The Expedition ANT-XXIII/3

of the Research Vessel Polarstern in 2006

Edited by
Christine Provost
with contributions of the participants

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1. ZUSAMMENFASSUNG UND FAHRTVERLAUF

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Der Antarktische Zirkumpolarstrom (ACC) ist die längste Meeresströmung der Welt und nimmt eine Schlüsselstellung in der Steuerung des globalen Klimasystems ein. Dieses 2000 km breite, ostwärts strömende und den antarktischen Kontinent umgebende Band kalten Wassers wird wird durch starke Winde aus Westen angetrieben. Die Drakestraße engt den ACC bis auf 700 km Breite ein und ist dadurch ein geeigneter Ort für Beobachtungen.

Die kontinuierliche Beobachtung des Wassertransportes und der Wassermassen-charakteristika im ACC ist entscheidend um die Kopplung zwischen diesem wichtigen Strömungssystem und den Klimaveränderungen auf der Erde zu verstehen. Das ist eine komplexe Aufgabe, weil der ACC aus sehr variablen schmalen Bändern schneller Strömungen und zahlreichen kräftigen Wirbeln verschiedener Grössen besteht.

Unser Experiment ist so konzipiert, dass sich Satellitenbeobachtungen und *in-situ* Beobachtungen ergänzen. Mit der Satellitenaltimetrie wird die Meeresspiegelhöhe entlang einer Stallitenbahn alle 10 Tage mit einer horizontalen Auflösung von 7 km gemessen. Die *in-situ* Messungen liefern Informationen über die vertikale Struktur der Wassermassen. Diese Informationen können Satellitenbeobachtungen nicht liefern.

Unser Haupttziel ist, die jährliche und saisonale Variabilität im ACC Transport, die vertikale Aufteilung in barotrophe und barokline Komponenten sowie die horizontale Aufteilung auf die Hauptfrontensysteme Subantarktische Front (SAF), Polarfront (PF) und südliche ACC Front (SACCF) zu bestimmen. Andere Ziele sind die Dokumentation der mittleren Wirbelbalance im ACC in der Drakestrasse, die Abschätzung des Bodenmomentes sowie das Gleichgewicht zwischen Windeintrag und mittlerer Wirbel Dynamik. Die zwei Hauptaufgaben der Expedition waren das Ausbringen von Strömungsmesserverankerungsketten entlang einer Spur des Jason Satelliten Altimeters und die Durchführung einer Reihe von hydrographischen Stationen in höherer Auflösung.

Die hydrographischen Stationen lieferten Tiefenprofile von Horizontalgeschwindigkeiten, Temperatur, Salzgehalt, Sauerstoff, Nährstoffen, Chlorophyll a, Alkalinität, Gesamt-CO_2, Chlorfluorkohlenstoffen (CFC) und Helium/Tritium. Mit Hilfe dieser Parameter werden die Wassermassen auf Herkunft, Schicksal, Alter, Mischung und Veränderungen seit der WOCE A21 1990er Expedition untersucht, sowie der CO_2 Partialdruck berechnet und die Quellen/Senkenfunktion für CO_2 anhand der relativen Rolle von physikalischen und biologischen Parametern abgeschätzt.

Die DRAKE Expedition war auch eine Gelegenheit, um die Fähigkeit des kinematischen GPS zu testen, ob der Meeresspiegel und der Zustand der Meeresoberfläche über eine Distanz von einigen Hundert km (ca. 800 km) mit einigen cm Genauigkeit gemessen werden kann. Die GPS Empfänger an Bord von FS *Polarstern* wurden zur Meeresspiegelerkundung genutzt. Eine kleine Oberflächenboje, mit einem GPS ausgestattet, wurde zur präzisen Kalibration des FS *Polarstern*-GPS auf die Meeresspiegeloberfläche genutzt. Die kleine Boje, welche mit dem Schiff verbunden war, wurde tagsüber an jeder CTD Station ausgebracht.

Im Rahmen des GEOTRACES-Projekts wurden Spurenelemente und deren Isotope gemessen. Diese Stoffe spielen eine wichtige Rolle als Tracer für Partikeltransport im Meer, Belüftung des Tiefenwassers, Eintrag vom Mikronährstoffen und Paleo-produktivität. Die Spurenstoffe liegen in sehr geringen Konzentrationen im Meer-wasser vor. Deshalb werden grosse Wasservolumina benötigt um eine messbare Menge aufzukonzentrieren. Dies wurde durch einige wenige *in-situ* Pumpenstationen und Wasserschöpferstationen realisiert.

Die Biologen an Bord untersuchten Temperaturadaptionsmechanismen von Fischen. Während der Expedition versuchten sie, lebende Tiere für Experimente am AWI zu fangen. Ihr Fanggebiet war King George Island. Vier Fischfallen wurden jeweils für 24h ausgebracht.

FS *Polarstern* legte am 12. Januar 2006 von Cabo Negro/Punta Arenas in Chile ab. An Bord waren 87 Personen, 44 Crew-Mitglieder und 44 Wissenschaftler von 12 Instituten aus 9 Ländern.

Unser Arbeitsrythmus wurde durch zwei Hauptaktivitäten gesteuert: die CTD/LADCP Stationen und das Ausbringen der Verankerungen. Verankerungen können aus Sicherheitsgründen nur bei Tageslicht ausgebracht werden. CTD/LADCP Stationen können Tag und Nacht durchgeführt werden. Die erste CTD Station begann 4 Uhr morgens am 16. Januar, der nun folgende Rhythmus von einer CTD-Station alle 3 Stunden wurde nur durch das Ausbringen der Verankerungen unterbrochen. Die Verankerungen konnten schnell und problemlos ausgebracht werden. Die letzte Hydrographie-Station des Transekts endete am 26. Januar um 22 Uhr. Bis zum 26. Januar hatten wir 10 Verankerungen ausgebracht, 51 hydrographische Stationen durchgeführt, inklusive von 15 GPS Bojen Stationen und 6 GEOTRACES Stationen.

Eine glückliche Kombination zwischen wissenschaftlichem Programm und logistischen Aufgaben von FS *Polarstern* bot uns die willkommene Gelegenheit einer Pause nach angestrengtem Arbeiten. Da der Flughafen nahe der chilenischen Antarktisforschungsstation *Bernardo O' Hig*gins auf der antarktischen Halbinsel geschlossen war, übernahm FS *Polarstern* den Transfer von 3 Wissenschaftlern des DLR von der argentinischen Station *Jubany* auf King George Island nach *Bernardo O' Higgins* auf die antarktische Halbinsel. Sowohl die argentinische Station *Jubany* auf King George Island als auch die chilenische Station *Bernardo O' Higgins* auf der antarktischen Halbinsel beherbergen deutsche Laboratorien. So bekamen wir alle die Gelegenheit, beide Stationen zu besichtigen und die einmalige antarktische Natur zu geniessen. Wir genossen die herzliche Gastfreundschaft der chilenischen und argentinischen Kollegen auf den jeweiligen Forschungsstationen. Unsere koreanischen Kollegen waren hocherfreut die Antarktisstation ihres Landes *Sejong* nahe *Jubany* besuchen zu können.

Wir nutzten die Gelegenheit der nächtlichen Passage von der antarktischen Halbinsel nach King-George-Island um einen Transekt von 7 CTD/LADCP/Rosetten-Stationen in der Bransfieldstrasse durchzuführen. In *Jubany* nahmen wir lebende antarktische Fische entgegen und holten die Fischverankerungen mit ausreichend Aalmuttern wieder ein. Sogar ein Octopus hatte sich in die Falle verirrt..

Wir fuhren weiter zu M9, mit einem Zwischenstop für zwei *in-situ* Pumpenstationen, um den hochaufgelösten CTD/LADCP/Rosetten-Transekt auf dem Rückweg zu wiederholen (siehe Karte). Das war eine einmalige Gelegenheit um die *in-situ* Variabilität in einem 10-Tage-Intervall zu dokumentieren, dem gleichen Zeitintervall wie die Satellitenbeobachtungen.

Die CTD-Wachen wurden reorganisiert und Verankerungsleute einbezogen um die Arbeit gleichmässig aufzuteilen und das CTD-Team zu entlasten. Die Probenahme für Nährstoffe und Sauerstoff wurde im Vergleich zum Hinweg von 22 auf 12 Proben reduziert. So blieben 11 Rosettenflaschen pro Station übrig, die das GEOTRACES-Team und das Fisch-Team nutzen konnte.

Der Rück-Transekt begann bei M9. Zwei Stationen wurden bei 58°S eingefügt um die Strömungen in den tiefen Canyons des *Scotia* Rückens zu untersuchen und die Druckgradienten in zwei Richtungen berechnen zu können. Zwei Stationen im nördlichen Teil des Ona Beckens wurden weggelassen da die LADCP's von den umliegenden Stationen auf dem Hinweg zur antarktischen Halbinsel konsistente Geschwindigkeiten .... 0.3 m/s zwischen 3000 und 3500 m Tiefe lieferten. Insgesamt wurden 45 Stationen auf dem Rückweg auf der Jason-Spur durchgeführt. Die letzte Station endete am 6. Februar um 23:33 Uhr bei Feuerland, Isla des los Estados und Le Maire Strait, in einem schönen Sonnenuntergang.

Insgesamt wurden auf dieser Expedition 105 hydrographische Stationen mit LADCP's durchgeführt (Details siehe S.31, Kapitel 3.4). Von diesen 105 Stationen wurden 7 nach einigen Stunden wiederholt (Stationen PS69/137, 140, 144, 161, 181, 183, und 193 bzw. Drake/ 6, 9, 13, 30, 50, 52).

SUMMARY AND ITINERARY

The Antarctic Circumpolar Current (ACC), the world largest current, is a key element of the global climate system. This 2,000 km broad ring of cold water which encircles the Antarctic continent is pushed eastward by the strong westerly wind belt. The ACC is constricted to its narrowest extent (700 km) in Drake Passage thus a convenient place for observations.

Monitoring the ACC transport and water mass characteristics is essential for understanding the coupling of this major current with climate change. It is not an easy matter since the current is concentrated in highly variable narrow bands of swift currents and energetic eddies of all sizes are numerous.

Our experimental set-up is designed to use the complementarity between satellite and *in-situ* observations. Satellite altimetry measures the sea level of the ocean along tracks every 10 days with an horizontal resolution of 7 km. The *in-situ* measurements will provide information on the vertical structure of the ocean, information that cannot be obtained by satellite.

The main objective is to determine the seasonal and interannual variability of the total ACC transport, its vertical partitioning between barotropic and baroclinic components, and its horizontal partitioning among the major fronts Subantarctic Front (SAF), Polar Front (PF), and Southern ACC Front (SACCF). Other objectives are to document the time-mean vorticity balance in the ACC at Drake Passage, estimating the bottom torque and balance between wind input and form drag and eddy-mean dynamics.

The two main tasks of the expedition were the deployment of a current meter mooring array along a ground track of Jason altimeter satellite and the realization of a refined array of hydrographic stations.

The hydrographic stations provided profiles of horizontal velocity, temperature salinity, oxygen, nutrients, chlorophyll-a, alkalinity, total CO_2, h chlorofluorocarbons elium/tritium and chlorofluorocarbons (CFC's) to properly examine the water masses (characteristics, origin, pathways, age, mixing, modifications since the WOCE A21 1990 cruise) and compute partial pressure of CO_2 and assess the source/sink of CO_2 (relative role of physical and biological parameters).

The Drake cruise was also an opportunity to test the ability of kinematic GPS to measure sea level and sea state over a distance of a few hundred km (order 800 km) with a few centimetres accuracy. The GPS receivers on board RV *Polarstern* were used for doing the sea level survey. A small surface buoy equipped with a GPS was used to calibrate precisely the RV *Polarstern* GPS with respect to the sea surface. The small buoy was deployed (attached to the ship) at each CTD station during the day.

In the context of the GEOTRACES project trace elements and isotopes were measured. These trace elements have very low concentration in seawater and large amounts of water have to be processed in order to detect them. Therefore a few pumping stations and specific large volume CTD casts are carried out.

Fish scientists on board were studying thermal adaptation strategies. During the cruise they aimed at collecting alive fish for the continuous work at AWI. Their fishing ground was King George Island. Four fish traps were deployed and stayed in place for over 24 hours.

RV *Polarstern* left Cabo Negro on 12 January with 88 persons on board of which 44 were crew members and 44 were involved in carrying out the scientific mission of the research cruise. The latter represented 12 institutes from 9 countries.

Our work was governed by the rhythm of two main activities: the CTD/LADCP/ rosette stations and the mooring deployments. Mooring deployment can only be performed during the day for security reasons. CTD/LADCP/rosette stations can be carried out around the clock day and night. The first CTD station started at 4 am on 16 January and the rhythm of one station every 3 hours was only stopped for mooring deployment. The moorings were swiftly deployed and located. The last hydrographic station of the section ended at 10 am on 26 January. Thus by 26 January in the morning we had deployed 10 moorings, carried out 51 hydrological stations, with 15 GPS buoy stations and 6 specific GEOTRACES casts or pumping stations.

An excellent combination between science and logistics offered us a timely and most welcome break after the frenetic efficient section. The airport near the Chilean station *Bernardo O'Higgins* on the Antarctic Peninsula being closed, RV *Polarstern* had to pick up 3 scientists from DLR, who were able to land at King George Island airport, and took them to O'Higgins. These scientists operated the satellite/radar station in *O'Higgins* until March when they would close it up and come back. Both the Argentinean *Jubany Station* on King George Island and the Chilean *O'Higgins Station* on the Antarctic Peninsula house a German laboratory. Thus, we all got the opportunity to visit each base and enjoy indicible breathtaking antarctic wildlife and scenery. We enjoyed the warm hospitality of the Argentinean and Chilean people of the bases. Our Korean colleagues were delighted to visit their country base *King Sejong Station* next to Jubany.

We took advantage of the night crossing between the Antarctic Peninsula and King George Island to perform a section of 7 CTD/LADCP/rosette stations across Bransfield Strait.

We picked up alive antarctic fish caught by the *Jubany Station* colleagues and recovered the fish traps with a satisfying amount of eelpouts. An octopus got caught.

We headed on to M9 (with a stop for two pumping stations) to perform again the CTD/LADCP/rosette high resolution section on the way back (see map). This is a unique opportunity to document *in-situ* variability at about a 10 days' interval as the altimetric satellite does.

The CTD shifts were reorganised to involve mooring people in order to share work and leave each one with some free time to enjoy life on board RV *Polarstern*. Sampling for oxygen and nutrients was reduced compared to the way in (12 samples instead of 22) and thus 11 bottles were available for GEOTRACES or fish groups at each cast.

The section back began at M9. Two stations were added near 58°S to investigate the flow in the deep canyons of Scotia Rise and permit to compute pressure gradients in two directions. Two stations were suppressed in the northern part of the Ona Basin. LADCP from stations in the area on the way to Antarctica had indicated consistent velocities in excess of 0.3 m/s between 3,000 and 3,500 m. A total of 45 stations were carried out along the Jason track on the way back. The last station resumed on 6 February at 23.33 h with Tierra de Fuego, Isla de los Estados and Le Maire Strait illuminated by a nice sunset.

Thus, a total of 105 hydrological stations with LADCP were performed during the cruise (see detailed list on page 31 see chapter 3.4). Among those 105 stations, 7 were repeated after a few hours (stations PS69/137, 140, 144, 161, 181, 183, und 193 resp. Drake/ 6, 9, 13, 30, 50, 52) namely the GEOTRACES stations.

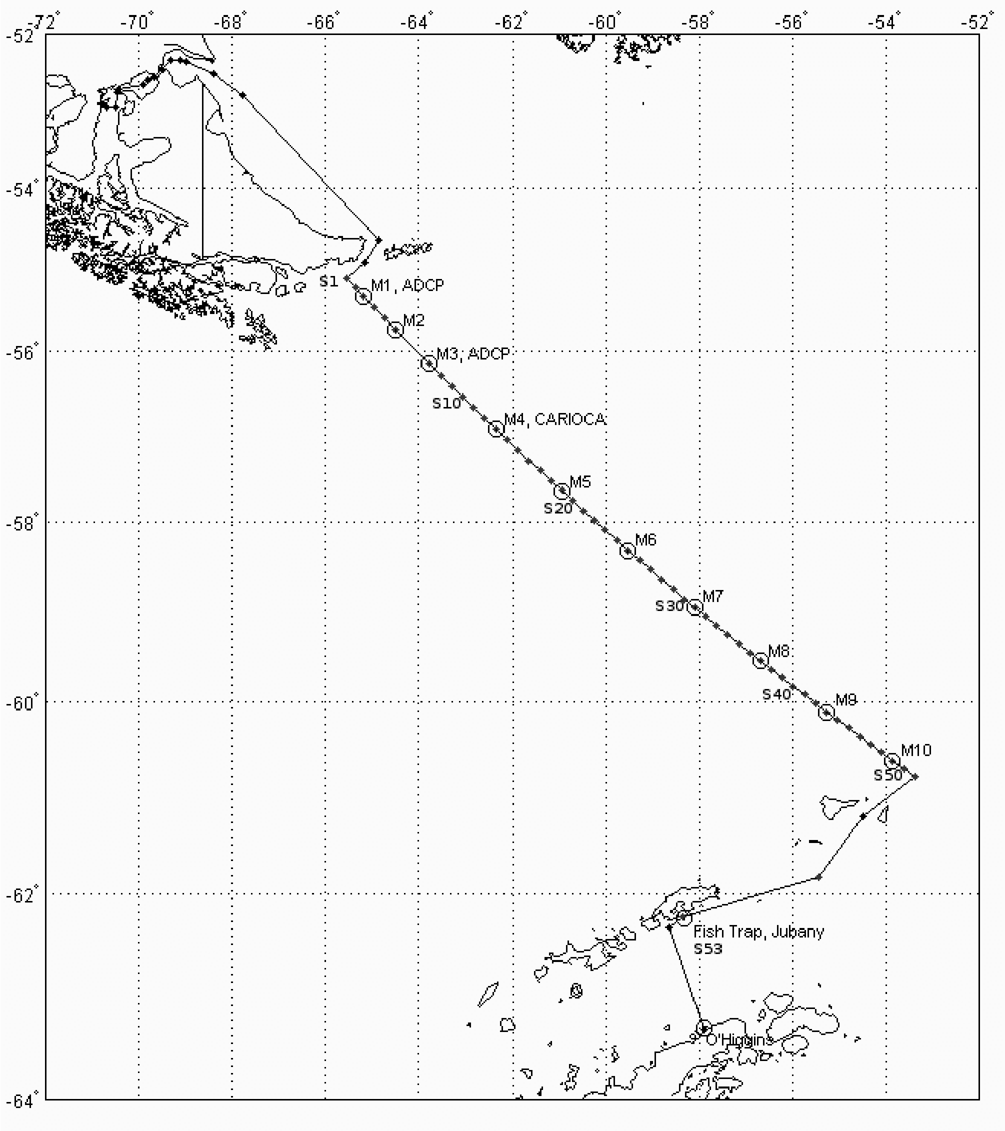

Fig. 1.1: Cruise track
Moorings and stations on the way to Antarctica

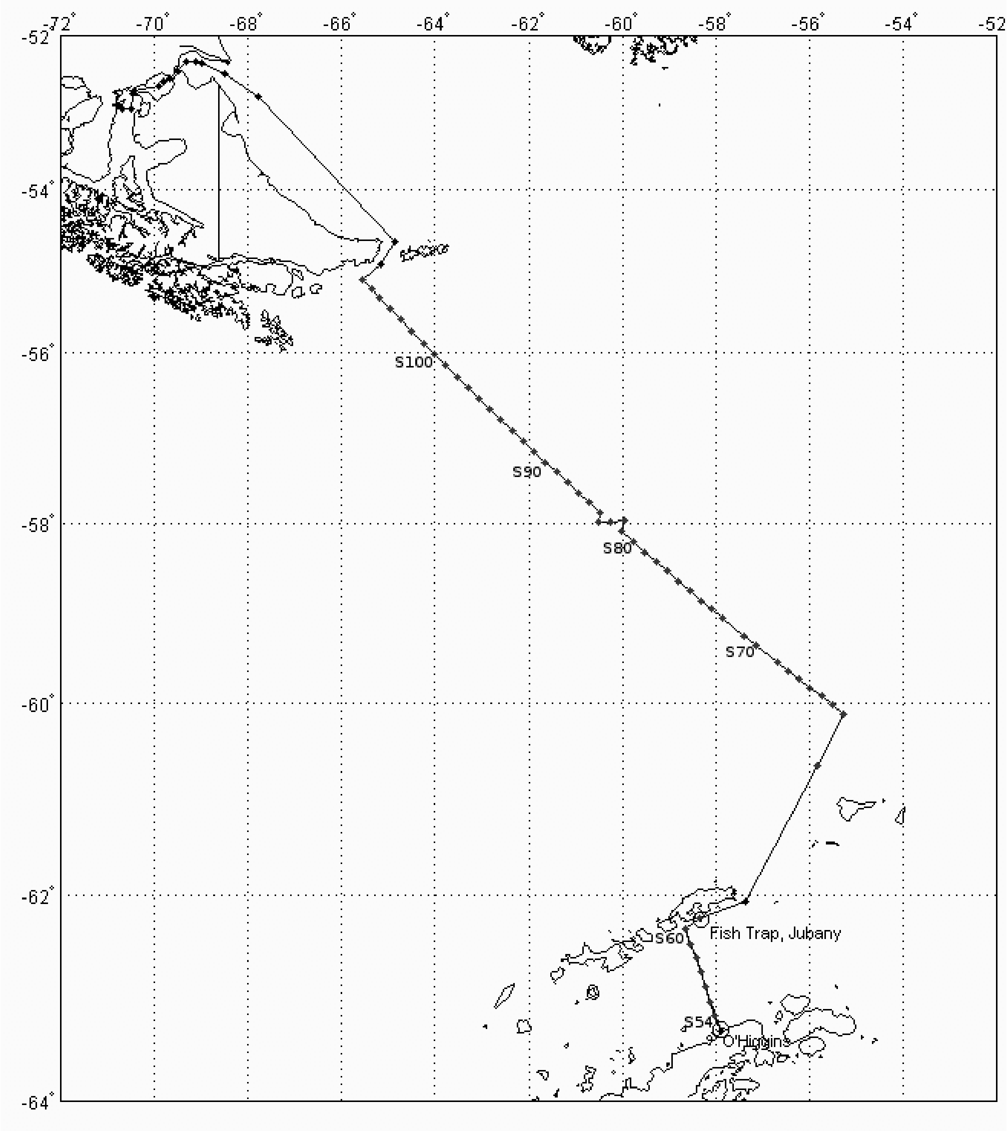

Fig. 1.2: Stations on the way back to Punta Arenas

Below are the times at which Jason-1 satellite flew over the track during the expedition:

2006/01/15	20:58:9.3654	local time:	17:58:9.3654
2006/01/25	18:56:40.865	local time:	15:56:40.865
2006/02/04	16:55:12.365	local time:	13:55:12.365

Acknowledgements

Special thanks to all the crew on board the RV *Polarstern* for their cooperation and their help, specially to Captain Uwe Pahl, Martin Fröb and Helmut Muhle.

