance with the Antarctic Coastal Current. The width and steepness of this gradient varies by a factor of two on a time scale of a few days. The gradient appears somewhat wider in the summer sections, but this might be an artefact due to the smaller number of data in summer.

The average geostrophic transport over six sections extending 35 km from the coast relative to 1000 db amounts to 1.2 +/- 0.6 Sv. There is no obvious correlation between the transport and the wind variations.

In most sections the gradient inverts from offshore towards the shelf edge. Assuming a constant reference level this can be interpreted as a counter current. However as geostrophy is no longer valid in the boundary layer this hypothesis has to be confirmed by direct current measurements. The horizontal resolution of the summer sections is not high enough to detect those features.

Over the shelf almost all sections show a decrease of the salinity to less than 34.3 which can be explained by the assumption that even in winter the water flowing by or under the ice shelves induces some melting. The resulting fresh water overcomes the salt gain due to freezing.

D. A small scale survey of the hydrographic conditions under the sea ice.

Objectives

1. To compare the upper ocean layer disturbed by the the ship with undisturbed conditions under the ice.
2. To find, if there are intermediate layers between the ice and the free water column where significant gradients can induce heat transport or generate stable layers which might be used as an habitat.

Work at sea

The motivation for these studies arose during the cruise. Consequently a suitable instrumentation had to be developed at sea. This was done with a NB-Smart CTD which was inserted on an L-shaped lever through a hole in the ice. However, various water intrusions into the instrument resulted in the failure of this technique. In consequence a special lever system was built to position a NB Mark 3b weighing about 40 kg below the ice (Fig. 27). Twenty four profiles were obtained reaching from the bottom of the ice down to 2 m below the ice surface with a maximum distance of 1 m from the entry hole. As the conductivity sensor was influenced by nearby ice platelets, salinity samples where drawn to check the sensor.

Preliminary results

All profiles were carried out during the second part of the cruise. Therefore they do not represent full winter conditions with significant ice formation. In contrary most profiles show a slight decrease of the salinity close to the ice which is most likely to explain by melting. Four examples are presented in Figure 28.

The profiles shown in Figure 28a were obtained at a station on rather new ice. A temperature drop of 0.06 K was observed within 40 to 50 cm below the ice. This was correlated with a remarkable decrease of the salinity. The fact that this water was below freezing and that the conductivity sensor recorded values corresponding to a free water salinity of less than 30 indicates that an ice/water mixture must have been present.

The occurrence of ice platelets is confirmed by the observations of UWE and by their appearence in the holes for the profiles on the fast ice of Drescher Inlet. Within the platelet layer the salinity dropped according to water samples by 0.2 (Fig. 28b). Repeated temperature profiles showed that the disturbances induced from below penetrate only 30 cm into the platelet layer demonstrating its stabilizing effect.

Under free floating ice floes three types of profiles were observed: a homogenious one (not shown here), a slightly but stable stratified one, representing conditions of low turbulent energy (Fig. 28c), and a highly variable one in time and space showing conditions of high turbulent energy (Fig. 28d). The high turbulent energy level was most likely induced by the onset of ice motion.

Heat fluxes were calculated from the profiles under the asumption of Austausch coefficients of 10-5 m^2/sec. Only the case shown in Figure 28a gives a significant transport of 25 W/m^2, whereas all others are less than 1.5 W/m^2.

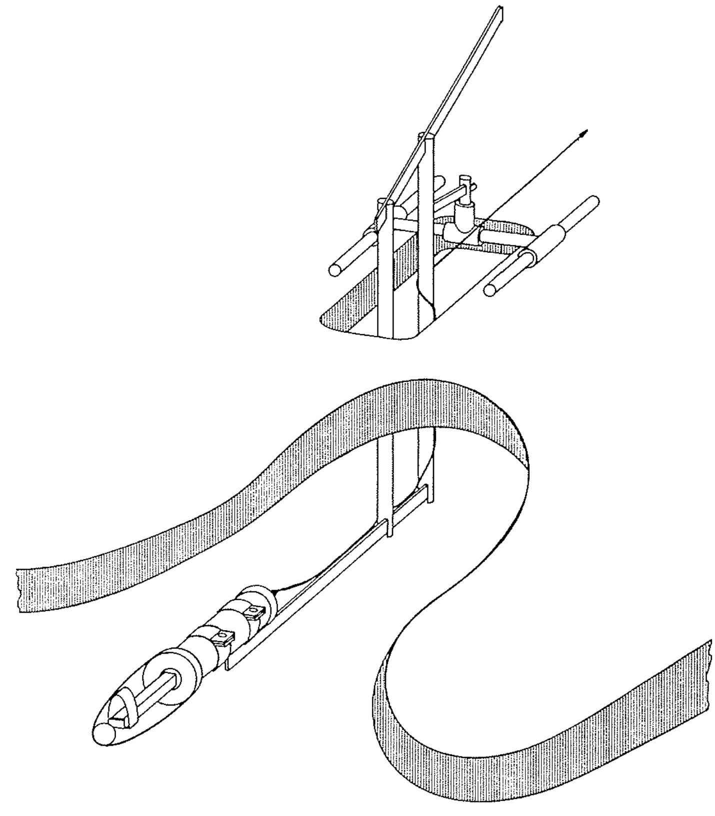


Fig. 27. L-shaped lever system which was used to measure CTD-profiles under the undisturbed ice cover.

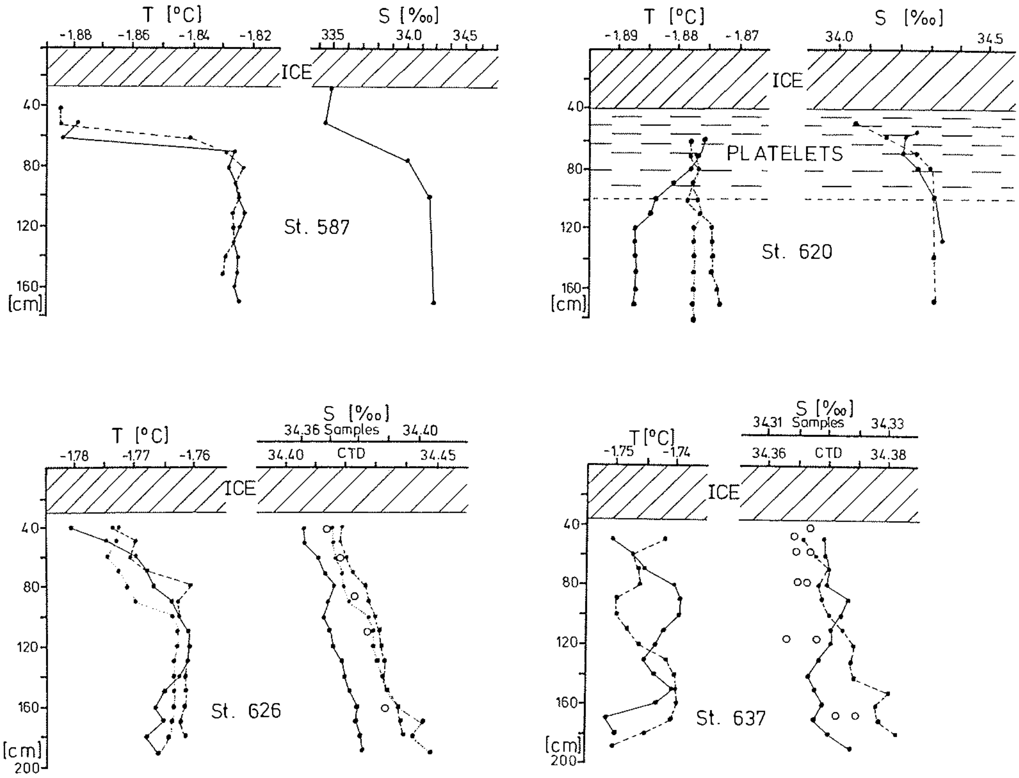


Fig. 28. Profiles of temperature and salinity measured under the ice at Stations 587, 620, 626 and 637. All temperature profiles are measured by the CTD. The salinities at Stations 587 and 620 and the open circles at Stations 626 and 637 are obtained from water samples. The salinity profiles at the two latter stations are obtained with the CTD.

3.10 Tracer chemistry and chemical oceanography

(L. Gordon, H. Klöser, S. Moore, D. Muus, U. Rabsch, M. Rhein, P. Salameh, P. Weiss, R. Weiss, R. Weppernig, F. Zaucker)

Objectives

The objectives of the tracer chemistry and chemical oceanography programs on ANT V/3 are closely tied to those of the preceeding leg of the expedition, ANT V/2, in attempting to broadly characterize the chemical and physical oceanography of the deep-water and coastal regimes of the eastern Weddell Sea in wintertime. The chemical program has involved close international cooperation among scientists at the University of Heidelberg, Scripps Institution of Oceanography, University of Bern, Oregon State University, Lamont Doherty Geological Observatory, and Louisiana State University.

Among the principal goals of the chemistry program on ANT V/3 has been the study of wintertime shelf water properties in the eastern shelf region and their relationships to the rates and mechanisms of Antarctic Bottom Water (AABW) formation. Based on summertime observations alone, the region of active AABW formation involving cold and saline shelf waters was found by Foster and Carmack to be limited to the region west of the Filchner Depression: Eastern Shelf Water (ESW) is not saline enough in summertime to contribute to this process. Since the coastal currents tend to move shelf water toward the west, a wintertime study of ESW would tell us whether a much larger region of the Antarctic coastline was involved during wintertime in the important processes of AABW formation. We came equipped with a number of geochemical tracer techniques to study these processes: carbon-14, the dissolved atmospheric freons F-11 and F-12, tritium, helium-3 and -4, neon, krypton-85, argon-39, deuterium and oxygen-18 stable isotopes, oxygen, nitrate, phosphate, silicate, radium-226, and barium.

Because of the important role of the Weddell Gyre in AABW formation, the chemical exchange which occurs between the surface waters of this region and the atmosphere has important implications for the long-term modulation of the chemical composition of the deep waters of the world ocean and the composition of the atmosphere. In the Weddell Gyre, the study of such chemical exchange processes is complicated by seasonal stratification, inhibition of air-sea exchange and wave mixing by seasonally and spatially variable ice cover, and by the short residence time of the surface waters in this region. In addition, there is known to be active entrainment of deep water into the winter surface layer from below. Comprehensive wintertime measurements of surface water dissolved gases, especially the carbon dioxide system, oxygen, freons, nitrous oxide, helium isotopes, neon, argon-39, and krypton-85, are therefore an important part of our program.

Another major focus of the chemical program is the interaction between seawater and ice - both shelf ice and sea ice. Distribution of the stable isotopes, deuterium and oxygen-18 and the noble gases helium and neon are extremely sensitive to the effects of melting at the underside of deep ice shelves, since this melting process introduces continental meteoric fresh water and entrapped air into the water column. When sea ice freezes, dissolved gases in the water are generally entrapped in the ice, but there is evidence in the literature that there may be some preferential exclusion of some noble gases, which may be a useful tracer of this freezing process. We therefore also directed our efforts at the study of waters adjacent to the shelf ice barrier and immediately below the freezing winter sea ice.

Aside from the biologically active summer surface water, the nutrient and oxygen distributions in the water masses of the Weddell Sea generally follow conservative mixing relationships. Thus, the chemists have been able to predict the finding that there is no pronounced biological activity prior to the development of the summer surface layer. The notable exception to this conservative behavior is in the distribution of silicic acid (silicate), which is markedly affected by the subsurface dissolution of biogenic particulate silica. Thus, in conjunction with our dissolved nutrient studies, we have undertaken a study of particulate biogenic silica distributions throughout the water column, extending from the northern edge of the pack-ice to the shelf waters in the South.

As a corrolary to our objectives concerning the formation of AABW, we have also undertaken to study the wintertime modification of the chemical properties of the coastal current along its path from Atka Bay to the coastal polynya region south of Halley Bay. Together with the physical studies being carried out on this current, the chemical data should allow us to place limits on the integrated effects of evaporation, precipitation, freezing, melting, gas exchange and biological processes along a considerable length of wintertime Antarctic coastline.

Finally, a number of the chemists have contributed to the study of under-ice processes which was so prominent on this expedition. The nature of this work and its objectives are discussed elsewhere in this report, in a special section devoted to this topic.

Work at sea

a. Sampling

Seawater samples for chemical measurements were collected in a number of ways, according to the requirements of the individual analyses. Samples for measurements which do not require exceptionally large volumes of water were generally drawn from the 24-bottle 10-liter rosette or from the 12-bottle 12-liter rosette. This included oxygen, nutrients, freons, tritium, stable isotopes, dissolved inorganic carbon (DIC), helium-3 and -4, barium, and biogenic silica. The sampling density for these parameters varied considerably, from nearly all depths at nearly all stations for oxygen and nutrients, to rather infrequently for the more exotic isotopic tracers, depending upon the application of each measurement and the ease of analysis or sample storage.

Samples requiring larger volumes were collected from separate wire casts using 270-liter Gerrard barrels. These included carbon-14, krypton-85, and radium-226. In addition, 7 samples of 1200 liters (5 Gerrard barrels each) were collected for argon-39.

The suite of geochemical measurements has been focussed on certain sections. This has included the long-shore section in the shelf water from Atka Bay to the Filchner Depression, the Drescher section, the section north of Halley Bay (Divergence Section), the section on the shelf west of Halley Bay, and the two long sections extending from the northern edge of the pack-ice to Atka Bay.

In addition, continuously pumped surface water was used to measure the partial pressures of carbon dioxide and nitrous oxide. This proved to be a problem in the ice, as none of the ship's water intakes was immune from clogging by brash ice swept under the ship while underway. In our experience, the best combination proved to be the deep intake at the bow, connected to the air-driven membrane pump, which could pass small ice particles without damage or loss of suction.

b. Experiments

Most of the chemical tracers discussed above are measured in shorebased laboratories using samples which are specially preserved or extracted aboard ship. The only measurements which were made on board are oxygen, nutrients, freons, and surface water and atmospheric carbon dioxide and nitrous oxide. Even in these cases, the final data will not be available until some months after the expedition, pending shorebased recalibrations and final data processing.

Dissolved oxygen was measured by a modified Carpenter-Winkler method using a new automated amperometric titration approach (see section 2.3.5). Nutrients were measured using a 5-channel colorimetric Autoanalyzer to determine silicate, phosphate, nitrite, nitrite plus nitrate, and ammonium. Biogenic silica samples were filtered on Nuclepore filters for later analysis at OSU by dissolution in sodium hydroxyde and subsequent autoanalyzer measurement of the silicate produced.

Freons (F-11 and F-12) were measured by gas-phase stripping and low-temperature trapping, followed by electron capture gas chromotographic analysis. Surface water carbon dioxide and nitrous oxide were measured by equilibrating pumped surface water with a gas phase which was measured by an automated gas chromatograph, using methane conversion and flame ionization for carbon dioxide and electron capture for nitrous oxide. Atmospheric freons, carbon dioxide, and nitrous oxide were also measured by these chromatographic methods.

Seawater samples for tritium, helium-3 and -4, and radium-226 were stored in appropriate containers for return to Heidelberg for analysis. Samples for carbon-14 were acidified and their carbon dioxide was extracted and trapped in sodium hydroxide for subsequent analysis in Heidelberg. Krypton-85 was extracted for return to the laboratories of W. Smethie at Lamont Doherty Geological Observatory and H. Loosli at the University of Bern for analysis. Argon-39 was similarly extracted for analysis in Bern. Seawater samples for deuterium and oxygen-18 were collected for return to Scripps Institution of Oceanography (SIO) to be analyzed in the laboratory of H. Craig. DIC seawater samples were poisoned with mercuric chloride and returned to the laboratory of C. D. Keeling at SIO for analysis.

Preliminary results

It must be recognized that a large number of the chemical measurements will not be completed until many months after the expedition, and that even for the shipboard measurements any interpretation must be regarded as extemely preliminary. Nevertheless, the data indicate some important conclusions.

The freon measurements strongly confirm the physical oceanographic observations that there was no active deep or bottom water formation occuring along the continental slope from Atka Bay to Halley Bay during the period of our measurements. A preliminary section of F-11 concentration is shown in Figure 29 for the section extending northwestward from Drescher Inlet across the coastal current. Although the F-11 isopleths dip sharply toward the continent in the depth range 0.5 to 1.5 km, there is no indication in these data that there is freon penetration across isopycnal surfaces, as would be required for new ventilation. The dip in F-11 isopleths simply reflects the dynamics of the coastal current moving toward the Southwest.

As during ANT V/2, surface water dissolved gas concentrations within the pack-ice belt show the combined effects of the blockage of air-sea exchange by sea ice and the entrainment of Warm Deep Water (WDW) from below. Oxygen and freons are everywhere undersaturated in these waters with respect to the atmosphere. There also seems to be greater undersaturation in the southern half of the section extending from the ice edge to Atka Bay, perhaps reflecting the new input of WDW from the east in this region. In the immediate coastal area, however, undersaturations are somewhat less, perhaps reflecting increased ventilation in coastal polynyas. The winter surface water under the pack-ice is generally supersaturated in carbon dioxide and nitrous oxide. This is also an effect of the admixture of WDW, which is enriched in these gases as a result of subsurface metabolic processes.

The ANT V/3 shipboard geochemical sampling and analysis effort will produce an extremely valuable data set for the study of wintertime conditions in this important region. We leave the ship with preliminary data reports for hydrographic properties, nutrients, oxygen and freons, and these data will become final in the coming months. However, a full interpretation of the geochemistry of this region must await the results of the many shorebased measurements.

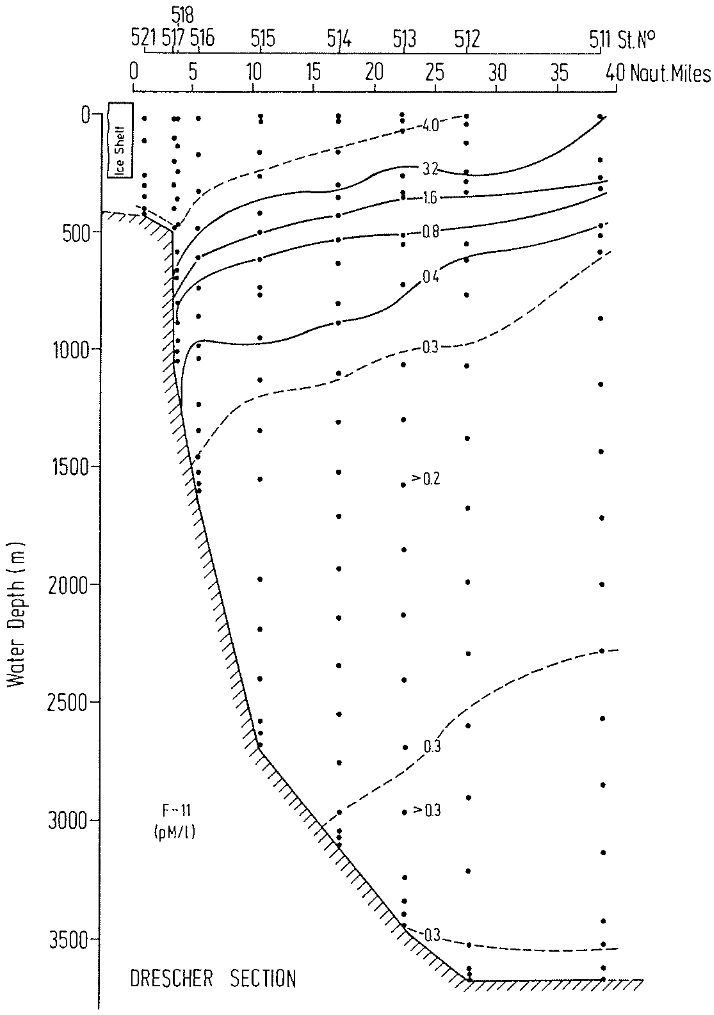


Fig. 29. F-11 concentrations along the section extending northwestward from the Drescher Inlet. (Preliminary results, not for citation).

3.11 Meteorology (H.-J. Belitz, D. Engelbart, R. Hartig, Ch. Kottmeier, R. Surkow)

Objectives

The meteorological program during the ships cruise consisted of two major parts. The first was to investigate the transport of ice flows in the Eastern and Central Weddell Sea by means of an array of drifting ice buoys. The continuous sampling of near surface meteorological data as well as the buoys positions will be used to determine the mean and relative movement of the floes, which lead to the divergence and convergence effects within the pack. The subsequent opening of polynyas will be studied in dependence on the wind conditions. The second part focussed on the wind and the temperature fields in the vicinity of the shelf ice edge at a site with frequent occurrence of coastal polynyas. Based on measurements on board "Polarstern" and on the adjacent shelf ice, the air mass modification due to different turbulent fluxes over the shelf ice, open water and sea ice surfaces had to be investigated.

Work at sea

a. Sampling
Ice buoy programme:
After the successful traverse through the pack-ice an array of 8 ARGOS-transmitting buoys was deployed off the eastern Weddell Sea coast. The buoys measure atmospheric pressure, air and housing temperature and six of them measure wind speed and wind direction as well. One buoy also gives the current speed and direction with respect to the drifting floe. An intercomparison run for all buoys was done prior to their deployment. Depending on the ice conditions at the sites planned for deployment, the instruments were transported by the ship or by helicopter to their locations. By use of an 10 inch ice auger, a hole was drilled through the floe. The buoy then was installed vertically with the lithium battery as deep as possible in order to keep it warm. A floating collar above the ice-strengthened hull prevents the buoy from sinking, if the ice floe should break. The 3 m tripod windmast on top of the hull provides a wind measurement above the maximum extent of surface roughness elements, which are mainly due to the ridging of ice floes. During the experiment data from the buoys were transmitted to the ship via satellite link about every second day. This gave useful information on the regional scale ice movement. The buoy programme, which was started on this cruise is to extend over a full yearly cycle of ice development in the Weddell Sea.

Coastal polynya processes:
With the buoys providing the regional scale background data, a meso-scale programme was performed including the "Polarstern" and measurements at the British "Halley Station" and the temporary "Drescher Station". On the ship the microcora radiosounding station was used to measure vertical profiles

of wind speed and direction, temperature, humidity and pressure. Doppler SODAR wind profiles covered most of the Planetary Boundary Layer (PBL) and gave both the horizontal and vertical wind components. Various fixed level instruments on the ship gave wind, temperature, humidity, pressure, global radiation, longwave radiation from above and cloud base height data. Most of these data were recorded using the SIC data acquisition system as 10 min averages values for almost the whole cruise. Other measurements included the launch of constant level balloons, which were released when an outflow of cold air over the polynya occurred. They proved to be well suited to drift at a level of 200-300 m above the surface and the signals could be received for several hours. On the bow mast of "Polarstern" a device consisting of two radiosondes was installed, which gave wind speed and temperature data from heights of 2 m and 14 m above the surface. At the "Drescher Station" vertical temperature profiles were measured with radiosondes. The PBL wind profiles were achieved by simultaneous theodolithe observation of pilotballoons. Near surface data were continuously sampled by means of an instrumented meteorological mast and an array of paper recording automatic wind and temperature stations. The "Halley Station" used the same radiosounding equipment as "Polarstern". Detailed turbulence measurements in the lower PBL were also performed using Sonic anemometers at the British station.

b. Experiments

Ice buoy programme:

The spacing of the buoys was planned to cover the mesoscale and synoptic scale atmospheric motions near the Antarctic coast. Figure 30 gives the initial positions and the drift of the buoys in the course of the expedition. Together with the buoys, which were deployed earlier during the "Polarstern" cruise ANT V/2 and another two of the British Antarctic Survey, thus the synoptic scale in the Weddell Sea was covered considerably better than usual. After two months seven of the eight buoys are still working reliably. One of them for unknown reasons failed immediately after deployment.

Coastal polynya processes:

The measurements from "Polarstern" and at the shelf ice stations were closely coordinated during 15 periods of intensified measurements. They should resolve the spatial differences and the temporal changes of the temperature and wind field at typical coastal polynia sites. During periods of intensified measurements "Polarstern" either moved on cross sections of 20-30 miles along or away from the coast or remained on fixed stations heading into the wind and soundings were done within short intervals of every 2 or 3 hours. A number of different meteorological events have been detected. We investigated regional and synoptic scale cold air outflows from the shelf ice over the polynya and the adjacent sea ice area. During several almost cloudless nights a local circulation with low level seaward flow and a counterflow above developed near the shelf ice edge. The

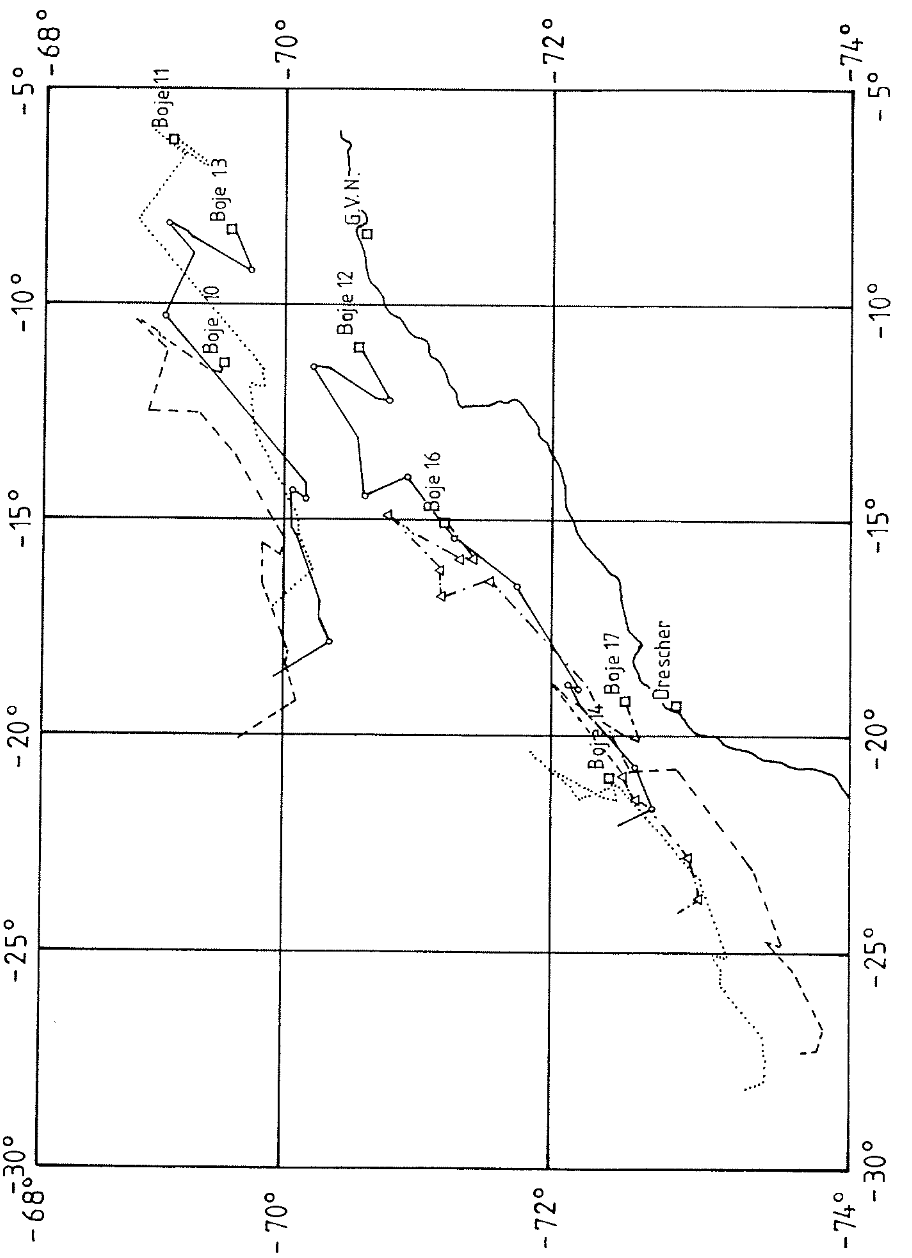


Fig. 30. Initial positions of ARGOS-buoys (mid October) and positions at the end of November in the eastern Weddell Sea.

evolution and passage of mesoscale vortices were also studied by the series of radiosoundings at the different stations. When "Polarstern" stayed several days in a coastal polynya, and when the advection was weak, the gradual modification of the air mass could be observed. Figure 31 shows a 24 h series of 4 radiosoundings of temperature and dew points during a situation, when the moisture content over the polynya increased considerably and led to the development of a cloud layer. After correcting for the temperature advection, which is obvious from the profile modification above the Planetary Boundary Layer, the change of total energy can be used to calculate the vertical fluxes from the surface. To determine the role of vertical heat, moisture and momentum exchange between the surface and the air mass more directly, wind and temperature were measured at the heights of 2 m and 14 m above the surface from the bowmast of the ship. Such data make it possible to apply a bulk formula for flux determinations.

