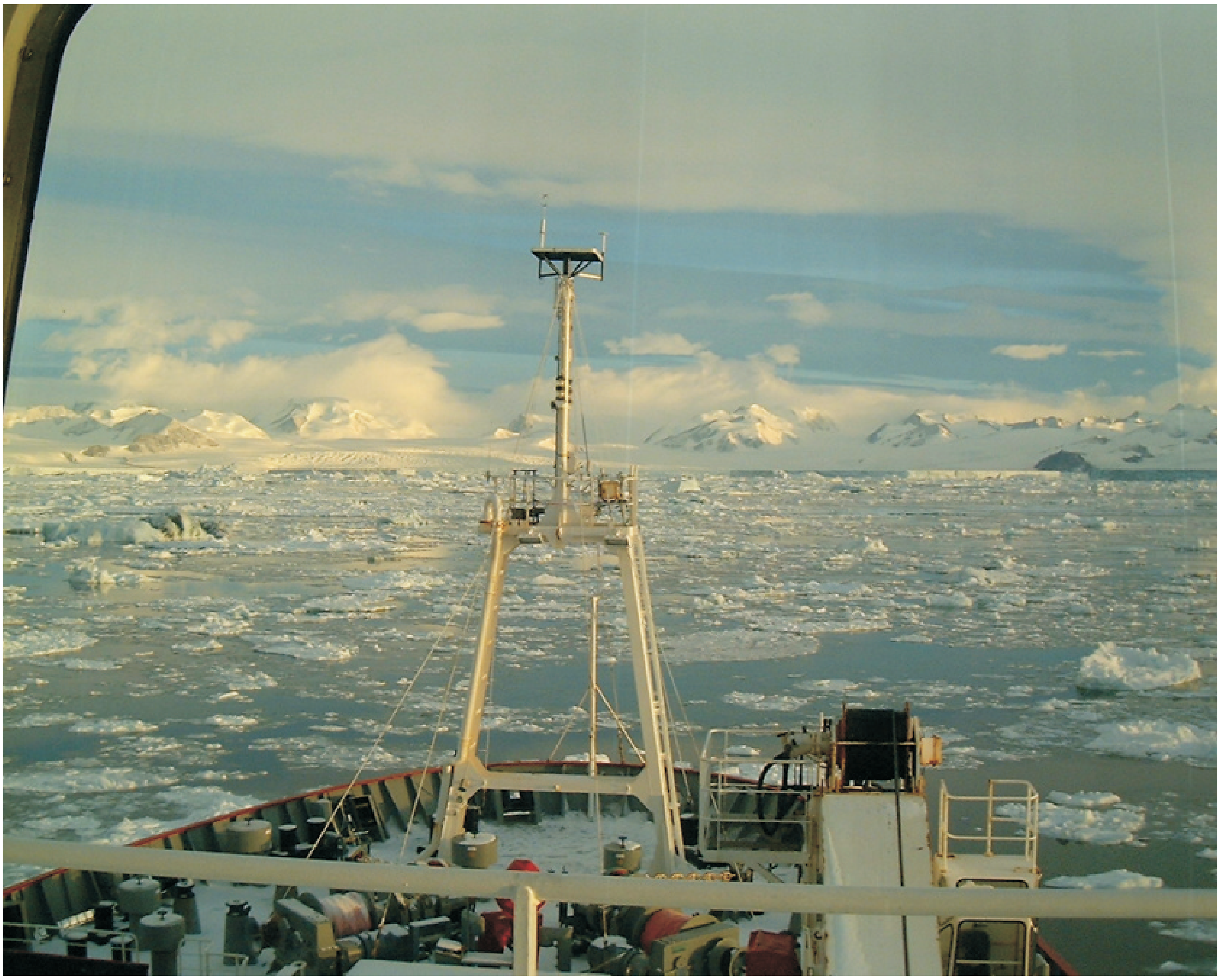

JR48 Cruise Report

The HILATS/SAGES Millennium Cruise

British
Antarctic
Survey

Cruise Report

RRS *James Clark Ross*

Cruise JR48
February to April 2000

Marine Geology
**Antarctic Peninsula Pacific Margin,
Prince Gustav Channel, northern Larsen Ice Shelf,
northern Weddell Sea, Scotia Sea
and Falkland Trough**

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with contributions from Peter F Barker, Kate E Darling, Jeff Evans, Ruth E Hale, Mike Kucera, Peter Morris and Colm O'Cofaigh

BAS Reference No. ES6/1/2000/1 April 2000

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Front cover photograph: view from the bridge of RRS *James Clark Ross* sailing into Larsen Inlet; the first ship ever to enter these waters.

Back cover: Dartcom HRPT image image of the northern Antarctic Peninsula for March 5th (day 065), 2000. Coastlines shown in green. Sea appears dark, land and floating ice appear brown and yellow, clouds appear blue and white.

CONTENTS

1. SUMMARY (CJP)

Cruise JR48 had three main objectives:

i) Survey and vibrocoring on the continental shelf east of the northern Antarctic Peninsula, in the areas formerly occupied by the northern Larsen and Prince Gustav Ice Shelves.

ii) 3.5 kHz survey and piston coring in the northern Weddell Sea, Scotia Sea and Falkland Trough, to investigate late Quaternary palaoceanography, particularly flow history of the Weddell Gyre and Antarctic Circumpolar Current.

iii) Sparker survey and rock drilling/vibrocoring on the continental shelf near Anvers I and near Seymour I: pilot study for a future Cenozoic project.