2. WEATHER CONDITIONS

Michael Knobelsdorf
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On the cruise ANT-XXIII/3 from Punta Arenas to King George Island the weather was very favourable. High pressure ridges or systems were dominating the cruise, stronger lows avoided the passage of RV *Polarstern*. During the cruise RV *Polarstern* was almost every time in the ‘right’ corridor.

While cruising through the famous strong wind zone, the reality showed no coincidence with statistics. The highest wind speeds ever measured were temporary wind gusts of about 8 BFT. Additionally, another event of a longer swell of about 5.0 m was reported.

Within the Drake Passage westerly winds prevail. Due to the smooth sea surface the main wind flow is almost hardly disturbed in comparison to the higher dissipation of motion energy on land surfaces. On the cruise this was evident using the very highly sophisticated output from the ECMW model.

On Saturday (14 January) RV *Polarstern* left Punta Arenas at about 20:00 local time (UTC- 3H). Temperatures of about 15 degrees and a calm sea allowed RV *Polarstern* to cross the Atlantic into the Le Maire Strait. In the wake of a low pressure system the RV *Polarstern* experienced temporarily a stronger wind field. Due to the narrowing of the airflow within Le Maire Strait the wind speeded up to 7 to 8 BFT, local gusts about 8 were measured.

The cruise benefited from nice weather conditions. Winds shifted between N and SW. The wind speeds reported were in the range of 4 to 7 BFT. The moorings and CTD measurements were on schedule.

On Sunday, 22 January, the Northwesterly winds freshened and the swell increased. The wind picked up to 7 to 8 Bft, mooring M-7 was a bit difficult to handle.

On 25 January RV *Polarstern* was located within a weak pressure gradient in a mainly northwesterly airflow. Wind speeds between 3 to 5 Bft were reported. The last mooring was successfully deployed.

From Thursday to Saturday south to southwesterly winds prevailed with reported wind-speeds between 3 and 5 Bft.

On Friday, 27 January, RV *Polarstern* was located at 62° S and 58° W and headed to *Jubany Station* on King George Island. The favourable wind conditions allowed the marine biologists to set up their fish traps. 24 hours later they were due to lift up again.

On Saturday, 28 January, the RV *Polarstern* stopped near the Chilean base of *Bernardo O'Higgins*. A high pressure ridge controlled the weather pattern. Almost sunny conditions were experienced so that the scenery of the Antarctic Peninsula was very much welcomed. Only for a while the famous katabatic winds were noticed. From one minute to the other the almost calm wind conditions turned to a wind increase to about 7 BFT. The sky showed the typical Lenticularis clouds which indicate Föhn conditions. Next day almost calm conditions persisted so that it was quite easy to collect the fish traps.

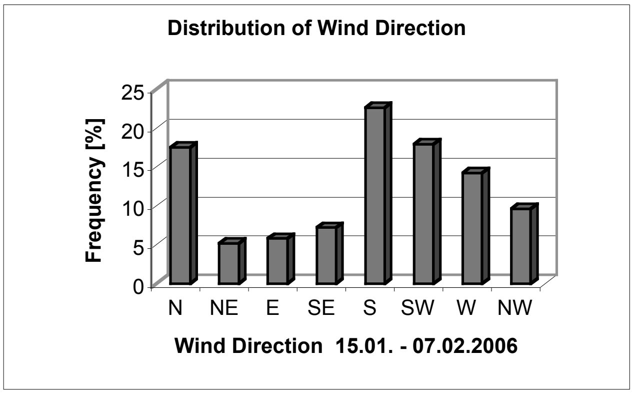
On the following days as RV *Polarstern* turned again back into the Drake Passage southerly winds with wind speeds between 4 and 7 Bft were reported. A high sitting on the Antarctic Peninsula controlled the weather pattern.

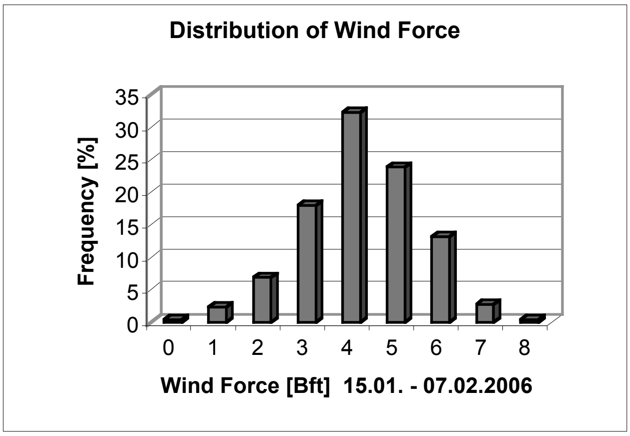
On Wednesday, 1st February, a stronger cyclogenesis developed at 59° S and 58° W. The following day the low, with a core pressure of 978 hPa, crossed the cruise track. As the system has already built a large wind sea, RV *Polarstern* experienced a strong swell about 5.5 m within almost calm wind pattern.

During the night to Thursday, as the low moved away, the pressure rose quite quickly. In the wake of the system the southerly winds picked up to 6 BFT. So on Friday the sum of windsea and swell created locally crosseas. This was not a major problem for the ship.

On the weekend close to the way back to Punta Arenas RV *Polarstern* came again under a high pressure system. It stabilized the weather pattern so quite calm conditions prevailed into Monday, 6 February. While heading into the Le Maire Strait the Northerly airflow increased with wind speeds picking up to 7 BFT. The combination of a high pressure system and the approach of a strong low pressure system increased the Northerly airflow, occasionally gale force gust were reported.

On the itinerary through the Atlantic and Magellan Strait RV *Polarstern* reached the final destination Punta Arenas with no major wind events. The mission was successfully completed.





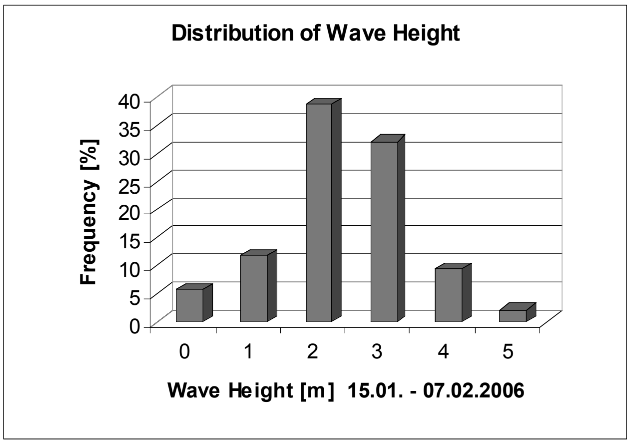


Fig. 2.1 - 3: Weather statistics

3. VARIABILITY OF THE ANTARCTIC CIRCUMPOLAR CURRENT

Objectives

Monitoring the ACC transport and water mass characteristics is essential for understanding the coupling of this major current with climate change. It is not an easy matter since the current is concentrated in highly variable narrow bands of swift currents and energetic eddies of all sizes are numerous.

The main objective is to determine the seasonal and interannual variability of the total ACC transport, its vertical partitioning between barotropic and baroclinic components, and its horizontal partitioning among the major fronts Subantarctic Front (SAF), Polar Front (PF), and Southern ACC Front (SACCF). Other objectives are to document the time-mean vorticity balance in the ACC at Drake Passage, estimating the bottom torque and balance between wind input and form drag and eddy-mean dynamics.

The work at sea is described in sections 3.1 to 3.5.

3.1 Ship's continuous observations (VM-ADCP, Gravimeter, Thermosalinograph)

3.1.1 VM-ADCP

Annie Kartavsteff[1)], Helmut Muhle[2)]
[1)]LOCEAN University Piere et Marie Curie, Paris
[2)]Laeisz (Bremerhaven) GmbH

Vertical profiles of ocean currents down to roughly 300 m depth were measured with a Vessel Mounted Acoustic Doppler Current Profiler (VM-ADCP, Ocean Surveyor in narrow band configuration, 150 kHz nominal frequency, manufactured by RDI), installed on the ship hull behind an acoustically transparent plastic window for ice protection.

The ADCP has four transducer heads, arranged in a square formation (Janus configuration), which point diagonally outwards at an angle of 30° relative to the vertical. The transducer heads simultaneously emit a sound pulse approximately every second, and record echoes returned from discontinuities in the water or from suspended particles. The echoes are range-gated into a series of vertical bins and analysed for their Doppler frequency shift which is related to the water velocity. Determination of the velocity components in geographical coordinates then requires a precise knowledge of the attitude of the ADCP transducer head, its tilt, heading, motion and geographic position. Attitude variables of the VM-ADCP were taken from the ship navigation system MINS (Main Inertial Navigating System).

In addition the ADCP can be used as a detector for zooplankton abundance by evaluating the echo amplitude.

The instrument settings were chosen to give a vertical resolution of horizontal velocities of 4 m in 80 depth bins, and a temporal resolution of 2 min after ensemble averaging over individual profiles taken at a rate of roughly 1 Hz. Calibration data for the ADCP velocity measurements were obtained during the cruise, during approach and departure from stations. Processing of the VM-ADCP data was done using the CODAS software package (developed by E. Firing and colleagues, SOEST, Hawaii). Processing steps follow that software programme:

- estimation of the drift of the PC-clock and correcting the profile times,
- loading the data into a codas database,
- verification of the transducer temperature and sound speed and determination of the thresholds,
- viewing of all profiles for flagging bottom and hydrographic wire interference and other glitches,
- correction of the satellite fixes for the distance between the ADCP transducers and the GPS antennas,
- calculation of misalignment angle between gyrocompass and data acquisition unit with water track method, assuming that the laser gyrocompass provides the true heading,
- rotation of the velocities by estimated angle,
- calculation of reference layer velocities to control the satellite fixes,
- mixing navigation data and ADCP data,
- gridding and plots,

The VM-ADCP data were collected continuously during the cruise whenever outside the economic zone waters.

A preliminary processing of the data from the southward crossing was performed on board. The velocity profiles reached down to 250 m depth most of the time. The first section across Drake Passage is presented in figure 3.1. The main features of the circulation appear clearly: cross track velocities exceed 0.8 ms^{-1} in the Subantarctic front (SAF) at 56°S and are somewhat smaller about 0.5 ms^{-1} in the Polar Front (PF). Along track velocities are smaller than cross track velocities, the section is perpendicular to the strong current features. First rough comparisons with LADCP are satisfying.

However it is noticed that the headings are poor and particularly at the times the ship slows down before a station or accelerates leaving the station. Thus a fair amount of editing of the data will be necessary. Furthermore the clocks from the ADCP and MINS at times show disagreements that have to be examined further.

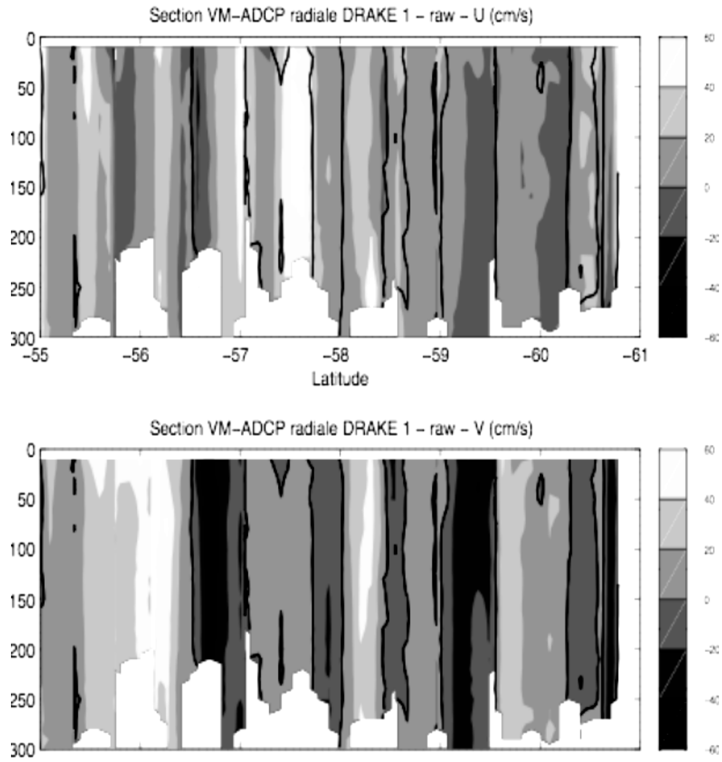


Fig. 3.1: Preliminary section of zonal (top) and meridional velocity on the southward crossing to Antarctica

3.1.2 Gravimeter

Felix Stöhr[1)], Helmut Muhle[2)]
[1)]LOCEAN University Piere et Marie Curie, Paris
[2)]Laeisz (Bremerhaven) GmbH

Gravimetric measurements were carried out using the gravimeter KSS-31 on board RV *Polarstern* on the F-deck. The gravimeter can perform gravity measurements at 10 second intervals and typical errors are below 1 mGal. The gravity anomalies expected across the Drake Passage are of the order of 44 mGal. This translates into a geoid height difference of roughly 8 m. The resolution is sufficient for our purposes.

The gravity-meter on board RV *Polarstern* is supposed to have a drift of only 3 mGal/month. Unfortunately we could not obtain the permission to perform gravity reference measurements in Punta Arenas. However, as track 104 is covered on the way south and back it will be possible to correct for the drift and relative values are enough for our purposes. We will combine the gravity measurements below track 104 with altimetric measurements and the large-scale geoid to compute the dynamic height profile along the satellite track.

The gravimeter had been working all along the cruise track.

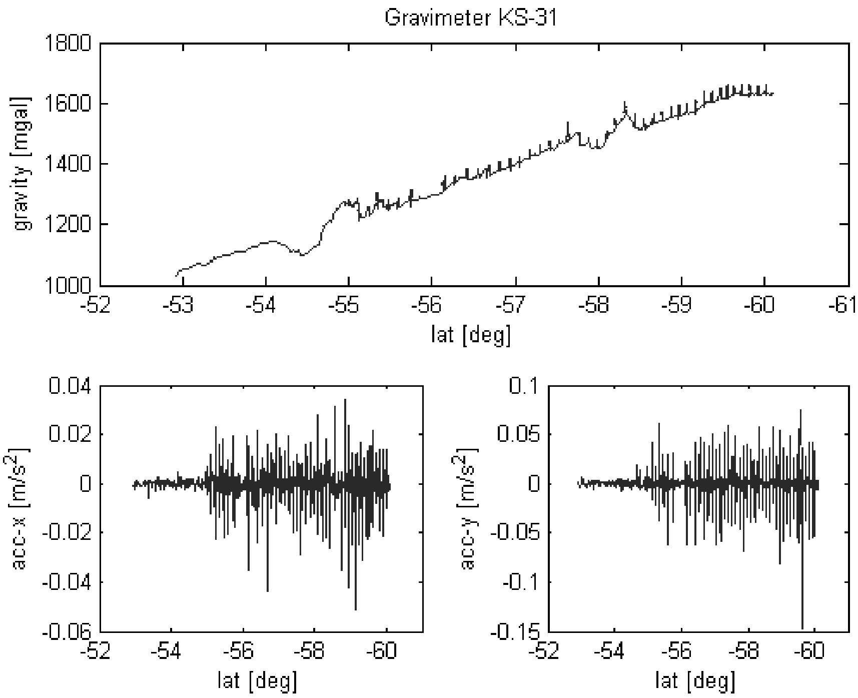


Fig. 3.2: Gravity and accelerations from on board gravimeter along Jason Track #104

3.1.3 Thermosalinograph

Mario Caceres Soto[1)], Helmut Muhle[2)]
[1)]Observer, University Valparaiso
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Data of the two thermosalinographs that are located in the bow (5 m) and keel (11 m) were extracted from the PODAS data server along the transects with a resolution of one data point per 10 minutes. Surface temperature and salinity data show that several frontal systems and eddies were crossed (Fig. 3.3).

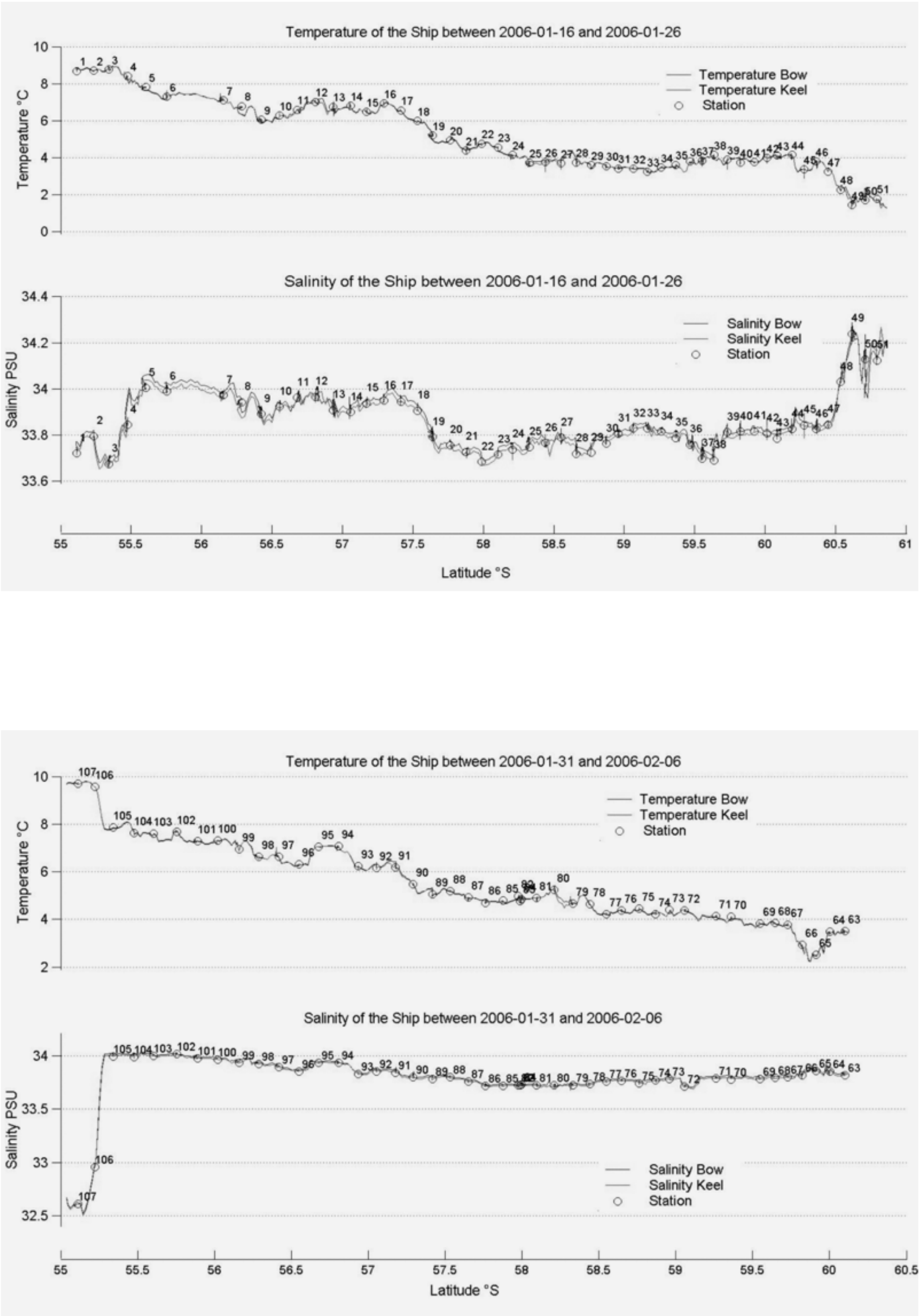

Fig. 3.3: Temperature and salinity from RV Polarstern thermosalinograph

3.2 Moorings

Jacques Lanoisellé[1)], Catherine Rouault[1)], Annie Kartavtseff[1)], Thierry Monglon[1)], Hervé Legoff[1)],Jae Hak Lee[2)], Sang Chul Hwang[2)]
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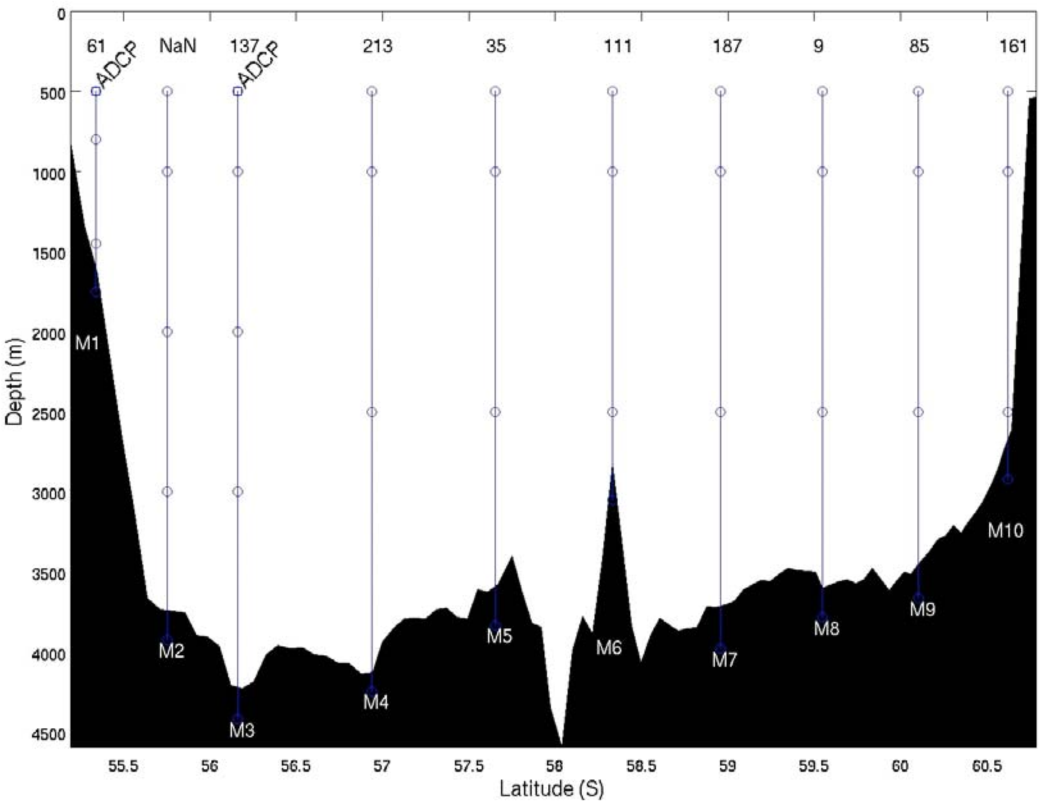
The main objective is to monitor the magnitude and variability of the ACC through Drake Passage.