Continuous aerological program:
During the whole cruise an aerological program was performed, which consisted of radiosonde launches at 0:00 H, 6:00 H and 12:00 H GMT. In this way two aerological cross sections were measured through the pack-ice belt at the beginning and the end of the cruise. Figure 32 gives the series of temperature soundings for the first transect through the pack-ice in late September and early October. Those soundings were considered, which were closest to 40°S, 45°S, 50°S, 55°S ... 75°S. With the corresponding wind soundings in Figure 33 the meridional structure of the Southern Hemisphere west wind belt is documented. The soundings on the voyage along the coast between 70°S and 77°S gave for the first time a thorough insight into the state of the atmosphere at that time of the year. The regular soundings in those periods, where the ship worked in a small area near the "Drescher Station", together with the simultaneous soundings of the "Georg von Neumayer", "Halley" and "Drescher" stations provided a good data coverage for the study of synoptic scale vortices. These cyclones are the important link between the Antarctic anticyclone and the midlatitude westerlies.

Preliminary results

The meteorological and drift data have been intercorrelated and the results show that the floe movement is closely linked to the stress exerted by the wind. Synoptic events like the passage of a cyclonic vortex were felt immediately by the floes and led to rapid displacements. The drift in general was directed to the left of the wind vector at angles between 0 and 90 degrees. The complete data set consists of about 1 data sample per hour and will be evaluated in detail later. The vertical heat and moisture fluxes over the polynya region have been determined by applying different methods. Under almost stationary conditions, case studies showed a daily mean turbulent heat flux of of more than 100 W/(m*m) and a latent heat flux of 50 W/(m*m). When

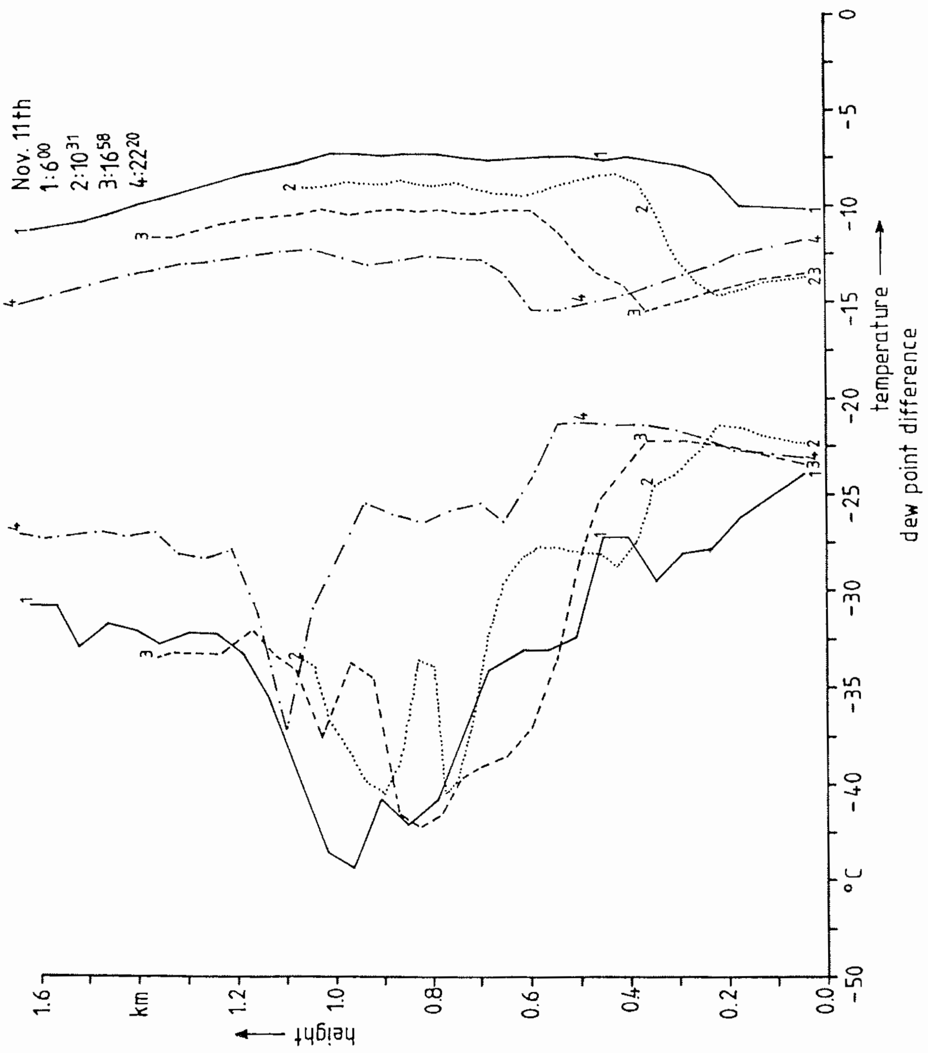


Fig. 31. Temperature and humidity modification of the Planetary Boundary over an Antarctic coastal polynya within 24 hours.
x-axis: temperature in degrees Celsius and dew point differences in K (origin is -20°C)
y-axis: heigth in km.

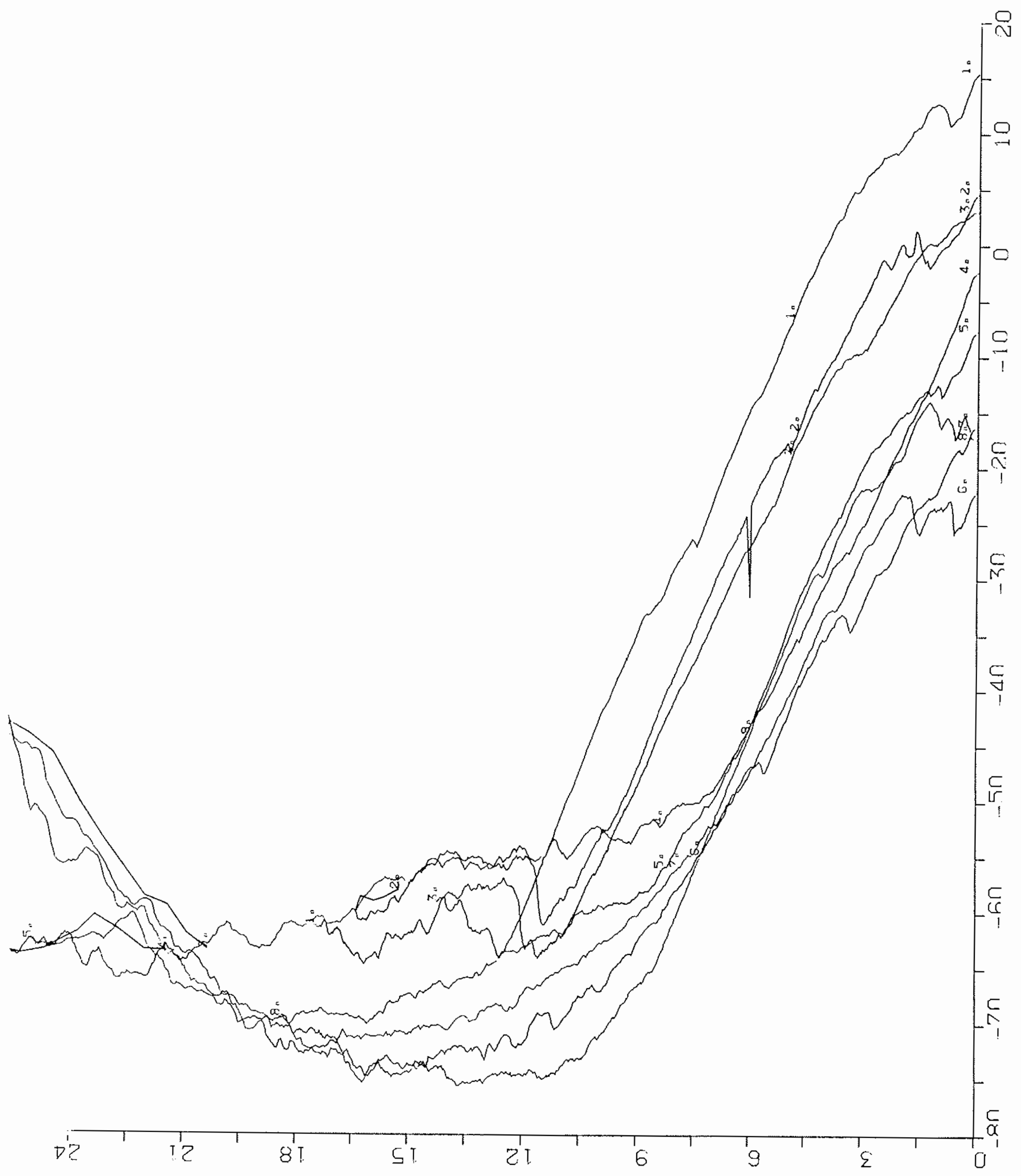


Fig. 32. Series of temperature profiles between 35°S and 75°S during maximum pack-ice extent, horizontal spacing between successive profiles is 5 degrees latitude.
x-axis: temperature in degrees Celsius
y-axis: height in km.

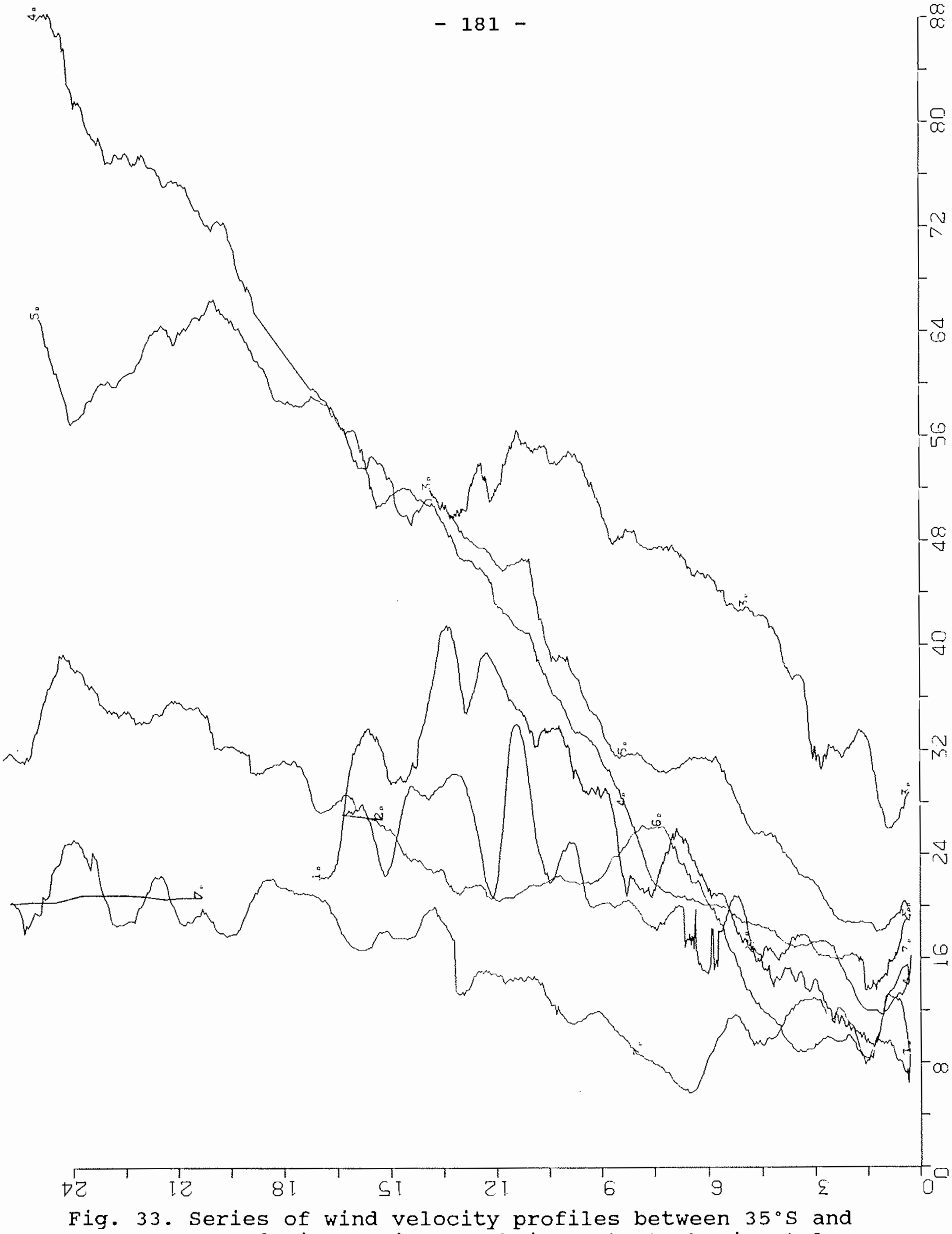


Fig. 33. Series of wind velocity profiles between 35°S and 75°S during maximum pack-ice extent, horizontal spacing between successive profiles is 5 degrees latitude.
x-axis: wind speed in m/s
y-axis: height in km.

the wind was stronger and when the temperature contrast between the air mass and the open water was higher, the heat flux increased up to several hundred W/(m*m). This indicates, that the intensified energy exchange over Antarctic coastal polynyas as well as their effect on cloud cover and precipitation play an important role over distance scales which are much larger then the polynyas themselves.

3.12 The under-ice water layer (H. Eicken, M. Elbrächter, E. Fahrbach, L. Gordon, H. Klöser, H.-P. Marschall, S. Moore, U. Rabsch, G. Rohardt, M. Rhein, R. Scharek, S. Schiel, V. Smetacek, C. Veth, R. Weiss, R. Weppernig, F. Zaucker)

Objectives

Brown discolouration of water immediately under the ice was observed from the ship's deck over an extensive area south of 74°S. Bucket samples revealed that the brown colour was imparted by a dense diatom crop dominated by the typically phytoplanktonic genus *Thalassiosira* which is also an important constituent of Antarctic spring phytoplankton blooms. This phenomenon of brown water under the ice as opposed to brown discolouration of the ice itself was considered to be important and a sampling programme was launched accordingly to study the following aspects:

1. Physical structure of the layer and factors leading to its stabilisation
2. Concentrations of oxygen, nutrients, and biomass within the layer
3. Relationship between organisms within this layer with those in the ice above and in the water column below
4. Growth performance of algae obtained from this layer under different light conditions

Work at sea

a. Sampling

Instruments and methods were devised to sample this layer with minimum disturbance. An L-shaped 1" water pipe with a 2 m vertical shaft and a 1 m horizontal arm to which plastic tubing was attached was used to obtain water samples. The device was inserted under the ice, so that the arm was parallel to the surface of the ice and the shaft perpendicular to it. Water was drawn up by a vacuum pump through the perforations on the outer 20 cm of the plastic tubing. A total of 5-7 depths from 1.70 m to the immediate undersurface of the ice were sampled, with closer spacing in the upper layers which were sampled last. Five to ten liter of water were collected from each depth and subsamples drawn for the following analyses: salinity, nutrients, plant pigments, particulate organic carbon and nitrogen, biogenic silica, species composition and biomass estimation by microscopy. A total of 24 profiles from 15 stations were obtained using this device.

Temperature and salinity gradients were recorded initially with the NB-smart-CTD probe which is sufficiently small and light to be affixed to the tip of the L-shaped rod. Unfortunately, two such probes flooded early on; the remaining functioning probes (NB Mark 3B) on board were too heavy (40 kg) and large to be deployed in a similar fashion and a more massive construction was made for the larger probe (Fig. 34). This involved a stable base to which a lever system was attached that permitted raising of the probe under the ice 1 m distant from the hole. The depth range obtained with this apparatus was from 2 m depth to the undersurface of the solid ice.

Oxygen samples were collected by means of a large volume syringe attached to the end of a shaft and inserted in the water through a hole of small diameter. The piston of the syringe was raised by pulling on a string.

To ascertain the relationship between algae and loose ice flakes and platelets below the solid ice cover or at the surface in open water, bucket samples were collected from the surface of holes or from a rubber boat respectively. In open water, the ice flakes were generally concentrated in rows tens to a few hundreds of meters apart. Water between the rows was also sampled on such occasions. The loose ice was separated from the water by passing the contents of the bucket immediately after collection through a 2 mm mesh sieve. A portion of the ice was deep frozen for later analysis of its structure and another portion melted and used for chlorophyll and microscopic analysis.

Water movement immediately below the ice was investigated by means of dye experiments. Dye clouds were injected at different depths and the dissipation and movement of the clouds registered by the video camera of the underwater vehicle UWE.

Primary production measurements were conducted in situ during a 24 hour station in Drescher Inlet.

Zooplankton was sampled from under the ice with a 55 μm NIPR-I net where water is driven through the mouth by means of a propeller.

b. Laboratory experiments

Growth performance of algae collected by the pumped samples was investigated under in vitro conditions. Natural sea water in 10 l glass bottles was inoculated with small quantities of brown water collected at 3 different sites. The water was incubated at 3 different light intensities (160, 60, 12 μE m^2/sec) and algal growth and nutrient uptake followed over 3 weeks.

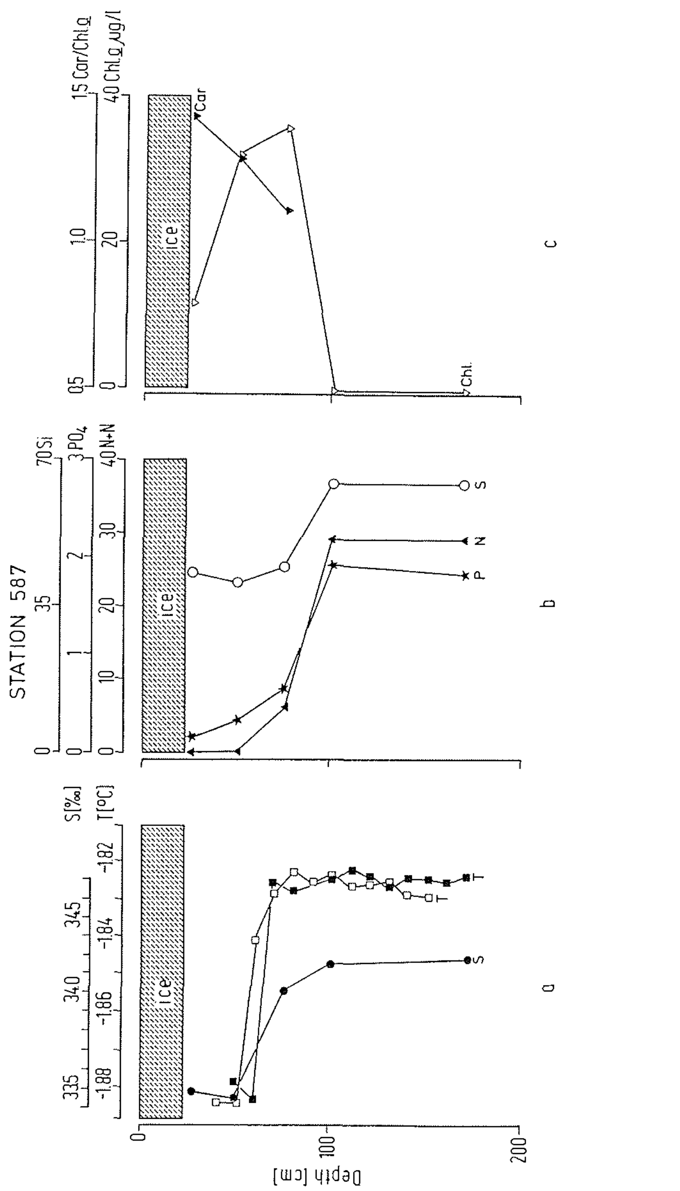


Fig. 34. Profiles recorded from the under-ice water layer at Station 587.
a Temperature and salinity: Temperature (2 profiles) was recorded with the CTD probe and salinity was measured with the salinometer from water samples.
b Nutrient concentrations: Notice that nitrate has been reduced to the limit of detection in the uppermost UIWL (N = nitrate + nitrite, P = phosphate, Si = silicia).
c Chlorophyll depth distribution and the carotenoid/chlorophyll ratios (R).

Preliminary results

The brown water phenomenon was first observed on 25. October when the ship was breaking ice during its first excursion south of Vestkapp. North of Halley Bay (at 75°S) brown water occurred in patches but south of the Halley Bay area (76°S) and off the Dawson-Lambton glacier (St. 544) it was almost always seen when the ship broke ice. The ship's wake was coloured brown when passing through ice with brown water below. This effect was definitely not due to crushing of brown ice by the ship, as water gushing up from cracks in breaking ice sheets at some distance from the ship left brown stains on the snow cover. Further, pieces of ice overturned at the side of the ship were frequently transparent whereas the water sloshing amongst the broken ice was coloured brown. The intensity of the colour varied considerably: from pale straw to a rich yellowish brown and was generally most intense along rafting seams and pressure ridges. As a rule, the thicker the ice the more intense the colour, although on occasion, brown water was also observed under new ice too thin to walk upon.

Closer examination of the brown water showed that it was invariably associated with masses of loose ice platelets of 1-20 cm size and 0.1 cm thickness. In situ observations by UWE showed that under the solid ice, the platelets were collected in loose layers under the solid ice that could easily be dispersed. Separation of the platelets from interstitial water by means of a sieve indicated that the Thalassiosira population was suspended in the latter rather than attached to the platelets. Brown water was also encountered under ice in the absence of a layer of loose platelets. In such cases (St. 587) the brown water was maintained in position under the ice by what appeared (as filmed with UWE) to be a layer of loosely intermeshed ice crystals. In contrast to the platelet layer, however, these ice crystals did not rise up and fill holes made in the ice. They also offered no resistance to the horizontally rotating arm of the sampling device.

By mid-November, brown water in the ship's wake was also observed in the Vestkapp area. However, the situation differed somewhat from that encountered south of 75°S. Whereas the brown water in the South was present as a layer under the ice, it was associated with brash ice between ice floes in the Vestkapp area. With the exception of Drescher Inlet, neither brown water nor ice platelets were found below intact ice sheets north of 74°S during this cruise.

Measurements:

a. South of 74°S

Most of the seven profiles, from 1.70 m to the ice undersurface, recorded from this region exhibited distinct gradients in chlorophyll and nutrient concentrations that were also reflected in temperature and salinity. Total nitrogen depletion in water from under the ice was recorded at 2 stations (584 and 587). Most stations were situated on thick, heavily ridged ice floes where conditions underneath were heterogeneous. Station 587 was an exception as the ice sheet was continuous and homogeneous over a 10 km^2 area.

Station 587 (76°03'S, 27°59'W):
Ice conditions:
This station was located at the outermost rim of the ice pack, 50 km offshore, facing the wide coastal polynya, south of the Halley Bay headlands. The ice floe in and under which sampling took place extended about 5 * 2 km with an average thickness of 20 cm. With the exception of a few smaller refrozen leads it was undisturbed without signs of ridging or rafting, suggesting tensional rather than compressional forces acting on the floe during its history. Its surface was covered with ice pancakes of approximately 50 cm diameter, partially overlapping one another. The immediate surroundings consisted of heavily ridged white ice thicker than half a meter as well as nilas ranging between 5 and 15 cm in thickness. At three stations, all within 15 km distance of Station 587, the solid ice cover, which had a thickness of 1 m and more, was underlain by at least another meter of ice platelets as described above. At all three stations (544, 584, 585) both platelets and solid ice were associated with large numbers of diatoms and other organisms.

Under ice water layer:
Profiles of various properties measured in water under the ice are presented in Figure 34 a-c. Temperature and salinity declined by 0.06 K and 0.7 ppm respectively from a depth of 50-80 cm below the solid ice up to its under-surface. The fact that this water was below the freezing point indicates that an ice/water mixture must have been present. Strong gradients in nutrients and chlorophyll corroborate the presence of a stabilised layer about 50 cm thick below the ice cover. Immediately below this layer, values for chlorophyll were much lower (0.15 µg Chl/l) but nevertheless higher than values measured in samples taken with the rosette sampler from the upper 100 m in the vicinity (St. 584: 0.08 µg Chl/l).

The relationship between nutrient and chlorophyll gradients bears a striking resemblance to the situation observed in a 'normal' water column during a declining diatom bloom: following nutrient depletion in the upper layer, in particular nitrate depletion, the diatom population sinks out and highest chlorophyll concentrations linger for some time at the pycnocline. Diatom populations suffering nitrogen depletion have a higher carbon to chlorophyll ratio than rapidly growing populations; the carotenoid:chlorophyll ratio rises accordingly. The latter ratios, also presented in figure 1c indicate that the pigment composition of the diatoms at 25 cm differed strikingly from those at 75 cm where nutrients were still abundant. Further, cursory microscope examination showed that the cells at 25 cm had ceased to divide, in contrast to those at 75 cm, where the frequency of dividing cells was very high and chain lengths (the crop was dominated by Thalassiosira spp.) much larger.

This interpretation of the sinking out of nutrient depleted diatoms in the under ice water layer also explains the profile obtained at Station 584 (Fig. 35). The relatively low chlorophyll concentrations in nutrient depleted upper layers here indicate that the population had already sunk out prior to sampling.

b. North of 74°S

As mentioned in the previous section, no stabilised ice/water layer under the solid ice cover was encountered in this region. Temperature and salinity profiles obtained from below various ice types on the western side of the polynya could be classified into three categories: i) vertical homogeneity, ii) slight but stable stratification, iii) high spatial and temporal variability in stratification. Types ii) and iii) were formed under melting ice under conditions of low and high turbulent energy, respectively. The latter was presumably induced by movement of the ice, whereas the lower salinity was generated by melting.

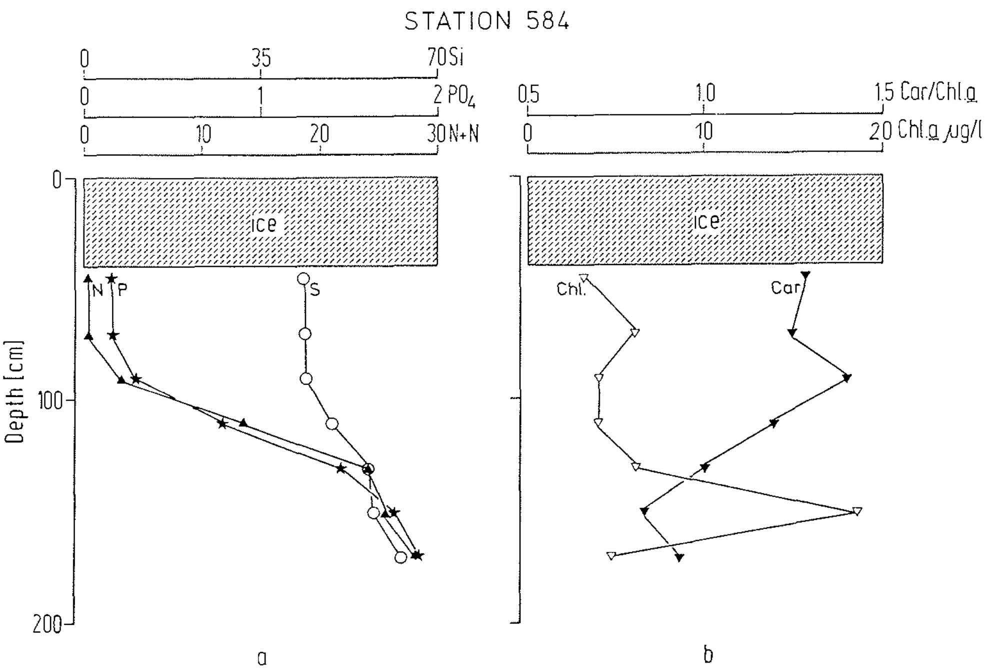


Fig. 35. Nutrient (a) and chlorophyll profiles (b) from Station 584. Legends as in Figure 34.

Indeed, large-scale disruption and melting of the sea ice commenced at about the time these studies were carried out (20.11.-30.11.86). Further, observations by UWE showed that no unconsolidated layer of platelets or crystals under the ice was present at any of the stations. A dye experiment was conducted under a floe, on a calm day when an almost negligible velocity difference between ice and water could be expected. It took only several minutes for the dye cloud to grow to the size of 1 m, indicating that quiescent conditions per se cannot be expected in the water layer under an ice floe.