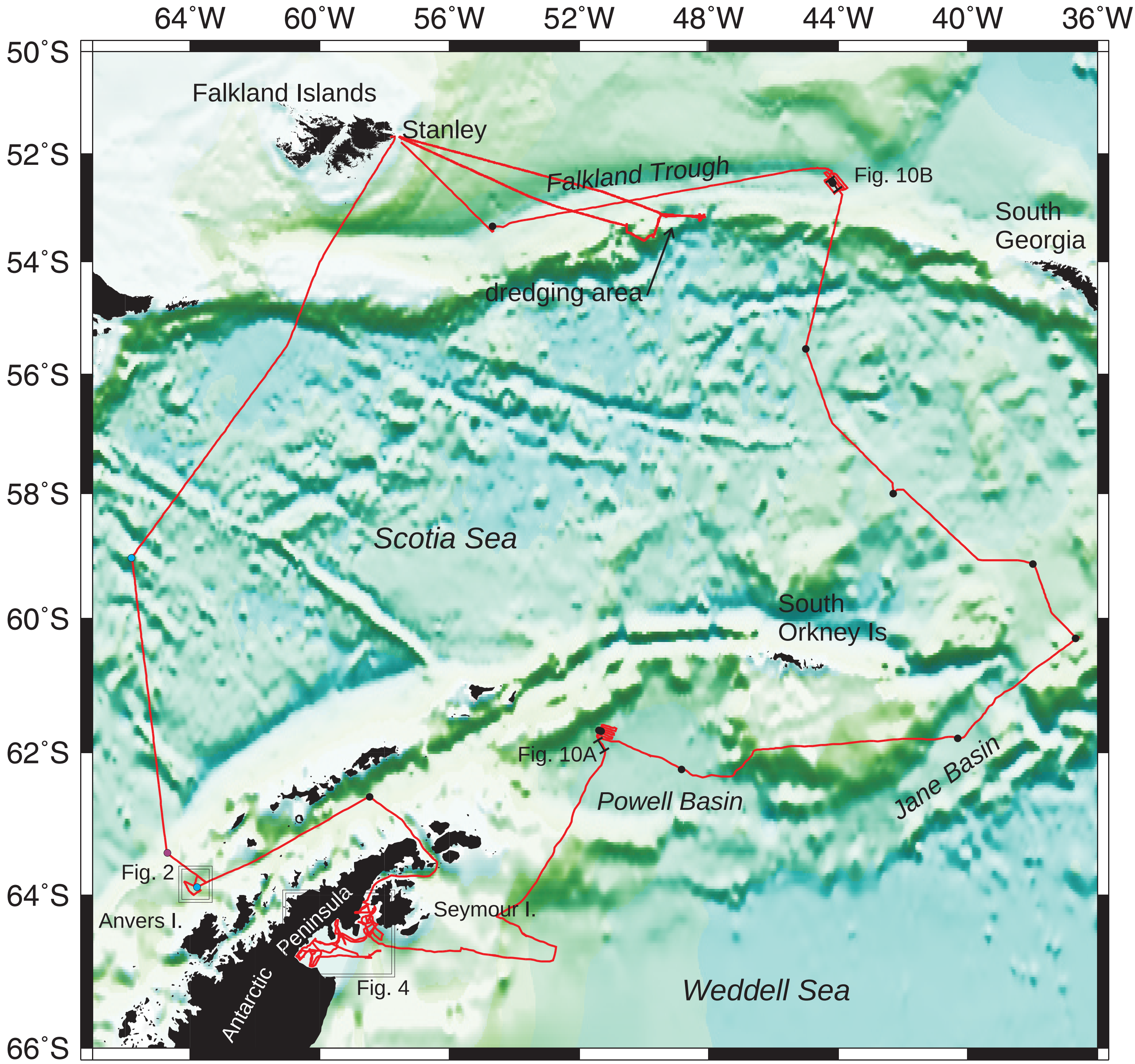
Underway measurements were to include bathymetric, 3.5 kHz and magnetic survey, and water sampling for plankton using the non-toxic seawater supply. A short dredging cruise was to be undertaken for Dr P F Barker, after the main coring cruise.

The coring cruise occupied 27.6 days (Feb 26th to March 25th, Stanley to Stanley), plus 4 days of mobilisation and 1.5 days demobilisation. The ship's track is shown in Fig. 1. The weather was generally good and only 2 days were lost to bad weather, fog and ice. All the objectives were achieved except the work near Seymour Island, which was not attempted because of shortage of time. Cores totalling 257 metres were obtained from 63 sites. Of these, 41 cores (plus 1340 km of track) were obtained from unsurveyed areas formerly covered by ice shelves. A transect of piston cores was obtained from the northern Weddell Sea (Powell Basin and Jane Basin) to the Falkland Trough; this work included detailed survey of two areas of sediment waves. Cenozoic outcrops were located and sampled on the shelf near Anvers Island.

Bathymetric and 3.5 kHz survey were run all the time the ship was under way. The Shipboard Three-Component Magnetometer operated throughout the cruise, and the towed magnetometer was used for a total of 8.7 days. 109 water samples were taken for plankton, plus 8 net hauls to 100 m and two sea-ice samples.

The dredging cruise occupied 4.8 days (March 27th to April 1st, Stanley to Stanley) and was terminated prematurely by the mechanical failure of the ship's bow thruster. Of the 5 dredge stations, 4 obtained large hauls of sedimentary rocks and one a small amount of igneous rock.

Fig. 1. Summary track chart for JR48. Background is a shaded-relief image of bathymetry. Ship's track in red, piston core sites shown as black dots. See also main track chart (foldout at end of report).



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Falkland Islands
Stanley
Falkland Trough
Fig. 10B
South Georgia
dredging area
Scotia Sea
South Orkney Is
Fig. 10A
Powell Basin
Jane Basin
Fig. 2
Anvers I.
Antarctic Peninsula
Seymour I.
Fig. 4
Weddell Sea

2. INTRODUCTION AND OBJECTIVES (CJP)

Cruise JR48 will contribute to two BAS projects within the SAGES programme (Significance in Antarctica of Global changES). These are SAGES-10K focused on the last 10,000 years, and SAGES-500K which includes the last 500,000 years of climate history as recorded in Antarctic sediments. A third proposal, SAGES-50M on Cenozoic sediments, was not funded for the period 2000-05. In order of importance, the cruise objectives were:

i) Survey (bathymetry/3.5 kHz, sparker/sidescan) and vibrocoring on the continental shelf SW of James Ross Island, in the areas formerly occupied by the northern Larsen and Prince Gustav Ice Shelves.

ii) 3.5 kHz survey and piston coring in the northern Weddell Sea, Scotia Sea and Falkland Trough, to investigate late Quaternary palaoceanography, particularly flow history of the Weddell Gyre and Antarctic Circumpolar Current.

iii) Sparker survey and rock drilling/vibrocoring on the continental shelf near Anvers I and near Seymour I: pilot study for a future Cenozoic project.

Underway measurements were to include bathymetric, 3.5 kHz and magnetic survey, and water sampling using the pumped non-toxic seawater supply. A short dredging cruise was to be undertaken for Dr P F Barker, after the main coring cruise.

2.1 Larsen/Prince Gustav Ice Shelves

The disintegration of Antarctic ice shelves has been much in the news as a possible indicator of anthropogenic global warming. It is known that the northern Peninsula ice shelves (Prince Gustav Ice Shelf, Larsen Inlet, Larsen-A) have been retreating during the period of historical observations (since 1843; Cooper 1997). Retreat speeded up in the late 1980's, and in 1995 a major breakout of Larsen-A and the Prince Gustav Ice Shelf occurred (Rott et al. 1996). It is not known whether (a) this rapid retreat is an event unique in the present interglacial period (i.e. the ice shelves were stable for some 12,000 years and are now retreating in response to anthropogenic warming) or (b) advance and retreat of these small ice shelves has occurred repeatedly in response to natural Holocene climate change (i.e. events such as the mid-Holocene warm period, the Little Ice Age etc.).

The answer may be found within the continental shelf sediments: are they all subglacial or do they contain layers which show open marine influence? The plan was to survey and core within the area of the old ice shelf in areas formerly beneath different types of ice (fast and slow flow, different drainage basin geology etc.), and along a transect from the coast east to the shelf edge at about 65°S, 55°W. This would be the first systematic documentation of sub-ice shelf sediments and open-water shelf sediments on the east side of the Antarctic Peninsula.

JR48 was the first scientific cruise to this area since the major breakout in 1995. The Greenpeace vessel *Arctic Sunrise* was in the area in 1997, and in advance of JR48 we were kindly given the bathymetric soundings she acquired. We also had satellite images of the ice shelf prior to the 1995 breakout. The exact itinerary for this part of the cruise was not fixed in advance, as it would necessarily depend on ice and weather conditions and on what we found as we went along.