An array of 10 subsurface current meter moorings (M1 to M10) has been deployed along ground track 104 of Jason altimetric satellite. Each mooring carries 3 current meters and seacats. The top instrument on M1 and M3 is an upward looking ADCP. M10 is equipped with two sediment traps.

Moorings 2, 4, 5, 6, 7, 8 and 9 are similar. See schematic drawings of the moorings below.

Tab. 3.1: Moorings positions

Mooring	Latitude	Longitude	
M1	55°20,514S	65°11,155W	Posidonia
M2	55°44,67S	64°27,41W	Posidonia
M3	56°07,92S	63°42,66W	Posidonia
M4	56°56,54S	62°19,61W	Posidonia
M5	57°37,63S	60°55,26W	Posidonia
M6	58°19,06S	59°31,34W	Posidonia
M7	58°57,50S	58°05,78W	Posidonia
M8	59°32,92S	56°41,3W	Posidonia
M9	60°06,04S	55°16,26W	2 releases
M10	60°37,61S	53°49,82W	2 releases



Distance in kilometers

Fig. 3.4: Mooring and current meter distribution along Jason-1 Track 104

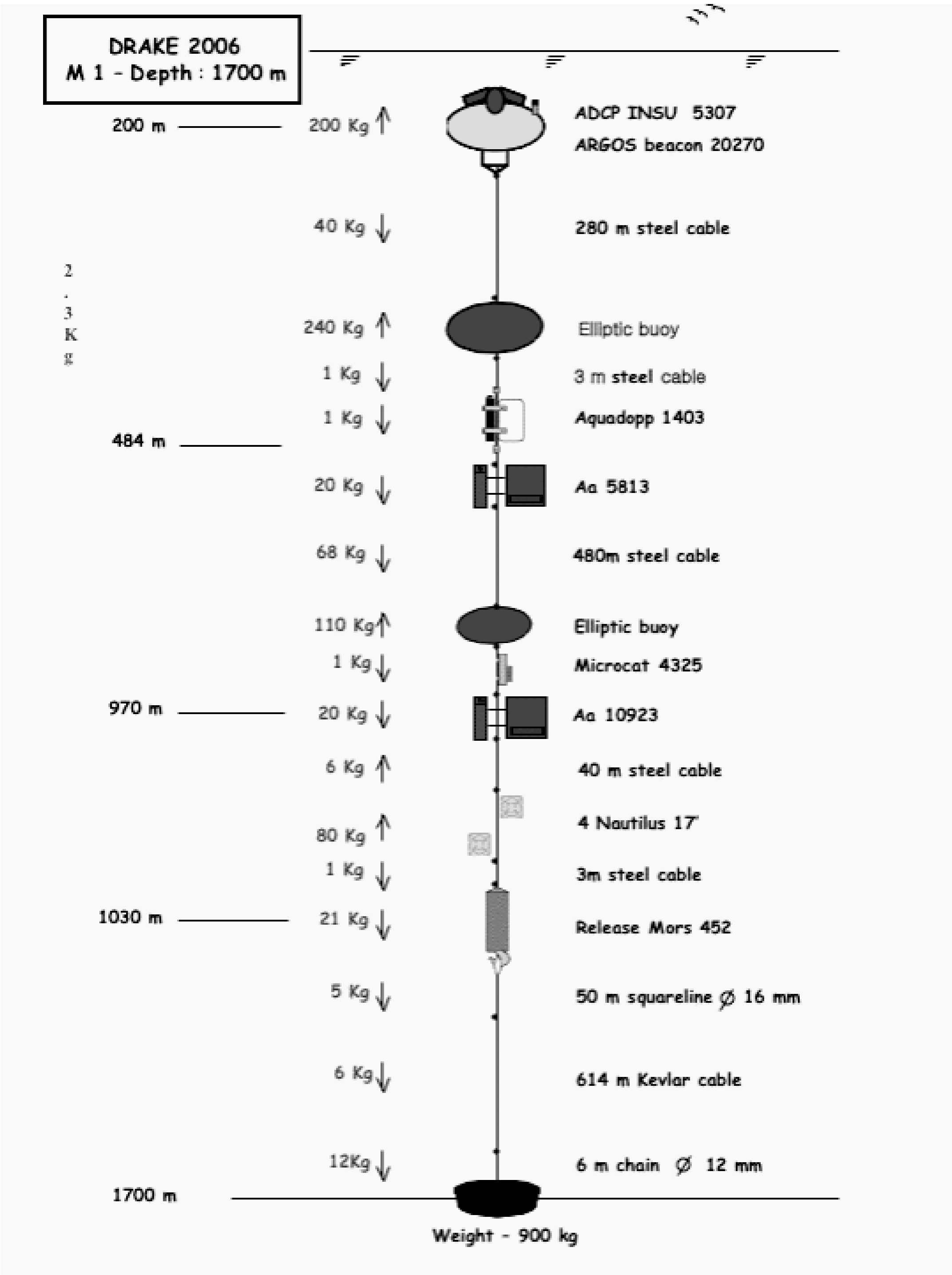


Fig. 3.5: Schematics of mooring 1

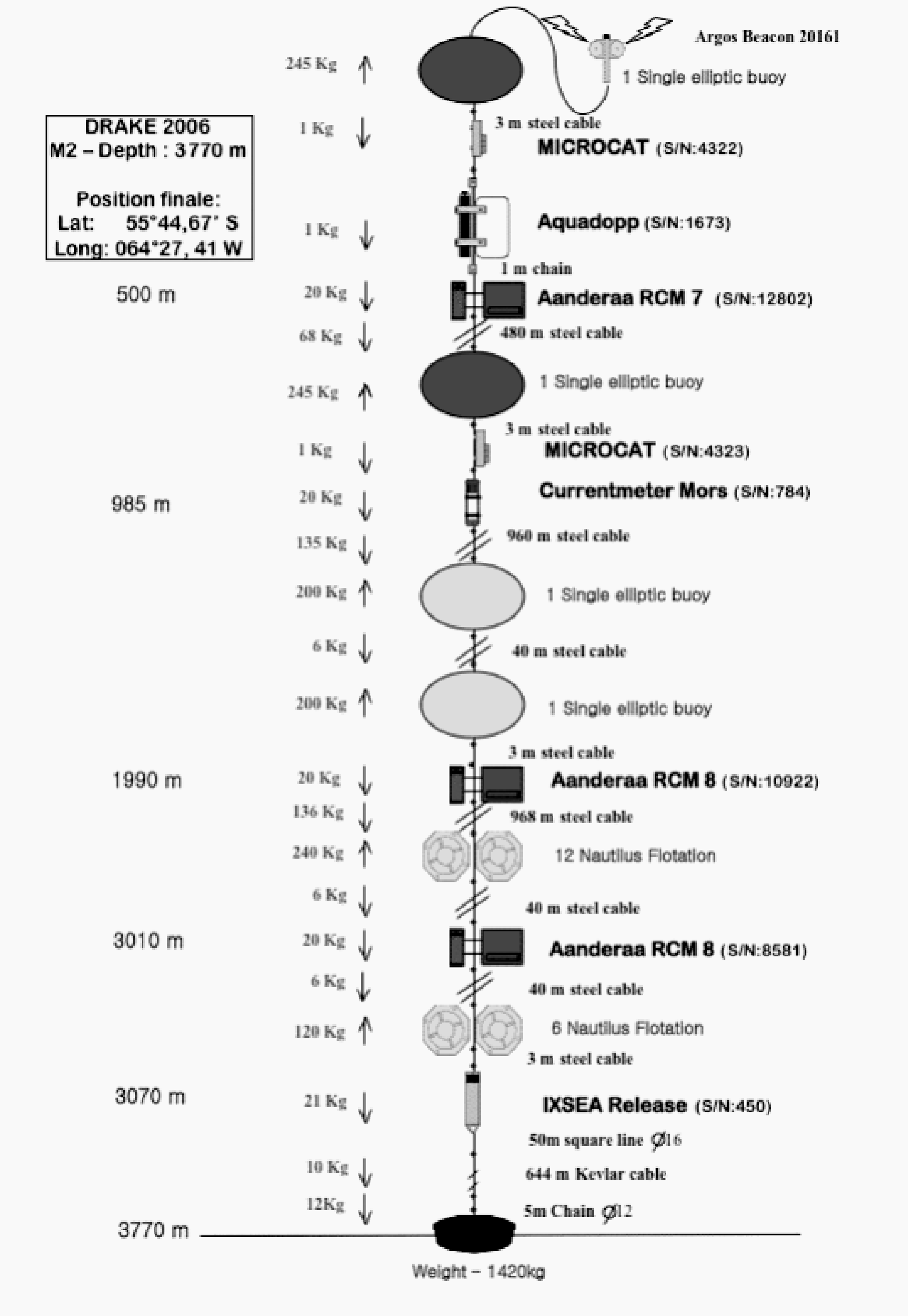


Fig. 3.6: Schematics of mooring 2. Moorings 4, 5, 6, 7 and 8 are similar to M2.

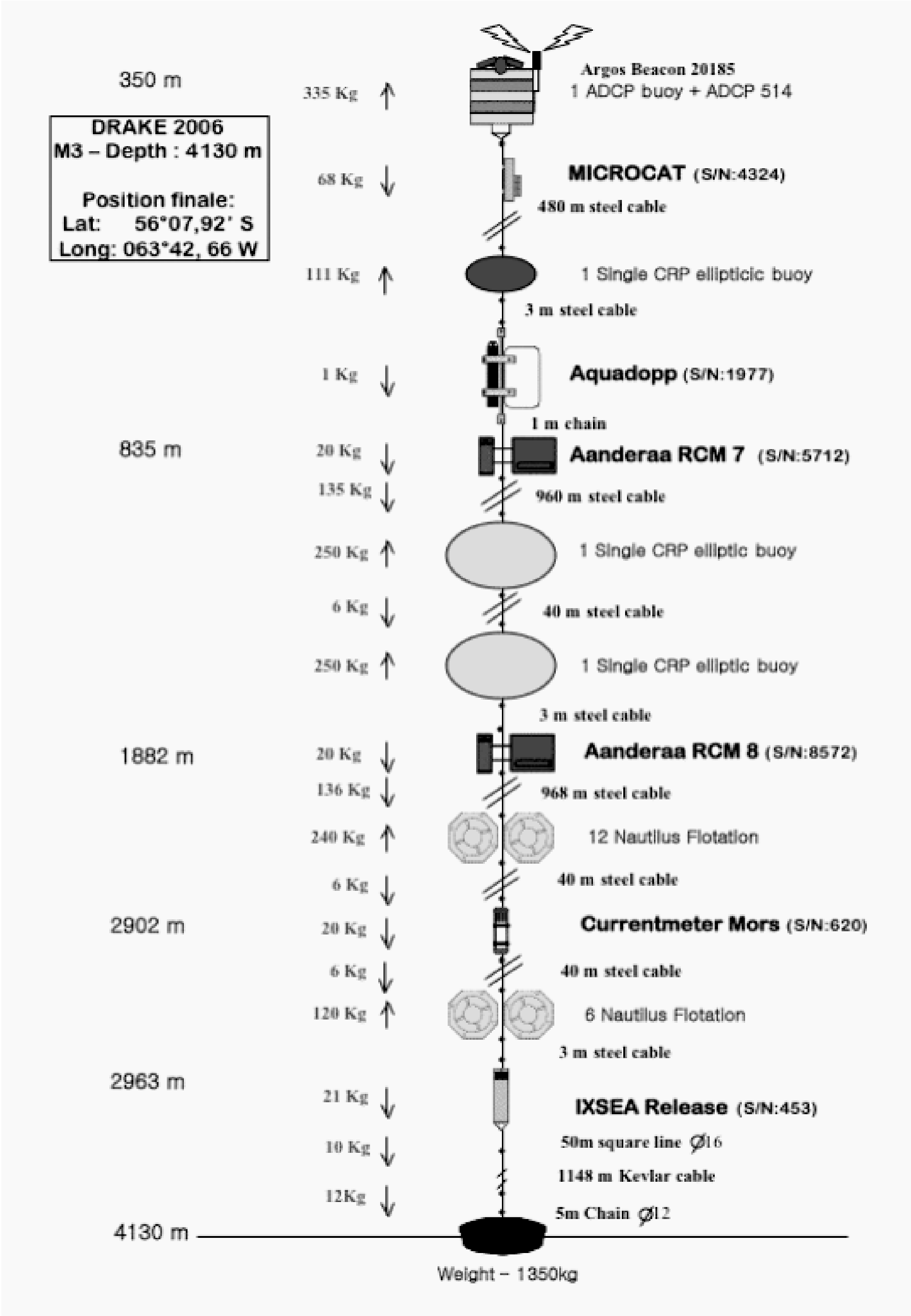


Fig. 3.7: Schematics of mooring 328

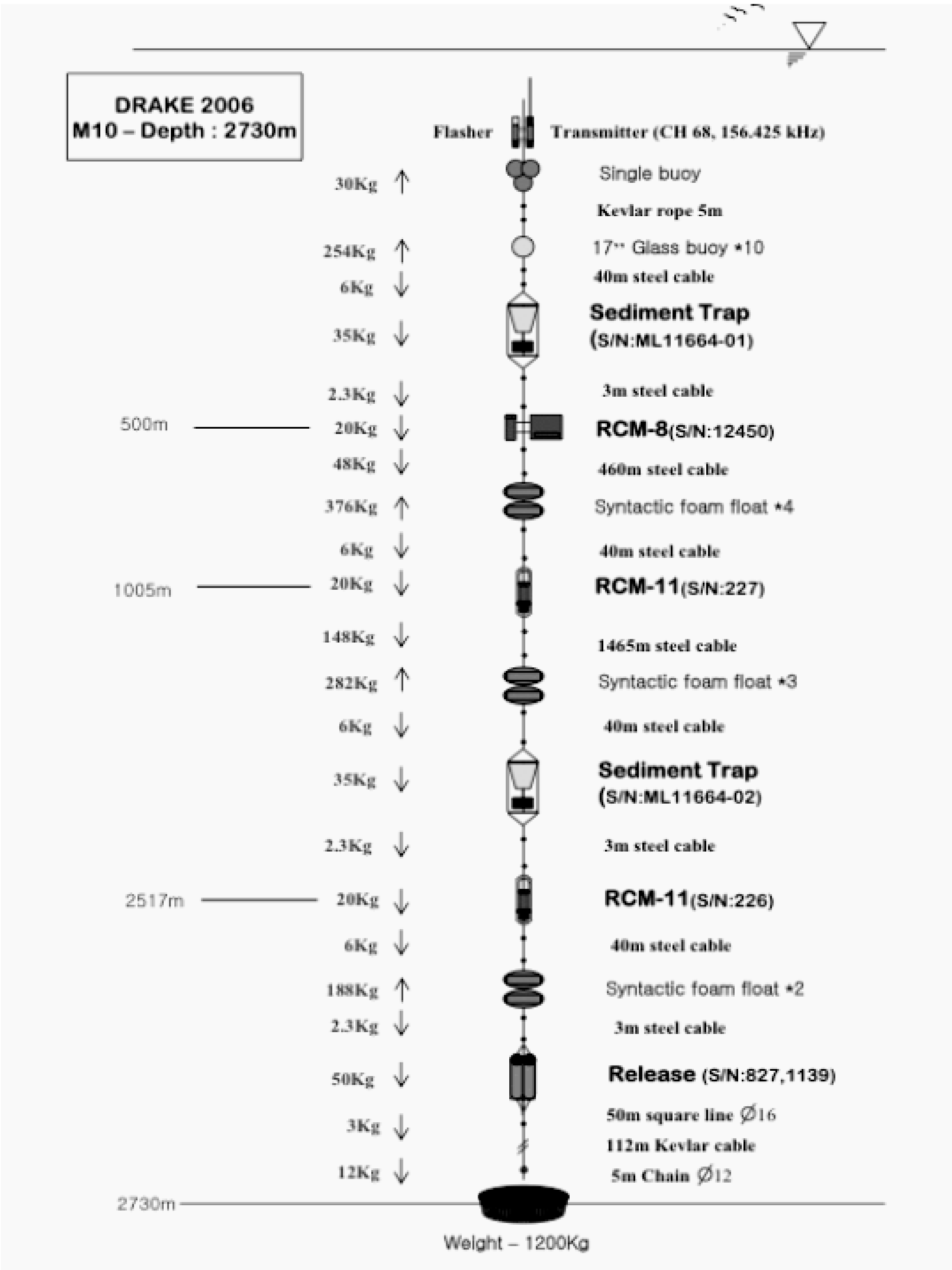


Fig. 3.8: Schematics of mooring 10

Mooring recovery is expected to take place from RV *Polarstern* in 2008.

One Bottom Pressure Recorder (BPR) is maintained by the Proudman Ocean Laboratory (POL) near Elephant Island. We were supposed to install another BPR from POL near M1 in northern Drake Passage. Unfortunately the BPR had not yet arrived in Punta Arenas when we departed nor when we came back from the cruise.

3.3 Hydrographic station work with CTD and water bottle sampling

Claudie Marec[1)], Marie-Noëlle Houssais[2)], Frédéric Vivier[2)], Nathalie Sennechael[2)], Nadine Chouaib[2)], Mehrad Rafizadeh[2)], Nicolas Barré[2)], Aurélie Spadone[2)], Fabiano Busdraghi[2)] (for the whole cruise) Catherine Rouault[2)], Annie Kartavtseff[2)], Jacky Lanoisellé[2)], Félix Stöhr[2)], Thierry Monglon[2)], Hervé Legoff[2)] (for the return journey)

[1)]DT-Insu/CNRS, Plouzané
[2)]LOCEAN University Piere et Marie Curie, Paris

The CTD used at hydrographic stations was of type Sea-Bird Electronics SBE911 plus. The CTD was supplemented by an oxygen sensor SBE 43, a transmissiometer (WetLabs C-Star, 660 nm wavelength), a chlorophyll-sensitive fluorometer (Chelsea Aquatracka). A bottom sensor alarm provided by RV *Polarstern* was attached to a 20 m rope below the CTD.

The CTD and peripheral instruments were attached to a multi-bottle water sampler type Sea-Bird 32 carousel holding nominally 24 12-l bottles. Two bottles (#22 and 23) were removed to provide space for two ADCPs (LADCP- section 5).

Salinity derived from the CTD measurements are calibrated by comparison with salinity of samples taken from the water bottles and analysed using a Guildline-Autosal-8400A salinometer that was adjusted to IAPSO Standard Seawater.

Altogether 112 CTD casts were carried out at a total of 105 hydrographic stations (see Station list A1 and station map on Fig. 1). 7 casts were repeated casts. Except for the 7 repeated casts that reached intermediate depths, all the casts went close to the bottom in order to let the LADCP observe the seafloor and thus compute LADCP motion with respect to the sea floor, thus reducing error bars on the LADCP derived horizontal velocity estimates.

During the first crossing of Drake Passage 51 stations were carried out with an average spacing of 12 nm between two consecutive stations. In order to deploy mooring M3 during day light, two stations before M3 were skipped.

7 stations were carried out across Bransfield Strait during the night transit between O'Higgins and Jubany.

The second crossing of DP from Antarctica to Tierra de Fuego started at M9. The same spacing of 12 nm was observed. At about 58°S, two stations were added to investigate the flow in the deep canyons of Scotia Rise.

At the end of the cruise the CTD sensors were sent to Seabird Company for calibration.

Below are plots from the raw data for the southward section.