Nutrient and chlorophyll profiles were either vertically homogeneous or exhibited a slight deviation in values from the uppermost depth. The latter were sometimes obtained from holes made in ridges where we hoped to tap pools of low salinity water trapped by inclined ice floes. However, high chlorophyll values were only recorded when the nozzle of the sampling tube was inserted in brash ice trapped between larger floes. Thalassiosira and a Phaeocystis-like colonial alga were the major contributions to plant biomass in the Vestkapp area. Further to the North, in the vicinity of Atka Bay, brash ice no longer contained Thalassiosira but was dominated by pennates and 'Phaeocystis' colonies. The latter became increasingly abundant further north and, in the marginal ice zone at about 58-60°S, imparted a strong yellow colour to the layer between the sea ice and snow cover. Apparently, colonisation of this layer occurred by percolation of sea water into this zone.

c. Drescher Inlet

In spite of a clear sky throughout the 24-hour experiment parallel light measurements showed considerable variation in the platelet layer. The results of the C-14 incubation experiments indicate that sufficient light for photosynthesis was available at 1 m depth for only 10 hours. Assuming a euphotic zone of 30 cm extent within this layer, total primary production was calculated at 30 mg C m^2/d at the measured chlorophyll concentrations of 25 µg/l. This is a low value considering the size of the crop and the extent of nutrient depletion. Presumably, initial growth was more rapid and declined as the light climate deteriorated due to the snow cover.

Samples of floating ice (frazil and larger platelets) collected from slicks in the polynya off the Drescher Inlet yielded chlorophyll concentrations of 40-50 µg Chl/l of melted ice. Parallel rows of floating ice (tens to hundreds of meters apart) yielded surprisingly similar values; concentrations in water between ice crystals were much lower. These results contrasted strikingly with those obtained from similar studies in the Peninsula region carried out in June during ANT V/1, indicating large regional and seasonal differences in the relationship between algae and ice crystals.

Ecological Implications of Brown Water

The presence of a previously unsuspected, stabilised water layer under a growing ice sheet raises some important questions that cannot be answered yet: what are the physical factors that lead to stabilisation of such an ice/water layer under a growing ice cover for periods of weeks? Why were such conditions apparently only present south of 74°S? Why was the salinity under the growing ice sheet (St. 587) at air temperatures well below -10°C lower than in the water column? Did the loose platelets encountered south of 74°S arise in situ or were they formed elsewhere and distributed under the ice cover subsequently. These and other questions will require a more detailed study before definitive answers can be expected; however, the impact of this layer on the nutrient chemistry and ecology of the area can be surmised from the available data.

The under-ice water layer (UIWL) combines features of the solid ice above and the free water below. In the region south of 74°S, where this layer was maintained in position by loose ice platelets or crystals, planktonic diatoms dominated, whereas in Drescher Inlet, where this water layer was confined by large, rigid ice plates, sessile pennate diatoms contributed most to biomass. However, this difference in community structure between the two environments might also be attributed to concomitant differences in seeding mechanisms: the protected neritic nature of Drescher Inlet permitting maintenance of a resident pennate population of typical ice algae, whereas the open waters of the coastal current favouring planktonic species. In any case, the UIWL functioned as a downward extension of the ice sheet in Drescher Inlet, whereas in open water its ecology resembled that of a miniature water column.

Large numbers of all developmental stages of the small calanoid copepod _Stephus longipes_ were collected in the NIPR-I net catches. This species was absent from water column hauls and was practically the only zooplankter collected under the ice. It is reported to be primarily a hyperbentic species and our results indicate that, during early spring, it lives and multiplies in the layer immediately below the ice. After the onset of large scale melting, it also appeared in water column catches.

Observations by UWE indicated that the platelet layer was inaccessible to krill in contrast to the looser ice/water mixture of the type found at Station 587. Thus, large numbers of krill were swept onto the ice during passage of the ship through this glassy ice where brown water without platelets was concentrated under rafting seams.

Apart from its importance as an immediate food source for herbivores like Krill and _Stephus_, the diatoms of the UIWL are likely to be of considerable significance for the southern Weddell shelf ecosystem. They grow at a time when the water column is at its most barren and their entry into the water column following dispersal of the platelet layer by strong water movement or by melting later on in the season will result in rapid elevation of biomass levels. However, there is reason to believe that nutrient depleted populations sinking through the UIWL will eventually enter the water column, even if the UIWL remains intact. Thus, chlorophyll concentrations in the 100 m water column at Station 544, occupied on October 28 and located in the middle of the former brown water area, were 30 times higher (0.3 mg Chl/m3) than at stations in the outskirts (543 and 545: 0.01 mg Chl/m3) or anywhere else along the coast of the southeastern Weddell Sea at that time. We suggest that this was a result of input of phytoplankton from the UIWL rather than in situ growth as there is no reason why growth conditions in the water column should have been more favourable at this site.

We conclude that the UIWL is a unique feature of certain regions of the Antarctic that deserves more attention in the future; particularly the physical factors leading to its formation should be investigated more thoroughly.

3.13 Phytoplankton and heterotrophic microorganisms in the water column (M. Elbrächter, W.W.C. Gieskes, U. Rabsch, R.Scharek, K. Schaumann, V. Smetacek, C. Veth)

Objectives

The aim of this programme was to study the development of the spring phytoplankton bloom and its associated heterotrophic microorganisms in relation to environmental factors. The following aspects were given special attention:

1. Standing stock and composition of phytoplankton and heterotrophic microorganisms were recorded from discrete depths and net tows.
2. Biomass accumulation was studied in relation to the physical structure of the water column, ambient light and nutrient decrease.
3. Possible seeding sources of the spring bloom were investigated in laboratory experiments.
4. Growth rates and photosynthetic capacity of the phytoplankton was studied on natural populations and in experimental vessels.
5. Pelagic bacteria and fungi concentrations were to be recorded. Isolates were taken into culture for assessment of activity parameters.
6. Horizontal and vertical turbulence spectra were measured simultaneously by means of a Laser-Doppler-Velocitimeter. Information on turbulent velocities were derived from the measured spectra.

Work at sea

Chlorophyll fluorescence was recorded *in situ* to a depth of 270 m at 44 stations located in the eastern Weddell Sea between the northern edge of the pack-ice and the polynya off "Halley Station" in the South. Properties related to suspended matter in the water column that will be measured later are seston weight, particulate organic carbon and nitrogen, and ATP. CTD profiles were recorded (see 3.9) as well as oxygen and nutrient concentrations (see 3.10) chemistry and chemical oceanography). The region surveyed most intensively was around Vestkapp. The instrument used for fluorescence profiling was a Sub-AquaTracka (Chelsea Instruments, Ltd.); it was calibrated frequently with chlorophyll samples taken at discrete depths that were measured spectrophotometrically. Below 270 m additional samples were taken down to a depth of 1000 m. At a total of 78 stations samples were taken for quantitative and qualitative microscope analysis of microplankton; at a number of these stations, samples were taken for counts of bacteria and fungi at up to 12 different depths. At 36 stations, measurements of primary production were conducted with a simulated *in situ* C-14 method; incubations lasted 12 hours, and samples were exposed to 5, 30 and 60 μmol PAR m^2/s. Turbulence in the polynya and also in the water under the sea ice was measured with a Laser-Doppler technique to obtain undisturbed measurements; small particles present in the water act as light scatterers.

Seeding potential of water and of sediments from different sites and depths was determined in the laboratories on board. Laboratory experiments were also done to assess growth rates and nutrient uptake by phytoplankton. Other experiments were conducted to determine the uptake rate of different metals by natural phytoplankton communities.

Preliminary results

During the first half of the cruise unexpectedly low chlorophyll concentrations were registered along the ice shelf, both near the surface and at greater depths. The number of algal cells was correspondingly low. This extreme phytoplankton scarcity can partly be ascribed to the fact that before 1 November the polynya was still frequently largely covered by ice which prevented light penetration to sufficient depth for production of new algal cells to take place. However, where areas of open water occurred the bottom of the euphotic zone, defined as the depth where 1% of the surface irradiance was found, was as deep as 200 m; Secchi disc visibility was between 70 and 80 m! Therefore in the open parts of the polynya, and also in areas with a thin ice cover, light was probably not a limiting factor for primary production; indeed, at many stations light saturation was already reached at 30 μmol PAR m^2/s. Nutrients were not limiting either: the concentration of phosphate, nitrate and silicate was high (see 3.10).

The scarcity of suspended matter during the first half of the cruise, in October, precluded the use of Laser-Doppler turbulence measurements since not enough light was scattered in the laser beam. The rate of C-14 incorporation by the extremely sparse phytoplankton crop was quite low, less than 0.4 µg C/h/l per µg chl a. As postulated for upwelling regions, phytoplankton may itself have to condition the water before cell divisions can take place effectively. Trace metal mixtures and selenium added to samples actually resulted in a production increase.

After 1 November, when the polynya had become an open-water area for most of the time, a gradual increase in chlorophyll concentration and in algal cell number was recorded. The increase was by far the most rapid at the sea-ice side, although here also chlorophyll values did not rise beyond 0.25 µg per liter. Close to the ice shelf little change was observed; even at the end of the cruise no more than 0.01 µg per liter was present locally. The increase in phytoplankton in the off-shelf polynya region was registered not only near the surface but also all the way down the water column, to a depth of at least 200 m. This increase could have been due to *in situ* growth. However, enrichment from the algal population associated with the ice (e.g. *Thalassiosira*) can occur prior to melting of the ice (see 3.8 and 3.12). The euphotic zone may at all times be inoculated from below, with cells of species that were not found in the ice: at most stations investigated, even at 500 m (in the Weddell Sea's warm deep water) many phytoplankton cells in a good physiological state were present. The algal crop associated with the sea ice was locally so dense that it was visible to the naked eye as a brown discolouration of the water in the ship's wake, and at the underside of floes turned upside-down by the ship breaking through the pack. The concentration of chlorophyll a in the 'brown water' (see 3.12) was up to 200 µg per liter, but this water was limited to the very surface: even at a depth of a few meters under the ice the concentration of chlorophyll was never more than 0.4 µg per liter. This may seem a low phytoplankton density, but the vertical extent of the crop was much greater than the crop associated with the ice. In the water column under the ice, up to 40 to 60 mg chlorophyll was locally present per m^2 in the upper 500 m. Assuming a C : chl a ratio of 50 (characteristic of a growing diatom population), the water column's phytoplankton biomass after 15 November may be estimated at up to 2 to 4 g C : a rather considerable contribution to the total plant biomass. The rate of C-14 assimilation of the cells of this increasing spring-bloom crop was between 0.4 and 2.75 µg C per µg chl a, per hour, which is much higher than the rate measured at the beginning of the cruise when very few cells were present and development of the population in experimental vessels at various irradiances was surprisingly low. Growth conditions were apparently more favourable when more algal cells were present. On the shelf side of the polynya phytoplankton density remained low until the end of November, presumably due to continuous advection of under-shelf water containing hardly any phytoplankton at all.

Light attenuation of the water increased directly in proportion to the increase of phytoplankton in the coastal polynya of Vestkapp. Absorption spectra of suspended matter freshly colected on glassfiber filters also indicated that healthy phytoplankton was the principle light absorber in this area. In the pack-ice zone to the North diatoms of the genera Nitzschia, Thalassiothrix, Rhizosolenia and Chaetoceros dominated the phytoplankton. Thalassiosira, Porosira and Coscinodiscus dominated in the South. Here, a variable part of the attenuation was also due to absorption of light by detritus. In the pack-ice region heterotrophic dinoflagellates (Protoperidinium) and protozoans (Tintinnids, Acantharia, and the Heliozoan, Stycholonche) were common, some of the dinoflagellates being found for the first time in the Southern Ocean. In the northern pack-ice zone, where at the northern edge chlorophyll concentrations were up to 0.6 µg per liter to a depth of 120 m, marine fungi were found in considerable numbers: Deuteromycetes up to 94,000 cfu/m3 (cfu = colony-forming units), yeast cells up to 63,000 cfu/m3, Phycomycetes 12,000 propagules per m3. The high level of these numbers together with large spatial variability suggests an active role of fungi in decomposition processes in Antarctic waters.

After the spring bloom had started, enough scattering particles were present to conduct turbulence measurements with the Laser-Doppler turbulence meter. Measurements off Drescher Inlet were made during periods of very low wind speeds and high insolation. Turbulence spectra showed only weak turbulence levels with energy dissipation rates of 2.10^{-10} - 2.10^{-8} W/kg, turbulent length scales of 1-3 m and turbulent velocities of 0.001-0.005 m/s. This can be considered as background turbulence, as is often found in the ocean. The shapes of the spectra showed isotropy in the high wavenumbers indicating only a weak stratification at the measurement depths (30-50 m). However, the very low values of turbulent energy, combined with the low wind stress and strong insolation, made the circumstances favourable for stratification to intensify in the upper layers of the Vestkapp polynya waters in November.

Turbulence measured in Atka Bay appeared to be different. The ice-covered bay was exposed to a strong wind stress and a considerable drift speed of the ice-cover was determined by Sat-Nav. Turbulence spectra also showed a background turbulence, but with a higher intensity of the dissipation rate (5.10^{-8} - 5.10^{-7} W/kg). Superposed on this background turbulence were bursts of high intensity turbulent kinetic energy, with related dissipation rates of 3.10^{-6} W/kg. The background turbulence shows length scales of more than 10 m, but the bursts had length scales of the order of 1 m. It is likely that these bursts can be related to overturning events of structures which are also visible in the CTD profile of the Atka-Bay station.

The Dutch contribution to the Antarctic cruise of RV "Polarstern" has been financially supported by the Netherlands Council of Sea Research (N.R.Z.).

Tab. 11. Chlorophyll concentrations (mg/m3), measured with a Sub-AquaTracka *in situ* fluorometer, calibrated with the spectrophotometric method of LORENZEN (1967). Estimated accuracy interval: +50% to -30%.

Station	Depth interval (m)						
number	0-25	25-50	50-75	75-100	100-150	150-200	200-270
10-493	0.09	0.12	0.10	0.08	0.02	-	-
10-494	0.10	0.11	0.10	0.04	0.02	0.02	0.02
10-498	0.08	0.16	0.16	0.04	0.03	0.03	0.03
10-499	0.10	0.10	0.10	0.09	0.07	0.06	0.06
10-501	0.05	0.05	0.08	0.08	0.08	0.06	-
10-503	0.03	0.03	0.05	0.05	0.03	0.02	0.02
10-504	0.03	0.04	0.05	0.10	0.13	0.10	0.05
10-508	0.01	0.01	0.01	0.01	0.02	0.04	-
10-510	0.01	0.02	0.02	0.03	0.03	0.01	0.01
10-512	0.06	0.04	0.03	0.03	0.03	0.02	0.02
10-513	0.01	0.01	0.01	0.03	0.04	0.04	0.02
10-514	0.02	0.02	0.02	0.03	0.04	-	-
10-515	0.02	0.02	0.03	0.04	0.04	0.02	0.02
10-526	0.03	0.03	0.03	0.03	0.03	0.03	0.02
10-527	0.01	0.02	0.02	0.02	0.01	-	-
10-528	0.02	0.02	0.02	0.02	0.02	0.03	0.02
10-543	0.04	0.03	0.02	0.03	0.03	0.04	0.03
10-544	0.29	0.23	0.19	0.15	0.10	0.10	0.09
10-545	0.15	0.13	0.11	0.12	0.12	0.10	0.08
10-548	0.06	0.06	0.06	0.06	0.07	0.06	0.05
10-550	0.12	0.10	0.11	0.12	0.12	0.09	0.09
10-561	0.05	0.05	0.05	0.05	0.04	0.04	0.03
10-563	0.03	0.03	0.03	0.04	0.04	0.03	0.04
10-566	0.01	0.01	0.01	0.01	0.01	0.01	0.01
10-569	0.08	0.08	0.07	0.07	0.06	0.06	0.05
10-584	0.10	0.10	0.12	0.10	0.09	0.08	0.08
10-592	0.17	0.20	0.17	0.20	0.25	-	-
10-595	0.11	0.09	0.07	0.06	0.06	0.06	0.06
10-597	0.14	0.15	0.09	0.05	0.05	0.05	0.05
10-599	0.15	0.15	0.15	0.15	0.15	0.10	0.06
10-600	0.08	0.08	0.07	0.07	0.07	0.06	0.05
10-602	0.12	0.12	0.12	0.12	0.11	0.10	0.06
10-604	0.25	0.22	0.21	0.10	0.08	0.07	0.06
10-621	0.09	0.09	0.09	0.09	0.09	0.09	0.08
10-624	0.18	0.18	0.18	0.18	0.18	0.15	0.06
10-626	0.23	0.20	0.20	0.20	0.10	0.05	0.05
10-633	0.22	0.22	0.18	0.14	0.09	0.08	0.07
10-647	0.37	0.37	0.37	0.15	0.10	0.05	0.05
10-648	0.50	0.50	0.30	0.20	0.10	0.05	0.05
10-649	0.29	0.29	0.20	0.10	0.07	0.04	0.04
10-650	0.50	0.50	0.40	0.20	0.07	0.05	0.05

Reference

LORENZEN CJ (1967) Determination of chlorophyll and pheo-pigments: spectrophotometric equations. Limnol Oceanogr 12: 343 - 346.

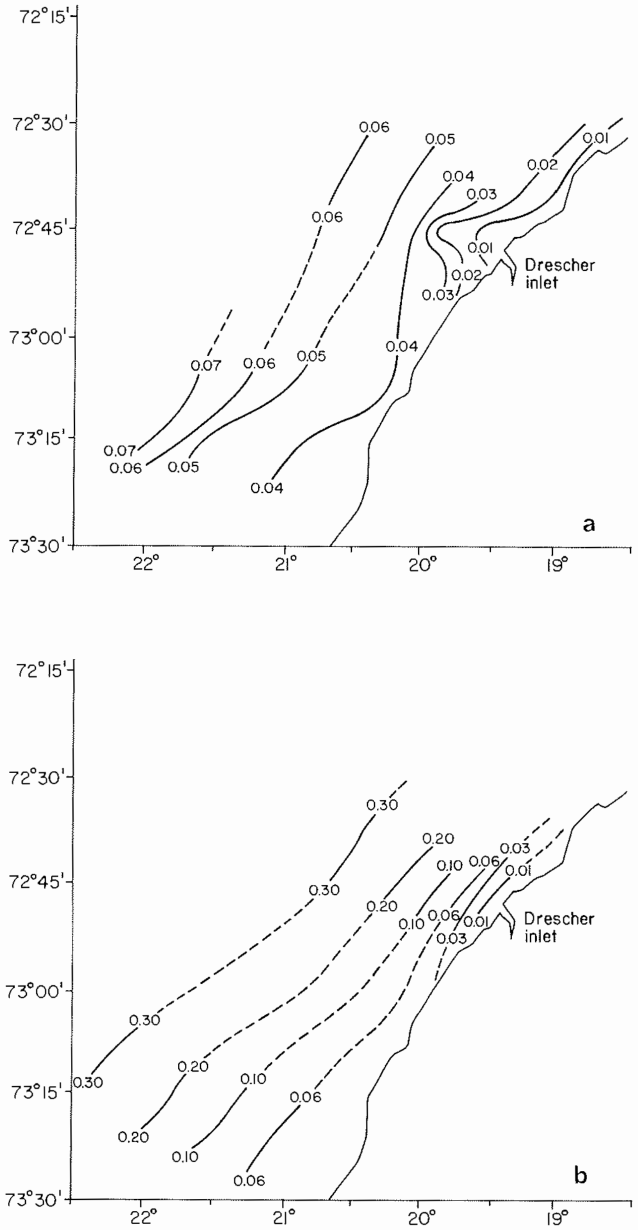


Fig. 36. Chlorophyll a concentraiton in the upper 50 m in the Vestkapp Box
a quasi-synoptic plot of measurements between 15 October and 4 November 1986
b situation on 17 and 18 November 1986.

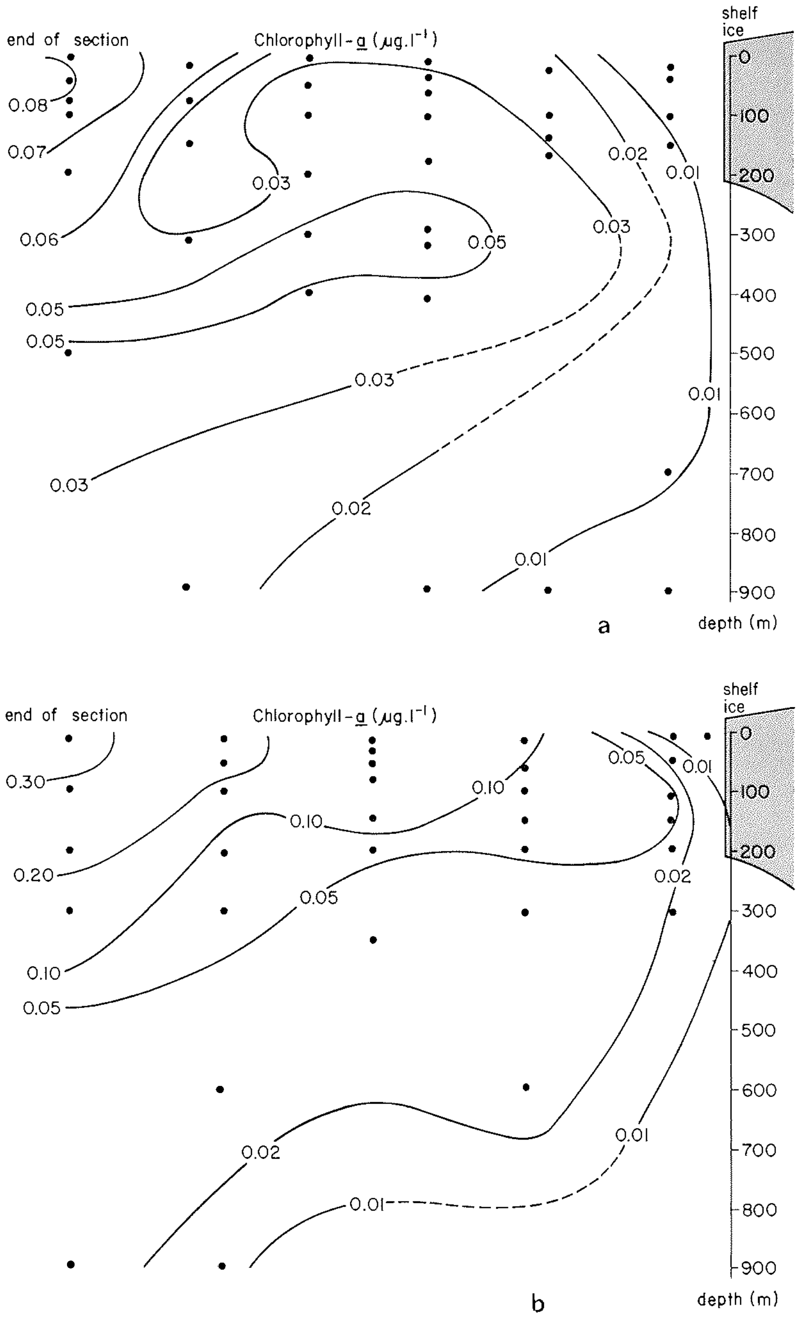


Fig. 37. Vertical distribution of chlorophyll a of sections perpendicular to the ice shelf in the Vestkapp Box. Parallel integrations of Figure 36 are
a between 15 October and 4 November 1986
b situation on 17 and 18 November 1986.

3.14 Zooplankton (G. Fransz, W. Hagen, I. Hempel, H.-P. Marschall, S. Marschall, E. Mizdalski, S. Schiel)

Objectives

Zooplankton of the eastern Weddell Sea has been studied by German groups every summer since 1979/80. The samples provided a fairly comprehensive picture of the summer aspect of the various zooplankton communities in the coastal current and offshore. Main purpose of the quantitative zooplankton studies of ANT V/3 was to obtain for the first time information about distribution in late winter and about strategies of zooplankton organisms to overcome the winter season.

The original plan was to sample a box grid in the coastal polynya off Vestkapp by oblique Bongo tows to compare the winter data with our data from January to February 1985 in the same area. Apart from a few oblique Bongo and RMT hauls, however, the dimensions of the polynya only allowed to employ vertical nets and the ice situation called for a more flexible sampling strategy. Instead of the grid sampling four transects were performed with four to five stations each from the shelf into the deep water at 72°40' to 75°30'S. The different transects should provide information about the variation in the zooplankton composition and abundance from the shelf to deeper water, also about the composition of the zooplankton communities in the different areas along the southern Weddell Sea coast. Another purpose of our studies was to obtain information on the temporal changes of species composition and population structure in the zooplankton in relation to phytoplankton development during spring. Therefore, two transects were repeated, the Drescher transect off Vestkapp four times which is identical with one of the summer transects, and Neptun's transect in the area about 30 miles south of Vestkapp twice with time intervals of one to five weeks. Thirty miles further south the Divergence transect was carried out followed by the Halley transect off "Halley Station" (75°30'S).

On a larger scale seasonal change and geographical variation of zooplankton in relation to ice cover was to be studied on our way from Bouvet Island to the Weddell Sea when passing through the pack-ice zone twice within two months later.

A further point of interest was the vertical distribution of copepods at this time of the year and whether they were in a resting stage or actively swimming and feeding. Furthermore, we were interested in the winter distribution and behaviour of krill, *Euphausia superba*, and particularly in its feeding habits and developmental stages. During summer (January/February) 1985 we found a large number of krill larvae in the Vestkapp region and the question arose, whether they belonged to a separate population or had originally come from the North and were finally transported to the Antarctic Peninsula by the Weddell gyre.

The investigations on biochemical adaptations to the extreme Antarctic environment which started on ANT III/3 (1985) were to be continued in special respect to the zooplankton lipid biochemistry during winter and early spring including investigations of trophic relationships using unsaturated fatty acids as marker lipids.

Further studies concentrated on the estimation of biomass of the various size fractions of zooplankton by determination of dry weight per size class of all major species especially all copepod species and stages present.

Work at sea

In summer, double oblique Bongo tows had been the standard sampling procedure. During ANT V/3, however,ice conditions precluded almost any towing of light gear. Therefore zooplankton was mainly sampled vertically, using a Bongo net of 300 µm (both nets) from 200 m to the surface. Nine pairs of oblique tows and vertical hauls carried out for comparison showed that the vertical and oblique catches are well comparable except for adult and juvenile euphausiids which are more frequent in oblique tows. In addition to the standard hauling depth of 200 m we also sampled the water column from 500 m to the surface to find out about species or stages of zooplankton organisms which might stay in deeper layers in this time of the year. Altogether 137 Bongo hauls were carried out. At most Bongo stations a 50 µm meshed cylindrical net with aperture of 0.07 m^2 and length 2.5 m (Fransz net) was used to collect from the upper 200 m also the smallest organisms such as copepod eggs and nauplii. The Multi net, equipped with 100 µm mesh size, was used 30 times on distinct transects. It sampled five selective depth layers from near the bottom or 1000 m depth respectively to the surface. During a time station at one of the Drescher transects vertical hauls were carried out at local midday and midnight for studies on the diurnal migration of copepods.

For investigations on the boundary layer between the sea ice and the water and between the water and the sea bottom, a NIPR-I net (equipped with 55 µm mesh size) and a Beyer sledge (equipped with 100 µm mesh size) were employed, respectively. These layers were also investigated by direct observations with the Remotely Operated Vehicle (ROV), as well as concentration of particles and organisms throughout the water column.

The material of the standard Bongo hauls (200 m) was sorted on board the ship, partly in major taxa and partly to the level of species and developmental stages (e.g.copepods were separated in adults and copepodids IV-V) like we did with the summer material of 1985. An example of the sorting results for a selected number of stations based on Bongo vertical hauls of the upper 200 m at the four repetitions of the Drescher transect is given in Table 12.

Most of the material of the Fransz net was analysed on board for copepod stages. The samples of the Bongo-, Fransz-, Multi-, NIPR-I net and Beyer sledge hauls were preserved in 4% buffered formaline. Separate catches of the Fransz net were used to study the rate of development in copepod nauplii and copepodids, and the production of eggs by adult females, in incubation experiments. The Nansen net (equipped with 100 µm mesh size) was used for sampling copepods for experimental studies on feeding, assimilation, respiration and growth.