2.2 Northern Weddell Sea, Scotia Sea, Falkland Trough

BAS has been collecting cores from these areas for several years and the basic glacial-interglacial record is reasonably well understood (Pudsey 1992, Howe et al. 1997, Pudsey &

Howe 1998). Within the SAGES-500K project we now have an opportunity to seek higher-resolution palaeoclimate records, i.e. climate change on a scale of hundreds to thousands of years, and to compare these with ice core records. Cores were planned at sites of high sedimentation rate, in a transect from the northern part of the Weddell Gyre (seasonally sea ice covered; eastward flow of the Weddell Gyre) across the Scotia Sea (seasonally sea ice covered to ice free; Antarctic Circumpolar Current flow) to the Falkland Trough (ice free, north of the Polar Front). Two areas of sediment waves were to be surveyed in detail. Some of the sites were repeats of earlier cores, while others required closely-spaced (2-3 miles) survey lines before final site selection. The itinerary for this part of the cruise was well known.

2.3 Cenozoic sediments on the continental shelf

Sediments 20-40 million years old record the early stages of Antarctic glaciation. They occur in only a very few places on land (King George Island, Seymour Island), but geophysical surveys show they probably occupy large areas of the continental shelf (Sloan et al. 1995, Larter et al. 1997). They are mostly buried by younger glacial deposits so are only accessible by deep drilling; ODP has drilled sites west of the Antarctic Peninsula and in Prydz Bay, and the Cape Roberts Project has drilled in the Ross Sea. Target areas for this cruise were north of Anvers Island and east of Seymour Island. In each area we planned to run sparker and/or sidescan survey and try one or two rock-drill sites. If we could successfully drill Cenozoic sediments, this would strengthen the case for re-submission of a Cenozoic project or participation in an international shelf drilling programme.

2.4 Underway measurements

Passage between sites was used to collect magnetic and bathymetric data to improve the regional database of Drake Passage, the northern Weddell Sea and Scotia Sea. Waypoints were chosen to avoid duplication of earlier ship tracks and to fill gaps in our coverage. Two ship-mounted three-component magnetometers were run all the time, as was the suite of meteorological instruments (anemometer, barometer, thermometer for air temperature).

Underway water sampling was conducted to obtain planktonic foraminifera for morphological and genetic studies, to compare with the fossil record (see section 4). This project extended studies by Dr Kate Darling in other parts of the world including the Arctic, and followed an earlier collection on cruise JR19. Sampling was done under way from the ship's non-toxic seawater supply in the prep lab. It was intended to collect foraminifera all the way from the temperate waters near the Falkland Islands to the edge of the pack ice.

2.5 Dredging

Dredging the North Scotia Ridge was intended to recover sedimentary rocks yielding age and environmental information on the initiation of deep Antarctic Circumpolar Current flow (see section 5). The palaeo-depth history of this section of the ridge is important, as it may have been the main barrier to circumpolar flow between 10 and 20 Ma. About 20 dredge stations were to be sited along the crest of the ridge between 57°W and 49°W. This was arranged as a separate week after the main coring cruise.

3. NARRATIVE (CJP)

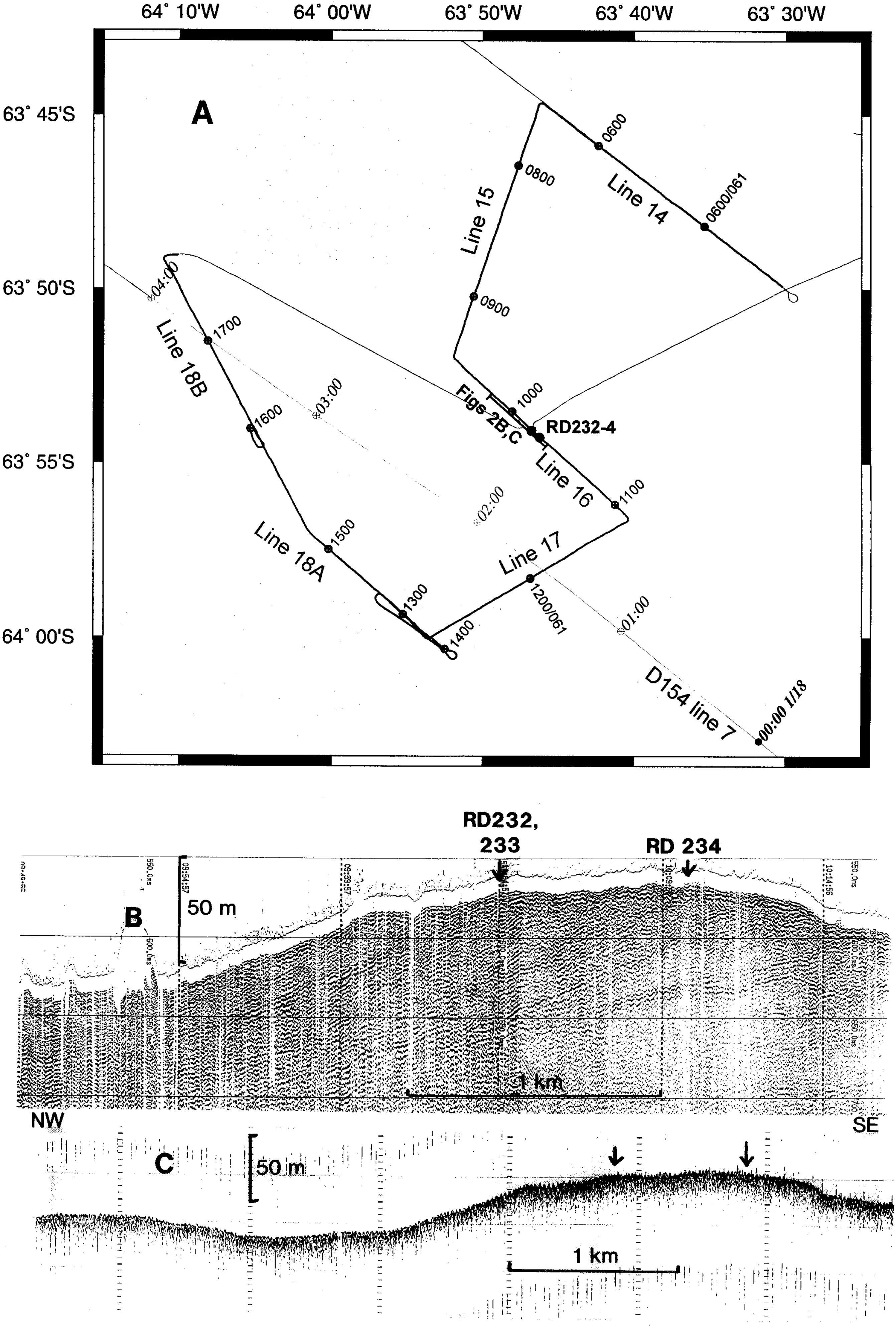
The scientific party joining for JR48 was delayed for a night at RAF Brize Norton by technical problems with the aircraft, arriving in the Falklands on the morning of Feb. 23rd. Fortunately, as all the BGS equipment was already at FIPASS, the ship's staff were able to commence mobilisation before we arrived. For a full account of the BGS mobilisation, see Skinner (2000). The RVS coring equipment had arrived by commercial seafreight to Mare Harbour on the 21st, and did not reach the ship until the afternoon of the 24th. The coring bucket, davits, auxiliary winch, core head rack and barrel rack were installed on the starboard side deck.