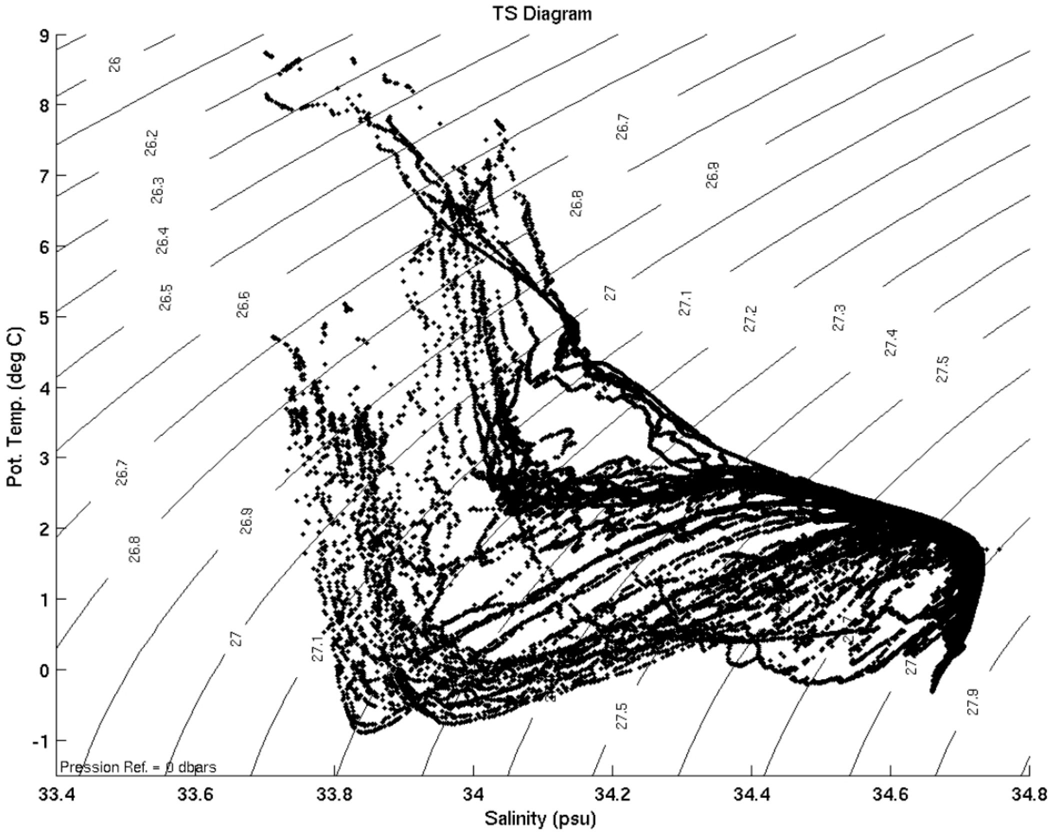


Fig. 3.9: Potential temperature/salinity diagram of the CTD profiler measured during ANT-XXIII/3

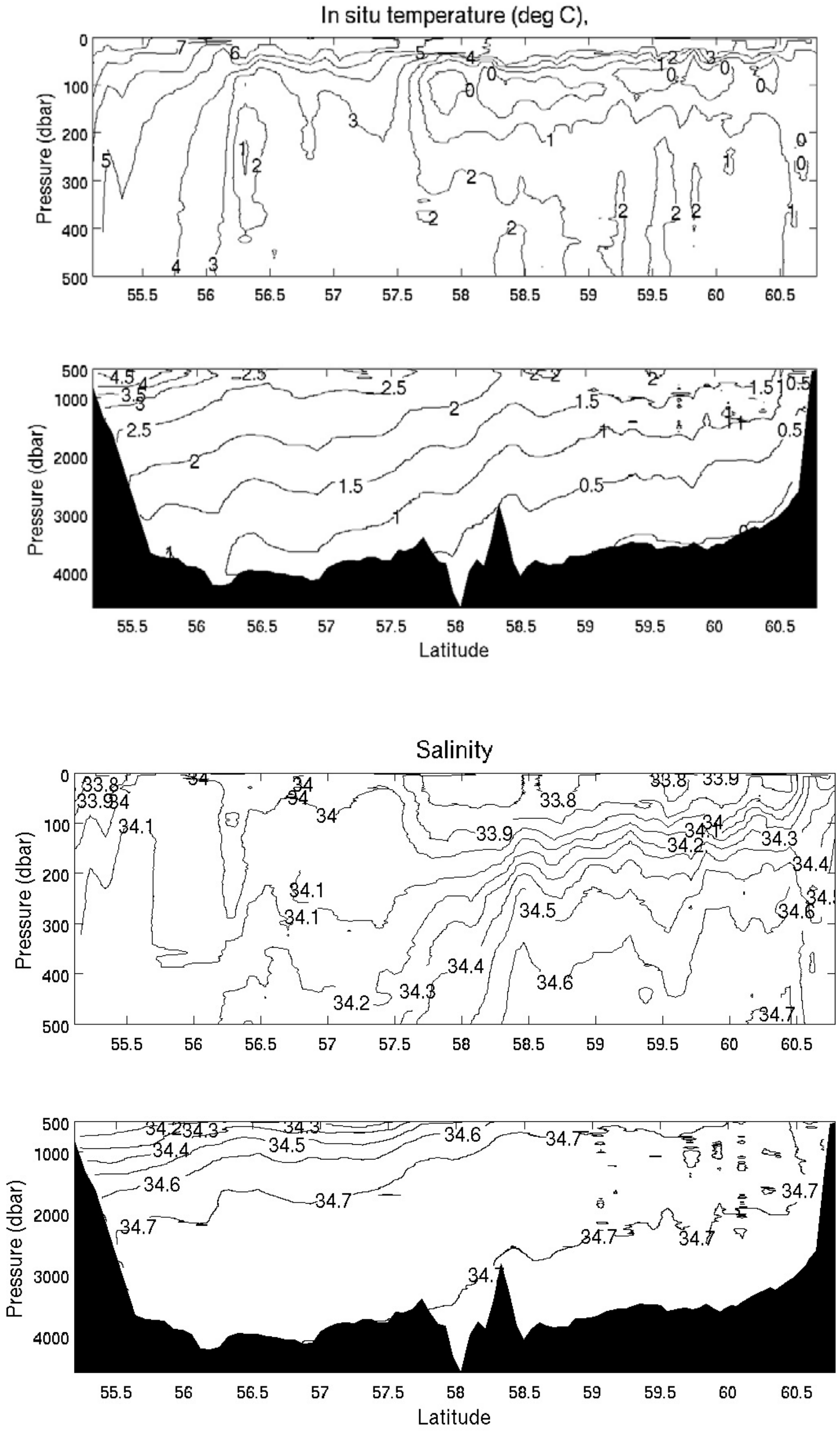


Fig. 3.10: Vertical transects of potential temperature (top) and salinity (bottom) across Drake Passage

3.4 LADCP

Nicolas Martin
LOCEAN University Piere et Marie Curie, Paris

The measurements were done with two RDI Workhorse 300 kHz ADCPs attached to the CTD rosette. A Master/Slave configuration was used in which the Master ADCP was down-looking and the Slave ADCP was up-looking. The Master ADCP was instructed to send 1 ping per ensemble and 1 ensemble per second. Using a synchronisation signal, the two ADCP emitted their ping simultaneously. With a bin size of 8 meters and a lowered speed of 1m/s, each ADCP were expected to perform 1 profile per second with an theoretical range of about 120 m. In fact, the range was about 100 m. An external battery case was used to supply power to the 2 ADCPs.

Between two consecutive stations, the data from the two ADCPs were downloaded from their internal memory card and the power supply was checked.

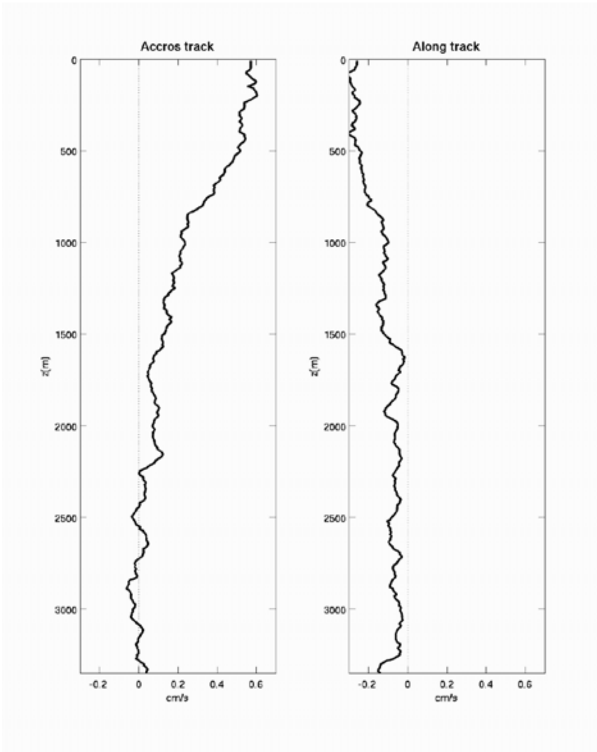


Fig. 3.11: LADCP-profile

At first, using RDI software WinADCP, the quality of data were tested in order to validate the raw data and to check the good working of the two ADCPs looking at the echo intensity and the correlation magnitude for each ping and each beam.

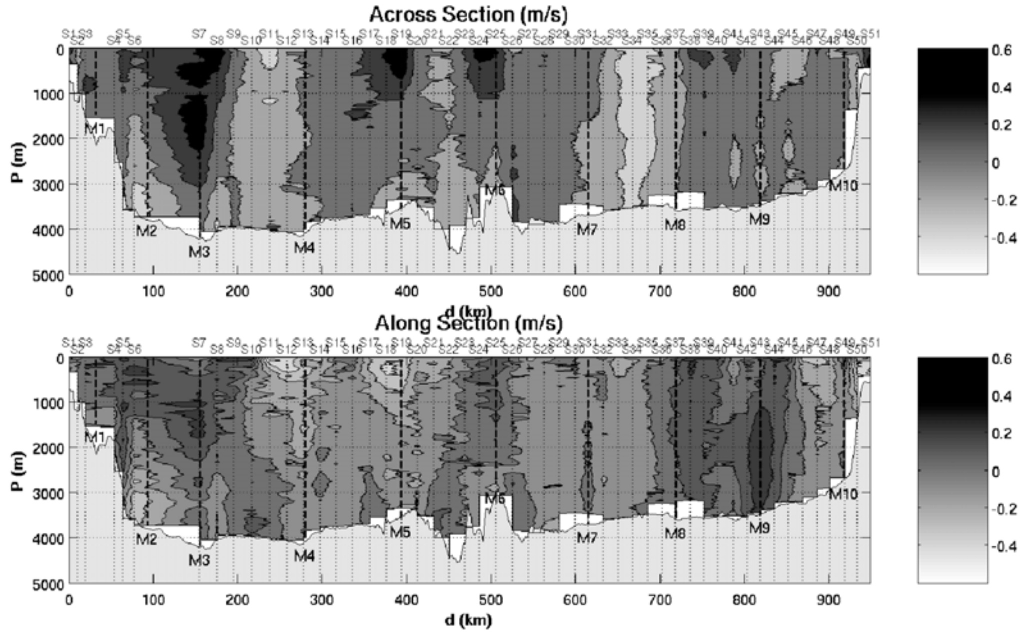
The second step consisted in the computation of the currents over the whole water column. To perform this computation, the software from Martin Visbeck (2002) was used. This process, using a linear inverse method, allows the use of external data such as CTD measurements to correct for speed of sound and to know the depth, the ship navigation from the GPS sensors, the velocity of bottom-track data from the downward looking ADCP to constrain the inversion and the surface detection from the upward looking ADCP.

The data coming from ship ADCP could be used to better constraint the first 300 meters, but this processing was not done on board and will be computed when we will be back.

These profiles were computed for the whole Drake Passage allowing computation of transport across the section.

References

Deep velocity profiling using lowered acoustic doppler current profilers: Bottom Track and Inverse solutions, Martin Visbeck, JAOT 2002, Vol 19, pp.794-807



3.12: Transect of currents from ADCP measurements during ANT-XXIII/3

3.5 Dissolved nutrients concentrations, total alkalinity and dissolved inorganic carbon

Louise Oriol[1)], Marielle Lacombe[2)], Joel Sudre[2)], Véronique Garcon[2)]

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[2)]LEGOS ONP, Toulouse

The distribution of dissolved nutrients (nitrates + nitrites, phosphates and silicates) will give us information on water masses and pathways, variability in water mass characteristics in the Drake Passage, cold water route of the thermohaline circulation.

At each station discrete bottle samples were collected at all levels for the analysis of dissolved nutrients concentrations: nitrates + nitrites, phosphates and silicates which were measured within a few hours after collection. Inorganic nutrients were determined with an AutoAnalyzer Skalar system belonging to the ARAGO laboratory. The determination of nitrate and nitrite is based on the method described by Armstrong et al. (1967), silicate was measured according to Grasshoff et al. (1983) and phosphate according to Gordon et al. (1993). Preparation of primary standard materials and reagents were done following the WOCE protocol (Gordon et al., 1993). Triplicates were collected every five CTD stations at the deepest and shallowest levels. Simultaneously, ten replicates were collected at mid-depths to better assess the reproducibility of the measurements. A total of 2500 samples was collected throughout the whole ANT-XXIII/3 leg.

A new method was tested to determine silicates concentrations by cyclic voltammetry. The silicate are non-electroactive species. The method involves complexing molybdenum salts in acidic solution with silicate to make it electroactive. A total of 330 samples were analyzed with this method. Comparison with silicate concentration determined on the Skalar is excellent.

Typical profiles of phosphate, silicate and nitrate+nitrite are presented below at stations 6 (55°45.4'S, 64°29.9'W), 29 (58°45.7'S, 58°32.6'W) and 46 (60°21.6'S, 54°33.7'W) distributed across the Subantarctic Front (SAF) and the Polar Front (PF). Vertical sections are shown from Punta Arenas to the Antarctic Peninsula.

At 11 CTD stations and at all levels, water was sampled for dissolved inorganic carbon (DIC) and total alkalinity (TA). At 40 CTD stations, surface water was collected from the ship's pump (pump's inlet of the thermosalinograph) for DIC and TA. Duplicates were done on some surface samples as well as on deep samples. Samples will be analyzed upon return by airfreight at the IPSL CO_2 service in Paris. This will allow the computation of the seawater partial pressure of CO_2 and thus the assessment of the source/sink role of CO_2 of this region.

References

Armstrong, F.A.J., Stearns, C.R., and Strickland J.D.H., 1967, The measurement of upwelling and subsequent biological processes by means of the Technicon AutoAnalyzer and associated equipment. Deep Sea Res., 14(3). 381-389.

Grasshoff, K., M. Ehrhardt, K. Kremling, 1983, Methods of seawater analysis, 2nd ref. Ed. Verlag Chemie GmbH, Weinheim, 419 pp.

Gordon, L.I., Jennings J.C.Jr., A.A. Ross, J.M. Krest, 1993, A suggested protocol for continuous flow automated analysis of seawater nutrients (Phosphate, Nitrate, Nitrite, Silicic acid) in the WOCE Hydrographic Program and the Joint Global Ocean Flux Study, WOCE HPO.

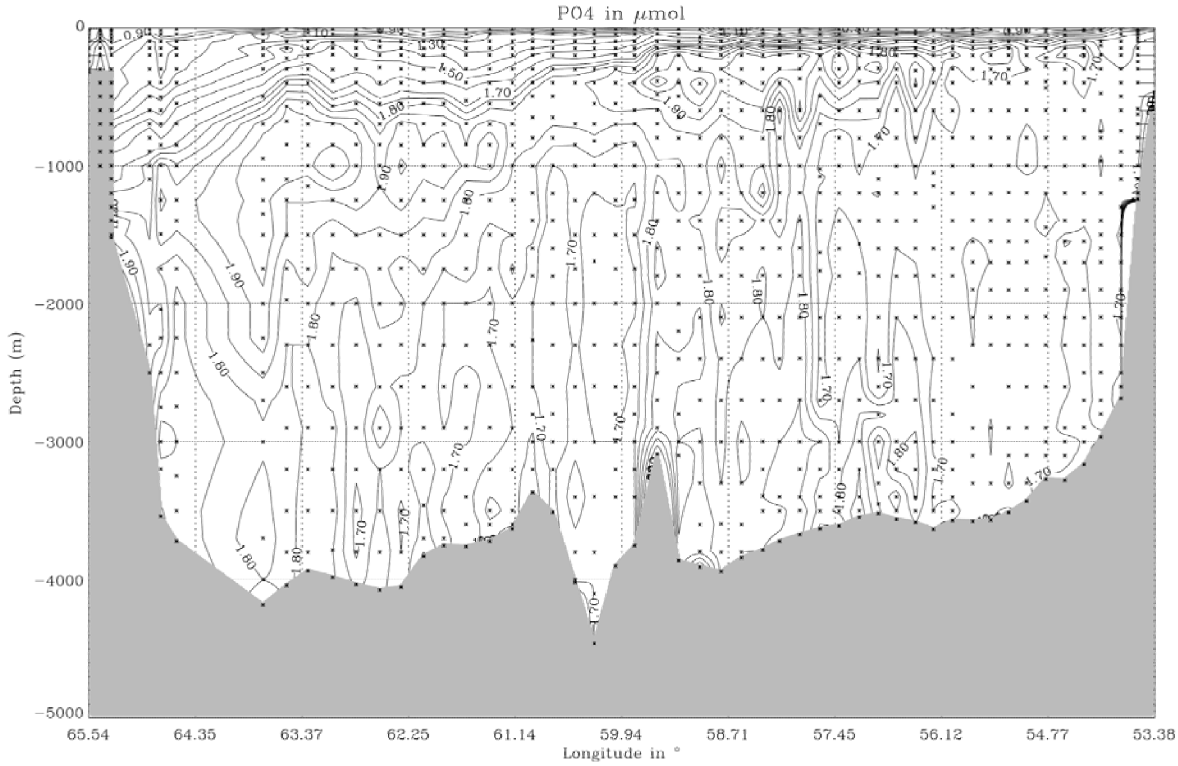

Fig. 3.13: Vertical section of the transect Punta Arenas – Antarctic Peninsula of PO_4 concentrations

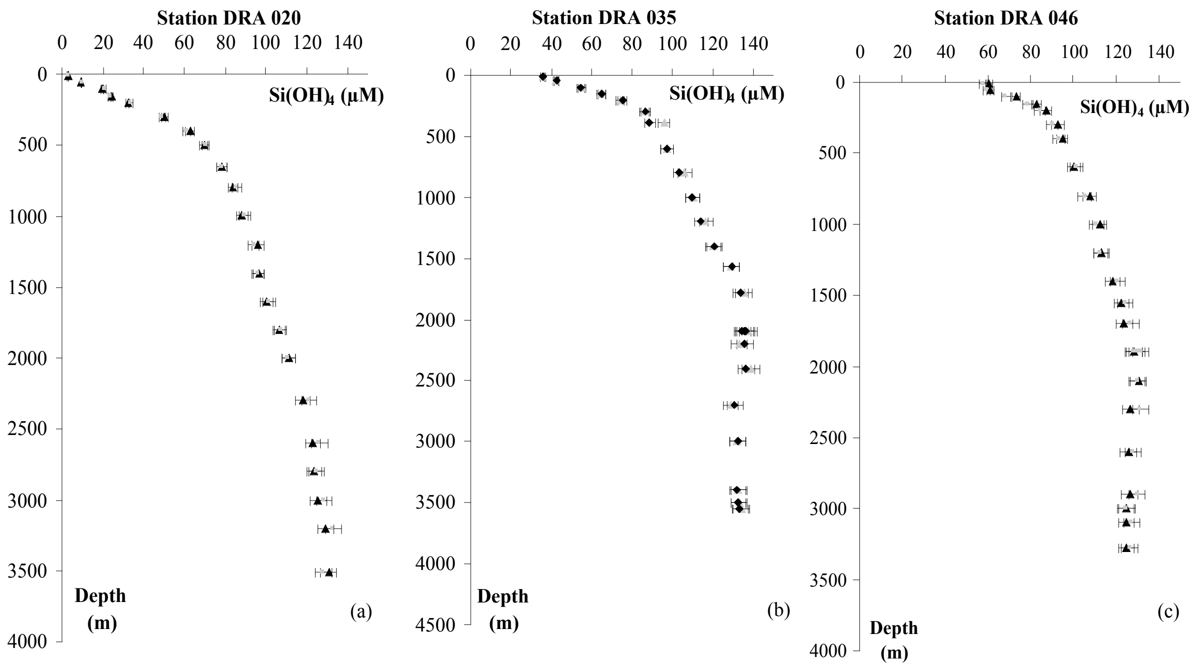

Fig. 3.14: Vertical profile of Si $(OH)_4$ (μM) in measured with colorimetry and cyclic voltammetry

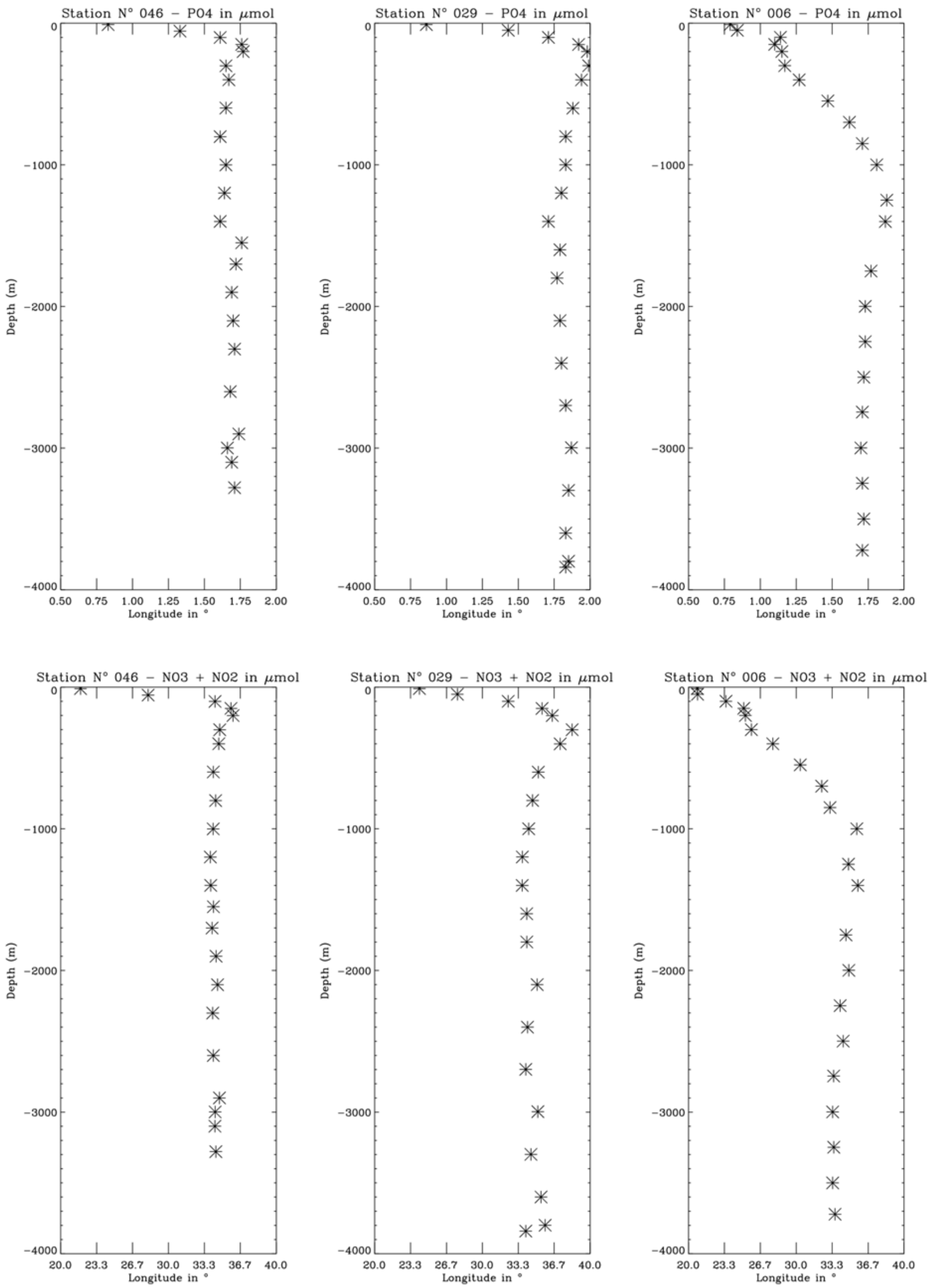

Fig. 3.15: Vertical profiles of PO_4 (top) and NO_3 (bottom)

3.6. Dissolved oxygen measurements

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LOCEAN University Piere et Marie Curie, Paris

At each station discrete bottle samples were collected for the analysis of dissolved oxygen which were measured within a few hours after collection. Dissolved oxygen was determined according to the Winkler method (Strickland and Parsons, 1972) using potentiometric titration. Replicates were collected at each CTD station. A total of 1,240 samples were collected during our ANT-XXIII/3 cruise. A vertical section of dissolved O_2 obtained during the Punta Arenas - Antarctic peninsula transect is shown in figure 3.16.