The samples for lipid and biomass analyses were obtained mainly by Nansen net, Bongo net (500 m hauling depth), Rectangular Midwater Trawl (RMT 1+8) or Krill net. The organisms were identified as far as possible, sexed and sorted according to developmental stage and body length. Nauplii of copepods (0.1 mm) and the cyclopoid copepod Oncaea spp. (0.3 mm) were the smallest organisms sorted out, adult krill (53 mm) and the chaetognath Sagitta gazellae (70 mm) the largest. The samples were subsequently frozen at -80°C. A total of more than 2000 samples of the following taxa were collected:
Siphonophores, ctenophores, pteropods, cephalopods, polychaets, juvenile and adult euphausiids (including Euphausia crystallorophias eggs), copepods, amphipods, mysids, chaetognaths, salps, fish larvae and phytoplankton (from open water, under ice cover, cultures).

The determination of the total lipid content, lipid classes and fatty acid composition will be done in cooperation with the University of South Florida in St. Petersburg, USA.

Feeding, assimilation and respiration experiments were carried out with the large copepods Calanus propinquus, Calanoides acutus, Metridia gerlachei and with the small dominant species Ctenocalanus citer and Racovitzanus antarctica. Natural phytoplankton suspensions or phytoplankton cultures were offered as food. Additional experiments were run with filtered seawater, to which a sea ice core was added. The behavioural response of the copepods to the presence of sea ice containing algae was studied. For the determination of assimilation rates, faecal pellets were picked out, washed and immediately deep frozen for dry weight and carbon analysis. Copepod respiration was measured by the Winkler method. All experiments were run at 0°C in a cooled laboratory container. In addition four tanks of 1 m3 were filled with surface water. Due to the low phytoplankton concentration in the water column, net phytoplankton was added. Calanus propinquus, Calanoides acutus and Metridia gerlachei of different developmental stage were added to two of the tanks. The standing stock and the chlorophyll a concentration were followed for approximately four weeks.

Tab.12. Drescher Transects. Bongo vertical 200-0m.

		I End October 1986				II Beginning November 1986					III Mid November 1986				IV End November 1986			
Echo depth (m)		417	1760	2753	3264	441	1091	1927	2481	3200	441	1103	2367	3351	449	967	2613	3406
Station No.		521	516	515	514	561	562	563	564	565	600	601	603	604	621	622	625	626
N/100 m³																		
Fishlarvae																	1	
Euphausiids	adults										1		1	1		4		
	larvae	2	3	7	3		2	4	4	9		2	2		2	10	16	5
E.superba	adults																	
	larvae																	
E.crystall.	adults										1		1	1		4		
	larvae		1	1				1	2						2	2	2	1
Tysanoessa	larvae		2	6	3		2	3	2	9		2	2			8	14	4
Copepods		946	275	90	429	414	356	201	1391	689	164	76	87	193	212	547	407	386
C.propinq.	adults	5	67	30	156	14	3	23	115	137	5	7	6	56	3	8	16	3
	C IV-V	53	49	14	100	26	13	23	53	75	21	12	11	43	7	75	74	37
C.acutus	adults	10	2	1	1	3	1	3	12	30	19	10	16	45	76	244	170	41
	C IV-V	103	17	2	6	30	6	13	14	43	18	4	5	7	22	37	14	4
M.gerlachei	adults	378	51	32	120	163	108	44	933	265	48	13	14	19	25	20	67	172
	C IV-V	376	79	2	29	176	224	92	257	122	52	30	34	12	78	156	62	125
R.gigas	adults	2												1				
	C IV-V		1		1	2	1	2	1	3	1		1		1	7	2	3
Carnivorous	adults																	
	C IV-V	10	6	6	15				6	14							2	1
Amphipods		2	4	3	2	4	2	2	1	2					1		1	2
Ostracods		349	65	29	219	24	7	28	37	31	1					5	2	
Chaetognaths		65	18	18	31	33	2	8	6	81	10	1	2	38	20	79	28	8
Appendicularians		2	1	1	13	3	4	1	2	1		1		6	1		2	2
Polychaets		19	7	9	22	4	3	2	1	4	1		1	2	1	3	1	4
Gastropods		5	3	2	1	6	17	9	5	10	1	2		2	3	5	2	4
Siphonophores		13	8		10	6		7	4	44	2			4	5	10	7	2

Preliminary results

The data sets obtained refer to:
two runs of pack-ice crossing (early October, early December)
four runs of Drescher transect (end October to late November)
two runs of Neptun transect (early and mid November)
one run of Divergence transect (early November)
one run of Halley transect (late October).

The first pack-ice crossing went from open water through the marginal ice zone into solid pack-ice and then through a zone of ice floes into the coastal polynya. The total plankton biomass decreased with increasing percentage of ice cover and ice thickness but increased slightly again near the polynya (e.g. in the species Oncea curvata). In the northern part of the crossing larvae of Euphausia frigida and E. superba occurred in fair numbers up to 200 per 100 m3 but were absent in the South. Ostracods and polychaets were more evenly distributed along the crossing. Fish larvae and appendicularians were virtually absent in early October. Chaetognaths and the copepods Calanoides acutus and Rhincalanus gigas (copepodids IV-V and adults) were the prominent features of the open water sample in the North. When entering the marginal ice zone the abundance of chaetognaths dropped by an order of magnitude and the two copepod species were replaced by another copepod, Metridia gerlachei and juvenile Calanus propinquus. In the zone of heavy pack-ice even those species were almost absent. In all copepods the ratio of adults to juveniles varied considerably. Also the numerous small copepod species Oithona similis and Ctenocalanus citer, as well as the eggs and nauplii of Calanus propinquus, decreased in density when entering the heavy pack-ice but remained present in fair numbers (Tab. 13).

At the Drescher transects abundance of zooplankton decreased from late October to late November and was much poorer than in January 1985. The relatively high figures at the first run were due to the abundance of Metridia gerlachei and of ostracods. But also chaetognaths, being much less frequent than in summer, amphipods and polychaets tended to decrease from run 1 to run 4. Run 3 in mid November was particularly poor. Euphausiid larvae and appendicularians were almost absent, they had been prominent elements of the zooplankton in January and February 1985.

At all winter stations copepods were dominant but their frequency was lower by one to two orders of magnitude compared to the summer values from the same area, particularly for juveniles (copepodids IV-V) and at the outer stations. The most abundant large copepod was again Metridia gerlachei, of the small species Oithona similis and Oncea curvata. On all four runs the ratio of adults to juveniles

Tab. 13. Estimates of density, biomass and respiration of small and large copepods and number per m3 of five abundant species in the upper 200 m averaged per transect for all developmental stages.
D = number per m3, B = dry weight in mg per m3, and R = respiration in µl O_2/m3/h.
The species are Oithona similis (Os), Oncea curvata (Oc), Ctenocalanus citer (Cc), Calanus propinquus (Cp) and Metridia gerlachei (Mg).

	< 1 mm			> 1 mm							
Transect	D	B	R	D	B	R	Os	Oc	Cc	Cp	Mg
Pack-ice 1	1997	5.8	28.2	5.4	2.9	3.0	1400	42	380	89	125
Drescher 1	857	3.3	15.2	3.4	2.5	2.3	589	126	46	80	20
Drescher //	1088	4.0	19.0	3.0	1.0	1.2	620	307	54	96	13
Into south	630	2.2	10.6	1.5	0.2	0.4	329	227	29	32	9
Halley 1	705	1.9	10.0	0.1	0.0	0.0	505	92	38	67	3
Diver-gence 1	1013	3.6	17.0	9.0	3.5	4.3	632	205	80	84	20
Drescher 2	1075	3.9	17.8	7.7	3.0	3.3	611	242	58	146	23
Neptun 1	1114	3.7	17.6	12.2	6.5	7.0	787	133	57	125	25
Halley 2	558	2.2	10.0	0.2	0.1	0.1	217	257	40	35	9
Diver-gence 2	1084	3.7	17.3	4.5	1.3	1.7	569	301	64	137	16
Neptun 2	965	3.4	15.8	2.7	0.6	0.8	577	219	74	83	14

(copepodids IV-V) was about 1:1. There were more Metridia gerlachei caught in end October/early November than later in spring. The poorest catches were in mid November. In Calanoides acutus the number of juveniles remained low over the four runs while adults increased considerably towards the end of November. Large Calanus propinquus were less frequent than the other two species in most samples with no obvious trend in season, abundance or adult/juvenile ratio. It was the only copepod with a clear increase in abundance with water depth. Vertical hauls taken by the Multi net at night showed higher numbers of Calanus propinquus in the upper 50 m water layer than those taken at daylight.

The Neptun's transect crossed a broader shelf. There the copepods were less abundant than over deeper water. Metridia gerlachei again was the dominant copepod. All taxa other than copepods were present in low numbers only. So the plankton was poorer than 30 miles further to the Northeast.

The Divergence transect was similar to the Drescher transect of the same period. Copepods, mainly Metridia gerlachei as well as ostracods and chaetognaths were dominant. The outermost station was extremely poor.

All stations on the Halley transect as well as the four stations off Dawson-Lambton glacier and one isolated station further south were rather poor in large copepods. Also the smaller species and stages were somewhat reduced in number, but not in such a large extend. Gastropods were dominant and increased with distance to the shelf ice barrier. Relatively high figures of gastropods are common to the southeastern Weddell Sea also in summer.

During dives with the Remotely Operated Vehicle (ROV) to the bottom concentration of particles was recorded on video with the camera tilted downwards and focussed to a distance of 40 cm. Every 15 m the descent was briefly stopped and a still picture taken.

Usually in the upper 100 m only very few particles and organisms were seen. Towards the bottom the number of particles increased drastically. Most of the particles and organisms were found in a layer extending some 50 to 100 m above the bottom. A shipboard made sucking net, which could be switched on and off from the deck, was used to do sampling in this layer. During the sampling period two times intense bioluminescense was observed on the video. Besides copepods and other small organisms a number of larger organisms like euphausiids, ctenophores, chaetognaths, siphonophores, fish and fish larvae could be observed occasionally.

The incubation experiments indicated that Oithona and Calanus nauplii do develop slowly, while the other species and all copepodids almost do not develop during the winter conditions. Calanus, Metridia and Oithona eggs hatched in the incubation containers at -1.5°C, and adult females of

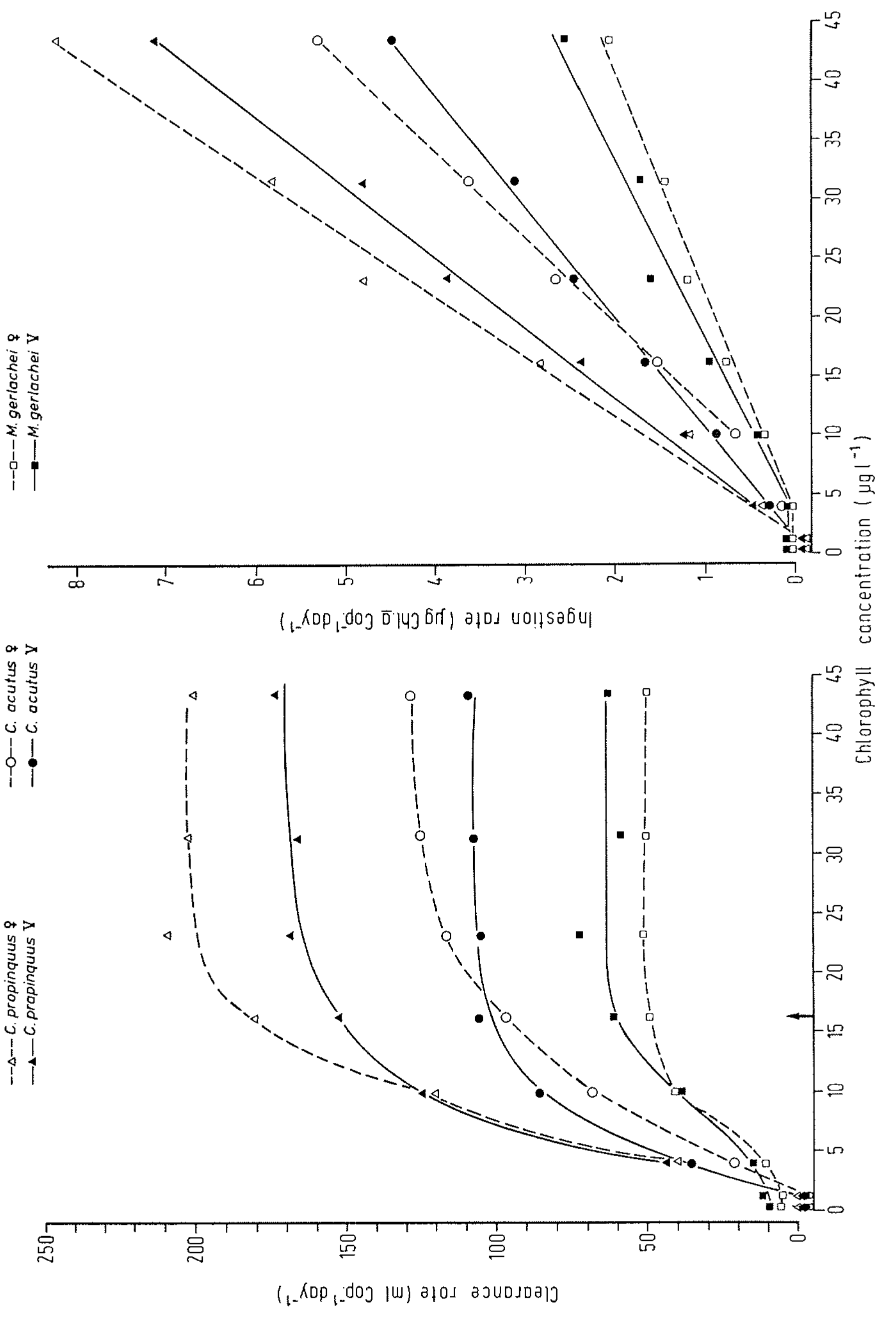


Fig. 38. Relationship between chlorophyll concentration and clearance rate (a) and ingestion rate (b).
↑ high egg production.

these species produced eggs in the absence of food throughout October and November. By this winter activity the frequency distribution of the stages is bimodal with peaks in nauplius 3 and copepodide 4 in most species. The continuous presence of almost all stages will ensure a rapid numerical response to the diatom spring bloom. Females and copepodite stage 5 of Calanus propinquus and Calanoides acutus did not feed at food concentrations less than 1 µg chl a/l, whereas Metridia gerlachei did feed at low rates. High feeding rates in all copepods studied were found at chlorophyll concentrations exceeding 10 µg/l (Fig. 38), and correspond with high egg production in the females of Calanus propinquus and Calanoides acutus.

3.15 Winter distribution, behaviour and feeding of krill (M. Elbrächter, H.-P. Marschall, S. Marschall, F.-P. Rapp)

Objectives

Investigations in austral summer have always shown that krill is a fast swimming and swarm forming pelagic animal, mostly feeding on phytoplankton. The high energy demands which go along with the pelagic life style, led to a number of speculations how krill can survive the low phytoplankton production during the Antarctic winter. In general it was expected, that the low phytoplankton concentrations during winter barely match the energy demands of krill. It has been suggested, that krill either reduces its metabolism and uses up reserves up to shrinking in body size or may switch to a different food source. During the winter cruise it was intended to study the over-wintering strategy of krill in respect to distribution, behaviour and utilised food resources.

There were some indications and diver observations, that krill may live either in the hyperbenthos or in the cryopelagic. Both are habitats, which can not be sampled with ordinary plankton gear. Therefore a Remotely Operated Vehicle (ROV, for technical details see 3.4) was used for direct observations in both habitats as well as in the water column.

When it became obvious from the underwater observations that krill is feeding heavily on ice algae and concentrates in areas where they are most abundant, a series of experiments was designed to see whether krill actually can distinguish between ice with different algae concentrations and what the cues are for being attracted. The question was further whether krill can scrape off algae growing on the surface of the ice or only feeds on algae washed out of the ice by the brine.

Work at sea

Distribution of krill during winter in the Weddell Sea:
The presence of krill washed onto the ice was visually monitored when "Polarstern" broke through sea ice. These observations were carried out whenever time permitted on the way through the pack-ice at the beginning of the cruise and throughout the period of field work. The observations were continued on a more regular schedule on the way out of the ice again. When ever possible specimens were collected from the ice, to proof whether it was actually krill and for later gut content analysis.

Behaviour and winter feeding of krill:
The ROV was used 27 times at 25 different positions for observations in the cryopelagic under the sea ice and on 12 stations in the water column and for observations at the bottom down to a maximum depth of 425 m. For details of operation see report above. The abundance and the in situ behaviour of krill in relation to environmental factors can be studied by analysis of still pictures (colour slides) and video recordings. Also the presence of other organisms was monitored.

Specimens collected at stations from the ice or in plankton nets were preserved in 2.5% Glutaraldehyd at 0°C and after 4 hrs transferred to 4% buffered Formalin. Specimens preserved this way are in very good condition for light microscopy and keep almost natural colour for several months. In order to reveal food sources of krill during winter, fore gut, hepatopankreas and gut of some 40 specimens were dissected already during the cruise and mounted on glass slides, embedded in Kaiser's Glyzerin Gelantine for analysis of gut content.

Laboratory experiments on feeding behaviour:
Krill, collected during the first leg of this cruise in the Peninsula area and kept alive on board "Polarstern" were offered at the same time two small floes of ambient sea ice with low and high concentrations of ice algae. This experiment was replicated with ice from different origin and with or without visible light. The experiments were recorded on video tapes, using a low light level camera. The feeding movements were filmed with a high resolution video system and documented by makrophotography. To evaluate whether the krill is attracted to the ice by changes in salinity or by chemical cues etc., the effect of different types of water was tested (see below).

In order to show whether krill can actually scrape off algae growing on the surface of the ice, cultures of ice algae were grown on glass plates. The reactions of krill to these plates were recorded on video tapes and documented by still photography.

Preliminary results

Distribution of krill during winter in the Weddell Sea:
Krill was found washed onto the ice from 59°S to 76°S (Fig. 39). Whenever there was ice on the way back from Atka Bay to the northern ice edge at 59°S, krill could be observed. The observations show that krill is widely distributed during winter under the sea ice of the Weddell Sea.

Behaviour and winter feeding of krill:
Krill could be observed on 13 of the 27 dives under the sea ice and only on one deep dive the vertical distribution of krill extended down to 37 m. Only on rare occasions krill was observed 1 or 2 m below the bottom of the ice. Usually the krill was in contact with or close to the ice. The scarcity of krill in the water column was confirmed by the very poor catches of RMT and Krill net. In net tows, if any only a few krill specimens were caught occasionally, even at stations, where there was a lot of krill observed underneath the ice.

On stations where krill was observed the bottom of the sea ice was usually rather uneven and high numbers of brine channels and wide brine pockets extended far up into the ice. In those places, algae concentration was sometimes so high, that for the colour video camera barely enough light was coming through. From the colour video it became obvious that ice algae concentration can be rather patchy with almost no intermediate values between areas with high and low concentrations.

Pressure ridges in the ice were found to be rather complex in structure. Ice floes were piled up with almost random orientation by that forming a labyrinth of gaps and galleries from the top of the ice down to the ridge keel. Gaps were often packed with brush ice and wet snow was to be seen on the submerged ice floes. All this leads to a tremendous increase in surface area within the ridges. In the brine pockets and channel system as well as in the ridges, krill was found to be concentrated in high numbers and feeding on the ice algae regardless of the orientation of the ice surface.

The preference to this areas has obvious advantages for the krill. The amount of surface area and along with this the amount of ice algae available is drastically increased. On the other hand krill in this habitat is to a great extent sheltered from its predators. This coincides with the observation that escape distance of krill found under plane ice was much higher. Unfortunately this behaviour impedes abundance estimates. Although the abundance of krill is underestimated in these cases the number of krill per area found under plane ice in the vicinity was by at least one order of magnitude lower. Besides krill three species of Ctenophores were observed frequently and sometimes in high numbers under the ice. From one of these species it is known, that it feeds on krill (Hamner, pers. comm.).

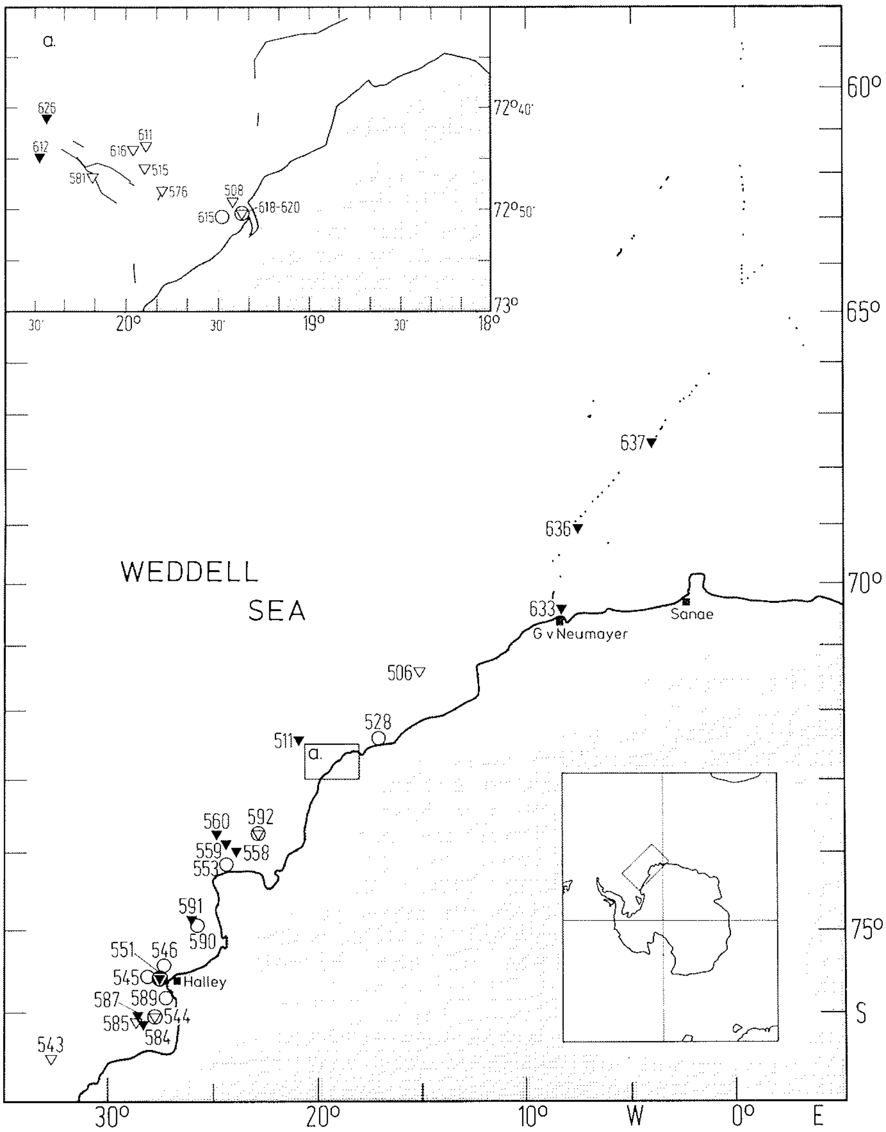


Fig. 39. Parts of the cruise track of "Polarstern" during leg 2 of the WWSP'86 along krill was observed on overturned ice floes. Station numbers and ROV dives under pack-ice or down to the bottom are indicated by ∇ or ○, respectively. Full symbols indicate stations where krill was observed during the dive.

Krill washed onto the ice and observed while feeding under the ice always showed a green hepatopankreas and a high gut fullness. The in situ observations of the krill distribution and behaviour showed, that krill occurs concentrated in areas with carpets of ice algae and that they heavily feed on them. The gut content, though not yet analysed in detail, revealed that krill was almost exclusively feeding on ice algae.

Laboratory experiments on feeding behaviour:
In laboratory experiments krill was offered the choice between ice floes with and without ice algae. In all experiments krill always showed marked preferences to ambient ice with higher algae content. Tests with white and red light showed no difference. This indicates that neither light nor the influence of ice on the salinity can explain why krill is attracted. Most likely chemical cues are involved. To show whether the observed behaviour can be explained by chemical cues alone, water with three different properties was frozen and used in a series of experiments. F/2 medium was made from GF/C (pore size 0.45 μm) filtered seawater with extreme low chlorophyll content. One part was stored in the dark. The other was used to raise a dense culture of different Thalassiosira species. The original F/2 medium and 500 ml of the culture were again GF/C filtered to remove all particulate material. Ice was then made from both kinds of water as well as from the unfiltered culture by freezing them at -10°C enclosed in plastic bags.

When offered ice made from the original F/2 medium versus frozen filtered water from the algae culture the specimens were more often but only for brief periods found under the latter, but the differences in reaction were not very pronounced. When offered ice from the filtered culture together with ice made from the unfiltered culture, the latter was clearly preferred and the specimens showed marked prolongation of feeding movements under this ice. These experiments show that besides chemical cues there is at least one other cue envolved.

The experiments with algae grown on glass in the lab showed that krill can very effectively scrape off surface films by touching the surface with the base of the first antenna and the tips of the thoracopods and then moving them from outside to inside over the surface by closing the feeding basket. The algae concentrate at the tips of the thoracopods and are then from time to time sucked towards the base of the thoracopods feeding basket during the opening of the filtering basket.

The investigations during the winter cruise have shown, that at least in late winter krill by no means starves, but is quite actively feeding under the ice and likely gains enough energy even to grow. Further there were unexpected high numbers of krill found far south in the Weddell Sea which are no members of the pelagic communities but were found to be a dominant part of the cryopelagic system. This change in habitat and food source seems to be a key to the success of krill in the ecosystem of the Antarctic.

3.16 Fish and fishlarvae (W. Ekau, G. Hubold, A. Wöhrmann)

Objectives

The importance of fish in coastal waters of the Weddell Sea became more evident since food investigations on top predators, seals and penguins were intensified. Fish are additional and links between krill and zooplankton and mammals or birds. The position and relative importance of fish in the food web may vary throughout the seasons. Interactions between the components are manyfold. Knowledge of the trophic position and population dynamics of the main fish species is essential to understand the functioning of this poorly known ecosystem.

So far, only summer data from early January to late February were available from the southern Weddell Sea. Main objective of the present late winter cruise was to obtain material and data on possible seasonal effects on population structure, condition, biochemical composition and reproduction cycle in both demersal and pelagic fish communities at the end of winter, when seasonal effects are expected to be most pronounced.

Work at sea

a. Sampling
Different gear was used for the collection of demersal and pelagic fish, and their respective pelagic larvae and juveniles. The activities were often hampered by the unpredictable ice conditions. Distribution of stations in the area was therefore opportunistic.

Agassiz Trawl (AGT):
A 3 x 1 m AGT with 1 cm meshes was deployed 21 times on bottom depths between 290 and 1010 m. The net was towed at 1 knot for 15 min. Three hauls were made north of Vestkapp, 12 to the South, 4 in the Halley Bay area, and 2 on the Spiess sea-mount (west of Bouvet Island).

Bottom Trawl (GSN):
The net was a 140 feet trawl with an effective opening of 22.5 m on ground. Mesh size in the cod end was 1 cm. The net was used 7 times on bottom depths of 230 to 550 m on the shelf south of Vestkapp. Due to the difficult bottom topography, hauling times varied between 9 and 23 min at 4 knots ship's speed.

Krill Net (KN):
Twelve pelagic hauls in depths between 640 m and the surface were made with a scientific Krill trawl. Net opening was 10 x 10 m. Mesh size was 10 mm in the cod end. A net sounder controlled net opening and depth to bottom. The net was hauled at 3-4 knots in double oblique hauls in the coastal polynya between Vestkapp and Halley Bay.

Rectangular Midwater Trawl (RMT 1+8):
A simple version of the RMT 1+8 without opening/closing device was hauled in 22 double oblique hauls between 500 m and the surface to collect postlarvae and pelagic juveniles. The net was towed behind the ship even in heavy pack-ice. The by-catch of macrozooplankton was used for biochemical and population studies. Hauling speed was 2 knots, the wire was payed out and retrieved at 0,3 m/s.

Bongo Nets (BO):
Larval stages were collected with a Bongo net. The standard net was equipped with 300/300 µm mesh gauze. Oblique hauls could only be made in 11 occasions in open water in the coastal polynya. At all other stations, the net was hauled vertically between 500 or 200 m and the surface.

In addition, fish larvae were occasionally collected by a multiple opening and closing net (Multi net), used for zooplankton collections. The Bongo and Multi net catches are reported in detail in the zooplankton section of this report.