Mobilisation was completed on the morning of Saturday Feb 26th (Julian Day 057). We sailed in the early afternoon and spent two hours at anchor while safety training, including boat drill, was carried out. Once clear of the land the 10 kHz PES, the 3.5 kHz profiler, the non-toxic seawater supply and Ocean Logger were turned on. The first calibration of the Shipboard Three-Component Magnetometer (STCM) was carried out under way, and the magnetometer was streamed at 6pm. Our course was SSW over the western end of the Falkland Trough and Burdwood Bank, then across Drake Passage to a practice rockdrill site suggested by Dr Rob Larter (BAS). The weather was good and we averaged nearly 12 knots, arriving at the site (a rock pinnacle at 620 m depth) in the afternoon of day 059. Three deployments of the rockdrill totalling 5 hours were necessary to recover sufficient basalt for chemical analysis and dating. High tilt angles of the rig suggested a very irregular surface, and the third deployment was delayed by the failure of the ship's bow thruster. On the way towards Anvers Island one more stop was made, a vibrocore site (VC231) on the upper slope at 1100 m depth. Core and rockdrill sites are listed in Table 1.

3.1 Anvers Island Shelf

The first work area for the cruise was the inner continental shelf off Anvers Island. The inner shelf contains sedimentary basins of Cenozoic age (see Objectives), and we aimed to locate and sample outcrops where the bedrock is not covered by younger glacial sediments. An area near the southeastern end of BAS multichannel seismic line D154-07 was selected for detailed sparker survey. Three NW-SE lines were run about 6-7 miles apart, with two NE-SW lines connecting them (fig. 2A). The central line appeared to contain the most promising outcrops (figs. 2B, C), so after recovery of the sparker and hydrophone in the early afternoon of day 061 we returned to an outcrop of northwest-dipping strata at 63°54'S, 63°47'W to drill. The weather was fine and clear, with a good view of Anvers Island some 20 miles to the southeast. Three rockdrill sites (RD231, 232, 234) were occupied in ~430 m of water. All recovered 0.4-0.5 m of predominantly dark grey diamict and siltstone, which although highly fractured was thought to be in-situ, with minor amounts of other lithologies (volcanics, granodiorite etc.). RD233 had to be terminated, and the start of RD234 delayed, by continued problems with the ship's bow thruster. The success of this part of the cruise demonstrated the feasibility of sampling Cenozoic sediments in the inner shelf basins.

Fig. 2A. Location of sparker lines on the shelf north of Anvers Island. Discovery 154 MCS Line 7 is also shown.
B. Sparker line 16 showing rock drilling sites 232-234 on northwest-dipping outcrop.
C. 3.5 kHz profile, same as sparker line 16; note thin drape of sediment northwest of the outcrop.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Line 16
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Line 18A
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D154 line 7
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RD 234
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NW
SE
C
50 m
1 km

The route to the second work area was through Bransfield Strait and Antarctic Sound. At some stage a practice piston coring site was considered desirable, and it was decided to locate this in Bransfield Strait, at one of six sites requested as contingency work by Dr Jesus Baraza (ICM, Barcelona). The site required only a 13 mile deviation from our track, and PC235 was deployed in 1700 m of water in the afternoon of day 062. Although the wind was northwesterly force 5-6, the sheltered location allowed the corer to be deployed safely. All went smoothly, the station took just over 3 hours and we recovered 6.2 m of sediment in a 9 metre corer. Two humpback whales came to watch us coring, and whale sightings were a daily occurrence for the next twelve days. After the core station we entered Antarctic Sound in the evening and waited at the southern end for nearly 7 hours, moving off at first light on day 063.

3.2. Northern Larsen area

The second work area was east of the northern Antarctic Peninsula. The areas to be surveyed were formerly occupied by the Prince Gustav Ice Shelf (the Röhss and Sjögren glacier tongues), and the northern Larsen Ice Shelf between Cape Longing and Seal Nunataks (fig. 3). Ours was the first cruise to conduct a systematic survey and sampling programme in this area (fig. 4 and main track chart). Data available prior to JR48 included a satellite image dating from 1992 (i.e. before the main 1995 breakout), and bathymetric soundings from the Greenpeace vessel *Arctic Sunrise* which visited part of the area briefly in 1997. These bathymetric data were kindly supplied by Dr R del Valle (IAA, Buenos Aires). We also had bathymetric data from R/V *Polar Duke* and *N.B. Palmer* (GEODAS database) and the Argentine chart of Trinity Peninsula. British Admiralty charts gave soundings in Prince Gustav

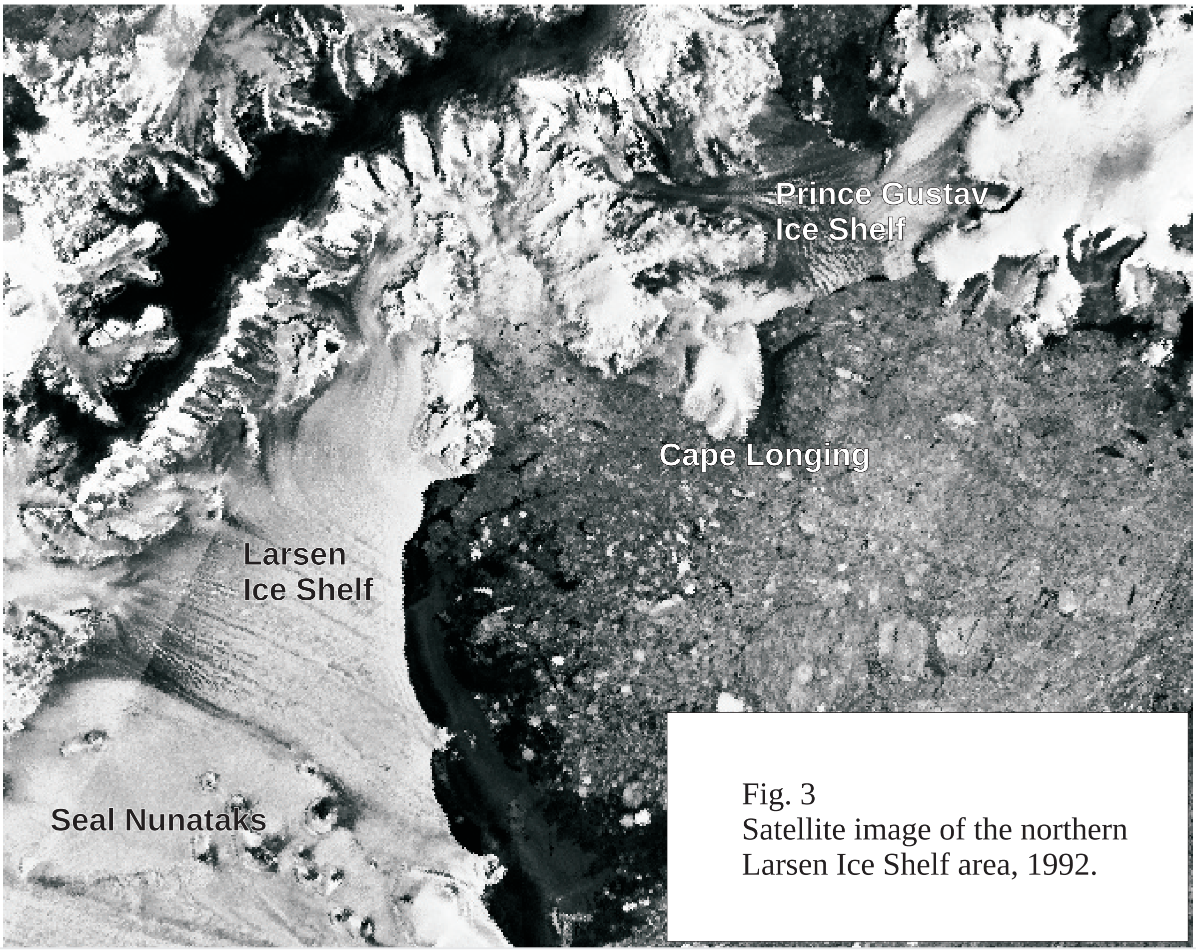


Fig. 3
Satellite image of the northern Larsen Ice Shelf area, 1992.