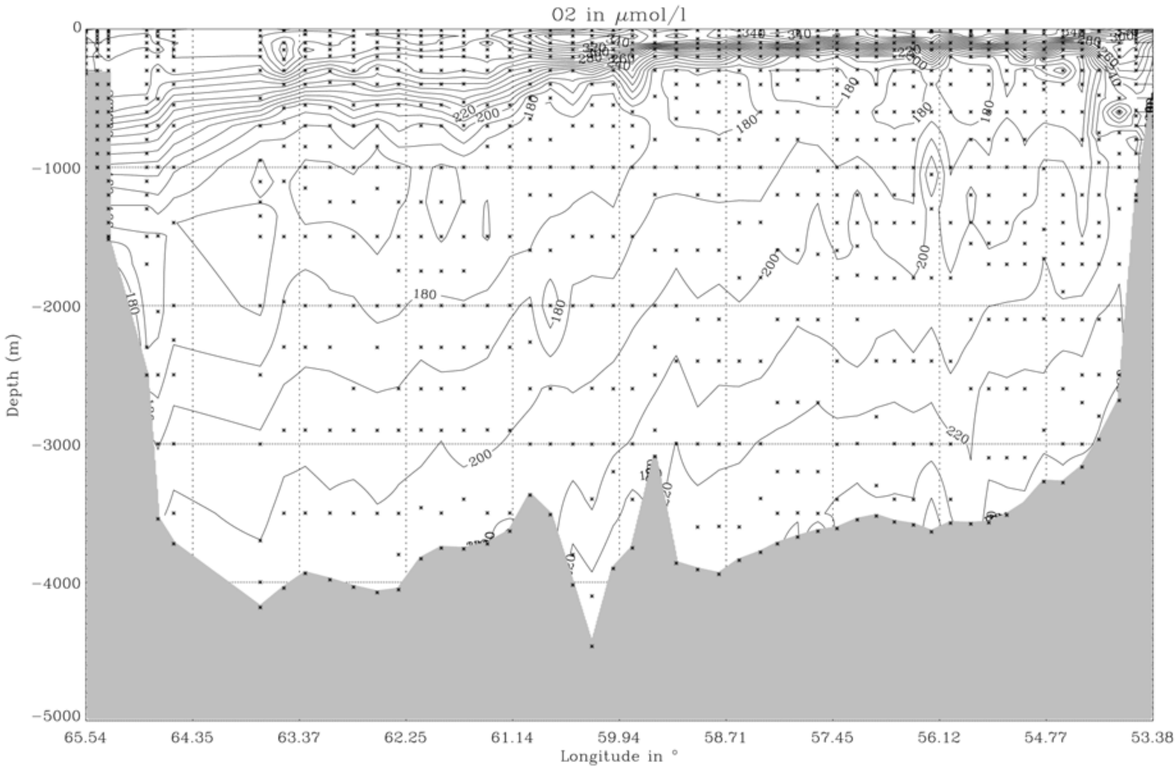

Fig. 3.16: Vertical transect of dissolved oxygen

3.7. Chlorophyll a

Laurence Beaumont[1)], Bernard Schauer[2)]
[1)]CNES Meudon
[2)]LOCEAN University Piere et Marie Curie, Paris

Measurements of chlorophyll a (Chl a) were carried out at each CTD station at discrete depth intervals ranging from 10 to 150 m. Chl a concentrations were also determined on a daily basis (at 6 pm, local time) in surface water collected from the ship's pump (pump's inlet of the thermosalinograph). Water samples for Chl a determination were filtered onto 25 mm diameter GF/F filters at pressures not exceeding 200 mbar. Filters were immediately transferred to centrifuge, then sealed and stored at –80° C waiting to be analyzed. Chl a was extracted with 6 ml of 90 % acetone during 24 hours at 5° C in the dark. The supernatant, obtained by centrifugation, was measured for Chl a content in a Turner 10-AU fluorometer. Calibration of the fluorometer was carried out at the beginning and at the end of the cruise following JGOFS protocol procedure. Chl a content was calculated using the equation given by Jeffrey and Humphrey (1975). Duplicate water samples were taken from depths ranging between 10 and 50 m. A total of 500 samples have been analyzed. A section of Chl a obtained during the Punta Arenas- Antarctic Peninsula transect is shown in figure 3.17.

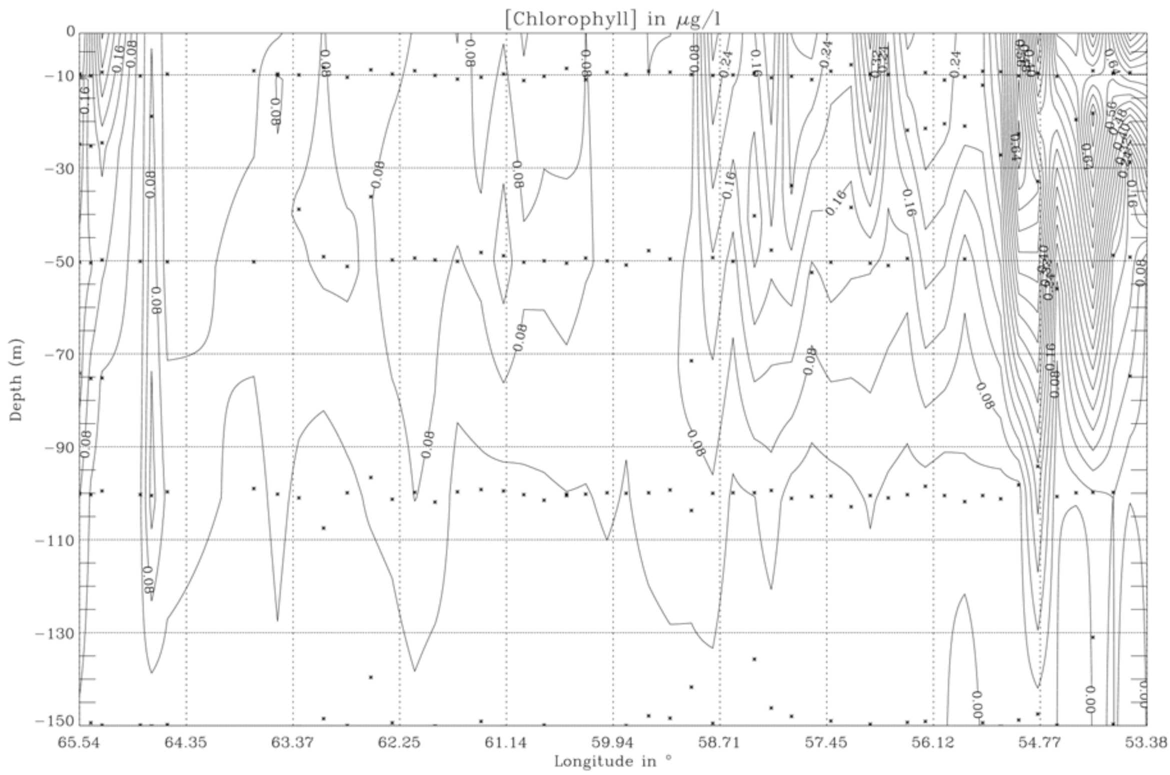

Fig. 3.17: Vertical transect of Chlorophyll a

References

Jeffrey, S.W. and G.F. Humphrey, 1975 : New spectrophotometric equations for determining chlorophylls-a, -b, -c1 and -c2 in higher plants, algae and natural phytoplancton. Biochem. Physiol. Pflanzen 167: 191-194.

4. TRACER MEASUREMENTS: HELIUM ISOTOPES, NEON, CFCS

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IUP Institute of Environmental Physics – Oceanography, University Bremen

Objectives

The Drake Passage is an important entry for several water masses as well as for trace substances like helium and CFCs from the Pacific into the Atlantic Ocean. They are carried with the Antarctic Circumpolar Current (ACC) around the Antarctic Continent and, thus, can enter the South Atlantic and the Weddell Sea.

Ocean surface water is mostly in equilibrium with atmospheric helium (mainly ^4He), the helium isotope ratio ($^3He/^4He$) and neon. Neon has no internal oceanic sources while primordial helium enters the ocean from spreading regions of the submarine ridge systems (mainly in the Pacific, mantle helium with a far higher $^3He/^4He$ ratio), from the earth crust (lower $^3He/^4He$), and from glacial ice.

CFCs are anthropogenic tracers and enter the ocean by gas exchange with the atmosphere. The evolution of these transient tracers in the ocean interior is determined by their temporal increase in the atmosphere since the middle of the last century and the formation, advection and mixing processes of intermediate, deep and bottom water.

A distinct water mass (southeast Pacific Deep Slope Water, SPDSW) carried by the ACC into the Atlantic was revealed on a tracer section across Drake Passage (Meteor 11/5 in 1990) by its elevated $^3He/^4He$-ratio close to the continental slope of South America in depth of 1,500 to 3,500 m. This tracer signal originates from water which was in contact with the submarine ridge system in the deep Pacific. This water mass enters the South Atlantic and is an important source of ^3He for the Atlantic Ocean and the Weddell Sea. The signal can be traced far further to the east and to the north. However, on a repeat section several years later (James Clarke Ross 40 in 1999) the high $^3He/^4He$ core was almost separated into two and partly shifted off the slope, indicating the high variability of the transport of this water mass.

During this cruise we repeated the tracer section across Drake Passage a bit further eastward but with a similar or even higher resolution as the two pervious cruises mentioned above. One aim is to observe the spatial and temporal variability of the high $^3He/^4He$ core from the deep Pacific (SPDSW). These measurements are perfectly accompanied by the oxygen and nutrient measurements, enabling a multiparameter analysis to calculate the fractions of SPDSW across Drake Passage. The transport into the Atlantic will be calculated by combining the SPDSW fractions with the velocity field from geostrophic calculations and lADCP measurements.

Further we repeated the observation of the evolution of the CFC inventory in the water masses entering the Atlantic Ocean from the Pacific, which are basically old but even in larger depths expected to be no longer CFC free.

Work at sea

On the Drake Passage section we took a total of 192 samples for helium isotopes and neon, distributed on 18 profiles, mainly to resolve and locate the assumed SPDSW core precisely. Additionally we took 330 samples for CFCs distributed on 22 profiles. Most of the profiles were carried out on the first section southward and thus will provide a synoptic section of the variable current system. Two stations were on the repeated second section northwards: one station to fill the gap in the southward section close to 55.9°S (both with He/Ne and CFCs) and one repeat of station PS89/138 (CFCs only to check for synopticity in the gas tracers).

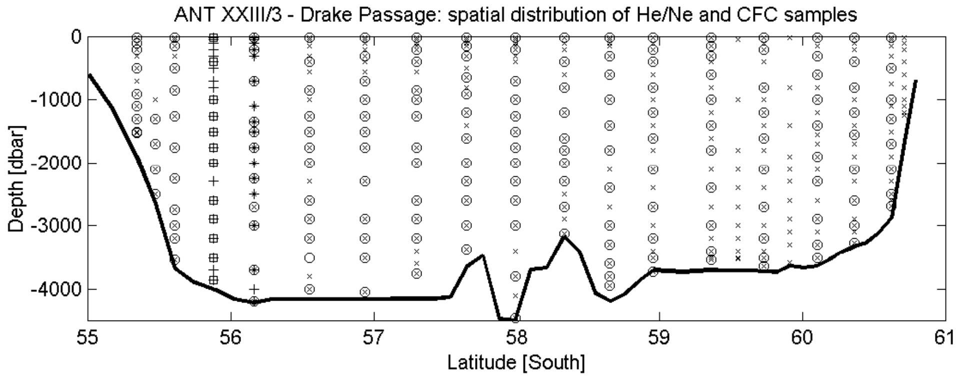

Fig. 4.1: Distribution of helium isotope and neon samples (o southward section, squares northward section) and CFC samples (x southward and + northward) across Drake Passage section. Bottom topography is only roughly indicated.

The helium isotope and neon water samples were tapped in copper tubes, carefully preventing smallest air bubbles during the filling of the tubes and squeezed at both ends to keep them gas-tight during transportation and storage. They were shipped home immediately after the cruise. In our Bremen noble gas lab they will be degassed and then analysed with a sector field and quadrupole mass spectrometer. The measurements are expected for summer 2006.

The CFC water samples are stored in glass ampoules without contact to the atmosphere during the tapping. Immediately after sampling the ampoules are sealed off by melting after a CFC free headspace of pure nitrogen had been applied. Also the CFC samples were shipped home to be analysed in the Bremen gas chromatography lab. The measurements will carried out by a gas chromatograph and electron capture detector system (GC/ECD).

5. SEA LEVEL AND SEA-STATE MEASUREMENTS BY GPS

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LEGOS ONP, Toulouse

Objectives

The along track GPS measurements in the Drake Passage have two main objectives:

- Measuring accurately the along track sea level with respect to the geodetic network, i.e. with respect to the International Terrestrial Reference Frame (ITRF). These sea level data combined with altimetric and gravimetric data (those collected during this campaign, completed with data from the geodetic satellite Grace) should allow to cross-compare the sea level estimates and to compute with the needed accuracy the geoid undulations along the JASON ground-track giving access to the absolute transport in this area.

- Measuring the Significant Wave Height (SWH) during the cruise. High-frequency GPS measurements (1 second sampling) will provide a good estimate of this parameter. These independent SWH measurements will be compared to model outputs, RV *Polarstern* observations and altimetric SWH measurements. This should allow a better validation and correction of the altimetric data as sea state bias is one of the major sources of altimetric errors.

Such GPS surveys at sea have been successfully conducted in previous campaigns over distances of few kilometres (Bonnefond et al., 2003). In Drake Passage the distance between the moving GPS receivers and the fixed GPS can be as long as 400 km at mid-way. Three GPS receivers installed on board RV *Polarstern* have been used during the cruise. These GPS data have been calibrated along the way with respect to GPS buoy measurements. They will be processed further in a kinematic mode with respect to ITRF stations located south of South America and in Antarctica to calculate continuously the position and height of the ship, and consequently of the sea level, along its route.

Work at sea

- GPS reference permanent stations
  The ITRF stations of *Jubany* (Argentina), *Belgrano* (Argentina), *Commandante Ferraz* (Brazil), *Palmer* (US), *Bernardo O'Higgins* (Chile) on Antarctica side, plus *Punta Ar*enas (Chile) and *Rio-Grande* (Argentina) on South America side, and *Orcada* (Argentina) to the east of Drake Passage, have been solicited to run their GPS receiver at 1s sampling data with a cut off angle of 10° elevation. These data will be made available after the cruise for further analysis. The *Rio Grande* and *Belgrano* multi-technique stations will permit a geodetic connection between GPS and nearby *Doris Stations* (both systems being used for the precise orbit determination of the Jason satellite).

- GPS receivers on-board RV *Polarstern*
  Two Trimble (GPS 5700) GPS have been installed on board RV *Polarstern*, before leaving Punta Arenas. One antenna has been fixed on port side and one antenna on starboard side, both on the highest accessible platform of the ship (Fig. 5.1). The two receivers, linked to the antenna by a 20 meter long cable, were set up to 1s sampling, 7° elevation cut off. They were running continuously. One Ashtech Z12 receiver was kindly provided on board the ship (the antenna is on the top platform of the ship). This receiver was also set up to 1s sampling, 10° elevation cut off. It was driven, as for the Ashtech Z12 of Punta Arenas, by a programme allowing an automatic downloading of the data via a PC lap top (Markus Ramatshi, personal communication).

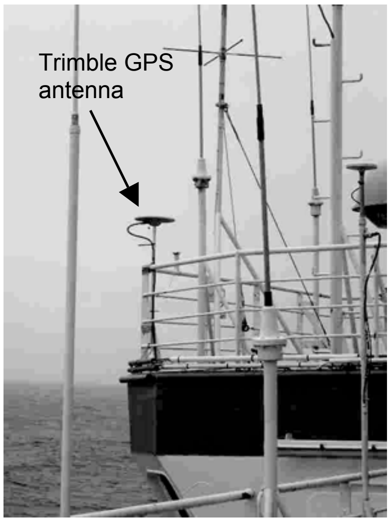

Fig. 5.1: Port side Trimble antenna

  Unfortunately, that receiver had to face frequent interruptions, apparently because of its old conception not optimized for kinematic survey.

- Buoy sessions
  In order to calibrate the on-board RV *Polarstern* GPS measurements with respect to the sea level, GPS buoy sessions were frequently conducted during CTD fixed stations along the two transects (Fig. 5.2). The antenna of a Trimble (GPS 5700) was fixed on the top of the buoy, in fact two safety buoys superimposed, and linked by a cable of 25 m long to the receiver (Fig. 5.3). The GPS was set up to 1s sampling, 7° elevation cut off. The buoy was moored on the back of the ship. The sessions were 2 hours long on average (during CTD casts), with few sessions of 4 to 5 hours during pumping stations. We collected a total of about 120 hours of GPS buoy data, during 50 sessions.

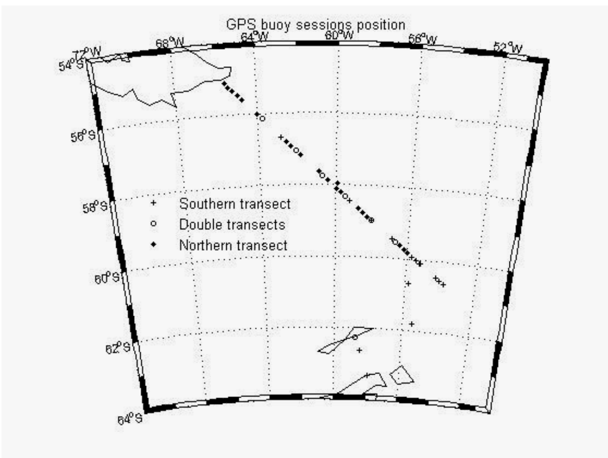

Fig. 5.2: GPS buoy sessions position


Fig. 5.3: GPS buoy (image by C. Clement-Chatel)

The simultaneous running of the buoy GPS receiver with on-board RV *Polarstern* GPS receivers, will be essential to perform a precise connection between the sea level and the RV *Polarstern* GPS antenna along its route (the buoy being itself calibrated with respect to the sea level). The buoy measurements will also be very helpful to estimate the swell and significant wave-height and its impact on RV *Polarstern* GPS measurements. GPS buoy sessions have been done in Punta Arenas (at the departure and at the arrival), and in *Jubany* and *O'Higgins*, providing important calibration points due to the proximity of fixed GPS stations.

In addition, during our few hours stop in *O'Higgins*, a GPS buoy session was conducted just above the tide gauge, which has been installed by IFAG (Andreas Reinhold). This tide gauge is a pressure sensor from Aanderaa, sampled at 10 min. and levelled with respect to the nearby fixed GPS station. This *O'Higgins* survey will provide a double check point of the sea level, one provided by the buoy, the other one provided by the tide gauge. We were expecting to do the same above the Punta Arenas tide gauge but unfortunately this tide gauge was out of order.

The GPS data require a quite heavy editing, validation and processing, especially when used in the kinematic mode and when an ultimate accuracy of few centimetres is expected on the vertical component. This will be done after the campaign. On board the RV *Polarstern*, only a checking control was done, providing a rough figure of the quality of the data. The number of received satellites, their coverage, the elevation of each satellite, the signal to noise ratio are some of the control parameters which have been checked on-board. An average of 8 satellites was received during the buoy sessions, with an elevation comprised between 10° and 80°, and a signal to noise ratio of 42 dBHz in average, indicating that the data should have a good quality level (Fig. 5.4).

- On-board gravimeter survey (see chapter 3.1.2 ship observations page 19)
- Additional data

Meteorological data from the weather station on-board (sea state, wind, pressure, temperature...) and outputs from the ECMWF models (wind sea, swell, SWH) will be used to compare with the sea-state estimates derived from GPS, altimetry and gravimeter data collected during the campaign.

Navigation data extracted from the Marine Inertial Navigation System and the ship navigation system may be also useful to distinguish and filter swell, roll and pitch movements from the GPS and gravimetric data.

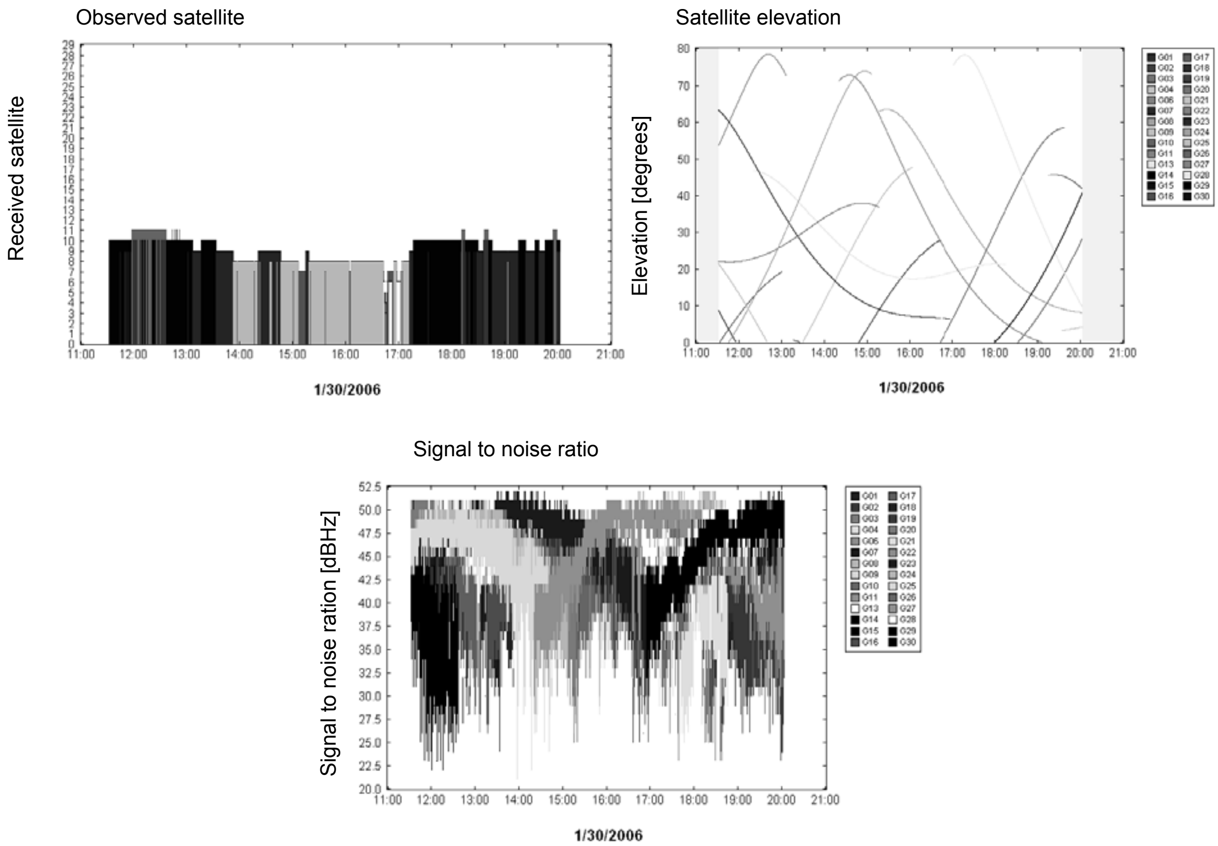

Fig. 5.4: GPS data checking with Trimble software (Buoy session 30/01/2006 during pumping station (60°29.287'S / 55°47.726'W))

Expected results

The main expected outputs of this work include:

- The demonstration that sea level and sea state GPS survey is feasible, with an acceptable error (to be defined), even over distances of few hundreds kilometres.
- The generation of sea state profiles for the southward and northward transects. They will be compared with altimetry, model outputs and observations made during the cruise.
- The generation of sea level height profiles for the southward and northward transects to be compared with altimetry for validation.
- The generation of a mean sea level and geoid profiles along the RV *Polarstern* track to be compared with altimetry.
-

The results of this experiment will be published and documented with a complete error budget .