Traps:
Three times fish traps were lowered to the sea floor at approximately 400 m. These activities were limited to fast ice edge at Drescher Inlet. Very few fishes were obtained, possibly due to the high density of predators in this area.

b. Processing
The fish were identified in most cases according to the FAO identification sheets (FISCHER and HUREAU, 1985). After measuring and weighing, specimens were stored frozen (-28°C) with the exception of Zoarcidae, Liparidae and Pogonophryne spp. which were preserved and stored in 10% formaldehyd. Fish larvae and pelagic juveniles were identified, measured and preserved in 4% formalin. Samples were also deep frozen (-80°C) for lipid analysis.

Samples of otoliths, stomach content, gonads and different tissues were taken fresh from about 400 individuals and preserved for further analysis including electrophoretic species separation, composition of the blood serum, lipid content, and functional morphology. Live fish were kept in cooled aquaria in a lab container installed on board. Studies on behaviour, food uptake and biochemical composition were conducted with those specimens.

Special attention was given to the species Chionodraco myersi, Trematomus scotti, and Trematomus eulepidotus (Fig. 40). These species occurred abundantly in summer 1985 and during the present collection and will be studied in detail for biochemical composition in the different seasons. Effects of starvation on composition of different body tissues was studied on fish kept in aquaria.

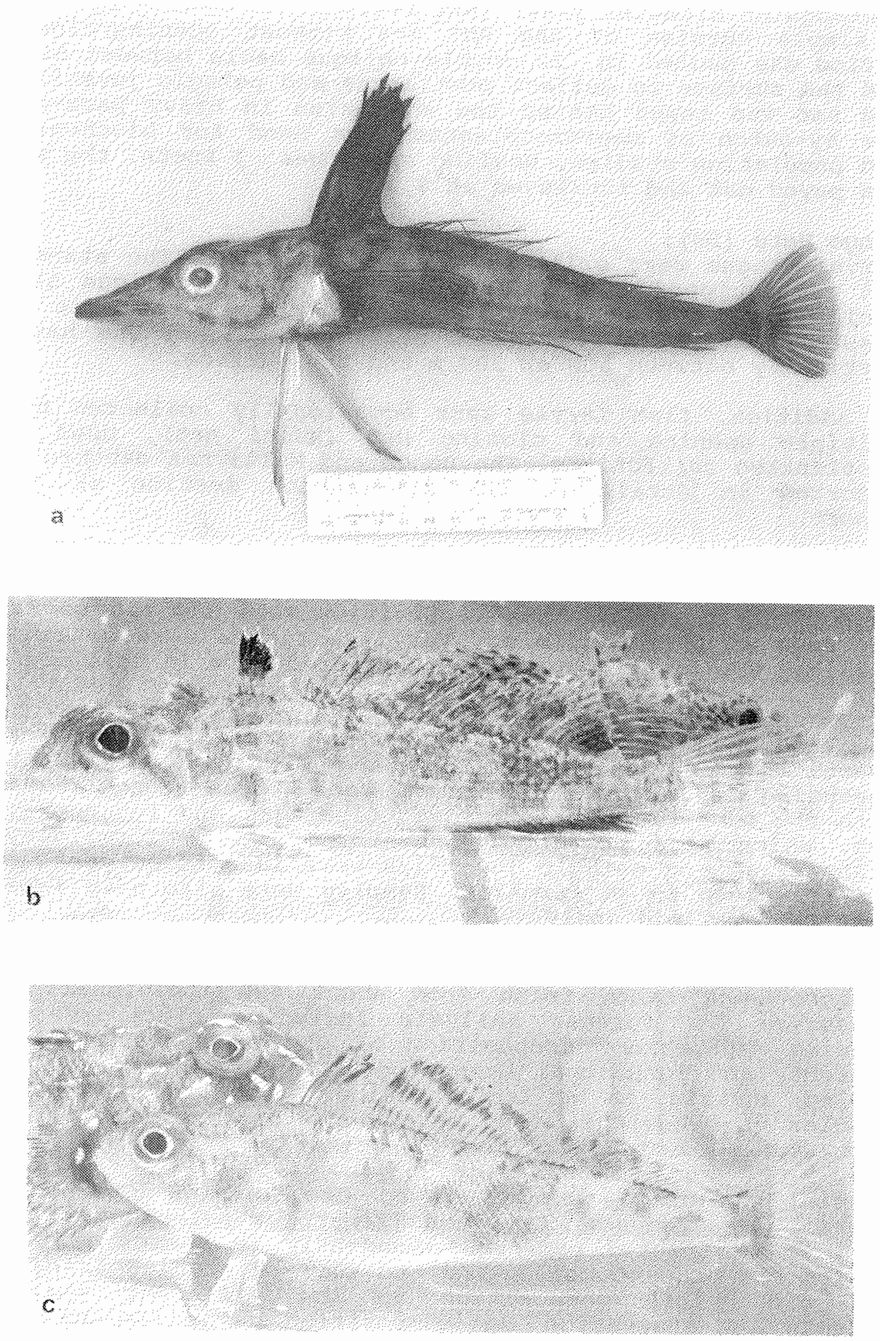


Fig. 40. Chionodraca myersi (a), Trematomus scotti (b) and Trematomus eulepidotus (c).

Preliminary results

Demersal Fish:
With the bottom gears AGT and GSN, 3881 fishes were caught. This number includes 180 juvenile Pleuragramma antarcticum which were collected pelagically during haul 594. By numbers, 98% of the fish belonged to the suborder Notothenioidei, representing 29 species plus several unidentified species of the genus Pogonophryne. Besides this suborder, fishes of the families Zoarcidae (24) and Liparidae (29), 8 Bathyraja spp., 7 Macrourus holotrachys and 2 Muraenolepis spp. were collected. 247 specimens of Octopoda and 5 squids were caught (Tab. 14).

The two Agassiz trawl catches on Spiess sea-mount were not included in Table 14. The hauls yielded 4 fishes of the following taxa: Notothenia squamifrons (1), Muraenolepis orangiensis (1), and Liparidae spp. (2).

Biomass estimates based on the 7 GSN hauls were 1.2 t/km^2 for the shelf south of Vestkapp. In comparison, the summer estimate was 0.7 t/km^2 for the same area based on 6 GSN hauls. Species composition did not vary significantly from summer to late winter. In both seasons, T. scotti, T. eulepidotus, and T. lepidorhinus were the dominating Nototheniids. Of the Channichthyids, Chionodraco myersi and Pagetopsis maculatus were the most abundant representatives.

Maturity stages of 12 species were investigated. Ripe gonads close to spawning were found in Chionodraco hamatus in one case. Females of T. eulepidotus, T. centronotus, Ch. hamatus, Cygnodraco mawsoni, Artedidraco loennbergi, A. shackletoni, and Pogonophryne scotti were in advanced maturity stages, indicating spring to early summer spawning. Gonads of T. lepidorhinus, T. scotti, Pagothenia bernacchii and Chionodraco myersi were less developed than in summer. Spawning of these species will rather occur in late summer to early winter.

First results of the analysis of stomach content of 14 species are shown in Table 15. The proportion of empty stomachs was relatively high for the Channichthyids and T. eulepidotus. These species tend to feed on pelagic fish and euphausiids. Benthos feeders had mostly filled stomachs. These findings compare well with stomach analyses made for fish collected in summer by SCHWARZBACH (1987), and show that at least by the end of winter, feeding occurs normally in the Weddell Sea Notothenioids. Seasonal effects, if any, are to be expected in pelagic fishes and in the pelagically feeding demersal fishes.

Pelagic Fish:
With the different gears, altogether 3525 pelagic fish or pelagic stages of demersal fish were collected. This number includes 180 juvenile and 25 adult P. antarcticum collected by Bottom trawl or obtained from stomachs of channichthyids (Tab. 16).

Tab. 14. Numbers of fishes collected in Bottom trawl (GSN) and Agassiz trawl (AGT) hauls, broken down for geographical areas Vestkapp-S, Vestkapp-N, and Halley.

Species	7 GSN Vest-S	3 AGT Vest-N	12 AGT Vest-S	4 AGT Halley	total
Nototheniops mizops			5		5
Trematomus eulepidotus	471	4	21	1	497
lepidorhinus	290	6	13	1	310
nicolai	12	1	1		14
scotti	748	2	40	6	796
centronotus	26		1		27
Pagothenia hansoni	5				5
bernacchii	1				1
Pleuragramma antarcticum	184			1	185
Pogonophryne scotti	23		2		25
Pogonophryne spp.	32	1	7	1	41
Histiodraco velifer	11		3		14
Dolloidraco longedorsalis	131	12	9	2	154
Artedidraco loennbergi	151	1	7		159
orianae	1				1
mirus	25		2		27
shackletoni	20	2			22
skottsbergi	55	3	3		61
Bathydraco marri	3		4		7
Cygnodraco mawsoni	39		1		40
Gerlachea australis	4		1		5
Gymnodraco acuticeps	12				12
Prionodraco evansii	7	3	2	2	14
Racovitzia glacialis	29	1	5		35
Chaenodraco wilsoni	5			1	6
Chionodraco hamatus	39	3	8	1	51
myersi	755		27	1	783
Cryodraco antarcticus	59		8	1	68
Pagetopsis macropterus	1	1		2	4
maculatus	199	9	7	8	223
Octopoda type 1	57	1	3		61
type 2	166	8	11	1	186
Decapoda (squids)	5				5
Macrourus holotrachys			7		7
Zoarcidae spp.	15		9		24
Liparidae spp.	28		1		29
Bathyraja spp.	8				8
Muraenolepis sp.	2				2
total	3838	58	208	29	4133

Tab.15. Analysis of stomach content of 14 species, in comparison to summer data (SCHWARZBACH 1987, ANT I and II).
Results in % of investigated stomachs.

	Stomachs of ANT V/3 winter/spring										Stomachs of ANT I and ANT II summer									
	No. of stomachs	Empty stomachs	Unidentified	Polychaets	Crustaceans	Euphausiids	Eggs/larvae	Pleuragramma ant.	Fish	Others	No. of stomachs	Empty stomachs	Unidentified	Polychaets	Crustaceans	Euphausiids	Eggs/larvae	Pleuragramma ant.	Fish	Others
Trematomus eulepidotus	63	48	22	2	10	18	-	-	-	-	63	23	-	-	27	26	-	-	-	24
T. lepidorhinus	13	31	54	7	8	-	-	-	-	-	68	40	-	34	26	-	-	-	-	-
T. nicolai	7	14	86		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
T. scotti	97	22	69	5	1	-	2	-	-	1	130	5	-	38	28	-	-	-	-	29
T. centronotus	20	10	50	-	-	-	30	-	-	10	36	11	-	22	52	-	-	-	-	15
Pagothenia hansoni	3	-	100	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-
P. bernacchii	2	-	100	-	-	-	-	-	-	-	10	-	-	32	54	-	-	-	-	14
Chionodraco hamatus	18	56	-	-	-	-	-	38	6	-	8	63	-	-	-	12	-	-	25	-
C. myersi	66	55	7	-	-	-	-	38	-	-	7	71	-	-	-	8	-	-	21	-
Cryodraco antarcticus	22	85	-	-	-	-	-	10	5	-	6	82	-	-	-	2	-	16	-	-
Pagetopsis maculatus	17	18	12	-	-	47	-	18	5	-	57	12	-	-	-	81	-	-	7	-
Cygnodraco mawsoni	36	-	24	-	3	-	-	52	21	-	18	17	-	-	30	-	-	-	53	-
Gymnodraco acuticeps	2	-	-	-	-	-	-	100	-	-	0	-	-	-	-	-	-	-	-	-
Dolloidraco longedorsalis	5	40	40	20	-	-	-	-	-	-	148	11	-	69	-	-	-	-	-	20

Tab. 16. Numbers of stages of pelagic fish collected with different gear between Atka Bay and Halley Bay.

Species	stage	n
Pleuragramma antarcticum	larvae	2941
Pleuragramma antarcticum	age 1	200
Pleuragramma antarcticum	age 2	170
Pleuragramma antarcticum	age 3	98
Pleuragramma antarcticum	age 4	1
Pleuragramma antarcticum	adults	25
Nototheniidae indet	larvae "A"	2
Nototheniidae indet	larvae "B"	3
Nototheniidae indet	larvae "C"	7
Chionodraco spp.	larvae	32
Chionodraco spp.	postlarvae	10
Chionodraco spp.	juveniles	4
Pagetopsis spp.	postlarvae	7
Pagetopsis maculatus	juv/adult	2
Cryodraco spp.	postlarvae	4
Cryodraco sp.	juvenile	1
Dacodraco hunteri	juvenile	3
Chaenodraco sp.	juvenile	1
Channichthyidae indet	postl./juv.	2
Bathydraconidae indet	postlarvae	1
Bathydraconidae indet	juvenile	3
Zoarcidae indet	larvae	2
Liparidae indet	larvae	2
Macrouridae indet	postlarvae	1
Notolepis coatsi	postlarvae	1
Bathylagus antarcticus	larvae	2
	total:	3525

16 taxa were distinguished. 2995 specimens were early larvae. 98.2% of these were P. antarcticum. Of the 530 postlarvae , juveniles and adults, 93% were Pleuragramma.

The pelagic fish biomass in October and November was extremely low. Main pelagic organisms by biomass were jellyfish, of which up to several kg were caught per haul. Our net hauls yielded few individuals of fish, where in summer hundreds were obtained. This finding hints to different distribution patterns of the pelagic species in the seasons.

Early in the season, the sparse pelagic fish community consisted of older postlarvae and juveniles of P. antarcticum and Channichthyids. Only few Larvae of Zoarcidae and Liparidae were collected. Except for P. antarcticum, and Ch. myersi, the yolk sac larvae could only be identified to family or genus. Three types of nototheniid larvae were distinguished.

First yolk sac larvae of Chionodraco sp. appeared in early November in depths below 500 m over the continental slope. On 18. of November, mass occurrence of early Pleuragramma antarcticum indicated hatching near Vestkapp. The larvae were confined to depths between 500 and 200 m over the slope of the continental shelf. After few days, larvae were also caught at 200 to 100 m depth. Standardized abundances in the hatching area were up to 100/100 m3. Summer values were as high as 50/100 m3 off Vestkapp and up to 300/100 m3 in the southern Weddell Sea (Gould Bay).

For the first time, eggs of P. antarcticum were found. The eggs occurred in the stomachs of benthos feeding fish Trematomus centronotus caught in 450 m water depth. In mid November, the 1.95 mm diameter eggs contained well developed embryos of 7 mm length with characteristic pigmentation of the yolk sac larvae collected later off Vestkapp. The pigment differs from older larvae in that a set of melanophores is found ventrally on the yolk.

The age structure of the juvenile P. antarcticum population was analyzed. Due to obviously slow growth during winter of this pelagic species, age groups 1, 2, and 3(4), as well as the larvae of the year could be separated clearly by length frequencies.

Mean length at age before onset of the new summer growth was established as:

Age 0	(hatching length)	10 mm SL	(in life)
Age 1	(Oct./Nov.)	39 mm SL	(fresh dead)
Age 2	(" ")	65 mm SL	(" ")
Age 3	(" ")	94 mm SL	(" ")
Age 4	(" ")	122 mm SL	(n=1)

Age 5+ fish may be from 145 mm SL onwards and were found in too low numbers for length frequency analysis.

Yearly length increments are 1. Yr: 29 mm
2. Yr. 26 mm
3. Yr. 29 mm
(4. Yr. 28 mm)

The growth of P. antarcticum can thus be defined as slow and linear during a prolonged juvenile phase. Accumulation of larger sizes around 170 mm SL (HUBOLD and EKAU, 1986) indicates considerably slower growth after first maturity at 5 years of age.

The first results of the fish investigations indicate a marked difference between the demersal and pelagic fish. Year round constant standing stock, normal feeding, and variable maturity cycles in benthic fishes seem to reflect little influence of antarctic winter. Length frequency distributions do not contain clear age class signals.

Benthopelagic fishes had a markedly lower feeding incidence and may show stronger seasonality. The pelagic fauna shows growth retardation, sharp spawning season and seasonal migrations which may be connected to the pelagic plankton cycle.

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3.17 Zoobenthos (H. Dahms, D. Gerdes, S. Hain, H.-P. Marschall)

Objectives

The composition, abundance and mode of life of benthic invertebrates are analysed with regard to the winter conditions in the Antarctic ecosystem. Material was collected for studies of taxonomy, zoogeographic distribution of organisms and for population dynamic studies; some taxa were sampled for specialists at German institutes. The data will be compared with those of other expeditions in order to recognize any seasonal influence on these components of the ecosystem. Selected benthic organisms, mainly molluscs, brachiopods and harpacticoids are kept alive for analysing growth rates, times of reproduction, basic metabolism and behaviour.

Work at sea

a. Sampling
Zoobenthos was collected at 43 stations along the shelf ice of the eastern Weddell Sea from Atka-Bay (NE) to south of Halley Station with special reference to the Vestkapp area (17 stations). The depth range in the area under investigation varied from 270 m to 3500 m. 19 Agassiz trawls, 7 bottom trawls and 2 dredge hauls provided data for analyses of the macro- and meiobenthos distribution. Additional information about endofauna and sediment were obtained from 12 Van Veen grab- and 5 box core samples. Fish traps provided material of macrobenthic organisms in good condition for rearing experiments.

After having taken subsamples from Agassiz trawl and Bottom trawl catches, the remaining material was sorted out in order to get an overview of the macrofauna and to obtain specimens for preservation (alcohol-/formaldehyd fixation; freezing at -30°C) and cultivation. The subsamples were taken for analysing the species abundance and diversity as well as the intraspecific size ranges and reproductive stages.

The species composition and abundance of the epibenthos was investigated by direct observation with the Remotely Operated Vehicle (ROV) described above.

The upper 15 cm of the box core samples and the complete Van Veen grab samples were washed on a 0.5 mm sieve. The remaining material was preserved prior to further studies on the distribution of the endobenthic fauna.

Meiofauna was enriched from samples of all bottom gears including the Beyer sledge by washing and stirring up macrofauna and organic debris in a basket and subsequent sieving the meiofauna-carrying supernatant on a fine screen.

b. Laboratory experiments

About 400 living molluscs and brachiopods were kept in aquaria in a temperature-controlled container for studying growth rates, oxygen consumption, gonad development and behaviour.

For growth analyses of patellacean gastropods and bivalves, 70 specimens were marked by softly grinding the shell edges. After definite periods of time, the growth of the animals will be estimated by using a microgrowth banding technique.

The respiration rates of different mollusc species are measured mainly by Winkler method; this work was conducted on the next legs.

Fresh and formalin preserved specimens of echinoderms and molluscs were dissected for determination of sexual maturity (number and size of eggs).

Ovigerous females of harpacticoid copepods were kept in petri-dishes and their offspring gave the stock for single-species-cultures providing the facilities for studies on ecophysiology, functional morphology, larval stages, behaviour and adaptations of reproductive processes. Embedding of several specimens was carried out for later histological and ultrastructural research. Microphotography and micro-video-cinematography of meiofauna will give information on habits and bionomy.

Preliminary results

The macro-endofauna of the research area is limited to the upper 5-10 cm of the sediment. It consists mostly of polychaetes and its biomass is very low compared to the macro-epifauna. Sponges, bryozoans and hydrozoans were clearly dominant elements of the continental shelf fauna down to 500 m. Echinoderms, especially ophiuroids, were quite common too, whereas polychaetes, crustaceans and molluscs were less important despite being abundant at almost all stations in high species diversity.

There was a striking number of epibenthic filter- and deposit-feeding organisms (polychaetes, holothurians, ophiuroids, sea anemones) using greater glass sponges (Fam.

Rossellidae) and hydrozoan colonies (Fam. Primnoidae) as a substrate. Some of these interspecific relationships appeared to be obligatory. About 300 photographs of preserved and living material were taken to prove these and other conspicuous faunal compositions and to draw up an inventory of the dominant macrobenthic specimens from the eastern Weddell Sea.

Direct observations of abundance and behaviour of benthic organisms were carried out with the aid of an ROV described above. Continuous video recording over a certain distance allowed to study abundance as well as also small scale patchiness and interspecific relationships in great detail. Sponges for example served as substrate for e.g. crinoids, holothurians and other organisms. Still photos taken from areas of specific interest will be used to interpret the video recordings. Further comparison with collected preserved material will help to determine species. The observation suggest a strong relationship between bottom currents and substrate on one hand and species composition and distribution on the other hand.

With the aid of in situ observations it is also possible to obtain information even on very fragile organisms which are never brought up by bottom trawls. For example the pictures showed at one station several specimens of an organism, most likely a siphonophore, which was attached to the substrate by a number of tentacles, with the body floating some 20 cm up to one meter above ground with the aid of a gas bladder at the top. Stick shape, jelly organisms were quite abundant seen on several stations, but up to now it was not possible to recover them from bottom samples. A number of fish species could be observed, obviously not very frightened by the vehicle.

Light level was surprisingly high even at a depth of more than 200 m due to the extremely clear water. Therefore on some stations it was possible to use the SIT camera of the vehicle without additional light. With the camera tilted upwards background illumination from the surface could be seen even at the depth of 425 m.

The results obtained during this cruise have shown that by using an ROV valuable quantitative data on the makrobenthos and also on the structure of benthic communities can be obtained in the Antarctic.

A special interest in molluscs (prosobranch gastropods, bivalves and amphineurans) showed that there are only some species like <u>Tugali mawsoni</u>, <u>Harpovoluta vanhoeffeni</u> (Gastropoda) and <u>Lissarca notorcadensis</u>, <u>Philobrya sublaevis</u> (Bivalvia) with a wide spread ecological range occuring in nearly every sample, whereas most of the species seemed to be closely related to special habitats or substrates like <u>Neoconcha vestita</u> (Gastropoda) and <u>Callochiton gaussi</u> (Polyplacophora) to dead bryozoan colonies. Further studies on material from previous expeditions and comparison with published data will give some more detailled information about the ecology of the molluscs found in the research area.

First determinations of the Weddell Sea molluscs showed the somewhat surprising trend that allegedly circumpolar and quite often occuring species were found very rarely and patchily during this leg, whereas other from literature poorly known and not often documented species were quite abundant. Further taxonomic and zoogeographic work has to support this trend.

Living animals in the aquaria were observed to be very inactive. Short periods of crawling are followed by long resting periods making it sometimes difficult to decide, whether a specimen is dead or alive.

Concerning the mode of reproduction several egg-ribbons and egg-capsules of gastropods were preserved in alcohol or kept alive for fixation at different developmental stages. REM-studies of the embryonic shells will yield information to which species they belong.

A wide range of size classes was observed in many species. The brittlestar Ophiurolepis brevirima, for example, a quite common species in the shelf area of the eastern Weddell Sea, occurred in size classes, ranging from 2 to 20 mm disk diameter. Size frequency analyses are still in progress and results have to be compared with corresponding summer data from this area and also to the gonad development of the species under consideration.

It became obvious that the stage of maturity even in the same species was very heterogeneous, indicating spawning periods to occur probably throughout the year. Chemical analyses (lipid content) of several specimens, preserved deep-frozen at -30°C, will provide better knowledge of the reproduction patterns and also of the growth of the animals.

Observations of feeding behaviour in aquaria showed Neobuccinum eatoni and H. vanhoeffeni to be predatory or saprophageous. Both species were caught in the fish traps. T. mawsoni on the other hand is a sediment feeder as shown by investigation of gut content as well as functional morphology of the radula.

Measurements of oxygen consumptions have been done with different benthic invertebrates, mainly molluscs. Typical respiration rates were found to lie between 2-15 μl $O_2/g/h$ wet weight, i.e. in an range also found from other authors for Antarctic species of comparable size. This work will be continued on leg ANT V/4 with special reference to other molluscs.

Meiofauna samples of the eastern Weddell Sea from 270-600 m depth almost everywhere contain the following groups of varying high species diversity and composition in the sequence of decreasing abundance : Nematoda, Harpacticoida, Turbellaria, Polychaeta, juvenile macrofauna, Ostracoda, Halacaridae, Oligochaeta, Kinorhyncha. In deep-sea samples of silty sediments the scarce meiobenthic endofauna was restricted to the upper 1,5-2 cm. Most of the harpacticoid species presented ovigerous females and developmental instars in Oct./Nov. Specimens obtained from sea-ice-cores or Beyer sledge were best for rearing - experiments because of their relatively unstressed condition. About 80% of the isolated ovigerous females fed on algal-mixtures and Mikrozell survived till the nauplii hatched after 10-15 days on the average. The size-distribution of Harpacticoida is marked by some dwarf epibenthic species most of them with low egg-numbers (2-7) but with comparatively large egg-sizes. Gigantism as typical for some macrobenthic groups does not occur. Remarkable are females of Tachidiidae which carried 2 large eggs. Nauplii hatched from these eggs had a yolk-content as high as never has been reported before for free living harpacticoids.

At first inspection harpacticoids from this cruise are represented by at least 13 families, 22 known genera and 7 probably new genera. 4 families and 9 genera are new for the Southern Ocean. All of about 32 species seem to be new to science except Microsetella norvegica, Perissocope typicus, Paralteutha villosa, Rhynchothalestris tenuicornis, Robertgurneya falklandiensis and Laophontodes whitsoni. These are except the planktonic M. norvegica endemic for the Southern Ocean (collected at Gauss Station, Kerguelen Isl., Campbell Isl., S. Georgia, S. Orkney and Falkland Isl.). They give an impression of the high degree of antarctic isolation providing a good potential for species radiation.

3.18 Weddell seals and Emperor penguins in Drescher Inlet (D. Gerdes, M. Gräfe, N. Klages, J. Plötz, P. Reijnders, R. Steinmetz, K. Zegers)

Objectives

Emperor penguins and Weddell seals are the most southerly ranging warm-blooded animals specialized to live in the high Antarctic latitudes throughout the year. They reproduce on fast ice during winter and spring, respectively. Both the permanent occurrence and high abundance of Weddell seals and Emperor penguins along the coast line of the eastern and southern Weddell Sea suggest, that these predators might have significant effects on their prey stocks,at least locally.

The objectives of the present studies were to collect information on:

a) the breeding biology of Weddell seals and Emperor penguins in Drescher Inlet. In particular growth rate in seals and penguins and whelping, suckling time and attendance in seals.

b) the role of Weddell seals and Emperor penguins as predators.
To elucidate that role five fundamental questions for each predator need answering:

- how many seals and penguins do exist in the area studied?
- what do they consume?
- how much do they consume?
- which size classes do they take?
- where do they obtain their prey?

c) the physiology in Weddell seals in order to describe hormone profiles and to provide values for chemical and physical blood parameters.

Ultimately the information obtained under the above mentioned objectives will be used for comparison with similar data collected on Weddell seals and Emperor penguins elsewhere.

Area of investigation:
The Drescher Inlet (72°52'S, 19°25'W) is located at the Vestkapp Ice Shelf, about 400 km southeast of the German "Georg von Neumayer Station". The funnel-shaped inlet points in an easterly direction and has a length of approximately 20 km. The inlet narrows down to 1.5 km about 10 km from the entrance and then tapers off in a southerly direction.

Field work:
The establishment of the "Drescher Station" on the Ice Shelf near by the inlet enabled research activities of five to six biologists and two meteorologists. We carried out a six-week programme on the ice from mid October to late November. The work was interrupted by altogether 13 days of snow drift.

Studies on Weddell seals:
Four breeding sites of Weddell seals were found, which turned out to be very discrete units. Body weight of 20 pups was weekly taken and 5 breeding females were weighed at the beginning and at the end of the study period to evaluate growth rate and weight loss, respectively. We took blood samples to investigate both the hormone profiles of adult females and furthermore chemical and physical blood parameters. We examined suckling behaviour, mother-pup interactions and moulting of pups. Fourty-one pups were tagged with rota tags to hopefully collect data on long-term survival and site fidelity.

The haul-out behavior of breeding females was recorded both by time lapse camera and radio transmitters. The latter were glued with a 2-components epoxy resin onto the back of the seal and the signals received have been registrated on a chart-recorder and on a digital data logger.

Some seals were provided with a Time-Depth Recorder (TDR) on their back, to get data on diving depth and duration of feeding trips. The technique of attachment of instruments proved to be successful. However, after some weeks the radio transmitters failed to function due to the damage of the aerial by the seals. For that reason recording of haul-out behaviour was conducted by time lapse camera. The information collected by TDR-application was meagre as the data logger could not be recovered in due time. This implicates battery failure by freezing causing loss of memory.