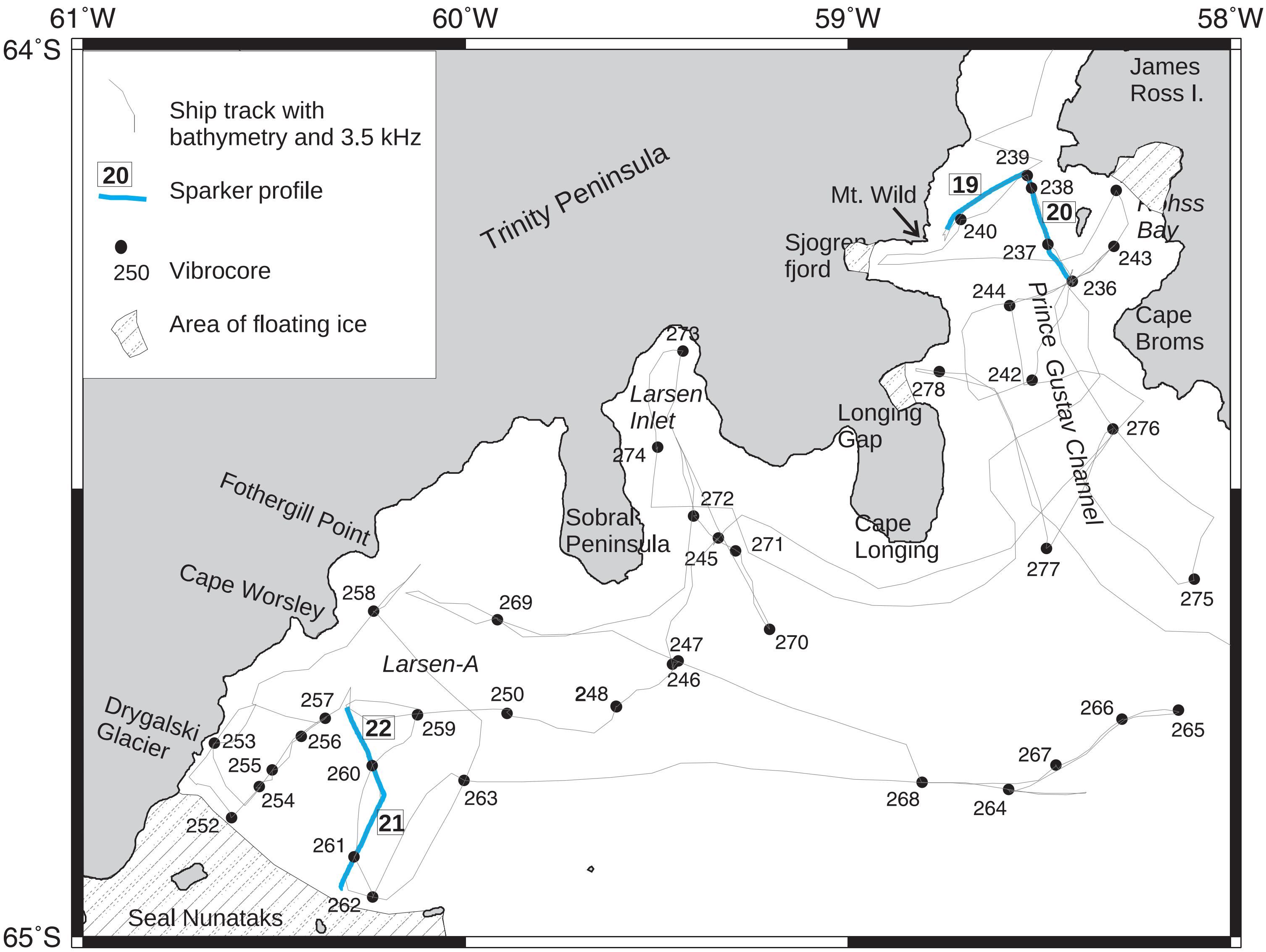


Fig. 4. Track chart of the northern Larsen area, with vibrocore sites and sparker lines. For a more detailed track chart of this area, see the foldout chart at the back of this report.

The ship had received Dartcom HRPT satellite images which showed the whole area to be essentially clear of ice, at least within the 1 km resolution of the system (see back cover). It was decided to start in southern Prince Gustav Channel and to sail there the pretty way, north of James Ross Island. After early fog, day 063 was fine and clear, and we made a fast passage through northern Prince Gustav Channel with stunning views of Vega Island and James Ross Island to port and Trinity Peninsula to starboard. Isolated bergs and stringers of pack ice were present, but we generally maintained 10-12 knots as far as 64°S. We noted a number of small tabular bergs with some 15 m of freeboard (top level with the bridge windows), therefore a total height of some 120m. It is possible these came from the most recent calving of Larsen-B, south of Seal Nunataks.

From Rum Cove (64°07'S) southwards was an unsurveyed area, with only a single line of *Arctic Sunrise* soundings to the south of Persson Island. On our arrival the northern part of the

the area between Cape Obelisk and Mt. Wild was clear of ice, but farther south there appeared to be only a narrow lead through the ice on the eastern side of the channel. There was a great variety of ice including tabular bergs, castle bergs, blue glacier ice, smooth floes, and pieces of old pack ice with spectacular pressure ridges. The amount of rock debris on and within the ice was unusually high by Antarctic standards. Wildlife included a pod of killer whales, crabeater seals on some of the ice floes, and an Antarctic skua which took a peck at the anemometer on the foremast (!). Abeam of Tumbledown cliffs we began a zigzag bathymetric survey to within 1 - 1 ½ miles of the headlands either side. Depths of nearly 1000 m in mid-channel shoaled to 800 m on the east side and 200 m near Mt. Wild. The central part of the channel had a drape of acoustically transparent sediment.

Near Mt. Wild we deployed the sparker for a line ENE towards Cape Obelisk, approximately along a flow line of the Sjögren Glacier tongue (fig. 5). Turning SSE, a second sparker line crossed this glacier tongue at right angles. This line was terminated at dusk (8 p.m) and we then selected 5 vibrocore sites back along the same line. Movement at night was restricted to a maximum speed of 4 knots along our own survey lines. Coming on station at night was often time-consuming, as a pool of open water had to be found where neither the ship nor the vibrocore cable would be menaced by drifting ice during the period of the deployment. The sites chosen sampled areas formerly beneath Röhss Glacier tongue (VC236), near Persson I (VC237), the channel-floor drape (VC238) and a small sediment pond (VC239). Finally VC240, occupied from 9-10 a.m. on day 064, sampled sediment proximal to Sjögren Glacier tongue. All recovered 5-6 m of sediment.