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6. GEOTRACES

Catherine Jeandel[1)], Michiel Rutgers van der Loeff[2)],
Jana Friedrich[2)], Catherine Pradoux[1)]
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[2)]Alfred-Wegener-Institut

Objectives

Our contribution to ANT-XXIII/3 DRAKE is proposed in the framework of the emerging GEOTRACES programme in Europe, recently endorsed by the Scientific Committee for Oceanographic Research (SCOR).

Developing a full understanding of the distribution and biogeochemical behaviour of **trace elements and their isotopes** (TEIs) in seawater has the potential to provide unique insights into a wide range of oceanic processes: quantifying key processes regulating the marine carbon cycle, insight into the mean velocity field and mixing processes in the ocean on very slow timescales with a direct link to the climate forcing (on present-day and geological time scales). With this approach we expect to achieve a better calibration of paleo-oceanographic proxies related to the climate forcing.

The Drake Passage is of primary interest since it is a key route for main water masses involved in the thermohaline circulation. Among them, one has to solve and to quantify the importance of the cold route for the returning flow into the South Atlantic. Another main target is to understand the role of the southern American tip (Patagonian Shelf) and the Antarctic Peninsula on the circulation and composition of the water masses flowing through the Drake passage, as for example the southeast Pacific Deep Slope Water, SPDSW. It is therefore important to know the distribution of TEIs in the water masses entering the Atlantic Ocean through Drake Passage.

Selected trace elements and isotopes are planned to be measured on samples collected in the DRAKE ANT-XXIII/3 cruise since they are useful tools for tracing the slow ventilation rates, the origin and pathways of the water masses, and particle flux in the ocean.

- The group of Thorium isotopes is of particular interest due to the particle reactivity of the element and the variability in half-lives amongst the isotopes. The Th isotopes differ strongly in their distribution pattern in the ocean as a consequence of their differing sources and half lives: they can be used to quantify the rate of particulate organic export at different time scales from days to weeks to scales associated with quaternary studies.
- ^{231}Pa is the decay product of ^{235}U, which is like ^{234}U conservatively distributed in the ocean. The study of the ^{230}Th/^{231}Pa distributions on the dissolved and different particulate phases, associated with the other tracers, helps to understand the

story of the water masses: their “ventilation age”, their pathways, and eventually if they have encountered intense particle scavenging.

- The couple Nd concentration - isotopic composition (IC) is an interesting tracer of the origin and of the circulation of oceanic water masses on the scale of an oceanic basin. Although less known and studies so far, close applications are expected from the distribution of Hf isotopes. Studying the distribution of this element in the deep waters (those imprinting the authigenic metalliferous sediments used for paleo-reconstructions) can also be used to calibrate the “proxy” Nd for paleo-studies.
- The first deep ^{226}Ra and shallow ^{228}Ra profiles in the Drake Passage were obtained in the GEOSECS Programme. In the past decade, various studies have been performed on radionuclides in the Drake Passage. A detailed section of ^{226}Ra and a course section of ^{228}Ra in the surface water were made by Hanfland, and the first ^{227}Ac profile was obtained by Geibert. Especially for ^{228}Ra, tracer of contact with coast and shelf sediments, and ^{227}Ac, tracer for upwelling of deep waters, the data base for their distribution in Drake Passage is extremely thin. We have previously made sections of ^{234}Th in surface water of the Bransfield Strait and the SE Pacific, but a section of this isotope, which is a measure of export production, has not yet been made across the Drake Passage.
- Particle reactive TEI’s as ^{210}Po, ^{210}Pb and ^{234}Th can serve as a tool to trace the fluxes of organic carbon, biogenic silica, proteinaceous matter selectively. In the open ocean, the particles that scavenge and remove ^{210}Pb and ^{210}Po from the water column consist mainly of organic matter, e.g. biodetritus, organic and inorganic colloids, plankton and nekton. The depletion of total ^{210}Pb with respect to ^{226}Ra in the surface water is caused by the removal with larger, sinking particles. In contrast, ^{210}Po/^{210}Pb disequilibria may not be associated with downward organic particle export only, but also caused by bacterial uptake and transfer to higher trophic levels (nekton). Global data show that ^{210}Po deficiencies decrease as ocean productivity increases which is contrary to the widely held concept that removal of bioreactive elements is more efficient in the productive ocean due to a larger population of sinking particles. Therefore, one of our tasks is the re-evaluation of Po as tracer for downward flux of organic carbon.

Because all these tracers bring different and complementary information on oceanic processes and transport of water masses, our strategy was to collect and/or filtrate volumes of seawater large enough to allow measuring all of them at the same location and depth.

Work at sea

The station location, date of sampling, depth and volume of samples collected are compiled in table 6.1

Seawater samples have been collected at 5 stations (+ some additional depths close to the northern slope during the trial station) on the way down along the DRAKE cruise track. At the last station of the section (PS69/181-DRA 50) large volume filtration using *in-situ* pumping at 6 different depths was also performed. We realized another pumping station in the eastern basin of the Bransfield Strait (PS69/183-DRA

52, 6 depths) and a last one the first day of the return trip, off the Drake section but exactly at the foot of the slope off the South Shetland Shelf (PS69/193-DRA 62, 6 depths). At all three pumping stations, the *in-situ* pumping was complemented by large-volume CTD sampling (with two additional casts) for analysis in discrete water samples at the same depths. Finally, we reconstituted "stations" on the way back, by piecing together samples collected over 5 neighbour CTD casts selected in order to characterize the water masses of the southern part of the Polar Front (PS69/205-DRA 74 to PS69/209- DRA 78), those found into the central canyon and within the Polar Front area (PS69/215-DRA 84 to PS69/219- DRA 88), those of the northern part of the Polar Front (PS69/225-DRA94 to PS69/229-DRA 98) and those close to the northern shelf of the Drake Passage. At each of these stations, only one or two levels have been sampled but we did close between 3 and 11 Niskin bottles at these specific levels (corresponding to about 36 - 132 l of seawater), allowing the measurements of Ac, Po, Pb, Ra, Nd, Th isotopes and REE concentration - a very large amount of different tracers in the same water sample. Such experiment is of a first importance in the framework of a pre-GEOTRACES cruise.

As already underlined, our plans are to analyze a maximum of tracers simultaneously, but this strongly depends on the volumes of water that have been collected each time. For some samples, identified by a star (*) in the table 6.1 intercomparison between AWI and LEGOS labs will be realized. As a first step, intercomparison will be focused on Th isotopes.

An aliquot of about one third of the Toulouse's seawater samples (12 l over 36 l) have been filtered on board immediately after sampling, spiked in ^{229}Th and co-precipitated/filtered for further chemical purification and mass spectrometric analysis. This will allow a first determination of Nd isotopic composition and ^{230}Th activity of these samples. The remaining seawater was acidified to pH 2 for storage and further complete analysis back in Toulouse (duplicate for Th and Nd, but ^{226}Ra and ^{231}Pa will also be determined on these samples).

For each of the collected samples, Toulouse's group also performed suspended particle filtrations (on about 36 l of seawater) in order to analyze further the chemical composition of these suspended particles: major and trace elements as well as Nd, Th and Pa isotopes will be measured by spectrometry after an acid digestion and a chemical purification of these particles.

Suspended matter in surface waters have been collected with a continuous centrifuge using the ship's seawater supply. This material will be analysed for all tracers in Toulouse and Bremerhaven and also contribute to the intercomparison exercise. Moreover, we want to investigate whether material collected in this way is suitable for wider scale intercomparisons in the framework of GEOTRACES.

On the stations where we performed large-volume CTD sampling, the AWI group filtered 60-80 l of seawater. The particulate fraction will be analysed for ^{210}Po, ^{210}Pb and Th isotopes; the filtrate was coprecipitated with MnO_2. The MnO_2 precipitate was counted on board for ^{234}Th, and will be analysed later for other Th and Ra isotopes and for Ac-227.

Test of automated ^{234}Th analyser
A filtration unit developed for automatic determination of ^{234}Th in surface waters, used for the first time during the first leg of this expedition (ANT-XXIII/1), was further tested and compared with ^{234}Th analyses with conventional methods. Detailed sections were made when passing the fronts, when crossing the transition from the open ocean to the shelf, and on our crossing of the Bransfield Strait. Although the instrument can collect samples for particulate and dissolved fractions separately, in order to improve counting statistics it was primarily used in the mode to measure only total ^{234}Th, the parameter that tells us the status of the surface water with respect to particle export to deeper layers after plankton production. The 47 mm diameter filters with precipitates were counted in a 10-channel beta counter. 25-mm diameter subsamples were then recounted in the smaller Riso counter with a much lower background, thus yielding a better signal to noise ratio. The efficiency of the MnO_2 coprecipitation was checked with a ^{230}Th spike, to be later analysed in Bremerhaven.

^{210}Po and ^{210}Pb were sampled from the surface water on the transect from South America to the Antarctic Penninsula. The water (20 l for dissolved, 20-100 l for particles) was taken from the ship's seawater supply which is operated by a membrane pump. The samples were filtered immediately; the dissolved fraction was chemically separated on board ship. The particles on the filters will be analysed in the lab at AWI. Aliquots of the water had been used to take samples for POC and chlorophyll a. In addition to the surface sampling, the three deep casts realised by *in-situ* pumping water over MnO_2-coated cartridges will be also used for measuring the depth distribution of ^{210}Po and ^{210}Pb.

Radium Isotopes will be analysed in the MnO_2-coated cartridges attached to the *in-situ* pumps. As ^{228}Ra is an important tracer of waters influenced by contact with the continent and may therefore be indicative of areas subject to Fe fertilization by the continent, we have made additional sampling of Radium isotopes in surface waters, especially in the regions closer to the Peninsula and the Argentinean coast. Along with all Radium sampling we have collected samples to be analysed for Barium by Dehairs (Brussels). It was found previously by Hanfland that the relationship between ^{226}Ra and silicate, which is quite good in certain ocean areas, does not hold in the regions of the ACC fronts, and we hope that the relationship with Ba may shed light on the form in which these elements are exported from the surface water.

Two 100 - l samples, one of Upper Circumpolar Deep Water (UCDW) and one of Lower Circumpolar Deep Water (LCDW), were collected for analysis of Hf isotopes by Frank and Rickli (IFM-GEOMAR/ETH Zürich).

Expected results
The distribution of the tracers mentioned will give information on the origin and pathways of water masses, and on the export of particles out of the euphotic zone. The present project is a valuable pilot for a full GEOTRACES transect in the DRAKE Passage that will be carried out two years later in the framework of IPY (Expedition Zero and Drake).

Tab. 6.1: Station location, date of sampling, depth and volume of samples

Station No. PS69/	DRAKE/	Instrument	day/mon/y	Latitude °	Longitude °	Depth (m)	Volume (liters)	Targeted Tracers
132		seawater intake	16.01.2006	-55°06.822	-65°32.970	surface	704	Ra
132	DRB 001	CTD/Rosette	16.01.2006	-55°06.86	-65°33 04	50	20	REE,Nd, Th
132	DRB 001	CTD/Rosette	16.01.2006	-55°06.86	-65°33 04	150,5	11	REE, Nd
132	DRB 001	CTD/Rosette	16.01.2006	-55°06.86	-65°33 04	320m	20 ml	Ba (0, 50, 150, 200, 300, 320m)
132	DRB 002	CTD/Rosette	16.01.2006	-55°13.98	-65°22.31	500	30	REE, Nd, Th, Pa
132	DRB 002	CTD/Rosette	16.01.2006	-55°13.98	-65°22.31	900	30	REE, Nd, Th, Pa
134		seawater intake	16.01.2006	-55°21.019	-65°09.967	surface	523	Ra surface, Ba surface, Po
137*	DRB 006*	CTD/Rosette	17.01.2006	-55°45	-64°30	20	36	REE, Nd, Th, Pa
137*	DRB 006*	CTD/Rosette	17.01.2006	-55°45	-64°30	300	36	REE, Nd, Th, Pa
137*	DRB 006*	CTD/Rosette	17.01.2006	-55°45	-64°30	1000	36	REE, Nd, Th, Pa
137*	DRB 006*	CTD/Rosette	17.01.2006	-55°45	-64°30	1800	36	REE, Nd, Th, Pa
137*	DRB 006*	CTD/Rosette	17.01.2006	-55°45	-64°30	2500	36	REE, Nd, Th, Pa
137*	DRB 006*	CTD/Rosette	17.01.2006	-55°45	-64°30	3654	36	REE, Nd, Th, Pa
137	DRB 006*	CTD/Rosette	17.01.2006	-55°45	-64°30	1250	20 ml	Ba (0, 10, 50, 100, 150, 200, 300, 400, 550, 700, 850, 1000, 1250m)
137		seawater intake	17.01.2006	-55°45.025	-64°30.33	surface	1488	Ra, Po, Chla, POC
138		seawater intake	17.01.2006	-56°09.188	-63°46.055	surface	1347	Ra, Po, Chla, POC
140	DRB09	CTD/Rosette	18.01.2006	-56°25	-63°10	1200	60	Th, Ac
140	DRB09	CTD/Rosette	18.01.2006	-56°26	-63°11	2400	60	Th, Ac
140	DRB09	CTD/Rosette	18.01.2006	-56°27	-63°12	3600	60	Th, Ac

Station No. PS69/	DRAKE/	Instrument	day/mon/y	Latitude °	Longitude °	Depth (m)	Volume (liters)	Targeted Tracers
144*	DRB013*	CTD/Rosette	19.01.2006	-56°55.96	-62°21	28	36	REE, Nd, Th, Pa
144*	DRB013*	CTD/Rosette	19.01.2006	-56°55.96	-62°21	226	36	REE, Nd, Th, Pa
144*	DRB013*	CTD/Rosette	19.01.2006	-56°55.96	-62°21	938	36	REE, Nd, Th, Pa
144*	DRB013*	CTD/Rosette	19.01.2006	-56°55.96	-62°21	2000	36	REE, Nd, Th, Pa
144*	DRB013*	CTD/Rosette	19.01.2006	-56°55.96	-62°21	3690	36	REE, Nd, Th, Pa
144*	DRB013*	CTD/Rosette	19.01.2006	-56°55.96	-62°21	3993	36	REE, Nd, Th, Pa
144	DRB013	CTD/Rosette	19.01.2006	-56°55.96	-62°21	4053	20 ml	Ba (10, 50, 101, 149, 200, 299, 401, 551, 700, 851, 1000, 1251, 1504, 1747, 2001, 2298, 2600, 2900, 3100, 3501, 3799, 4053 m)
144		seawater intake	19.01.2006	-56°56.03	-62°21.09	surface	1788	Ra, Po, Chla, POC
150		seawater intake	20.01.2006	-57°37.841	-60°52.142	surface	82	Po, POC, Chla
161*	DRB030*	CTD/Rosette	22.01.2006	-58°52	-58°18.1	20	36	REE,Nd, Th, Pa
161*	DRB030*	CTD/Rosette	22.01.2006	-58°52	-58°18.1	100	36	REE,Nd, Th, Pa
161*	DRB030*	CTD/Rosette	22.01.2006	-58°52	-58°18.1	600	36	REE,Nd, Th, Pa
161*	DRB030*	CTD/Rosette	22.01.2006	-58°52	-58°18.1	1200	36	REE,Nd, Th, Pa
161*	DRB030*	CTD/Rosette	22.01.2006	-58°52	-58°18.1	2200	36	REE,Nd, Th, Pa
161*	DRB030*	CTD/Rosette	22.01.2006	-58°52	-58°18.1	3000	36	REE,Nd, Th, Pa
161*	DRB030*	CTD/Rosette	22.01.2006	-58°52	-58°18.1	3677	36	REE,Nd, Th, Pa
161	DRB030	CTD/Rosette	22.01.2006	-58°51.944	-58°17.984	3793	20 ml	Ba (10, 50, 100, 150, 200, 300, 400, 600, 800, 1000, 1200, 1400, 1600, 1800, 2100, 2400, 2700, 3000, 3200, 3400, 3500, 3700m)
174		seawater intake	24.01.2006	-60°04.712	-55°15.976	surface	15	Po, POC, Chla

Station No. PS69/	DRAKE/	Instrument	day/mon/y	Latitude °	Longitude °	Depth (m)	Volume (liters)	Targeted Tracers
181-1	DRB50	CTD/Rosette	25.01.2006	-60°42	-53°37	33	36	REE,Nd, Th, Pa, Ra
181-1	DRB50	CTD/Rosette	25.01.2006	-60°42	-53°37	254	96	REE,Nd, Th, Pa, Ra, Ac
181-1	DRB50	CTD/Rosette	25.01.2006	-60°42	-53°37	500	96	REE,Nd, Th, Pa, Ra, Ac
181-1	DRB50	CTD/Rosette	25.01.2006	-60°42	-53°37	750	36	REE,Nd, Th, Pa, Ra
181-1	DRB50	CTD/Rosette	25.01.2006	-60°42	-53°37	1240	20 ml	Ba (10, 30, 50, 70, 100, 150, 200, 250, 300, 400, 500, 600, 700, 800, 900, 1000, 1100, 1200, 1240m)
181-2		ISP	25.01.2006	-60°42.467	-53°37.025	50	182	Ra, REE, Nd, Th, Pa, Po
181-2		ISP	25.01.2006	-60°42.467	-53°37.025	254	357	Ra, REE, Nd, Th, Pa, Po
181-2		ISP	25.01.2006	-60°42.467	-53°37.025	500	836	Ra, REE, Nd, Th, Pa, Po
181-2		ISP	25.01.2006	-60°42.467	-53°37.025	750	420	Ra, REE, Nd, Th, Pa, Po
181-2		ISP	25.01.2006	-60°42.467	-53°37.025	1100	552	Ra, REE, Nd, Th, Pa, Po
181-2		ISP	25.01.2006	-60°42.467	-53°37.025	1400	911	Ra, REE, Nd, Th, Pa, Po
181-3	DRC50	CTD/Rosette	26.01.2006	-60°42	-53°37	750	84	Ra, REE, Nd, Th, Pa, Po
181-3	DRC50	CTD/Rosette	26.01.2006	-60°42	-53°37	1000	108	Ra, REE, Nd, Th, Pa, Po
181-3	DRC50	CTD/Rosette	26.01.2006	-60°42	-53°37	1187	96	Ra, REE, Nd, Th, Pa, Po
183-1	DRB52	CTD/Rosette	26.01.2006	-61°50	-55°26	30	60	REE, Nd, Th, Pa, Ra

Station No. PS69/	DRAKE/	Instrument	day/mon/y	Latitude °	Longitude °	Depth (m)	Volume (liters)	Targeted Tracers
183-1	DRB52	CTD/Rosette	26.01.2006	-61°50	-55°26	220	96	REE, Nd, Th, Pa, Ra, Ac
183-1	DRB52	CTD/Rosette	26.01.2006	-61°50	-55°26	400	96	REE, Nd, Th, Pa, Ra, Ac
183-1	DRB52	CTD/Rosette	26.01.2006	-61°50	-55°26	750	36	REE, Nd, Th, Pa
183-2		ISP	26.01.2006	-61°50.095	-55°37.286	31	1115	Ra, REE, Nd, Th, Pa, Po
183-2		ISP	26.01.2006	-61°50.095	-55°37.286	220	293	Ra, REE, Nd, Th, Pa, Po
183-2		ISP	26.01.2006	-61°50.095	-55°37.286	400	753	Ra, REE, Nd, Th, Pa, Po
183-2		ISP	26.01.2006	-61°50.095	-55°37.286	750	378	Ra, REE, Nd, Th, Pa, Po
183-2		ISP	26.01.2006	-61°50.095	-55°37.286	1465	192	Ra, REE, Nd, Th, Pa, Po
183-2		ISP	26.01.2006	-61°50.095	-55°37.286	2180	794	Ra, REE, Nd, Th, Pa, Po
183-3	DRC52	CTD/Rosette	27.01.2006	-61°51	-55°37	20	72	REE, Nd, Th, Pa, Ra
183-3	DRC52	CTD/Rosette	27.01.2006	-61°51	-55°37	1465	96	REE, Nd, Th, Pa, Ra, Ac
183-3	DRC52	CTD/Rosette	27.01.2006	-61°51	-55°37	2180	96	REE, Nd, Th, Pa, Ra, Ac
183-3	DRC52	CTD/Rosette	27.01.2006	-61°51	-55°37	2180	20 ml	Ba (31, 220, 400, 2180m)
Admirality Bay Jubany		seawater intake	27.01.2006	-62°15.427	-58°43.031	surface	1942	Ra
O' Higgins		seawater intake	28.01.2006	-63°18.296	-57°58.015	surface	1517	Ra
Jubany			29.01.2006	-62°15	-58°44	11	12	REE, Nd, Th surf. Ice Melting Water
Jubany		seawater intake	29.01.2006	-62°15.579	-58°42.739	surface	20	Po, POC, Chla