We tried stomach lavage using the water-offloading technique. For that occasion the seals were immobilized with a mixture of Valium and Ketamine. With the aid of an endoscope the degree of stomach contents was checked in advance.

At every opportunity we made trips by skidoo to count non-breeding seals outside the colonies with the objective to recover individual seals being marked with coloured epoxy glue for estimation of group size.

A total of 13 non-breeding seals was killed near the fast ice edge during morning hours between 7:00-10:00 local time. They were taken immediately after they had hauled out, with the aim to get full stomachs for quantitative food analyses. All seals killed were weighed and measured. Furthermore, the skulls and left fore flippers were collected for age determination.

Various tissues for histological and cytological investigations were collected for the "Anatomische Anstalt" of the University of Munich, Germany.

Studies on Emperor penguins:
Adults and chicks were counted by direct and aerial census. The spatial extent and movements within the colony was recorded. The average duration of foraging trips was determined in the second half of November. At this time all chicks had entered the creche stage and both parents were foraging. As there was only one possible way to the open sea to forage, movements to and from the rookery could be monitored by binoculars from a point at the Shelf Ice edge overlooking the entire entrance of the inlet.

Non-selective samples of 30 chicks each were weighed at the beginning and end of the observation period. The mortality rate of both chicks and adults was investigated.

Thirty-four diet samples were taken during the period from October 28 to November 20 to assess the total daily food intake and diet composition during the chick-rearing period. Adults returning from a foraging trip were captured approximately 1 km from the fast ice edge, restraint and transferred by skidoo to a set-up. The water-offloading technique was used to obtain quantitative diet samples.

Two adult penguins found dead were collected for display.

Preliminary results

Weddell seals:
The total population of Weddell seals in the Drescher Inlet amounted to around 250 individuals. During the investigation period a remarkable fluctuation of numbers of non-breeding Weddell seals was recorded. Approximately 70% of the non-breeders were subadults (1 to 3 years old).

Pup production in the four breeding sites was 28, 13, 8 and 19 individuals respectively, all together 68 pups in the inlet. The birth of a pup could be filmed by video-camera. Out of 28 pups, 2 still-births caused by suffication were found. After whelping no mortality occurred in the group under study, which is a mortality rate of 7% during the breeding period.

The mean weight of 7 one-day-old pups was 29 kg with a maximum of 33 kg and a minimum of 24 kg (Fig. 41). Body growth of pups was rapid. They doubled their mean birth weight within 11 days and arrived on an average at 105 kg at the age of 32 days, with a maximum of 119 kg and a minimum of 94 kg. The heaviest pup in that colony weighed 151 kg at the age of about 6 weeks and got just weaned.

The energy demands on breeding females are high. During the 5 to 6 week period of lactation they do not feed. As a result, the mean body weight of 5 breeding females felt from over 518 kg (min. 483 kg, max. 620 kg) to only 372 kg (min. 327 kg, max. 439 kg), a mean weight loss of 147 kg which represents nearly 30% of the starting weight of the females (Fig. 42). Part of this weight loss was reflected in a mean weight increase of 80 kg by their pups. Of 13 stomachs 12 were filled with large amounts of liquid food pulp containing sometimes almost intact specimens of fish and large numbers of fish otoliths.

Preliminary results from roughly sorted material indicate that fish was the major food item of all seals. The bentho-pelagic icefish Channichthyidae seem to be an important prey species in the spring diet of seals. Compared with the summer diet of Weddell seals from the same area (PLÖTZ 1986) the pelagic silverfish Pleuragramma antarcticum was found to a far lesser extent in the spring diet.

Quantitative and qualitative analyses will be continued in the laboratory and compared with the composition of fish catches from the same area.

Emperor penguins:
The direct census on the 24th of October yielded a total of 6660 chicks, 6890 breeding birds and 630 non-breeders present in the colony at this date. The number of chicks indicate a total of ca. 13300 breeding birds in the inlet. Signs of the presence of penguins were found in the entire area of the inlet with exception of a 3 km strip at the fast

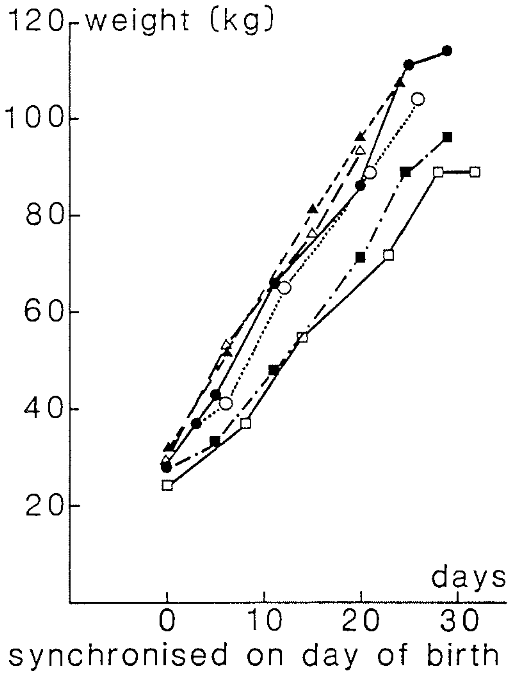

Fig. 41. Weight change of Weddell seal pups during lactation.

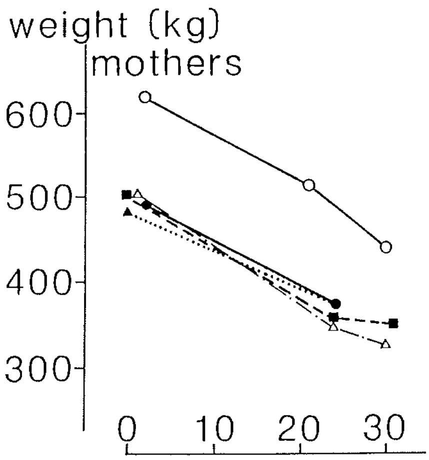

Fig. 42. Weight change of Weddell seal cows during lactation.

ice edge. The colony was obviously split up several times into subcolonies of between 3000 and 300 individuals. Their composition and sites changed frequently.

The average time an adult was away from the rookery was about 36 hours. At any time of the day, fifteen-minutes counts at hourly intervals during several days showed a similar number for the penguins leaving and entering the rookery. Therefore it is concluded that a marked diurnal rhythm in foraging activity did not exist.

Chicks gained on average 180 grams per day between 20th October to 18th November. In late November, the most advanced and heaviest chicks (app. 14 kg body weight) showed already signs of moulting.

Though difficult to quantify because of a constantly shifting layer of snow covering the carcasses on the sea ice, the frequent visits at the sites indicate that chick mortality was highest during the early stages and dropped to very low figures in November. Adult mortality at the colony was very low. Despite of extensive searches only six animals were found dead.

Mean meal size is in the order of 2 to 3 kilograms and consisted entirely of pelagic crustaceans, squid and fish. Euphausia superba, Psychroteuthis glacialis and Pleuragramma antarcticum were the most prominent components. No benthic prey was found.

Reference

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3.19 Aerial counts of penguins, seals and whales in the eastern Weddell Sea (G. Hempel, B. Stonehouse)

Objectives

The primary objective was to obtain data from which stocks of emperor penguins Aptenodytes forsteri and Weddell seals Leptonychotes weddelli could be estimated along the eastern Weddell Sea coast between 71°S and 76°30'S. Secondary objectives were to map the distribution of these species, especially breeding concentrations, and record the presence of whales.

Observations:

RV "Polarstern's" early spring cruise along the eastern Weddell Sea coast gave unique opportunities for counting Weddell seals and Emperor penguins in breeding concentrations. Flights from the ship between 21 October and 28 November, in twin-engined helicopters at heights of 500 to 2000 ft allowed detailed examination of pack-ice and coastal fast ice, aerial counts of penguin and seal concentration, and visits by counting teams to Emperor colonies. Surveys were flown usually in good weather with visibility more than 20 nm, mainly within a radius of 50 nautical miles (nm) of the ship. At least two observers were carried, covering both sides of the aircraft. A few flights that were combined with ice observations were mainly over pack-ice; those dedicated to seal and penguin surveys were mainly over fast ice attached to the coastal ice shelf, where most concentrations were found.

Groups of seals and penguins along the ice edge were counted from heights of 300-500 ft and horizontal distances of 150-200 m. Seal breeding groups were counted and photographed from similar distances except among icebergs, where it was often necessary to fly closer and overfly each colony twice for checking. Penguin breeding colonies were photographed from about 500 ft at a 45° angle. Counting parties were landed 200-250 m away, where possible across wind from the colonies, to ensure minimal disturbance. Whales were noted wherever seen; particular attention was paid to a population of southern bottlenose whales *Hyperoodon planifrons* at Vestkapp, which was seen almost daily during operations close to Drescher Inlet.

Course, height and airspeed were recorded at two-minute intervals; track was later plotted in using the wind vector at the ship, corrected where possible by bearings between ship and aircraft. Total time in the air was 42 hrs in 26 flights; the longest flight took just over four hours. The whole coastline from Coats Land to Atka Bay, Dronning Maud Land was examined, except for a stretch of about 25 miles between Atka Bay and Kapp Norvegia. The total coastline covered was about 1300 km.

Preliminary results

Emperor penguins:
Three previously unrecorded emperor penguin colonies were discovered at Dawson-Lambton, Riiser-Larsen and previously known Halley Bay colonies were counted by ground teams; the Stancomb-Wills and previously known Atka Bay colonies were photographed from the air for later counting, and the size of the Drescher Inlet colony is known from other studies (see 3.18). Emperor penguins were generally seen at the edge of the fast ice close to their colonies, only rarely away from them; a few such concentrations of over 100 birds were noted both on fast ice and on pack-ice within a few miles of land. No colony was found in or close to Norselbukta, which no longer exists as a sheltered bay. A total population of 51,500 chicks is estimated, representing a projected total adult population of 130,000, approximately 170 per nm or 95 per km of coast. The two largest colonies were in the southern half of the observation area, taking 74°30'S as dividing line.

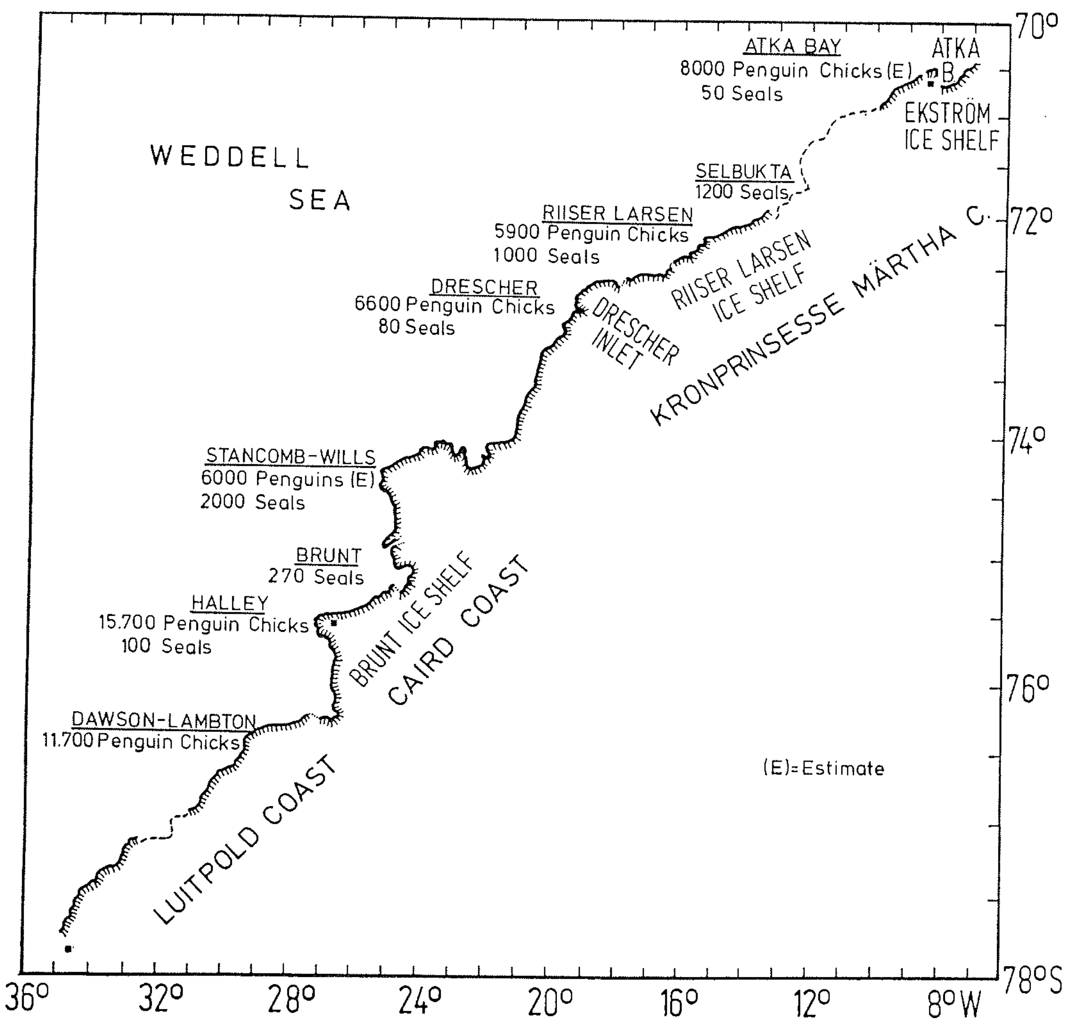

Fig. 43. Distribution of Emperor penguins and Weddell seals along the eastern Weddell Sea coast.

Weddell seals:
Previously unrecorded major breeding areas were identified (see Fig. 43) and counted from the air. Of particular note were very large concentrations at Brunt Ice Shelf, Stancomb-Wills Promontory and Riiser-Larsen Ice Shelf, and the more diffuse but numerous breeding groups at Selbukta, which together held over 4300 breeding females. Thus almost 90% of the estimated breeding population lived north of 74°30'. For seals breeding in small groups away from the main areas, a total population of over 5000 breeding females is estimated, representing a projected total adult population of 12,000, approximately 16 per nm or 9 per km of coast. Actual abundance figures are much higher in the North, and lower in the South.

Whales:
Most often seen were southern bottlenose whales usually singly or in small groups of two to five. These also joined to form larger schools; we recorded a group of 12 off Stancomb-Wills Promontory and groups of 12 and 29 off Vestkapp. The Vestkapp population included two small calves. We saw also male and female killer whales <u>Orca orcinus</u> (each seen once) and rarely minke whales <u>Balaenoptera acutorostratus</u>.

We thank pilots G. Mahler and E. Folkerts, and K. Beyer, W. Ekau, W. Hagen, I. Hempel, N. Klages, S. Marschall, E. Mizdalski, R. Scharek, R. Weppernig and F. Zaucker for their help in counting penguin colonies.

3.20 <u>Aerial reconnaisance for the Filchner Ice Islands</u>
(<u>G. Hempel</u>, G. Mahler, L. Suhrmeyer)

In June 1986 the northern part of Filchner Ice Shelf between the Schweitzer-Lerchenfeld Glaciers and Berkner Island broke off and disintegrated into three major and several small ice-islands. By this the shelf ice edge receded by ca. 100 km. This was seen from meteorological satellites which showed, that ca. 20,000 km3 of ice mass was involved. In October, the head of the Soviet Antarctic Programme asked "Polarstern" for help in exploring the situation of "Drushnaya" summer station, situated in the central part of the former Filchner Ice Barrier.

Objectives

- To provide information on the actual position of the ice islands,
- to explore present ice conditions around the islands to predict the possibilities of "Polarstern's" passage to Vahsel Bay, "Belgrano II", "Drushnaya" and "Filchner" stations in January 1987,
- to explore the fate of "Drushnaya Station".

The aerial surveys:
Three aerial surveys by the twin-engined Ecureil helicopter D-Hast were carried out. The first two on 27 October from position 76°33'S, 32°39'W, the third most extensive one on 9 November from position 77°10'S, 33°54'W. In order to widen the exploratory range for the third survey, a kerosine depot was established by the second helicopter on the western ice island A 24 at the former Argentinean base "Belgrano I". For the three surveys flight time of the helicopter HAST was 2.5, 3, and 6.5 hours, respectively. During the first flight visibility was limited by haze, particularly in the western part of the observation area. On the second flight strong winds hampered navigation and caused a somewhat early return to the vessel. The third flight in the night 9/10 November was favoured by splendid weather conditions with little wind and excellent visibility. The low midnight sun gave much contrast to the otherwise rather monotoneous landscape.

The first flight on 27 October served as a preliminary reconnaissance to get a rough picture of the position of the ice islands and their surroundings. The helicopter followed mainly the northern shoreline of the three islands. The former Argentinean base "Belgrano" was clearly recognized but "Drushnaya" was not seen, presumably because of poor visibility. We looked in vain for the Horn of Drushnaya, the pointed northern edge of the ice shelf, which had been a prominent feature during past years.

The second, more detailed and better documented survey with a professional navigational record based on radar location and dead reckoning resulted in a first map of the three islands with positions for certain corner points of all three islands. It furthermore showed that Vahsel Bay was partly filled by A 24 and partly by icebergs of all sizes. Also the seven mile wide channel between A 24 and A 23 was not navigable, as was the eastern flank of A 22 and the broad area between the ice islands and the new barrier of Filchner Ice Shelf. Again, "Drushnaya" was not seen on this flight. Large icebergs north of A 22 were taken as indication for a major calving in the area of the former Horn of Drushnaya.

At the third survey during the night of 9/10 November the helicopter had a much wider range, permitting a more thorough exploration and mapping. This time "Polarstern" was 40 miles closer to the islands, and therefore the helicopter was in radar range of the vessel for the major part of the survey. First the helicopters landed at "Belgrano I" on A 24, than HAST followed the northern coastline of A 24 and A 23. On A 23 we spotted "Drushnaya Station" and had a brief landing there. Then we circumnavigated A 22 almost completely. After the second refuelling at "Belgrano I" the helicopter circumnavigated the western and southern parts of A 24 and returned to the vessel after a flight across the Vahsel Bay.

The ice situation on the northern side of the islands proved to be much easier than in late October. There was a more or less continuous polynya all along the northern coasts of the three islands, leading finally into Gould Bay. Vahsel Bay, the channels between the islands and the area south of the islands were still full of many kinds of icebergs and sea ice floes. There were, however, indications for the formation of a new polynya in front of the new Filchner Ice Shelf barrier. On the basis of the new navigational data, a revised map of the three islands was established which served as reference for the proper photogrammetric and radar surveys by the two German aircraft Polar 2 and Polar 4 and by "Polarstern" in January 1987.

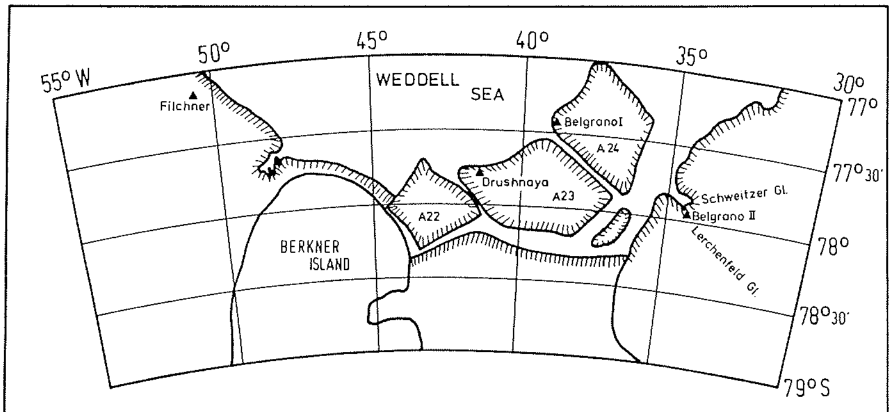

Fig. 44. The position of the ice islands A 22, A 23, A 24 in November 1986.

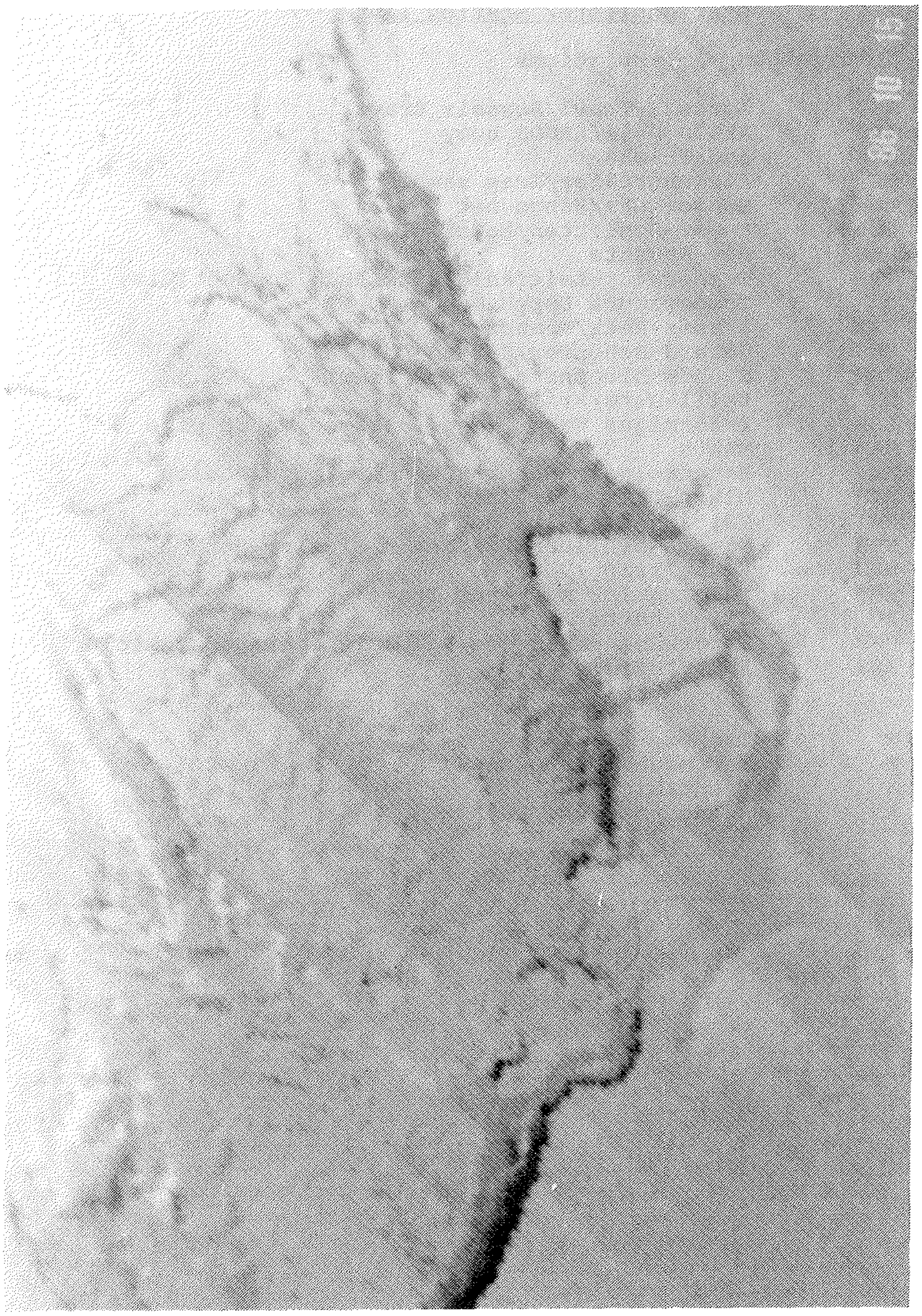

Fig. 45. Soviet weather satellite photograph of the Filchner ice islands taken on 15 October 1986. The westernmost island under cloud cover.

3.21 Stationsliste/ Station list

Abkürzungen/ Abbreviations

AGT	Agassiz-Trawl/Agassiz trawl
ARG	ARGOS Boje/ARGOS buoy
ATR	AquaTracka
BG	Backengreifer/Grap sampler
BO	Bongo-Netz/Bongo net
BSL	Beyer-Schlitten/Beyer sledge
BRO	Bio-Rosette
CTD	Temperatur-Leitfähigkeitssonde/Conductivity Temperature Depth sonde
FRA	Fransz-Netz/Fransz net
GES	Gerard-Schöpfer/Gerard bottle
GSN	Grundschleppnetz/Bottom trawl
KN	Krill-Netz/Krill net
LSE	L-förmiges Wasserrohr/L-shaped water pipe
MAN	Manta
MET	Meteorologie-Schnitt/Meteorology section
MIN	Mikro-Netz/Micro net
MN	Multi-Netz/Multi net
NSN	Nansen-Schließnetz/Nansen closing net
REU	Reuse/Trap
RMT	Rectangular Midwater Trawl
RO	CTD-Rosette
UWE	Unterwasserfahrzeug/Remotely operated vehicle
XBT	Bathythermograph

T	Tag/Day
M	Morgendämmerung/Dawn
N	Nacht/Night
A	Abenddämmerung/Dusk

:at. !o.	Date	Position		Echo depth (m)	Gear	Haul No.	Day time	Start (GMT)	Haul dur. (min)	Depth (m)	Comment
487	03/10/86	54º38,7'S	006º00,8'O	2.950	BRO	1		6:18	40	300	
					MIN	1		6:25		15	
					FRA	1	T	7:05	10	200	
					BO	1	T	7:25	17	200	
					MN	1	T	8:40	36	1.000	
488	03/10/86	54º39,8'S	006º08,3'O	3.093	XBT	1	T	10:07			
489	04/10/86	57º50,7'S	002º26,5'O	3.500	MIN	2		5:30		15	
					BRO	2		5:42	55	300	
					BO	2	M	6:53	12	200	Grieseleis
					FRA	2	T	7:10	10	200	
490	04/10/86	58º05,6'S	002º14,3'O	4.950	BO	3	T	9:30	7	200	
					FRA	3	T	9:40	15	200	
					MN	2	T	10:30	30	1.000	Netz 3-5 n. ausgel.
					RO	3		11:11	126	2.000	
					MIN	3		11:15		15	
91	05/10/86	59º53,3'S	000º04,2'O	5.397	BRO	4		6:30	38	665	
					MIN	4		6:36		15	
					BO	4	T	7:25	10	200	
					FRA	4	T	7:40	10	200	
					BRO	5		8:03	7	20	V-Station 4
92	05/10/86	60º36,3'S	000º45,3'W	5.351	BRO	6		17:07	64	530	V-Station 5
					MIN	5		17:08		15	
					BO	5	A	18:26	10	200	Doppelhol
					FRA	5	A	19:00	10	200	
					MN	3	N	19:50	45	1.000	
93	06/10/86	61º36,7'S	002º22,8'W	5.344	BRO	7		9:01	47	505	
					MIN	6		9:10		15	
					BO	6	T	10:04	10	200	Doppelhol
					FRA	6	T	10:45	10	200	
					ATR	1	T	10:55	15	220	
94	07/10/86	63º24,0'S	004º48,6'W	5.265	BRO	8		8:14	39	487	S o/oo-Sonde ungenau
					MIN	7		8:15		15	
					BO	7	T	9:10	10	200	Doppelhol
					FRA	7	T	9:50	15	200	
					ATR	2	T	10:07	18	220	
5	07/10/86	64º02,9'S	006º03,6'W	5.221	XBT	2	T	17:26			
6	07/10/86	64º03,3'S	006º06,9'W	5.220	XBT	3	T	17:31			
7	07/10/86	64º04,3'S	006º10,4'W	5.221	XBT	4	T	17:39			
8	08/10/86	65º07,3'S	007º10,1'W	5.097	MIN	8		8:00		15	
					ATR	3	T	8:19	15	220	
					RO	9		8:47	98	1.000	
					BO	8	T	10:45	10	200	
					BO	9	T	11:46	36	1.000	
					FRA	8	T	12:30	10	200	
9	09/10/86	67º08,8'S	006º54,9'W	4.883	ATR	4	T	12:35	16	220	
					BRO	10		13:00	46	377	
					MIN	9		13:00		15	
					BO	10	T	14:05	7	200	
					FRA	9	T	14:20	10	200	
					UWE		T	14:51	15	4	
)	10/10/86	69º01,2'S	006º10,4'W	2.637	ARG	1	T	10:00	50		
l	10/10/86	69º25,8'S	006º09,7'W	2.361	MIN	10		16:13		15	
					BO	11	T	16:21	10	200	
					BO	12	T	17:00	18	500	
					FRA	10	T	17:20	10	200	