By then the ice within Sjögren "Glacier" (i.e. fjord) had loosened enough for the ship to work some 4 miles in to 58°55'W, 1.3 miles from the ice front, which took an hour. Beyond the shoal area near Mt Wild, depths of 500-700 m were encountered. We then headed east at 5-8 knots depending on ice, towards Röhss Bay. South and east of Persson Island we found increasingly clear ice conditions. In a flat calm and brilliant sunshine we took VC241 about 20 metres from the ice front in Röhss Bay, in over 500m of water, recovering nearly 5 m (fig. 6).

3.5 kHz survey lines were then run south and southwest out of Röhss Bay, west across Prince Gustav Channel, and south across the entrance to Longing Gap to just south of the 1993 ice front (fig. 4). The echo character beneath Röhss Glacier tongue is generally smoother and more reflective than that on the Sjögren side. This may result from differences in bedrock, with Trinity Peninsula Group or granite debris on the Sjögren side likely to be much more bouldery than that derived from the soft Cretaceous sediments on James Ross Island. VC242 was taken at the end of the survey line just beyond the ice front. The ship proceeded very slowly in darkness and loose ice back towards VC243, near the 1995 ice front southeast of Persson Island. The night's final site, VC244, sampled distal Sjögren glacier tongue sediment. These cores recovered 4.7-6 m.

Day 065 saw the start of overcast, cold weather and generally light southerly winds. We added to the survey of Prince Gustav Channel by running lines south to the site of VC242 then east towards Cape Broms and Nygren Point. The area from Nygren Point southwestwards lies at depths typical of Antarctic continental shelves (400-550 m). Ice of all types including increasingly large tabular bergs slowed our progress to 4-7 knots. We nosed into the entrance to Larsen Inlet but it was too full of ice to be able to work. We took VC245 (5.6 m) in over 700 m of water, then continued south past Sobral Peninsula until dusk. Coring overnight was initially hampered by mist and drifting ice (an attempted repeat of VC246 had to be aborted because of the difficulty of safely positioning the ship). Later in the night the visibility cleared and progress was made a little farther west. Vibrocores 248-250 had poor recovery in stiff diamict (0.7-2.7 m), but it was considered the diamict matrix was too soft to make it worth trying the rockdrill.

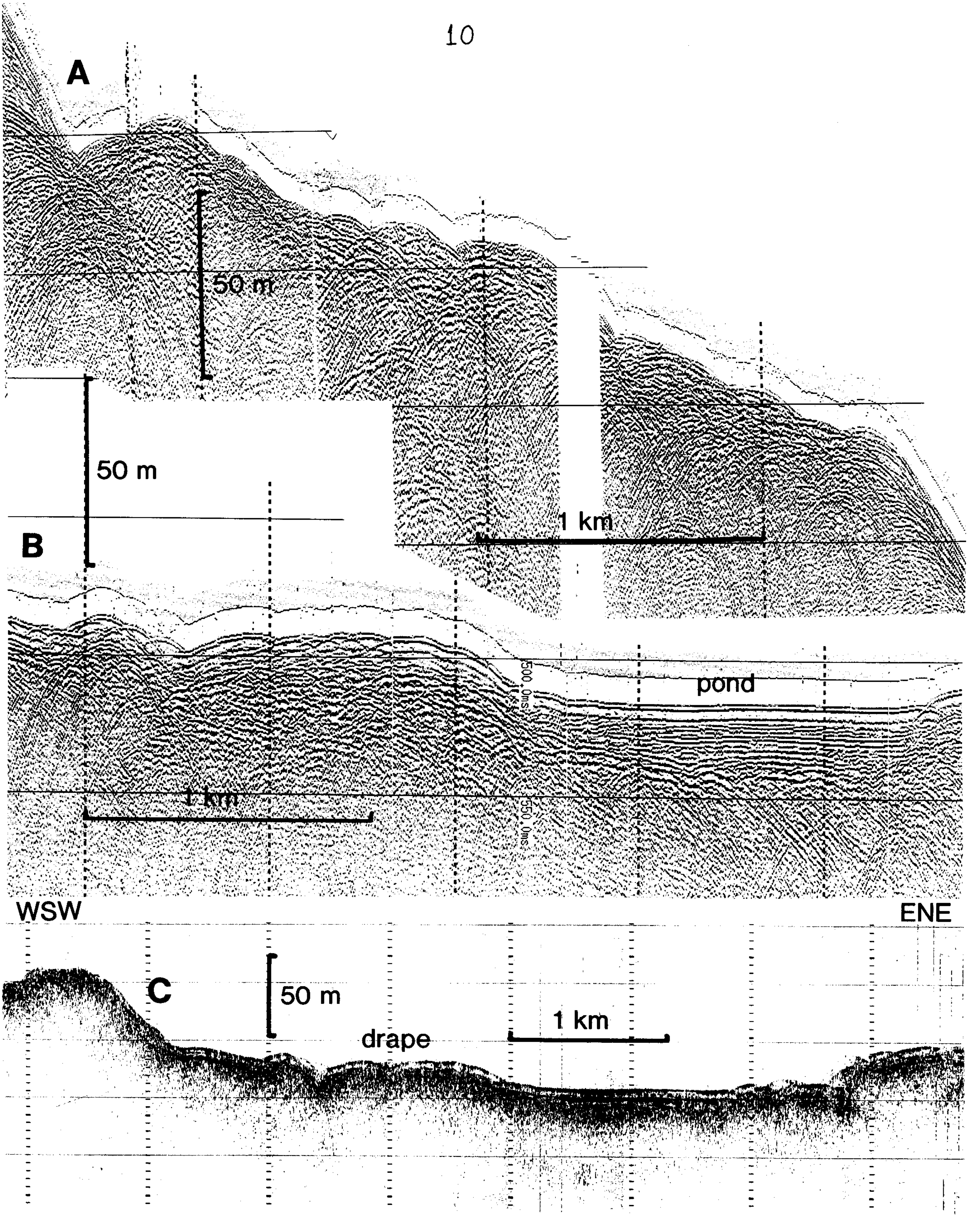


Fig. 5. Profiles in Prince Gustav Channel; locations on Larsen track chart (foldout).
A. Sparker line 19; hummocky topography, sediment formerly beneath Sjögren glacier tongue, near Mt Wild
B. Sparker line 19; draped and ponded sediment near centre of channel
C. 3.5 kHz line, same as fig. 6B.