Station No. PS69/	DRAKE/	Instrument	day/mon/y	Latitude °	Longitude °	Depth (m)	Volume (liters)	Targeted Tracers
193-1	DRB62	CTD/Rosette	30.01.2006	-60°39	-55°48	320	60	REE, Nd, Th, Pa, Ra
193-1	DRB62	CTD/Rosette	30.01.2006	-60°39	-55°48	498	96	REE,Nd, Th, Pa, Ra, Ac
193-1	DRB62	CTD/Rosette	30.01.2006	-60°39	-55°48	870	96	REE,Nd, Th, Pa, Ra, Ac
193-1	DRB62	CTD/Rosette	30.01.2006	-60°39	-55°48	1500	36	REE, Nd, Th, Pa
193-1	DRB62	CTD/Rosette	30.01.2006	-60°39	-55°48	3450	20 ml	Ba (20, 320, 490, 870, 1500, 2500, 3450m)
193-2		ISP	30.01.2006	-60°39.467	-55°48.058	200	1397	Ra, REE, Nd, Th, Pa, Po
193-2		ISP	31.01.2006	-60°39.468	-55°48.059	500	708	Ra, REE, Nd, Th, Pa, Po
193-2		ISP	01.02.2006	-60°39.469	-55°48.060	1000	191	Ra, REE, Nd, Th, Pa, Po
193-2		ISP	02.02.2006	-60°39.470	-55°48.061	1500	519	Ra, REE, Nd, Th, Pa, Po
193-2		ISP	03.02.2006	-60°39.471	-55°48.062	2500	654	Ra, REE, Nd, Th, Pa, Po
193-2		ISP	03.02.2006	-60°39.471	-55°48.062	3500	822	Ra, REE, Nd, Th, Pa, Po
193-3	DRC62	CTD/Rosette	30.01.2006	-60°39	-55°46	3451	96	REE,Nd, Th, Pa, Ra, Ac
193-3	DRC62	CTD/Rosette	30.01.2006	-60°39	-55°46	2500	96	REE,Nd, Th, Pa, Ra, Ac
193-3	DRC62	CTD/Rosette	30.01.2006	-60°39	-55°46	320	60	Ac
193-3	DRC62	CTD/Rosette	30.01.2006	-60°39	-55°46	24	12	REE, Nd, Th surf.
197		seawater intake	31.01.2006	-59°47.076	-56°01.559	surface	20	Po, POC, Chla

Station No. PS69/	DRAKE/	Instrument	day/mon/y	Latitude °	Longitude °	Depth (m)	Volume (liters)	Targeted Tracers
199		seawater intake	31.01.2006	-59°38.013	-56°26.33	surface	448	Ra
204		seawater intake	01.02.2006	-58°57.596	-58°06.273	surface	20	Po, POC, Chla
205	DRA74	CTD/Rosette	01.02.2006	-58°52.17	-58°18.19	30	140	REE, Nd, Th, Pa, Ra, Ac, Pb, Po, Ba, POC
206	DRA75	CTD/Rosette	01.02.2006	-58°45.75	-58°32.91	400	140	REE, Nd, Th, Pa, Ra, Ac, Pb, Po, Ba, POC
207	DRA76	CTD/Rosette	02.02.2006	-58°39.07	-58°47.35	1200	140	REE, Nd, Th, Pa, Ra, Ac, Pb, Po, Ba, POC
208	DRA77	CTD/Rosette	02.02.2006	-58°32.84	-59°2.02	2498	140	REE, Nd, Th, Pa, Ra, Ac, Pb, Po, Ba, POC
209	DRA78	CTD/Rosette	02.02.2006	-58°26.25	-59°16.49	3780	140	REE, Nd, Th, Pa, Ra, Ac, Pb, Po, Ba, POC
210		seawater intake	02.02.2006	-58°19.856	-59°30.999	surface	115	Po, POC, Chla
215	DRA84	CTD/Rosette	03.02.2006	-58°044	-60°27.7	10	36	REE, Nd, Th, Pa, Ba
215	DRA84	CTD/Rosette	03.02.2006	-58°044	-60°27.7	4447	96	REE,Nd, Th, Pa, Ra, Ac, Ba
216	DRA85	CTD/Rosette	03.02.2006	-57°52.56	-60°27.66	3500	96	REE,Nd, Th, Pa, Ra, Ac, Ba
217	DRA86	CTD/Rosette	03.02.2006	-57°45.73	-60°42.65	50	36	REE, Nd, Th, Pa, Ba
	DRA86	CTD/Rosette	03.02.2006	-57°45.73	-60°42.65	80	36	REE, Nd, Th, Pa, Ba
	DRA86	CTD/Rosette	03.02.2006	-57°45.73	-60°42.65	2400	96	REE, Nd, Th, Pa, Ba
218	DRA 87	CTD/Rosette	03.02.2006	-57°39	-60°56	400	36	REE, Nd, Th, Pa, Ba
	DRA 87	CTD/Rosette	03.02.2006	-57°39	-60°56	1800	96	REE, Nd, Th, Pa, Ra, Ac, Ba
219	DRA 88	CTD/Rosette	04.02.2006	-57°31.91	-61°10.41	10	36	REE, Nd, Th, Pa
	DRA 88	CTD/Rosette	04.02.2006	-57°31.91	-61°10.41	900	96	REE, Nd, Th, Pa, Ra, Ac

Station No. PS69/	DRAKE/	Instrument	day/mon/y	Latitude °	Longitude °	Depth (m)	Volume (liters)	Targeted Tracers
225	DRA94	CTD/Rosette	05.02.2006	-56°48'36	-62°35	4080	140	REE, Nd, Th, Pa, Ra, Ac, Pb, Po, Ba, POC
226	DRA95	CTD/Rosette	05.02.2006	-56°40.674	-62°49	2400	140	REE, Nd, Th, Pa, Ra, Ac, Pb, Po, Ba, POC
227	DRA96	CTD/Rosette	05.02.2006	-53°32.86	-63°04	1800	140	REE, Nd, Th, Pa, Ra, Ac, Pb, Po, Ba, POC
228	DRA97	CTD/Rosette	05.02.2006	-56°24.68	-63°18.52	1040	140	REE, Nd, Th, Pa, Ra, Ac, Pb, Po, Ba, POC
229	DRA98	CTD/Rosette	05.02.2006	-56°16.233	-63°32.147	90	140	REE, Nd, Th, Pa, Ra, Ac, Pb, Po, Ba, POC
229		seawater intake	05.02.2006	-56°16.233	-63°32.147	surface	20	Po, POC, Chla
Ra profile 1		seawater intake	06.02.2006	-55°36.164	-64°44.516	surface	1256	Ra
Ra profile 2		seawater intake	06.02.2006	-55°25.892	-65°01.037	surface	1100	Ra
Ra profile 3		seawater intake	07.02.2006	-55°08.607	-65°30.712	surface		Ra

* used for Th intercalibration

7. ADAPTIVE COMPETENCE AND ECOLOGY OF COLD-STENOTHERMAL TELEOSTEI IN THE EASTERN WEDDELL SEA AND AT THE ANTARCTIC PENINSULA IN COMPARISON TO SUB-ANTARCTIC SPECIES

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Alfred-Wegener-Institut

Objectives

Temperature largely affects poikilothermal marine animals and thus determines their biogeography. Latitudinal distribution of fish populations is thus mainly defined by their tolerance towards temperature, i.e. eurythermal fish inhabit wider latitudinal ranges than stenothermal species. In polar fishes, temperature adaptability differs between high-Antarctic and sub-Antarctic animals. Members of the family Zoarcidae inhabit temperate, subpolar and polar waters, and thus represent a model system for the study of temperature adaptation versus acclimatisation. Our recent studies suggest that Antarctic Zoarcidae avoid the extreme cold high-Antarctic waters, thereby possessing higher tolerance against warmer temperatures. On the other hand Notothenioidei represent the most important and most specialized fish group in the Southern Oceans, occupying all available habitats. Comparative physiological, biochemical and molecular studies of sub-polar species from Bouvet Island and species from the Eastern Weddell Sea as well as from the Antarctic Peninsula should give an insight into universal principles of thermal adaptation strategies at higher phylogenetic levels. Collecting live animals for the continuous work at the AWI was one major aim of the cruise. During the cruises we had taken a close look on the major cellular energy demanding and providing processes. Ion and pH regulation as a result of active and passive processes across the membranes are very sensitive to temperature changes. Different strategies in the relation of active and passive fractions are discussed for cold-adapted and temperate species. In gills, a close relationship between ion regulation and energy demand becomes visible, as the main ion pump, the Na^+/K^+ ATPase, is located in the mitochondrial-rich chloride cells. Therefore, the capacities of key enzymes for ion regulation should be linked to aerobic capacities in different species along the latitudinal cline. The second approach will focus on genomic techniques to identify differentially expressed genes within the latitudinal cline and new candidate genes with so far unknown functions, which contribute to thermal plasticity. Therefore, samples from freshly captured fish were taken during ANT-XXIII/2 for further analyses at the AWI. DNA extraction and subsequent analyses should give further insight into phylogenetic relationships of high- and sub-Antarctic fauna. Catch composition of the sub-Antarctic Agassiz trawls will be compared with high Antarctic catches from the Eastern Weddell Sea.

Work at sea
The entire programme was performed during ANT-XXIII/2 and ANT-XXIII/3. On this leg animals were collected by means of baited bottom traps in different depths at King George Island. Due to problems with the cooling system of the aquarium container, which could not be fixed during the time between the legs in Punta Arenas, we spent most of the time in establishing an alternative aquarium system in one of the common cooling containers and to keep it running. Agassiz trawls at the Antarctic Peninsula were cancelled, since the higher mortality of such catches could have caused additional problems for the whole animal stock. Instead, fish from *Jubany Station*, caught especially for our projects by Dr. Katja Heise, AWI, with fish traps at about 15 to 30 metres, were picked up after deployment of our fish traps at King George Island. Since the sea water-cooling system of the ship did not work either, we used - in an exceptional interdisciplinary collaboration with the oceanographers - the deep sea water coming up with the CTD to get cold water for the frequent water exchanges.

For later analyses fish were anaesthetized with MS-222 (0.3 g/l) before being killed. Samples from blood, liver gills, heart, brain, muscles and if possible kidney were quickly removed and frozen instantaneously in liquid nitrogen. The samples are kept at -80 °C for later molecular genetic, biochemical and physiological studies at the AWI.

On board RV *Polarstern* our physiological programme mainly focused on the capacity and temperature sensitivity of a number of key enzymes in energy metabolism. Extractions of membrane proteins, namely Na^+/K^+ ATPase and the mitochondrial F_1F_O ATPase, from different tissues were optimized for maximum activities and stability in several species. The success of the protein enrichment in membrane preparations was determined in relation to crude extracts and cytosolic fractions. For processing large sample numbers a microplate based ATPase test using inorganic phosphate determination by malachite green reagents (Henkel et al. 1988) was established for both ATPases and compared with the common optical-enzymatic test. During this leg further samples should have been analysed. Due to the large efforts regarding animal maintenance (see above),this work started on ANT-XXIII/2 will be completed for all samples at the AWI. This dataset will be further completed by determination of specific mRNA expression and protein quantification by means of antibodies at the AWI.

The mRNA samples will be further analysed for differentially expressed genes at the institute. Thereby, we hope to identify various strategies of energetic and thermal adaptations in these species along the latitudinal cline and the underlying molecular mechanisms.

Preliminary results

-Fish traps:
At King George Island 4 baited traps had been deployed in different depth in or close to Admiralty Bay, where the highest abundance have been expected. Trap 1 was deployed on the approach to the bay at 606 metres, trap 2 at the entrance of the bay at 462 metres. Trap 3 was deployed as far as possible in the bay, where a depth of more then 400 metres could be kept (444 metres). Trap 4 was placed outside the bay

on the way to Maxwell Bay at about 730 metres. Each of the four baskets of one trap was baited either with natural fish (herring) or a mixture of fish oil and fish meal applied in plastic flasks or cotton mesh. After about 48 hours all traps were recovered. The traps were highly specific for eelpouts (*Pachycara brachycephalum*) (Table 7.1). In trap 2, two *Paraliapris spec.* were caught, probably the same species as in the 1,000 metres trap out of Atka Bay (ANT-XXIII/2). One cephalopod came up with trap 4, sucked at the floating body. Additionally, different amphipods in variable amounts were present.

Tab. 7.1: Number of individuals of *P. brachycephalum* caught in the baited traps

	Station	Depth (m)	Total	Number by type of bait			
				fish meal cotton mesh	fish meal flask	fish meal flask	natural fish
Trap 1	184-1	606	20	3	2	7	8
Trap 2	184-2	462	19	7	4	4	4
Trap 3	184-3	444	63	9	5	4	45
Trap 4	184-4	728	98	23	55	12	8

Although most fish were caught at the highest depth (trap 4) in accordance with earlier results from bottom and Agassiz trawls (ANT-XVII/3; EASIZ III), the distribution of *P. brachycephalum* seems to be quite variable between 400 and 800 metres. In former years the traps at position 2 were always more successful than during this expedition. Therefore the actual success of a trap may depend more on other factors like food availability, seasonality, local currents or topography. Clearly, at position 4 the slope was very steep. In this trap most fish were significantly smaller (about 10 cm) than at any other position. A detailed determination of size and length distribution have not been performed to avoid additional stress to the animals. No clear preference regarding the bait have been determined. Nevertheless, the bait in the cotton mesh clearly helped to distribute the bait.

- Survival of the fish on board: After two weeks on the ship, more than 95 % of the eelpouts were still alive. All *Notothenia corriceps* (about 40 individuals), picked up at *Jubany Station* had survived so far. All fishes will be sent by airfreight to Bremerhaven after the leg.

References

Henkel, R.D., VandeBerg, J.L., and Walsh, R.A. A microassay for ATPase. Anal Biochem 169: 312-318., 1988.

8. PELAGIC DISTRIBUTION AND ABUNDANCE OF SEABIRDS AND SEA MAMMALS IN THE DRAKE PASSAGE DURING THE ANT-XXIII/3 OCEANOGRAPHIC CRUISE

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Background and scientific objectives

To achieve a proper understanding of the structure and functioning of marine food webs in polar regions and to predict the effect of natural or anthropogenic perturbations on these ecosystems, accurate estimates of the distribution and biomass of top-level consumers (seabirds and marine mammals) are needed. The Drake Passage is a an important foraging area and a major migratory pathway for seabirds and marine mammals of the Antarctic Peninsula and the Scotia region. The monitoring of the pelagic distribution and abundance of these predators in the Drake Passage is therefore of prime importance since a warming of 3° C of the Antarctic Peninsula and associated changes in sea-ice extent and food availability (Antarctic krill) has been observed in the last 50 years.

The aims of this study conducted during the oceanographic cruise ANT-XXIII/3 was to conduct a survey of the pelagic distribution and abundance of seabirds and sea marine mammals in the Drake Passage to 1) investigate the oceanographic factors (sea temperature, waters masses, salinity etc.) that affect the distribution and biomass of birds and mammals and 2) by using previous pelagic surveys in the area to examine the long-term changes in the top predators community of the Drake Passage.

Work at sea

Birds and mammals were counted on board RV *Polarstern* during continuous 10-min sessions conducted every hours between 15 January and 7 February 2006. Observations were made from the bridge only when the ship was travelling. All birds and mammals, spotted by a single observer in the fore 45° sector on one side of the ship, within a distance of 300 m, were tallied. Observations had always been carried out using a 10 X 40 binocular. At the end of each 10-min survey, the number of species following the ship were counted at the back of the ship to avoid multiple reports of the same individual. Because small, discrete species (eg. storm-petrels) are more easily missed than larger, more conspicuous ones (eg. large albatrosses), a time-species count was simultaneously performed to estimate the probability of detection for each species. Easy access to the bridge allowed observations to be made in excellent conditions.

Preliminary results

A total of 2078 birds (35 species) and 111 mammals (15 species) were counted between 15 January and 8 February during 100 10-min surveys (Table 8.2).

Tab. 8.2: Birds observed during ANT-XXIII/3

Code	Species	Latin Name	Numbers
MAPE	Magellanic Penguin	*Spheniscus magellanicus*	**2**
ADPE	Adelie Penguin	*Pygoscelis adeliae*	**Out of survey**
CHPE	Chinstrap Penguin	*Pygoscelis antarctica*	**358**
GEPE	Gentoo Penguin	*Pygoscelis papua*	**5**
ROPE	Rockhopper Penguin	*Eudyptes chrysocome*	**29**
MRPE	Macaroni Penguin	*Eudyptes chrysolophus*	**9**
PESP	Unidentified Penguins		**34**
CRPE	Unidentified Crested Penguins	*Eudyptes sp.*	**19**
WALL	Wandering Albatross	*Diomedea exulans*	**90**
NRAL	Northern Royal Albatross	*Diomedea epomophora sanfordi*	**2**
SRAL	Southern Royal Albatross	*Diomedea epomophora epomophora*	**6**
GTAL	Unidentified Great Albatrosses	*Diomedea sp.*	**11**
BBAL	Black-browed Albatross	*Thalassarche melanophrys*	**89**
GHAL	Grey-headed Albatross	*Thalassarche chrysostoma*	**2**
WCAL	White-caped Albatross	*Thalassarche cauta*	**1**
LMSA	Light-mantled Sooty Albatross	*Phoebetria palpebrata*	**3**
SGPE	Southern Giant Petrel	*Macronectes giganteus*	**36**
NGPE	Northern Giant Petrel	*Macronectes halli*	**59**
GPSP	Unidentified Giant Petrels	*Macronectes sp.*	**9**
SOFU	Southern Fulmar	*Fulmarus glacialoides*	**90**
ANPE	Antarctic petrel	*Thalassoica antarctica*	**3**
CAPE	Cape petrel	*Daption capense*	**459**
SNPE	Snow petrel	*Pagodroma nivea*	**Out of survey**
SPPE	Soft-plumaged petrel	*Pterodroma mollis*	**8**
BLPE	Blue Petrel	*Halobaena caerulea*	**13**
ANPR	Antarctic prion	*Pachyptila desolata*	**242**
NBPR	Narrow-billed Prion	*Pachyptila belcheri*	**Out of survey**
PRSP	Unidentified Prions	*Pachyptila sp.*	**312**
WCPE	White-chinned petrel	*Procellaria aequinoctialis*	**36**
SOSH	Sooty Shearwater	*Puffinus griseus*	**30**
MASH	Manx Shearwater	*Puffinus puffinus*	**1**
SHSP	Unidentified Shearwaters	*Puffinus sp.*	**Out of survey**
WISP	Wilson's Storm-Petrel	*Oceanites oceanicus*	**38**
BBSP	Black-bellied Storm-Petrel	*Fregetta tropica*	**52**
SPSP	Unidentified Storm-Petrels		**3**
MADP	Magellanic Diving-Petrel	*Pelecanoides magellani*	**4**
DPSP	Unidentified Diving-Petrels	*Pelecanoides sp.*	**1**
PTSP	Unidentified Petrels	*Pterodroma sp.*	**1**
ANSG	Antarctic Shag	*Phalacrocorax atriceps bransfieldensis*	**5**
SPSK	South Polar Skua	*Catharacta maccormicki*	**Out of survey**
SUSK	Subantarctic skua	***Catharacta lonnbergi***	**8**
SKSP	Unidentified Skuas	*Catharacta sp.*	**2**
CHSK	Chilean Skua	*Catharacta chilensis*	**2**
KEGU	Kelp Gull	*Larus dominicanus*	**1**
ANTE	Antarctic Tern	*Sterna vittata*	**2**
SATE	South-American Tern	*Sterna hirindinacea*	**Out of survey**
SHBI	Pale-faced Sheathbill	*Chionis alba*	**1**
		TOTAL	**2078**

ALBATROSSES AND PETRELS (23 species)
PENGUINS (5 species)
OTHERS (7 species)
35 bird species

Tab. 8.3: Mammals observed during ANT-XXIII/3

Code	Species	Latin Name	Numbers
SAFS	South American Fur Seal	*Arctocephalus australis*	**1**
ANFS	Antarctic Fur Seal	*Arctocephalus gazella*	**1**
FSSP	Unidentified Fur Seal	*Arctocephalus sp.*	**2**
SESE	Southern Elephant Seal	*Mirounga leonina*	**1**
LEOS	Leopard Seal	*Hydrurga leptonyx*	**1**
CRSE	Crabeater Seal	*Lobodon carcinophaga*	**Out of survey**
WESE	Weddell Seal	*Leptonychotes weddellii*	**Out of survey**
SPWH	Sperm Whale	*Physeter macrocephalus*	**1**
AMWH	Antarctic Minke whale	*Balaenoptera bonaerencis*	**3**
FIWH	Fin whale	*Balaenoptera physalus*	**2**
SEWH	Sei Whale	*Balaenoptera borealis*	**1**
HUWH	Humpback Whale	*Megaptera novaeangliae*	**46**
LFPW	Long-finned Pilot Whale	*Globicephala melas*	**15**
KIWH	Killer Whale	*Orcinus orca*	**4**
CODO	Commerson‘dolphin	*Cephalorhynchus commersonii*	**Out of survey**
HODO	Hourglass dolphin	*Lagenorhyncus cruciger*	**31**
DOSP	Unidentified Dolphins		**2**
		TOTAL	**111**

SEALS (6 species)
CETACEANS (9 species)
15 mammal species

9. BETEILIGTE INSTITUTE / PARTICIPATING INSTITUTES

	Adresse /Address
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CNRS Plouzané	DT-INSU/CNRS Bat IPEV BP74 29280 Plouzané/ France
CNRS Villiers	CEBC Villiers en Bois 79360 Beauvoir sur Niort/ France
DWD	Deutscher Wetterdienst Hamburg Abteilung Seeschifffahrt Bernhard-Nocht Str. 76 20359 Hamburg / Germany
HeliTransair	HeliTransair GmbH Am Flugplatz 63329 Egelsbach / Germany
IfM HH	Institut für Meereskunde Bundesstr. 55, Geomatikum, 4th floor D-20146 Hamburg / Germany
IUP	Institut für Umweltphysik (IUP) Ozeanographie Institute of Environmental Physics Oceanography Otto-Hahn-Allee 1 D-28359 Bremen / Germany

	Adresse /Address
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LEGOS	LEGOS Laboratoire d'Etudes en Géophysique et Océanographie Spatiales Unité Mixte de Recherche CNRS, UPS, CNES, IRD 18 avenue Edouard Belin 31055 Toulouse / France
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Koschnick	Nils	AWI	Technician	German
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Sudre	Joël	CNES Toulouse	Engineer	French
Sultan	Emmanuelle	LOCEAN	Engineer	French
Vivier	Frédéric	LOCEAN	Scientist	French

11. SCHIFFSBESATZUNG / SHIP'S CREW

Reederei F. Laeisz G.m.b.H — Reise/leg ANT-XXIII/3
Name of Ship: RV POLARSTERN
Nationality : GERMAN
Punta Arenas - Punta Arenas

No.	Name	Rank
1.	Pahl, Uwe	Master
2.	Grundmann, Uwe	1.Offc.
3.	Ziemann, Olaf	Ch.Eng.
4.	Hering, Igor	2. Offc.
5.	Wunderlich, Thomas	2.Offc.
6.	Bratz, Herbert	3.Offc.
7.	Türke, Helmut	Doctor
8.	Koch, Georg	R.Offc.
9.	Simon, Wolfgang	1.Eng.
10.	Schnürch, Helmut	3.Eng.
11.	Wanke, Steffen	3.Eng.
12.	Haefke, Bernd	ElecEng.
13.	Feiertag, Thomas	ELO
14.	Fröb, Martin	ELO
15.	Muhle, Helmut	ELO
16.	Riess, Felix	ELO
17.	Clasen, Burkhard	Boatsw.
18.	Neisner, Winfried	Carpenter
19.	Burzan, Gerd-Ekkeh.	A.B.
20.	Hartwig-Lab.,Andreas	A.B.
21.	Kreis, Reinhard	A.B.
22.	Lamm, Gerd	A.B.
23.	Moser, Siegfried	A.B.
24.	Pousada Martinez, S.	A.B.
25.	Schröder, Norbert	A.B.
26.	Schultz, Ottomar	A.B.
27.	Beth, Detlef	Storek.
28.	Dinse, Horst	Mot-man
29.	Fritz, Günter	Mot-man
30.	Hoppe, Kurt	Mot-man
31.	Krösche, Eckard	Mot-man
32.	Watzel, Bernhard	MotMan
33.	Fischer, Matthias	Cook
34.	Martens, Michael	Cooksmate
35.	Tupy, Mario	Cooksmate
36.	Dinse, Petra	1.Stwdess
37.	Tillmann, Barbara	Stwdss/Kr
38.	Deuß, Stefanie	2.Stwdess
39.	Hu, Guo Yong	2.Steward
40.	Möller, Wolfgang	2.Steward
41.	Schmidt, Maria	2.Stwdess
42.	Sun, Yong Sheng	2.Steward
43.	Yu, Chung Leung	Laundrym.
44.	Felsenstein, Thomas	Apprent.