Stat. No.	Date	Position		Echo depth (m)	Gear	Haul No.	Day time	Start (GMT)	Haul dur. (min)	Depth (m)	Comment
					FRA	11	T	17:35	5	50	
					FRA	12	T	17:40	5	10	
					ATR	5	T	17:45	15	220	
					BRO	11		18:10	38	400	
					UWE		T	18:57	7		
502	11/10/86	70º00,4'S	006º58,5'W	1.725	ARG	2	M	6:00	45		
503	11/10/86	70º02,2'S	007º21,9'W	1.685	MIN	11		13:30		15	
					BO	13	T	13:30	7	200	
					FRA	13	T	13:40	10	200	
					ATR	6	T	13:55	15	220	
					RO	12		14:20	92	1.666	
					UWE		T	16:00	20		
504	12/10/86	70º30,4'S	008º02,5'W	300	UWE		T	6:00	74		
					BO	14	T	7:35	7	200	Atka Bucht
					MIN	12		7:58		15	
					BO	15	T	8:00	12	230	Atka Bucht
					FRA	14	T	8:10	5	10	
					FRA	15	T	8:15	5	50	
					FRA	16	T	8:20	10	200	
					ATR	7	T	8:33	15	220	
					RO	13		8:55	38	257	
					Dredge	1	T	13:16	24		
					BO	16	T	14:28	41	175	Atka Bucht
505	12/10/86	70º40,8'S	008º14,7'W	313	ARG	3	A	18:55	120		
506	13/10/86	71º24,8'S	015º04,4'W	2.035	ARG	4	T	11:55	63		
					ARG	5	T	14:00			
					BRO	14	T	14:15	30		
					MIN	13		14:16		15	
					BO	17	T	15:30	25	500	
					UWE		T	16:02	36		
507	14/10/86	72º43,5'S	019º50,5'W	2.410	ARG	6	T	9:15	75		
					REU	1	T	15:30	120	470	
					REU	1	N	15:30	1.020	2	
					REU	1	N	20:00	780	470	
					REU	1	N	20:00	780	470	
					REU	1	N	20:00	780	470	
508	15/10/86	72º49,3'S	019º25,0'W	485	UWE		T	12:15	53		
					Dredge	2	T	14:12	31		
					BO	18	N	15:24	4	200	Drescher Inle
					REU	1	T	15:30	120	470	
					BO	19	T	15:50	15	330	
					ATR	8	T	19:26	14	220	
					MIN	14		19:34		15	
					RO	15		19:50	38	427	
509	16/10/86	72º48,2'S	019º34,6'W	810	GKG	1		6:28			kein Sediment
					MIN	15		6:30		15	
					RO	16		7:57	61	757	
510	16/10/86	72º41,9'S	019º50,4'W	2.680	ATR	9	T	13:59	14	240	
					RO	17		14:20	55	650	
					MIN	16		15:59		15	
511	17/10/86	72º25,0'S	020º54,4'W	3.648	RO	18	T	6:48	175	257	
					UWE		T	10:00	35		
					BRO	19		10:49	41	584	
					MIN	17		10:50		15	
512	17/10/86	72º32,1'S	020º34,7'W	3.575	MN	4	N	0:20	35	1.000	

Stat. No.	Date	Position		Echo depth (m)	Gear	Haul No.	Day time	Start (GMT)	Haul dur. (min)	Depth (m)	Comment
					MIN	18		14:13		15	
					ATR	10	T	17:27	15	250	
					RO	20	A	18:17	182	427	
					BRO	21		21:34	40	610	
					BO	20	A	22:39	4	200	
					BO	21	N	23:12	10	500	
					FRA	17	N	23:40	10	200	
513	18/10/86	72º38,3'S	020º25,6'W	4.211	RO	22	T	6:00	158	757	
					MIN	19		7:12		15	
					ATR	11	T	8:43	16	250	
					BO	22	T	9:12	4	200	
					FRA	18	T	9:20	10	200	
					BRO	23		9:39	30	516	
					MN	5	T	10:40	30	1.000	
					GKG	2		11:15			
514	18/10/86	72º40,7'S	020º05,5'W	3.050	GKG	3		14:11			
					MIN	20		15:04		15	
					RO	24	T	16:01	144	650	
					ATR	12	T	18:27	14	220	
					BO	23	T	19:00	4	200	
					BO	24	A	19:40	10	500	
					FRA	19	T	19:50	10	200	
					FRA	20	T	20:00	10	200	
					BRO	25		20:38	32	500	
					MN	6	A	21:43	31	1.000	
515	19/10/86	72º46,1'S	019º54,4'W	2.745	ATR	13	T	6:00	19	270	
					MIN	21		6:30		15	
					BO	25	M	6:46	4	200	
					FRA	21	T	7:00	10	200	
					FRA	22	T	7:10	10	200	
					GKG	4		7:33			
					UWE		T	9:18	23		
					RO	26		23:36	134	2.675	
516	19/10/86	72º48,9'S	019º39,6'W	1.675	GKG	5		10:36			
					RO	27		11:35	107	1.601	
					MIN	22		12:34		15	
					MN	7	T	13:55	30	1.000	
					BO	26	T	14:44	4	200	
					BO	27	T	15:20	10	500	
					FRA	23	T	15:40	10	200	
517	19/10/86	72º52,0'S	019º35,6'W	600	AGT	1	T	16:50	30		
					RO	28		19:39	48	481	
					MIN	23		21:33		15	
					GES	1		22:15	75	450	
518	19/10/86	72º50,0'S	019º39,6'W	1.140	RO	29		23:00	71	1.053	
519	20/10/86	72º48,5'S	019º38,1'W	1.500	MN	8	N	0:55	15	500	
520	20/10/86	72º52,3'S	019º34,7'W	470	NSN	1	T	6:00	7	200	Lebendfang
					NSN	2	T	6:24	7	200	Lebendfang
					NSN	3	T	6:45	7	200	Lebendfang
					NSN	4	T	7:07	7	200	Lebendfang
					BG	3		8:30			kein Sediment
					AGT	2	T	10:11	22		
					BSL	1	T	11:25	64		
					BG	1		12:35			
					BG	2		13:08			

Stat. No.	Date	Position		Echo depth (m)	Gear	Haul No.	Day time	Start (GMT)	Haul dur. (min)	Depth (m)	Comment
521	20/10/86	72º52,5'S	019º30,9'W	420	BO	28	T	15:04	4	200	
					RO	30		15:35	103	420	jo-jo
					MIN	24		15:58		15	
522	20/10/86	72º50,9'S	019º40,0'W	485	AGT	3	T	18:28	21		Riesenschwaemme
					FRA	24	A	19:45	10	200	
					MN	9	A	20:30	25	500	
					REU	2	N	23:15	780	411	
					REU	2	N	23:15	780	411	
					REU	2	N	23:15	780	411	
					REU	2	N	23:15	780	411	
					REU	2	N	23:15	780	411	
					REU	2	N	23:15	780	411	
523	21/10/86	72º49,9'S	019º35,5'W	840	RMT	1	T	6:11	40	200	RMT einfach, offe
					AGT	4	T	7:25	24		101 Feinsortierun
					BG	4		8:29	36		kein Sediment
524	21/10/86	72º51,0'S	019º25,7'W	465	RMT	2	T	10:15	40	200	RMT einfach, offe
525	21/10/86	72º46,2'S	019º24,9'W	1.104	RO	31		13:00	15		Station abgebroch
526	21/10/86	72º39,6'S	018º54,5'W	2.535	RMT	3	T	15:05	40	200	RMT einfach, offe
					BO	29	T	16:10	40	235	
					BO	30	T	17:10	4	200	
					MIN	25		17:10		15	
					BO	31	T	17:30	10	500	
					FRA	25	T	18:00	10	200	
					MN	10	A	18:55	40	1.000	
					ATR	14	T	19:40	31	250	
					RO	32		20:21	127	2.512	
					NSN	5	A	22:53	17	500	
527	22/10/86	72º23,5'S	016º37,4'W	314	AGT	5	T	6:27	25		301 Unterprobe
					RO	33		7:30	46	291	
					GES	2		8:20	106	290	
					ATR	15	T	10:18	43	130	
					MIN	26		11:09		15	
					BG	5		11:10			kein Sediment
					BO	32	T	12:13	4	200	
					80	33	T	12:34	15	260	
					FRA	26	T	12:43	10	200	
					RMT	4	T	13:22	35	200	RMT einfach, off
528	22/10/86	72º28,1'S	017º20,6'W	290	RMT	5	T	17:18	40	200	MT einfach, offe
					AGT	6	T	18:30	28		201 Feinsortieru
					BO	34	T	19:44	4	200	vor VestKapp
					MIN	27		20:08		15	
					BO	35	T	20:08	5	270	vor Vestkapp
					FRA	27	T	20:20	10	200	
					MN	11	T	20:35	10	270	
					ATR	16		21:05	21	250	
					RO	34		21:38	42	280	
529	23/10/86	72º33,4'S	018º06,8'W	1.135	RO	35		6:03	99	1.143	
530	23/10/86	72º32,9'S	018º32,0'W	1.965	BO	36	T	9:16	5	200	Vestkapp
					FRA	28	T	9:23	10	200	
					BO	37	T	10:06	10	200	
					RO	36		10:32	98	1.942	
					MIN	28		10:37		15	
531	23/10/86	72º48,9'S	019º21,4'W	436	GSN	1	T	15:42	23		Haker um 16.03
					UWE			17:16	25		
532	23/10/86	72º49,9'S	019º39,6'W	956	BO	38	T	19:00	4	200	

Stat. No.	Date	Position		Echo depth (m)	Gear	Haul No.	Day time	Start (GMT)	Haul dur. (min)	Depth (m)	Comment
					BO	39	T	19:40	10	500	
					RO	37		20:09	68	948	
					FRA	29	A	21:25	10	200	
533	24/10/86	72º44,4'S	019º25,0'W	2.095	MET	1		1:50			
					MET	2		3:00	30		
					RO	38		23:48	122	1.862	
534	24/10/86	72º44,5'S	020º11,8'W	3.025	MET	3		4:58			
535	24/10/86	72º44,4'S	020º34,2'W	3.233	MET	4		6:33			
536	24/10/86	72º50,4'S	019º36,8'W	595	GSN	2	T	13:09	13		Haker um 13.22
537	24/10/86	73º05,6'S	020º14,4'W	420	GSN	3	T	19:27	16		
538	24/10/86	73º07,2'S	020º45,8'W	1.760	RMT	6	A	21:47	90	500	RMT einfach, offen
539	25/10/86	74º06,1'S	024º39,7'W	519	BG	6		14:30			
					BG	7		15:00			
					MIN	29		15:06		15	
					NSN	6	T	15:39	11	300	Lebendfang
					NSN	7	T	16:05	10	300	Lebendfang
					BO	40	T	16:47	17	500	
540	25/10/86	74º06,5'S	024º41,2'W	1.100	KN	1		17:30	95		kein Fang
541	26/10/86	75º31,5'S	027º13,1'W	228	NSN	8	T	8:51	51	200	
					MIN	30		9:23		15	
542	27/10/86	76º31,8'S	031º03,0'W	428	RO	39		9:22	41	421	Filchner Graben
543	27/10/86	76º32,6'S	032º38,0'W	527	RO	40		13:43	50	516	Filchner Graben
					MIN	31		14:22		15	
					BO	41	T	14:45	4	200	
					BO	42	T	15:20	10	500	
					FRA	30	T	15:37	10	200	
					GES	3		15:45	120	500	
					BRO	41		17:54	37	500	
					UWE		T	18:53	54	3	
					ATR	17	T	19:54	32	270	
544	28/10/86	76º04,2'S	027º54,8'W	340	MIN	32		8:04		15	
					RO	42		8:08	40	334	
					ATR	18	T	8:50	18	270	
					UWE		T	9:18	62	4	
					BRO	43		10:36	20	140	
					BO	43	T	11:20	30	320	
					FRA	31	T	11:35	10	200	
					FRA	32	T	11:45	5	50	
					NSN	9	T	12:05	9	300	Lebendfang
					MN	12	T	13:00	15	330	
545	28/10/86	75º37,6'S	027º50,1'W	269	NSN	10	N	0:23	7	200	Lebendfang
					RO	44		18:50	45	264	
					MIN	33		18:51		15	
					ATR	19	T	19:40	17	270	
					BO	44	T	20:12	4	200	
					BO	45	A	20:36	5	250	
					FRA	33	T	20:50	10	200	
					UWE		A	21:13	86	271	
					BRO	45		22:54	24	200	
					BG	8		23:30			
					BG	9		23:53			
546	29/10/86	75º30,7'S	027º18,7'W	255	KN	2	T	6:22	28	50	kein Fang
					BO	46	T	9:05	4	200	
					MIN	34		9:28		15	
					RO	46		9:31	43	233	

Stat. No.	Date	Position		Echo depth (m)	Gear	Haul No.	Day time	Start (GMT)	Haul dur. (min)	Depth (m)	Comment
					FRA	34	T	10:20	10	200	
					FRA	35	T	10:35	5	50	
					GES	5		10:40	70	195	
					GES	4		11:00	50	200	
					UWE		T	17:00	76	229	
547	29/10/86	75º34,5'S	027º25,4'W	295	MET	8		3:25	30		
					MET	5		19:20	45		
					MET	6		21:20	45		
					MET	7		23:40	46		
548	30/10/86	75º47,1'S	029º09,6'W	426	MET	9		5:35	35		
					RO	47		6:05	48	418	
					BG	10		6:58			
					ATR	20		7:30	35	270	
					BRO	48		8:20	25	300	
					MIN	35		8:22		15	
					80	47	T	9:05	4	200	
					BO	48	T	9:45	7	400	
					FRA	36	T	9:57	8	200	
549	30/10/86	75º41,8'S	028º37,9'W	435	RO	49		12:00	35	422	
					MIN	36		12:25		15	
					BO	49	T	12:50	4	200	
					FRA	37	T	12:54	10	200	
550	30/10/86	75º40,5'S	028º13,7'W	317	RO	50		14:04	31	318	
					MIN	37		14:31		15	
					ATR	21	T	14:38	34	270	
					BO	50	T	15:25	4	200	
					FRA	38	T	15:32	10	200	
551	30/10/86	75º36,4'S	027º43,6'W	257	RMT	7	T	17:45	30	200	RMT einfach, off
					RMT	8	T	18:30	30	200	RMT einfach, off
552	31/10/86	74º40,0'S	025º00,0'W	654	KN	3	T	6:20	100	550	
553	31/10/86	74º02,4'S	024º22,7'W	350	AGT	7	T	14:04	36		30l Unterprobe
					RO	51		15:26	36	290	
					UWE		T	16:21		381	
					RMT	9	A	18:10	50	350	RMT einfach, off
					GES	6		19:40	50	350	
554	31/10/86	74º03,1'S	024º34,9'W	910	RO	52		21:50	59	941	
555	01/11/86	74º02,4'S	024º42,1'W	1.590	RO	53		0:38	108	1.686	
556	01/11/86	74º01,2'S	025º07,0'W	2.310	RO	54		6:45	123	2.269	
					MIN	38		8:32		15	
					GES	7		8:55	125	2.200	
557	01/11/86	73º57,1'S	024º05,3'W	625	BG	11		16:45			
558	02/11/86	73º56,3'S	024º08,4'W	782	BO	51	T	6:40	4	200	
					BO	52	T	7:15	10	500	
					UWE		T	7:48	64	10	
					NSN	11	T	9:16	10	500	Lebendfang
559	02/11/86	73º53,6'S	024º24,6'W	1.250	BO	53	T	10:45	4	200	
					FRA	39	T	11:10	10	200	
					UWE		T	11:24	38	5	
560	02/11/86	73º47,9'S	024º49,6'W	2.130	BO	54	T	13:55	4	200	
					FRA	45	T	14:05	10	200	
					BO	55	T	14:20	4	500	
					FRA	40	T	14:35	10	200	
					UWE		T	14:46	54		
					NSN	12	T	15:50	10	500	Lebendfang
561	03/11/86	72º52,5'S	019º30,2'W	430	AGT	8	T	10:31	19		1 grosser Stein

Stat. No.	Date	Position		Echo depth (m)	Gear	Haul No.	Day time	Start (GMT)	Haul dur. (min)	Depth (m)	Comment
					ATR	22		11:40	30	270	
					MIN	39		12:10		15	
					RO	55		12:17	43	427	
					BO	56	T	13:13	4	200	
					FRA	41	T	13:20	10	200	
					MN	13	T	13:50	15	420	
					RO	56	T	14:17	12	300	
562	03/11/86	72º50,6'S	019º41,4'W	1.114	RO	57		15:30	68	1.000	
					MIN	40		15:44		15	
					BO	57	T	16:52	4	200	
					MN	14	T	17:40	20	1.000	
563	03/11/86	72º49,4'S	019º42,8'W	1.950	ATR	23	T	18:31	31	270	
					BO	58	T	19:15	4	200	
					FRA	42	T	19:25	10	200	
					RO	58		19:44	65	1.000	
564	03/11/86	72º49,7'S	019º52,7'W	2.474	FRA	43	A	21:30	10	200	
					RO	59		21:49	70	1.000	
					MIN	41		21:49		15	
					BO	59	A	23:15	4	200	
565	04/11/86	72º45,2'S	020º18,4'W	3.125	ATR	24	T	0:40	18	270	
					RO	60		1:06	67	1.000	
					MIN	42		1:33		15	
					BO	60	N	2:31	9	200	
					FRA	44	N	2:45	15	200	
					MN	15	M	3:50	25	1.000	
566	04/11/86	73º16,5'S	021º04,5'W	573	AGT	9	T	8:45	25		Netz gerissen
					RMT	10	T	10:00	60	480	RMT einfach, offen
					ATR	25		12:37	16	270	
					RO	61		12:58	44	475	
					BO	61	T	14:00	5	200	Suedschnitt 1.Stat.
					MIN	43		14:26		15	
					MN	16	T	14:36	13	400	
567	04/11/86	73º19,0'S	021º23,9'W	810	MIN	44		15:50		15	
					RO	62		15:50	52	847	
					BO	62	T	17:00	5	200	Suedschnitt 2.Stat.
					FRA	46	T	17:05	10	200	
					MN	17	T	17:42	19	700	
568	04/11/86	73º17,9'S	021º35,0'W	1.603	RO	63		18:57	56	1.000	
569	04/11/86	73º13,4'S	021º49,2'W	2.180	ATR	26	T	21:12	31	270	
					BO	63	A	22:00	5	200	Suedschnitt 3.Stat.
					FRA	47	N	22:10	15	200	
					RO	64		22:29	57	1.000	
					MIN	45		22:37		15	
570	05/11/86	73º05,9'S	022º20,9'W	3.220	BO	64	N	2:00	5	200	Suedschnitt 4.Stat.
					FRA	48	N	2:15	15	200	
					MN	18		2:34	22	1.000	
					BRO	65		3:43	55	1.000	
571	05/11/86	73º26,1'S	020º38,3'W	350	RMT	11	T	9:45	35	265	RMT einfach, offen
					RMT	12	T	10:37	36	305	RMT einfach, offen
					RMT	13	T	12:00	45	360	RMT einfach, offen
					AGT	10	T	13:20	31		2 grosse Steine
					KN	4	T	14:45	95	370	
					KN	5	T	17:45	95	370	
572	05/11/86	73º30,0'S	020º45,5'W	315	MET	12		0:00			
					MET	13		1:15	30		

Stat. No.	Date	Position		Echo depth (m)	Gear	Haul No.	Day time	Start (GMT)	Haul dur. (min)	Depth (m)	Comment
					MET	14		2:25	30		
					MET	15		3:40	30		
					MET	10		21:50	30		
					MET	11		22:55	30		
573	06/11/86	73º06,8'S	020º15,0'W	331	RO	66		6:05	39	407	
					GES	8		6:50	70	395	
					BG	12		8:42			
					KN	6	T	9:20	95		
					KN	7	T	12:20	90	440	
574	06/11/86	72º46,2'S	019º30,9'W	600	KN	8	T	16:50	104	640	
					KN	9	T	19:30	120	480	
575	07/11/86	72º49,6'S	019º26,7'W	670	RMT	14	T	6:10	75	400	RMT einfach, of
					RMT	15	T	7:52	56	300	RMT einfach, of
					RMT	16	T	9:03	39	200	RMT einfach, of
					AGT	11	T	13:10	25		2 grosse Steine
576	07/11/86	72º48,4'S	019º48,2'W	2.320	MIN	46		16:05	13		
					RO	67		17:34	70	1.500	
577	07/11/86	72º46,8'S	019º53,6'W	2.665	RO	68		21:02	78	1.500	
578	08/11/86	72º40,4'S	020º22,9'W	1.950	MET	16		0:41			
					RO	69		0:43	63	1.500	
					MET	17		2:39	30		
					MET	18		4:00	30		
					MET	19		5:10	30		
					MET	20		6:18	42		
579	08/11/86	72º52,0'S	019º33,0'W	441	RO	70		6:23	37	433	
580	08/11/86	72º51,4'S	019º41,4'W	710	RO	71		7:38	54	931	
					RMT	17	T	8:34	36	200	RMT einfach, of
					GSN	4	T	11:25	14		Haker 11.39
581	08/11/86	72º46,9'S	020º10,5'W	2.950	UWE		T	13:54	86		
					LSE	1		14:05	95		
					MIN	47		15:19	5		
582	08/11/86	72º54,3'S	019º49,7'W	1.210	RMT	18	T	17:31	46	400	RMT einfach, of
					RMT	19	A	18:28	38	200	RMT einfach, of
583	09/11/86	77º10,6'S	033º58,0'W	499	RO	72		22:45	35	494	
					MIN	48		22:45	12		
584	10/11/86	76º07,7'S	028º18,2'W	362	BRO	73		12:13	29	320	
					ATR	27	T	12:45	32	270	
					MIN	49		12:46	12		
					BO	65	T	13:30	5	200	Suedlich Halley
					UWE		T	15:38	87	12	
					RMT	20	T	15:40	35	300	RMT einfach, of
					LSE	2		16:00	112		
					BO	66	T	18:47	33	210	Suedlich Halley
					AGT	12	T	20:54	21		Netz gerissen
585	11/11/86	76º01,2'S	028º22,4'W	368	RMT	21	M	6:11	44	310	RMT einfach, of
					AGT	13	T	7:38	24		201 Unterprobe
					LSE	3		9:30	205		
					UWE		T	9:34	145	10	
586	11/11/86	76º08,5'S	028º38,2'W	324	KN	10	T	16:00	80	320	
587	12/11/86	76º06,7'S	028º27,0'W	376	KN	11	T	8:10	85	390	
					LSE	4		10:20	186		
					UWE		T	11:02	89	50	
					MIN	50		11:06	10		
					BO	67	T	11:27	5	200	Suedlich Halley
					BO	68	T	11:50	10	395	Suedlich Halley

Stat. No.	Date	Position		Echo depth (m)	Gear	Haul No.	Day time	Start (GMT)	Haul dur. (min)	Depth (m)	Comment
588	12/11/86	75º57,5'S	027º24,6'W	443	KN	12	T	16:15	95	400	
589	12/11/86	75º50,4'S	027º11,9'W	318	BO	69	T	19:07	5	200	Suedlich Halley
					UWE		A	19:24	87	310	
					AGT	14	T	21:27	27		AGT verbogen
590	13/11/86	74º54,7'S	025º58,5'W	583	BSL	2	T	6:32	78		
					UWE		T	8:14	99	417	
					AGT	15	T	10:35	20		201 U-Probe
					RMT	22	T	11:46	49	370	noerdl Halley
591	13/11/86	74º53,2'S	026º00,1'W	422	UWE		T	13:24	190	10	
					LSE	6		13:38	180		
					LSE	5		13:38	180		
					BO	70	T	16:18	5	200	Noerdlich Halley
					BO	71	T	16:49	10	400	Noerdlich Halley
					BO	72	T	17:20	10	400	Noerdlich Halley
					LSE	7		19:00	75		
592	14/11/86	73º55,0'S	022º58,6'W	211	RMT	23	T	6:30	40	230	
					BSL	3		7:30	59		
					GSN	5	T	9:00	15		Leine 800 m
					UWE		T	10:40	78	214	
					MIN	51		12:13	17		
					BO	73	T	12:14	5	200	
					BO	74	T	12:32	5	200	
					FRA	50	T	12:40	10	200	
					LSE	8		12:49	128		
					ATR	28	T	12:54	23	175	
					MN	19	T	13:23	10	170	
593	14/11/86	73º56,3'S	023º29,3'W	343	GSN	6	T	17:27	9		
594	15/11/86	73º42,3'S	021º59,9'W	370	LSE	10		6:00	150		
					LSE	9		6:00	150		
					GSN	7	T	10:11	10		
					BO	75	T	11:28	5	200	
					BO	76	T	11:52	10	400	
					FRA	51	T	12:05	10	200	
595	16/11/86	73º21,7'S	021º19,2'W	422	BRO	74		10:00	42	415	
					MIN	52		10:26	14		
					BO	77	T	10:55	5	200	Suedschnitt II
					FRA	52	T	11:05	10	200	
					FRA	53	T	11:15	15	200	
					ATR	29	T	11:34	31	270	
596	16/11/86	73º18,8'S	021º28,7'W	1.235	RO	75		13:14	38	620	
					MIN	53		13:17	27		
					BO	78	T	14:04	5	200	Suedschnitt II
					FRA	54	T	14:10	10	200	
					FRA	55	T	14:25	5	50	
597	16/11/86	73º17,5'S	021º31,3'W	1.500	BRO	76		15:23	38	634	
					ATR	30	T	16:03	27	270	
598	16/11/86	73º13,2'S	021º41,5'W	2.018	RO	77		18:44	36	606	
					MIN	54		18:47	14		
					BO	79	T	19:36	5	200	Suedschnitt II
					FRA	56	T	19:45	10	200	
					FRA	57	T	19:55	20	200	
599	16/11/86	73º08,7'S	022º09,5'W	2.642	BRO	78		21:34	40	610	
					MIN	55		21:41	13		
					BO	80	A	22:27	5	200	Suedschnitt II
					FRA	58	T	22:40	10	50	

Stat. No.	Date	Position		Echo depth (m)	Gear	Haul No.	Day time	Start (GMT)	Haul dur. (min)	Depth (m)	Comment
					FRA	59	T	22:55	10	200	
					ATR	31	T	23:07	30	270	
600	17/11/86	72º52,0'S	019º33,0'W	442	BRO	79		6:00	26	300	
					MIN	56		6:43	10		
					BO	81	T	6:49	5	200	Drescher III
					ATR	32	T	7:12	30	270	
					FRA	60	T	7:45	10	200	
					FRA	61	T	7:55	15	200	
601	17/11/86	72º51,0'S	019º41,7'W	1.128	BRO	80		8:09	24	300	
					MIN	57		8:33	11		
					BO	82	T	8:42	5	200	Drescher III
					FRA	62	T	8:45	10	200	
					FRA	63	T	8:55	10	50	
602	17/11/86	72º48,8'S	019º48,0'W	2.450	BRO	81		10:26	20	300	
					MIN	58		10:47	13		
					ATR	33		10:47	30	270	
603	17/11/86	72º47,6'S	019º57,4'W	2.587	BRO	82		13:15	21	300	
					MIN	59		13:20	8		
					BO	83	T	13:46	5	200	Drescher III
					FRA	64	T	13:55	10	200	
					FRA	65	T	14:05	10	200	
604	17/11/86	72º40,8'S	020º22,5'W	3.253	BRO	83		15:52	27	300	
					MIN	60		16:16	12		
					BO	84	T	16:35	5	200	Drescher III
					BO	85	T	17:00	10	500	Drescher III
					FRA	66	T	17:15	10	200	
					FRA	67	T	17:25	10	50	
					ATR	34		17:37	29	270	
					BRO	85		18:11	134	185	
					RO	84		19:00	84	3.384	
					MN	20	A	21:06	25	1.000	
605	17/11/86	72º47,9'S	019º54,7'W	2.603	MIN	61		0:12	19		
					RO	86		23:18	106	2.630	
606	18/11/86	72º49,5'S	019º49,6'W	2.307	RO	87		6:00	87	2.300	
					MIN	62		9:42	10		
607	18/11/86	72º52,5'S	019º50,4'W	1.732	MN	21	T	9:30	25	1.000	
					BO	86	T	10:18	10	500	Drescher III
					RO	88		10:38	67	1.697	
					MIN	63		10:56	9		
					MAN	1		11:48	128	38	
					BO	87	T	12:50	10	500	Vor Drescher
608	18/11/86	72º51,2'S	019º30,8'W	556	RO	89		16:01	36	388	
					MIN	64		16:18	13		
					MN	22	T	18:40	13	400	
					BO	88	T	19:05	5	200	Vor Drescher
					BO	89	T	19:29	8	200	Vor Drescher
					BO	90	T	19:50	5	200	Vor Drescher
					BO	91	A	20:05	37	400	Vor Drescher
					BO	92	A	20:51	40	210	Vor Drescher
					BO	93	A	21:36	42	210	Vor Drescher
609	19/11/86	72º49,3'S	019º36,2'W	1.368	AGT	16	T	11:15	44		dicker Stein
610	19/11/86	72º43,9'S	019º53,8'W	2.730	BO	94	T	19:36	60	500	
					RO	90		20:50	135	2.730	
					MIN	65		21:37	10		
611	20/11/86	72º43,8'S	019º53,7'W	2.891	UWE		T	8:02	66	8	