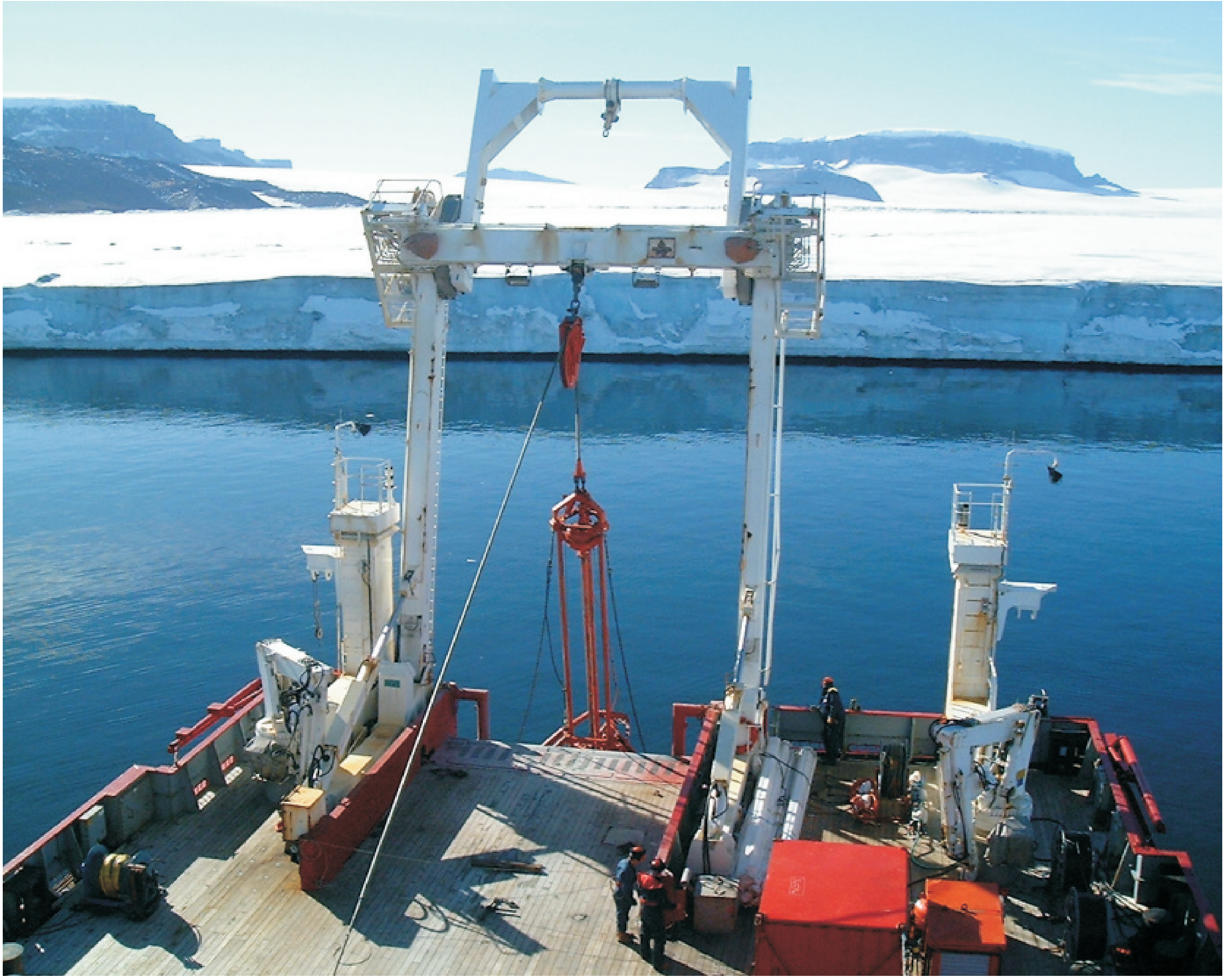


Fig. 6. RRS *James Clark Ross* coring just off the ice front, Röhss Bay. Water depth 517 m!

Day 066 was spent exploring the area just east of Drygalski Glacier. The southerly wind had left a large area of relatively open water north of Seal Nunataks. From VC250 we headed west, briefly north to the axis of the deep (900 m) channel mapped by *Arctic Sunrise* (del Valle et al., 1998), then SW to the ice front near Pedersen Nunatak. Again we cored just off the ice front in nearly 500 m of water. This time we tried the RVS corer rigged as a 3 m gravity corer (CC sample only) as well as the vibrocorer (0.5 m recovery). The advantages of the gravity corer are (i) shorter wire trips on the ship's main winch than the BGS winch, (ii) time spent with the corer on the seabed is only 1-2 minutes, making station-keeping in difficult ice conditions much less critical.

Proceeding WNW along the ice front we noticed large patches of rock debris at the edge of the rapidly melting ice. The origin of this as supraglacial debris, or as en- or subglacial debris exposed by melting, was of interest, as would be a comparison of modern debris with that in the cores. It was decided to attempt to sample the rocks, so the rescue boat was launched with a crew of three equipped with a geological hammer and boathook. The collection of some 100 kg of rocks was analysed on board for lithology, clast shape and surface features (see section 4). Still in overcast, calm conditions the ship edged into the southwest corner of the bay then northeast along the front of Drygalski Glacier, a huge mass of deeply crevassed blue ice. VC253 near the

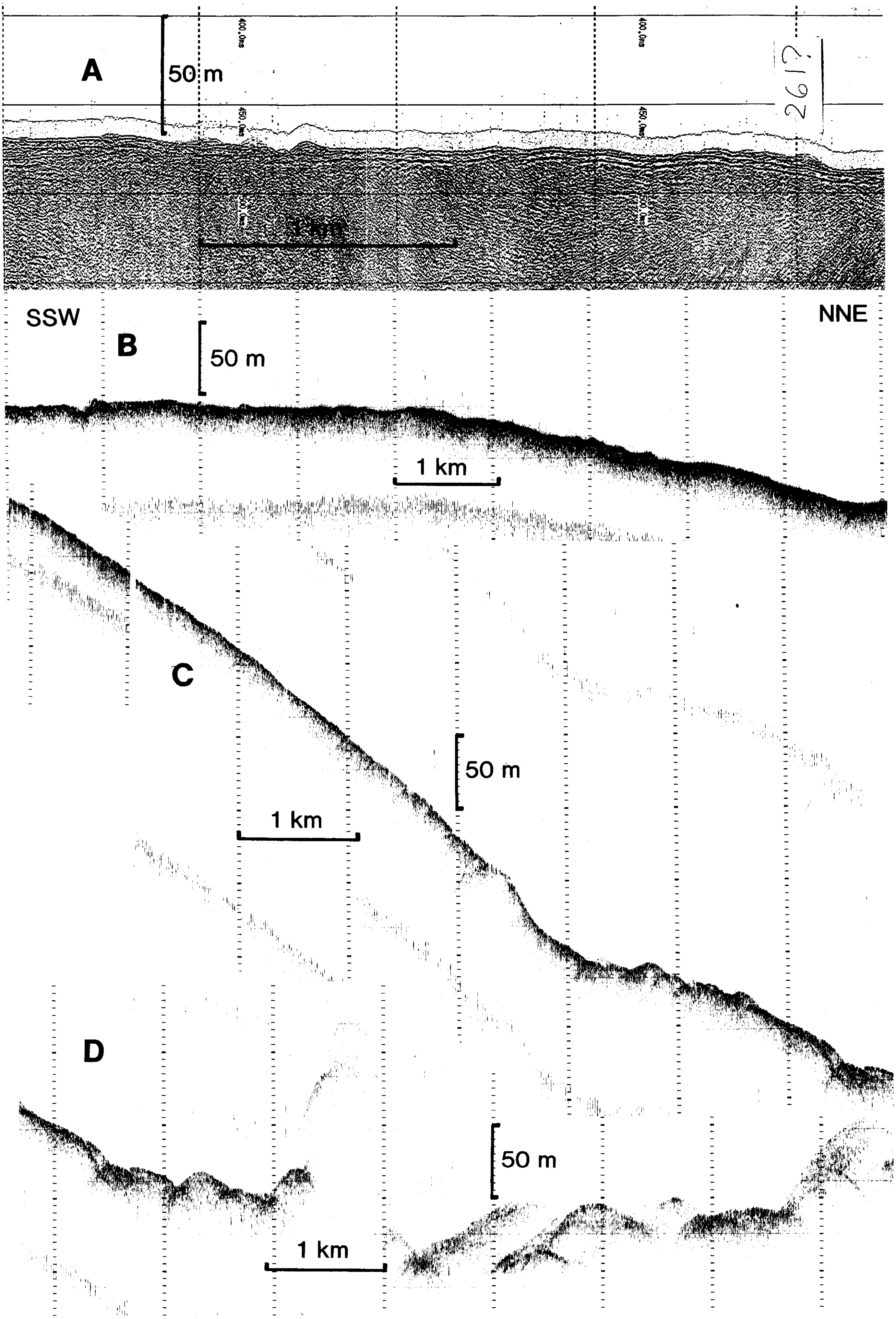
VC253 near the glacier snout (554 m water depth) recovered only a bag of gravel, although the penetration depth was 2.7 m. The night's coring was restricted to our approach line from the channel, and the first station (VC254) was delayed by problems with the DGPS. Nevertheless four short cores (1-3.3 m) were obtained, the deepest in 900 m of water.