ANNEX 1: STATION LIST

Station AWI #	LOCEAN #	Date	Time	Latitude	Longitude	Depth [m]	Wind [m/s]	Gear	CFC
PS69/132-1	DRA001	16.01.06	07:13	55° 6,92' S	65° 33,14' W	362,8	SW 10	CTD/RO	
PS69/133-1	DRA002	16.01.06	09:12	55° 14,00' S	65° 22,33' W	1033,6	SSW 9	CTD/RO	
PS69/134-1	DRA003	16.01.06	11:13	55° 20,40' S	65° 11,27' W	1592,8	SW 7	CTD/RO	yes
PS69/134-2	M1	16.01.06	16:42	55° 20,51' S	65° 11,12' W	1636,8	W 9	MOOR	
PS69/135-1	DRA004	16.01.06	19:12	55° 28,47' S	64° 57,54' W	2580,8	WSW 13	CTD/RO	yes
PS69/136-1	DRA005	16.01.06	23:53	55° 36,29' S	64° 44,83' W	3653,6	WSW 11	CTD/RO	yes
PS69/137-1	DRB006	17.01.06	04:13	55° 45,05' S	64° 30,29' W	3773,6	W 6	CTD/RO	
PS69/137-2	DRA006	17.01.06	07:31	55° 45,38' S	64° 30,01' W	3771,6	NW 8	CTD/RO	
PS69/137-3	M2	17.01.06	12:51	55° 44,76' S	64° 27,84' W	3784,0	NW 9	MOOR	
PS69/138-1	DRA007	17.01.06	17:01	56° 9,23' S	63° 46,07' W	4175,6	NW 7	CTD/RO	yes
PS69/138-2	M3	17.01.06	22:26	56° 8,89' S	63° 43,51' W	4165,6	NW 4	MOOR	
PS69/139-1	DRA008	18.01.06	00:50	56° 17,07' S	63° 31,95' W	4097,2	N 7	CTD/RO	
PS69/140-1	DRB009	18.01.06	05:00	56° 25,46' S	63° 18,30' W	3984,0	N 9	CTD/RO	
PS69/140-2	DRA009	18.01.06	08:10	56° 24,79' S	63° 18,07' W	3983,2	NNW 9	CTD/RO	
PS69/141-1	DRA010	18.01.06	12:25	56° 33,06' S	63° 3,92' W	4029,2	SW 1	CTD/RO	yes
PS69/142-1	DRA011	18.01.06	16:53	56° 40,75' S	62° 49,97' W	4076,0	E 3	CTD/RO	
PS69/143-1	DRA012	18.01.06	21:08	56° 48,50' S	62° 35,47' W	4127,6	S 4	CTD/RO	
PS69/144-1	DRB013	19.01.06	01:45	56° 55,92' S	62° 20,95' W	4088,4	SSW 5	CTD/RO	
PS69/144-2	DRA013	19.01.06	05:07	56° 56,16' S	62° 21,76' W	4098,4	SSW 6	CTD/RO	yes
PS69/144-3	M4	19.01.06	10:53	56° 56,30' S	62° 20,64' W	4087,6	SSE 6	MOOR	
PS69/144-4	CARIOCA	19.01.06	11:54	56° 56,04' S	62° 18,44' W	4092,0	S 6	TD	
PS69/145-1	DRA014	19.01.06	13:25	57° 3,32' S	62° 6,94' W	3876,8	SSE 5	CTD/RO	
PS69/146-1	DRA015	19.01.06	17:20	57° 10,23' S	61° 53,57' W	3807,6	SE 8	CTD/RO	
PS69/147-1	DRA016	19.01.06	21:52	57° 17,67' S	61° 38,84' W	3783,6	SSE 10	CTD/RO	yes
PS69/148-1	DRA017	20.01.06	01:52	57° 24,81' S	61° 24,01' W	3750,8	SSE 14	CTD/RO	
PS69/149-1	DRA018	20.01.06	05:27	57° 31,85' S	61° 9,81' W	3890,8	SSE 15	CTD/RO	
PS69/150-1	DRA019	20.01.06	09:35	57° 38,20' S	60° 55,76' W	3326,4	SSE 14	CTD/RO	yes
PS69/150-2	M5	20.01.06	13:34	57° 37,70' S	60° 56,34' W	3335,6	SSE 11	MOOR	
PS69/151-1	DRA020	20.01.06	16:10	57° 45,82' S	60° 43,01' W	3524,8	S 12	CTD/RO	
PS69/152-1	DRA021	20.01.06	19:45	57° 52,61' S	60° 28,40' W	4029,6	SW 10	CTD/RO	
PS69/153-1	DRA022	20.01.06	23:35	57° 59,11' S	60° 13,88' W	4504,0	SW 10	CTD/RO	yes
PS69/154-1	DRA023	21.01.06	03:51	58° 6,24' S	60° 0,38' W	3904,8	SW 7	CTD/RO	
PS69/155-1	DRA024	21.01.06	07:40	58° 12,45' S	59° 46,68' W	3766,8	W 6	CTD/RO	
PS69/156-1	DRA025	21.01.06	11:35	58° 19,44' S	59° 31,99' W	3232,0	W 6	CTD/RO	yes
PS69/156-2	M6	21.01.06	15:39	58° 19,14' S	59° 31,87' W	3126,8	WNW 6	MOOR	
PS69/157-1	DRA026	21.01.06	17:15	58° 26,26' S	59° 16,87' W	3905,2	WNW 8	CTD/RO	
PS69/158-1	DRA027	21.01.06	21:10	58° 32,89' S	59° 2,12' W	3964,0	NW 7	CTD/RO	
PS69/159-1	DRA028	22.01.06	00:54	58° 39,45' S	58° 47,40' W	3939,6	N 7	CTD/RO	yes
PS69/160-1	DRA029	22.01.06	04:34	58° 45,74' S	58° 32,64' W	3888,0	N 10	CTD/RO	
PS69/161-1	DRB030	22.01.06	08:20	58° 52,22' S	58° 17,97' W	3772,4	N 11	CTD/RO	
PS69/161-2	DRA030	22.01.06	11:49	58° 52,14' S	58° 18,15' W	3784,4	N 12	CTD/RO	
PS69/162-1	DRA031	22.01.06	15:16	58° 57,42' S	58° 5,90' W	3769,6	N 13	CTD/RO	yes
PS69/162-2	M7	22.01.06	19:16	58° 57,23' S	58° 6,07' W	3768,8	N 15	MOOR	
PS69/163-1	DRA032	22.01.06	22:50	59° 3,69' S	57° 51,37' W	3671,2	N 14	CTD/RO	
PS69/164-1	DRA033	23.01.06	02:35	59° 9,66' S	57° 37,37' W	3648,8	N 13	CTD/RO	
PS69/165-1	DRA034	23.01.06	06:22	59° 15,54' S	57° 23,40' W	3616,0	NW 8	CTD/RO	
PS69/166-1	DRA035	23.01.06	10:13	59° 21,73' S	57° 8,57' W	3551,6	W 7	CTD/RO	yes
PS69/167-1	DRA036	23.01.06	13:50	59° 27,98' S	56° 54,86' W	3540,0	WNW 6	CTD/RO	
PS69/168-1	DRA037	23.01.06	17:31	59° 32,91' S	56° 41,34' W	3566,0	WNW 6	CTD/RO	
PS69/168-2	M8	23.01.06	21:44	59° 32,75' S	56° 41,38' W	3564,0	W 6	MOOR	
PS69/169-1	DRA038	23.01.06	23:58	59° 38,11' S	56° 26,31' W	3599,6	WNW 5	CTD/RO	

Station AWI #	LOCEAN #	Date	Time	Latitude	Longitude	Depth [m]	Wind [m/s]	Gear	CFC
PS69/170-1	DRA039	24.01.06	03:32	59° 43,85' S	56° 13,07' W	3626,8	WNW 6	CTD/RO	yes
PS69/171-1	DRA040	24.01.06	07:10	59° 49,30' S	55° 58,60' W	3571,2	WNW 5	CTD/RO	
PS69/172-1	DRA041	24.01.06	10:55	59° 55,15' S	55° 44,55' W	3575,2	NW 4	CTD/RO	
PS69/173-1	DRA042	24.01.06	14:34	60° 0,58' S	55° 30,26' W	3582,8	NW 8	CTD/RO	
PS69/174-1	M9	24.01.06	19:39	60° 5,95' S	55° 16,92' W	3516,4	NW 8	MOOR	
PS69/174-2	DRA043	24.01.06	20:29	60° 5,00' S	55° 14,61' W	3514,0	WNW 10	CTD/RO	yes
PS69/175-1	DRA044	25.01.06	00:15	60° 11,25' S	55° 1,68' W	3430,0	W 8	CTD/RO	
PS69/176-1	DRA045	25.01.06	04:11	60° 16,38' S	54° 48,19' W	3272,0	WNW 6	CTD/RO	
PS69/177-1	DRA046	25.01.06	07:45	60° 21,61' S	54° 33,65' W	3277,2	WNW 5	CTD/RO	yes
PS69/178-1	DRA047	25.01.06	11:31	60° 26,70' S	54° 18,68' W	3171,6	NW 6	CTD/RO	
PS69/179-1	DRA048	25.01.06	14:51	60° 32,10' S	54° 5,39' W	2971,2	N 5	CTD/RO	
PS69/180-1	M10	25.01.06	19:28	60° 37,38' S	53° 50,43' W	2792,4	NE 6	MOOR	
PS69/180-2	DRA049	25.01.06	20:10	60° 36,89' S	53° 47,69' W	2734,0	NNE 6	CTD/RO	yes
PS69/181-1	DRB050	25.01.06	23:52	60° 42,49' S	53° 38,07' W	1828,8	ENE 8	CTD/RO	
PS69/181-2	Pumps	26.01.06	01:00	60° 42,27' S	53° 36,69' W	1456,4	NE 8	ISPumps	
PS69/181-3	DRC050	26.01.06	05:29	60° 42,45' S	53° 36,91' W	1470,8	NNE 5	CTD/RO	
PS69/181-4	DRA050	26.01.06	06:59	60° 42,18' S	53° 36,72' W	1586,8	ENE 2	CTD/RO	
PS69/182-1	DRA051	26.01.06	09:27	60° 47,25' S	53° 21,79' W	446,8	WSW 6	CTD/RO	
END	OF	SECTION							
PS69/183-1	DRB052	26.01.06	19:48	61° 49,68' S	55° 26,32' W	826,4	SW 3	CTD/RO	
PS69/183-2	Pumps	26.01.06	21:32	61° 51,06' S	55° 37,27' W	2615,6	SSW 8	ISPumps	
PS69/183-2	Pumps	27.01.06	02:21	61° 51,17' S	55° 37,25' W	2496,0	SW 6	ISPumps	
PS69/183-3	DRC052	27.01.06	02:28	61° 51,14' S	55° 37,26' W	2507,6	SSW 6	CTD/RO	
PS69/184-1	DRA053	27.01.06	12:21	62° 11,48' S	57° 54,63' W	605,6	SW 5	TRAPF	
PS69/184-2		27.01.06	13:52	62° 12,14' S	58° 19,77' W	462,0	SW 5	TRAPF	
PS69/184-3		27.01.06	14:34	62° 8,02' S	58° 26,95' W	444,0	SSW 6	TRAPF	
PS69/184-4		27.01.06	15:45	62° 16,74' S	58° 22,05' W	728,4	SSW 5	TRAPF	
JUBANY									
O'HIGGINS									
SECTION	ACROSS	BRANS	FIELD						
PS69/185-1	DRA054	28.01.06	19:49	63° 10,96' S	58° 0,60' W	98,4	SW 7	CTD/RO	
PS69/186-1	DRA055	28.01.06	21:14	63° 2,64' S	58° 7,08' W	160,0	WSW 6	CTD/RO	
PS69/187-1	DRA056	28.01.06	22:38	62° 53,93' S	58° 13,32' W	436,4	SSW 4	CTD/RO	
PS69/188-1	DRA057	29.01.06	00:21	62° 45,54' S	58° 19,46' W	808,8	SW 4	CTD/RO	
PS69/189-1	DRA058	29.01.06	02:10	62° 37,01' S	58° 25,63' W	1684,0	SW 4	CTD/RO	
PS69/190-1	DRA059	29.01.06	05:02	62° 28,41' S	58° 31,74' W	1413,6	SSW 3	CTD/RO	
PS69/191-1	DRA060	29.01.06	07:34	62° 19,90' S	58° 37,67' W	520,8	WNW 4	CTD/RO	
END	OF	BRANS	FIELD	STRAIT	SECTION				
PS69/192-1	DRA061	29.01.06	11:44	62° 10,95' S	57° 55,17' W	589,6	SW 7	TRAPF	
JUBANY									
PS69/193-1	DRB062	30.01.06	11:15	60° 39,71' S	55° 49,69' W	3676,8	SSW 11	CTD/RO	
PS69/193-2	Pumps	30.01.06	12:30	60° 39,47' S	55° 48,08' W	3615,2	SSW 11	ISPumps	
PS69/193-2	Pumps	30.01.06	17:59	60° 39,31' S	55° 46,78' W	3596,0	S 11	ISPumps	
PS69/193-3	DRC062	30.01.06	18:07	60° 39,29' S	55° 46,74' W	3595,2	S 10	CTD/RO	
START	SECTION								
PS69/194-1	DRA063	31.01.06	00:11	60° 5,99' S	55° 15,71' W	3515,2	S 3	CTD/RO	
PS69/195-1	DRA064	31.01.06	03:30	60° 0,25' S	55° 30,63' W	3585,2	SSE 5	CTD/RO	
PS69/196-1	DRA065	31.01.06	06:55	59° 54,77' S	55° 44,88' W	3573,2	SE 6	CTD/RO	
PS69/197-1	DRA066	31.01.06	10:19	59° 49,26' S	55° 58,59' W	3573,6	SSE 8	CTD/RO	
PS69/198-1	DRA067	31.01.06	13:47	59° 43,73' S	56° 12,84' W	3624,8	SE 6	CTD/RO	

Station AWI #	LOCEAN #	Date	Time	Latitude	Longitude	Depth [m]	Wind [m/s]	Gear	CFC
PS69/199-1	DRA068	31.01.06	17:16	59° 38,66' S	56° 27,06' W	3605,4	SE 4	CTD/RO	
PS69/200-1	DRA069	31.01.06	20:35	59° 32,79' S	56° 41,28' W	3564,8	SSW 3	CTD/RO	
PS69/201-1	DRA070	01.02.06	00:52	59° 21,51' S	57° 9,01' W	3550,4	S 5	CTD/RO	
PS69/202-1	DRA071	01.02.06	04:39	59° 15,62' S	57° 23,10' W	3614,8	S 4	CTD/RO	
PS69/203-1	DRA072	01.02.06	09:25	59° 3,37' S	57° 51,75' W	3671,6	N 0	CTD/RO	
PS69/204-1	DRA073	01.02.06	13:28	58° 57,59' S	58° 6,20' W	3771,6	N 7	CTD/RO	
PS69/205-1	DRA074	01.02.06	17:06	58° 52,17' S	58° 18,19' W	3781,6	NNE 8	CTD/RO	
PS69/206-1	DRA075	01.02.06	20:55	58° 45,75' S	58° 32,92' W	3887,2	N 10	CTD/RO	
PS69/207-1	DRA076	02.02.06	00:48	58° 38,88' S	58° 47,05' W	3922,8	NNW 7	CTD/RO	
PS69/208-1	DRA077	02.02.06	04:50	58° 32,83' S	59° 1,98' W	3960,0	NNW 8	CTD/RO	
PS69/209-1	DRA078	02.02.06	08:49	58° 26,57' S	59° 16,10' W	3831,6	NNW 5	CTD/RO	
PS69/210-1	DRA079	02.02.06	12:57	58° 19,86' S	59° 30,94' W	3257,2	NW 1	CTD/RO	
PS69/211-1	DRA080	02.02.06	16:51	58° 12,60' S	59° 46,27' W	3772,4	S 5	CTD/RO	
PS69/212-1	DRA081	02.02.06	20:24	58° 5,68' S	60° 0,43' W	4154,4	S 9	CTD/RO	
PS69/213-1	DRA082	02.02.06	23:47	57° 58,50' S	59° 57,61' W	4260,4	S 9	CTD/RO	
PS69/214-1	DRA083	03.02.06	03:35	57° 59,24' S	60° 14,26' W	4511,2	SE 10	CTD/RO	
PS69/215-1	DRA084	03.02.06	07:41	57° 59,71' S	60° 30,43' W	4464,0	SSE 7	CTD/RO	
PS69/216-1	DRA085	03.02.06	11:39	57° 52,57' S	60° 27,68' W	3957,2	SSE 6	CTD/RO	
PS69/217-1	DRA086	03.02.06	18:12	57° 45,70' S	60° 42,02' W	3562,0	S 6	CTD/RO	
PS69/218-1	DRA087	03.02.06	22:08	57° 39,06' S	60° 56,01' W	3388,0	WSW 6	CTD/RO	
PS69/219-1	DRA088	04.02.06	01:47	57° 31,97' S	61° 10,41' W	3654,8	SSW 4	CTD/RO	
PS69/220-1	DRA089	04.02.06	05:45	57° 24,98' S	61° 24,50' W	3762,0	SSW 4	CTD/RO	
PS69/221-1	DRA090	04.02.06	09:42	57° 17,58' S	61° 39,12' W	3789,6	SE 1	CTD/RO	
PS69/222-1	DRA091	04.02.06	13:34	57° 10,56' S	61° 53,21' W	3812,0	NE 3	CTD/RO	
PS69/223-1	DRA092	04.02.06	17:24	57° 3,30' S	62° 7,33' W	3872,8	NE 6	CTD/RO	
PS69/224-1	DRA093	04.02.06	21:10	56° 56,11' S	62° 21,63' W	4095,6	ENE 6	CTD/RO	
PS69/225-1	DRA094	05.02.06	00:57	56° 48,37' S	62° 35,76' W	4127,6	E 6	CTD/RO	
PS69/226-1	DRA095	05.02.06	04:44	56° 40,68' S	62° 49,98' W	4075,6	E 9	CTD/RO	
PS69/227-1	DRA096	05.02.06	08:26	56° 32,89' S	63° 4,34' W	4026,8	E 8	CTD/RO	
PS69/228-1	DRA097	05.02.06	12:16	56° 25,02' S	63° 18,13' W	3982,0	E 6	CTD/RO	
PS69/229-1	DRA098	05.02.06	15:58	56° 17,27' S	63° 32,07' W	4094,0	E 5	CTD/RO	
PS69/230-1	DRA099	05.02.06	19:35	56° 9,76' S	63° 45,95' W	4146,0	ENE 3	CTD/RO	
PS69/231-1	DRA100	05.02.06	23:36	56° 1,34' S	64° 0,82' W	3967,6	NNE 5	CTD/RO	
PS69/232-1	DRA101	06.02.06	03:22	55° 53,42' S	64° 15,10' W	3873,6	N 9	CTD/RO	yes
PS69/233-1	DRA102	06.02.06	07:36	55° 45,34' S	64° 29,93' W	3770,0	N 10	CTD/RO	
PS69/234-1	DRA103	06.02.06	11:45	55° 36,32' S	64° 44,49' W	3660,4	N 13	CTD/RO	
PS69/235-1	DRA104	06.02.06	15:35	55° 28,67' S	64° 57,54' W	2589,2	N 14	CTD/RO	
PS69/236-1	DRA105	06.02.06	19:00	55° 20,53' S	65° 11,34' W	1616,4	N 10	CTD/RO	
PS69/237-1	DRA106	06.02.06	21:32	55° 13,43' S	65° 21,87' W	1007,6	N 15	CTD/RO	
PS69/238-1	DRA107	06.02.06	23:33	55° 6,78' S	65° 33,08' W	356,8	NNE 14	CTD/RO	