:at. lo.	Date	Position		Echo depth (m)	Gear	Haul No.	Day time	Start (GMT)	Haul dur. (min)	Depth (m)	Comment
					LSE	11		8:30	80		
					BO	95	T	10:22	35	200	querab Drescher
					BO	96	T	11:06	5	200	querab Drescher
					MN	23	T	11:53	22	1.000	
					MN	24	T	12:38	7	200	
					MAN	2		12:53	98	50	
612	20/11/86	72º44,9'S	020º28,3'W	3.138	UWE		T	15:45	51	8	
					MIN	66		15:50	13		
					LSE	14		15:59	146		
					LSE	13		15:59	146		
					LSE	12		15:59	146		
513	20/11/86	72º52,0'S	019º23,7'W	403	BSL	4	T	21:10	65		
514	21/11/86	72º46,8'S	020º11,4'W	3.079	BO	97	N	0:07	37	260	querab Drescher
					BO	98	N	0:58	5	200	querab Drescher
					MN	25	M	1:55	25	1.000	
					MN	26	M	2:33	7	200	
					MAN	3		2:45	75	50	
515	21/11/86	72º50,8'S	019º28,9'W	1.447	RMT	24	T	6:05	60	460	
					UWE		T	7:30	92	423	
					AGT	17	T	9:44	20		keine Steine
					RMT	25	T	11:18	60	500	
					RMT	26	T	12:30	40	300	
					RMT	27	T	13:20	25	50	
516	21/11/86	72º44,1'S	019º57,5'W	2.867	UWE		T	15:34	76	10	
					LSE	15		16:03	132		
					MIN	67		16:15	16		
517	21/11/86	72º43,3'S	019º52,6'W	2.678	BO	99	A	19:52	15	500	querab Drescher
					MAN	4		20:07	186	50	
518	22/11/86	72º51,0'S	019º22,6'W	1.133	UWE		T	8:44	58		
					RO	91		9:03	36	393	
					BSL	5	T	9:57	56		
					BO	100	T	13:21	39	210	Vor Vestkapp
					BO	101	T	14:08	42		vor Vestkapp
					BO	102	T	15:09	5	200	vor Vestkapp
					BO	103	T	15:30	5	200	vor Vestkapp
					MN	27	T	16:17	29	1.000	
					AGT	18	T	17:48	24		2 grosse Steine
19	22/11/86	72º51,9'S	019º22,8'W	397	LSE	16		19:40			
					UWE		A	21:05	58		
					BRO	92		21:20	30	389	
					REU	3	T	22:00	2.280	4	
					REU	3	T	22:00	2.280	4	
					REU	3	T	22:00	2.280	4	
					REU	3	T	22:00	2.280	4	
					REU	3	T	22:00	2.280	4	
					REU	3	T	22:00	2.280	4	
20	24/11/86	72º51,9'S	019º22,8'W	397	RO	93		6:06	32	390	
					UWE		T	7:14	72	4	
					LSE	17		9:00	120		
					LSE	18		9:00	120		
					RO	94		15:21	26	387	
21	24/11/86	72º52,0'S	019º32,9'W	441	BRO	95		16:35	30	429	
					BO	104	T	17:15	5	200	Drescher Schnitt IV
					BO	105	T	17:40	10	420	Drescher Schnitt IV
					FRA	68	T	18:00	10	200	

Stat. No.	Date	Position		Echo depth (m)	Gear	Haul No.	Day time	Start (GMT)	Haul dur. (min)	Depth (m)	Comment
					FRA	69	T	18:15	15	200	
					ATR	35		18:30	30	270	
622	24/11/86	72º51,1'S	019º40,7'W	973	BRO	96		19:42	47	918	
					MIN	68		20:10	16		
					BO	106	A	20:30	5	200	Drescher Schnitt
					BO	107	A	21:13	10	500	Drescher Schnitt
					FRA	70	A	21:35	10	200	
					FRA	71	A	21:45	15	200	
623	24/11/86	72º46,5'S	019º32,5'W	1.538	BO	109	N	0:55	5	200	Naehe Drescher IV
					BO	110	N	1:15	5	200	Naehe Drescher IV
					MN	28	A	23:22	24	1.000	
					BO	108	N	23:55	37	200	Naehe Drescher IV
624	25/11/86	72º50,0'S	019º44,7'W	1.806	BRO	97		6:00	49	1.000	
					ATR	36		6:51	29	270	
					FRA	72	T	10:20	10	200	
					FRA	73	T	10:30	10	200	
625	25/11/86	72º46,8'S	019º57,4'W	2.620	BRO	98		8:32	50	1.000	
					MIN	69		9:30	10		
					BO	111	T	9:34	5	200	Naehe Drescher IV
					BO	112	T	10:00	10	200	Naehe Drescher 1V
626	25/11/86	72º41,2'S	020º25,8'W	3.415	BRO	99		12:17	49	1.030	
					MIN	70		12:31	5		
					BO	113	T	13:17	5	200	Naehe Drescher IV
					BO	114	T	13:44	10	500	Naehe Drescher 1V
					FRA	74	T	14:00	20	200	
					FRA	75	T	14:10	15	200	
					ATR	37		14:30	29	270	
627	26/11/86	72º03,5'S	015º27,6'W	434	RO	100		8:04	48	425	
					MIN	71		8:10	13		
					GES	9		9:30	66	409	
					NSN	13	T	10:50	15	400	
					BO	115	T	11:27	9	430	Noerdl Vestkapp 1
					AGT	19	T	12:39	25		6 grosse Steine
628	26/11/86	71º48,9'S	015º40,1'W	1.155	BO	116	T	15:05	10	500	Noerdl Vestkapp 2
					NSN	14	T	15:37	11	400	
629	26/11/86	71º44,7'S	015º44,4'W	1.319	BO	117	T	17:10	10	500	Noerdl Vestkapp 3
					BO	116	T	17:10	10	500	Noerdl Vestkapp 3
630	27/11/86	70º58,3'S	012º30,3'W	1.877	BO	118	T	4:20	10	500	Cape Norwegia
631	27/11/86	71º05,8'S	012º23,7'W	891	BO	119	T	6:15	10	500	Cape Norwegia
632	27/11/86	71º12,4'S	011º33,3'W	231	BO	120	T	8:36	19	50	Cape Norwegia
					RO	101		9:58	42	352	
					MIN	72		10:10	13		
					GES	10		10:45	45	334	
633	28/11/86	70º25,0'S	008º16,0'W	607	RO	102		6:00	46	501	
					GES	11		6:50	70	500	
					BO	121	T	7:55	5	200	Atka Bucht
					BO	122	T	8:26	10	490	Vor Atka Bucht
					MIN	73		8:39	12		
					ATR	38		8:43	30	270	
					FRA	76	T	9:15	10	200	
					LSE	19		9:41	64		
					MAN	5	T	10:33	160	50	
					LSE	20		11:10	232		
					NSN	15	T	15:34	11	400	
					BO	123	T	16:06	10	500	NW vor Atka

Stat. No.	Date	Position		Echo depth (m)	Gear	Haul No.	Day time	Start (GMT)	Haul dur. (min)	Depth (m)	Comment
634	28/11/86	70º21,0'S	008º41,5'W	1.025	BO	124	T	18:30	10	500	Vor Atka
635	28/11/86	70º07,4'S	008º33,2'W	1.904	BO	125	A	20:34	5	200	Vor Atka
					BO	126	A	21:03	15	500	Vor Atka
636	29/11/86	69º02,4'S	007º34,8'W	3.233	LSE	21		8:30	150		
					RO	103		11:29	60	1.000	
					BO	127	T	12:41	5	200	Querung Pack-Eis
					FRA	77	T	12:50	10	200	
					LSE	22		12:51	162		
					GES	12		13:04	21	20	
					MIN	74		14:45	2		
637	30/11/86	67º31,9'S	003º56,1'W	4.566	RO	104		8:18	58	1.020	
					MIN	75		8:33	13		
					LSE	23		8:43	40		
					BO	128	T	9:27	5	200	Querung Pack-Eis
					LSE	24		9:44	111		
					BO	129	T	9:53	10	500	
					FRA	78	T	10:10	10	200	
					GES	13		10:25	25	20	
638	01/12/86	66º01,9'S	000º46,7'W	4.603	RO	105		4:00	70	1.020	
					MIN	76		9:53	5		
					GES	14		15:13	15	20	
639	02/12/86	66º59,4'S	004º57,8'O	4.182	RO	106		4:00	66	1.025	
640	02/12/86	66º23,4'S	004º12,5'O	3.474	RO	107		12:05	48	1.020	
					MIN	77		12:25	10		
641	02/12/86	65º47,0'S	003º25,8'O	3.714	RO	108		17:28	145	3.700	
					MIN	78		19:34	6		
642	02/12/86	65º08,4'S	002º44,6'O	1.381	RO	109		23:27	47	1.020	
643	03/12/86	64º01,2'S	001º20,8'O	3.669	RO	110		11:20	148	3.692	
					MIN	79		12:12	9		
644	03/12/86	64º24,5'S	000º22,2'O	4.517	RO	111		18:57	33	1.020	
645	04/12/86	62º58,3'S	000º22,8'O	5.318	RO	112		6:00	194	5.415	
					MIN	80		9:00	20		
					BO	130	T	9:46	5	200	Packeis-Querung
					BO	131	T	10:14	10	500	Packeis-Querung
					FRA	79	T	10:35	10	200	
					FRA	80	T	10:45	10	200	
646	04/12/86	61º30,5'S	000º21,9'O	5.386	RO	113		20:17	54	1.020	
647	05/12/86	60º00,0'S	000º22,0'O	5.365	RO	114		6:00	196	5.442	
					BO	132	T	9:28	5	200	Packeis-Querung
					MIN	81		9:45	19		
					BO	133	T	9:55	15	500	Packeis-Querung
					FRA	81	T	10:15	10	200	
					FRA	82	T	10:25	10	200	
					ATR	39	T	10:43	29	270	
					BRO	115		11:13	24	300	
					MN	29	T	12:22	31	1.000	
648	05/12/86	59º29,6'S	000º24,5'O	5.233	ATR	40	T	15:46	27	270	
					MIN	82		16:08	7		
					RO	116		16:17	49	1.020	
					BO	134	T	17:17	7	200	Packeis-Querung
					FRA	83	T	17:25	10	200	
					FRA	84	T	17:35	10	200	
					BO	135	N	21:49	7	200	Packeis-Querung
649	05/12/86	59º00,4'S	000º22,3'O	4.043	ATR	41	T	20:25	27	270	
					RO	117		20:56	40	1.020	

Stat. No.	Date	Position		Echo depth (m)	Gear	Haul No.	Day time	Start (GMT)	Haul dur. (min)	Depth (m)	Comment
					MIN	83		21:17	9		
					FRA	85	A	22:00	10	200	
					FRA	86	A	22:00	10	50	
650	06/12/86	57º59,7'S	000º23,7'O	4.090	MN	30	T	6:35	35	1.000	
					RO	118		7:12	160	4.102	
					MIN	84		9:42	18		
					BO	136	T	10:03	5	200	Packeis-Querung
					BO	137	T	10:30	10	500	Packeis-Querung
					FRA	87	T	10:50	10	200	
					FRA	88	T	11:00	5	50	
					ATR	42	T	11:09	34	270	
					RO	119	T	12:00	34	1.020	
651	07/12/86	54º44,7'S	000º05,4'O	731	AGT	20	T	12:31	23		Netz verdreht
					FRA	89	T	13:20	10	200	
					AGT	21	T	14:30	32		

3.22 **Stationskarten/Station maps**

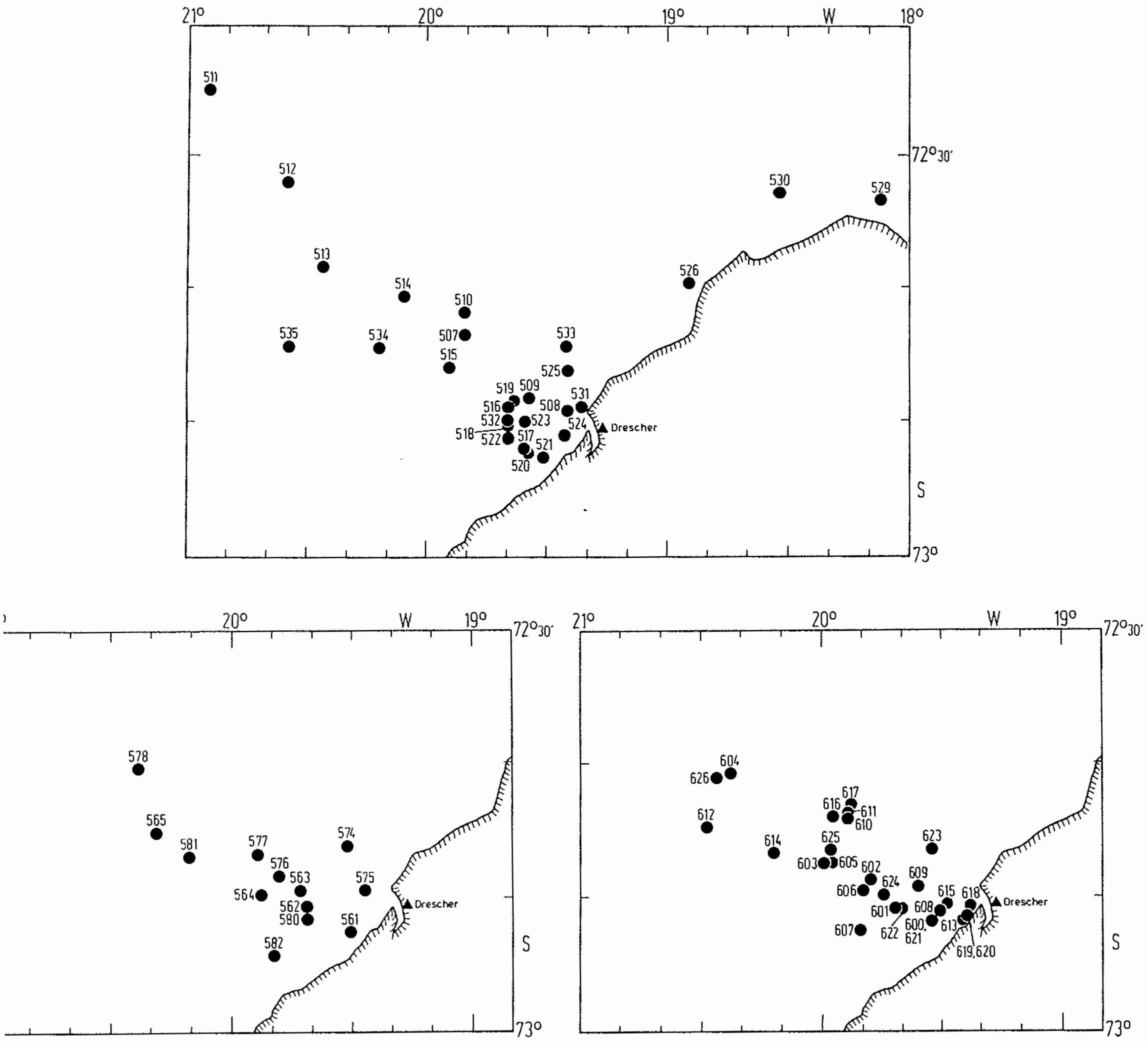

Abb. 46. Stationskarte vom Untersuchungsgebiet I.

Fig. 46. Station map of investigation area I.

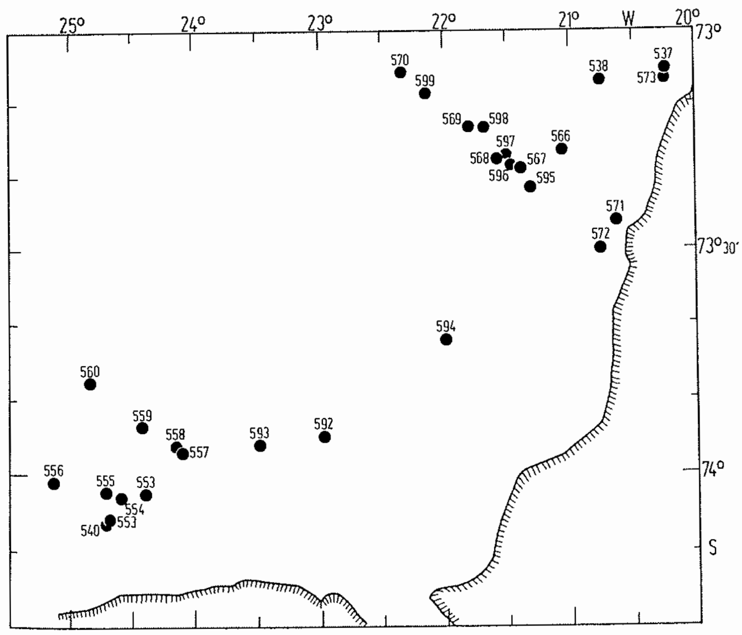

Abb. 47. Stationskarte vom Untersuchungsgebiet II.

Fig. 47. Station map of investigation area II.

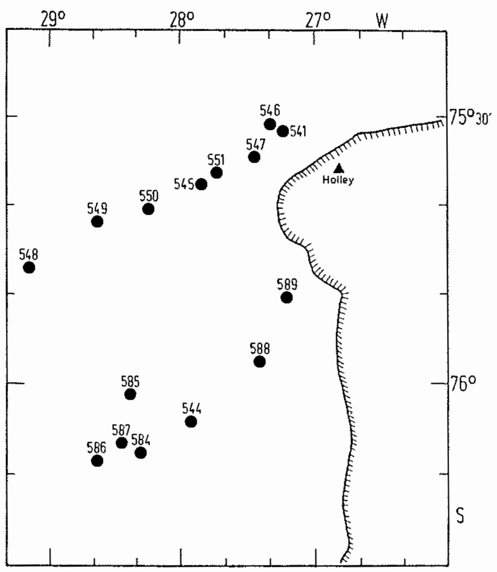

Abb. 48. Stationskarte vom Untersuchungsgebiet III.

Fig. 48. Station map of investigation area III.

4. Fahrtteilnehmer/Participants

1. Fahrtabschnitt 1/ Leg 1

Name name	Vorname first name	Institut institute
Aycaguer	Cristina	URU
Balguerias	Eduardo	IED
Beecken	Susanne	BFA
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Bluszcz	Thaddäus	AWI
Bolas	Mark	AWI
Dimmler	Werner	AWI
Ernst	Ruth	AWI
Ernst	Wolfgang	AWI
Harm	Urte	BFA
Höpner Petersen	Godtfred	IPÖ
Klöser	Heinz	AWI
Kock	Karl-Hermann	BFA
Köster	Friedrich	BFA
Mallwitz	Joachim	ZIM
Marschall	Hans-Peter	AWI
Mühlenhardt-Siegel	Ute	BFA
Mumm	Nicolai	AWI
Niewland	Gerard	NIOZ
Ochsenhirt	Wolf	SWA
Phan	van Ngan	IO/USP
Pietschok	Dietmar	BFA
Richter	Bernd	SWA
Sahrhage	Dietrich	BFA
Schillat	Bodo	BFA
Siegel	Volker	BFA
Vosjan	Jan Hendrik	NIOZ
Weigelt	Volker	AWI
Whitehouse	Michael	BAS

2. Fahrtabschnitt/Leg 2

Name name	Vorname first name	Institut institute
Ackley	Stephen F.	CRREL
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Babst	Ulrike	AWI
Bader	Gerhard	IUP
Bartsch	Annette	AWI
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Chipman	David L.	LDGO
Christiansen	M.B.	SIO
Comiso	Josefino C.	GSFC
Dieckmann	Gerhard	AWI
El Naggar	Saad	AWI
Flenner	Gunnar	AWI
Guerrero	Raul	AHS
Gordon	Arnold L.	LDGO
Helmke	Elisabeth	AWI
Hoeber	Heinrich	MIH
Huber	Bruce A.	LDGO
Jennings	Joe C.	OSU
Junghans	Hans-Georg	IUP
Kalt	Peter	PIUB
Köhler	Herbert	SWA
Lange	Manfred	AWI
Lundström	Volker	HSW
Mahler	Günter	HSW
Manley	Thomas O.	LDGO
Martinson	Douglas, G.	LDGO
Masson	Robert A.	SPRI
Moore	Stuart	SPRI
Mumm	Nicolai	AWI
Mursch	Petra	AWI
Pabst	Andrea	AWI
Rabe	Werner	SWA
Radlinger	Wolfgang	HSW
Roether	Wolfgang	IUP
Scheduikat	Michael	AWI
Schlosser	Elisabeth	UI
Schlosser	Peter	IUP
Schott	Rüdiger	AWI
Squire	Vernon	SPRI
Tüg	Helmut	AWI
Van Woy	Frederick A.	SIO
Wadhams	Peter	SPRI
Wamser	Christian	AWI
Werner	Hans-Dieter	IUP
Weidel	Holger	HSW
Weyland	Horst	AWI
Witte	Hannelore	AWI

3. Fahrtabschnitt/Leg 3

Name name	Vorname first name	Institut institute
Bartsch	Annette	AWI
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Beyer	Kerstin	AWI
Dahms	Hans-Uwe	OLD
Dimmler	Werner	AWI
Eicken	Hajo	AWI
Ekau	Werner	AWI
Elbrächter	Malte	BAH
Engelbart	Dirk	IMH
Fahrbach	Eberhard	AWI
Folkerts	Ekkehard	HSW
Franzs	George	NIOZ
Gerdes	Dieter	AWI
Gieskes	Winfried	NIOZ
Gordon	Louis	OSU
Gräfe	Manfred	AWI
Grenfell	Thomas	UW
Hagen	Wilhelm	AWI
Hain	Stefan	AWI
Hartig	Rüdiger	IMH
Hempel	Gotthilf	AWI
Hempel	Irmtraut	IPÖ
Hubold	Gerd	IPÖ
Klages	Norbert	PEM
Klindt	Holger	AWI
Klöser	Heinz	AWI
Kottmeier	Christoph	IMH
Mahler	Günter	HSW
Marschall	Hans-Peter	AWI
Marschall	Sigrid	AWI
Mizdalski	Elke	AWI
Möhle	Michael	HSW
Moore	Stanley	OSU
Muus	David A.	SIO
Ochsenhirt	Wolf	SWA
Plötz	Joachim	AWI
Püttker	Jochen	SWA
Rabsch	Uwe	IFMK
Rapp	Frank-Peter	IPÖ
Reijnders	Peter J.H.	NIOZ
Rhein	Monika	IUP
Rohardt	Gerd	AWI
Salameh	Peter	SIO
Sell	Martinus	HSW
Scharek-Mutlu	Renate	AWI
Schaumann	Karsten	AWI
Schiel	Sigrid	AWI
Smetacek	Victor	AWI
Spindler	Michael	AWI
Steinmetz	Richard	AWI
Stonehouse	Bernhard	SPRI
Surkow	Rainer	IMH

Name name	Vorname first name	Institut institute
Veth	Cornelis	NIOZ
Weiss	Portia	SIO
Weiss	Ray	SIO
Weppernig	Ralf	PIUB
Wöhrmann	Andreas	IPÖ
Zaucker	Friedrich	IUP
Zegers	Jacobus	NIOZ

5. Beteiligte Institute/ Participating Institutions

	Institutsadresse/Institute address	Expeditions-teilnehmer/ participants	Fahrtab-schnitt/ leg
	Bundesrepublik Deutschland		
AWI	Alfred-Wegener-Institut für Polar-und Meeresforschung Columbusstraße 2850 Bremerhaven	50	1,2,3
BAH	Biologische Anstalt Helgoland Außenstelle List 2282 List/Sylt	1	3
BFA	Bundesforschungsanstalt für Fischerei Institut für Seefischerei Palmaille 9 2000 Hamburg 50	8	1
GIK	Geologisch-Paläontologisches Institut der Universität Kiel Olshausenstraße 40-60 2300 Kiel	1	1
HSW	Helikopter Service Wasserthal GmbH Kätner Weg 43 2000 Hamburg 43	8	2,3
IFMK	Institut für Meereskunde an der Universität Kiel Düsternbrooker Weg 20 2300 Kiel	1	3
IMH	Institut für Meteorologie und Klimatologie der Universität Hannover Herrenhäuser Straße 2 2000 Hannover 21	5	3
IPÖ	Institut für Polarökologie der Universität Kiel Olshausenstraße 40-60 2300 Kiel	5	1, 3
IUP	Institut für Umweltphysik der Universität Heidelberg Im Neuenheimer Feld 366 6900 Heidelberg	7	2,3

Institutsadresse/Institute address		Expeditions-teilnehmer/ participants	Fahrtab-schnitt/ leg
MIH	Meteorologisches Institut der Universität Hamburg Bundesstraße 55 2000 Hamburg 13	1	2
OLD	Universität Oldenburg Fachbereich 7 Ammerländer Heerstraße 67-69 2900 Oldenburg	1	3
SWA	Deutscher Wetterdienst Seewetteramt Bernhard-Nocht-Straße 76 2000 Hamburg 4	6	1,2,3
ZIM	Zoologisches Institut und Museum der Universität Hamburg Martin-Luther-King-Platz 3 2000 Hamburg 13	2	1
<u>Argentinien</u>			
AHS	Servicio de Hidrografia Naval Avenida Montes de Ocar, 2124 1271 Capital Federal	1	2
<u>Brasilien</u>			
IO/ USP	Instituto Oceanografico Universidade de Sao Paulo Cidade Universitaria, Butanta Sao Paulo CEP 05 508	1	1
<u>Großbritannien</u>			
BAS	British Antarctic Survey Madingley Road Cambridge CB3 0ET	1	1
SPRI	Scott Polar Research Institute University of Cambridge Lensfield Road Cambridge CB2 1ER	5	2,3
<u>Niederlande</u>			
NIOZ	Netherlands Institute for Sea Research Post Box 59 1790 Ab den Burg, Texel	5	1, 3
RIN	Research Institute for Nature Management Post Box 59 1790 Ab den Burg, Texel	2	3

Institutsadresse/Institute address		Expeditions-teilnehmer/ participants	Fahrtab-schnitt/ leg
Österreich			
UI	Institut für Meteorologie und Geophysik Universität Innsbruck Innrain 52 6020 Innsbruck	1	2
Schweiz			
PIUB	Physikalisches Institut der Universität Bern Sidlerstraße 5 3012 Bern	2	2,3
Spanien			
IEO	Instituto Espanol de Oceanografia Centro Canaria	1	1
Südafrika			
PEM	Prey Identification Service Port Elizabeth Museum P.O.Box 13 147 Humewood 6013	1	3
Uruguay			
URU	Universidad de la Republica Uruguay Departmento de Biologica Marina y Pesquera Alberto Las Places 1550 Montevideo, R.O. del Uruguay	1	1
Vereinigte Staaten von Amerika			
CRREL	Cold Region Research Engineering Laboratory 72 Lyme Road Hanover, N.H. 03755	2	2
GSFC	Goddard Space Flight Center Greenbelt, Maryland 20771	1	2
LDGO	Lamont-Doherty Geological Observatory of Columbia University Palisades, N.Y. 10964	6	2

Institutsadresse/Institute address		Expeditions-teilnehmer/ participants	Fahrtab-schnitt/ leg
OSU	College of Oceanography Oregon State University Corvallis, Or 97331	3	2,3
UW	University of Washington Seattle, Wa 98195	2	2,3
SIO	Scripps Institution of Oceanography University of California, San Diego La Jolla, Ca 92093	6	2,3