The next day we made good progress surveying the central part of the Larsen-A area. From the last and deepest core site (where the rig was recovered with a bent core barrel, the first damage it had sustained), we headed west to the point off Drygalski Glacier where we had turned back the evening before. We were able to work the ship some 15 miles up the coast through loose ice, in overcast calm conditions with light powder snow falling. The seabed was smooth or hummocky with no 3.5 kHz penetration. Depths were 400-600 m about 2 miles off the coast. We turned back at Fothergill Point, as the ice ahead was too dense to work through, and took one vibrocore (VC258, 1.5 m) east of Cape Worsley.

With all the inshore work it had been impossible to empty the food-waste retention tank for several days (the tank must be emptied at least 12 miles from the nearest land), and it was now full. Luckily it was not necessary to go right out to sea, as there is a point at 64°46'S, 59°56'W which is more than 12 miles from Sobral Peninsula, Lindenberg Island and Cape Worsley. We therefore headed for this point to empty the tank. As there was now so little ice to the south we could make 8-10 knots in open water, SSW to the ice shelf front at 60°10'W near Larsen Nunatak. The generally smooth seabed looked promising for a sparker profile and there was no risk of the tow cables being damaged by ice. Sparker line 21 was directed NNE, perpendicular to the flowlines of the Drygalski ice stream(see fig. 3). The sparker and 3.5 kHz clearly showed an iceberg-ploughed shelf province down to 430 m water depth, a smooth slope from 430 to 700 m, and a hummocky trough floor (fig. 7). The line was diverted to the NNW after 6.5 miles as there was a wider lead in the ice that way. The night's four vibrocore sites were VC259 in the trough, VC260 on the slope, and VC261 and 262 in the furrowed shelf area. Recovery was only 0.6-1.9 m, but coring proceeded smoothly. As we were accumulating more bathymetric data, and the *Arctic Sunrise* soundings were in good agreement with ours, it was now possible to run new survey lines at night, albeit slowly, filling in gaps in our coverage.

Overnight it was so cold on deck (-14°C) that the rock drill froze up and the vibrocorer retract winch also froze intermittently, thawing out once submerged. Unmelted snow still lay on the decks, and the core bench was thick with ice which had formed when core sections were washed off. The vibrocorer barrel was being washed as much as possible while still outboard, to reduce the amount of ice on deck. Day 068 was spent on the continental shelf east of the historical ice shelf limit. Despite the availability of bathymetric soundings from the GEODAS database, this area was also considered officially unsurveyed and subject to the same restrictions on ship movement as the inshore areas. A long 3.5 kHz line along 64°50'S showed monotonously hard, smooth seabed with a few iceberg furrows, at depths of 360-450 m; a thin sediment drape was present east of 58°35'W. At 58°23'W we encountered a vast ice floe which barred further progress to the east. The opportunity was taken to sample sea ice for foraminifera, by ramming the ship's bow into the floe and scooping up fragments of ice (and red paint) with a long-handled shrimping net and bucket.

We then returned to core at the edge of the draped area (VC264, 4.0 m), and proceeded NE along the edge of the floe to find core sites for the night. Although it was at first thought the ice was the northern edge of the main Weddell pack, there was water sky beyond it. Re-examination of the Dartcom HRPT image from day 065 suggested the floe was a 5 x 7 mile ice mass, clearly visible to the south of our present position on that date. It had drifted NNW 13 miles in 3 days. Overnight in poor visibility three vibrocores were taken (3-5 m recovery), and a fourth (VC268, 0.9 m) in the early morning on the hard, furrowed seafloor some 10 miles west of the vast floe.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50 m
1 km

The following day (069) was extremely productive. A compilation of our bathymetric data by Peter Morris showed that the obvious gaps in coverage were in the bay west of Sobral Peninsula, and Larsen Inlet. In a light westerly breeze and excellent visibility we ran in towards Sobral Peninsula, passing it about 3.5 miles off. The whole of the bay to the west was a chaotic mass of ice of all shapes and sizes, packed into the bay by several days of generally southerly winds. Although it was obviously impenetrable by a ship, we were able to proceed west along its southern edge to link up with our track on day 067. Hundreds of crabeater seals watched our progress from the ice floes, and snow petrels flocked around the ship. The only penguins we saw were solitary Adélies on a few of the floes. On the way back we took VC269 (0.9 m) to sample sediment derived from the Bombardier and Dinsmoor glaciers (fig. 3).

We then headed east and northeast round Sobral Peninsula to see if we could make any progress in Larsen Inlet. The echo character and sediment recovery in Prince Gustav Channel and the Larsen-A area were so different that Larsen Inlet had assumed greater significance as a possible intermediate glacial setting. Although at first sight our way appeared to be barred by ice, as usual as we got closer leads opened up, and we went up the fjord in fine style, at 10 knots in 800 m of water. The *James Clark Ross* was the first ship ever to explore Larsen Inlet. There was rather too much ice to be able to work in darkness, so reluctantly we turned back at 6.15 pm. Coming out in the evening light, with pale grey-blue mountains all around and a mirror-calm sea with new ice forming and vistas of magnificent icebergs, was quite magical. We ran a survey line to the southeast and cored at three sites overnight, obtaining recovery of 2.4-6 m at VC270-272.

The early morning of day 070 saw the ship gliding up Larsen Inlet again, in a flat calm sea covered in new ice (pancakes and raft ice), with the Sobral Peninsula cliffs prominent on the west side. We made sinuous but steady progress at 3-5 knots right up to the head of the inlet, a mile from the glacier front. VC273 was the most spectacular core site ever, surrounded by ice and mountains rising to 1750 m; we obtained nearly 6 m from a hummocky seabed at 507 m depth. Our return track was offset 1-2 miles to the west, delineating an 800 m deep trough in the centre of the fjord; the shallowest sounding was 262 m, 0.7 miles off the Cretaceous cliff outcrop. We took one more core about half way down the inlet (VC274). While we were on station there was a dramatic change in the weather. The wind went round to north and the temperature rose about 12°C in as many minutes. The snow melted off the decks and soon the encrusted ice could be chipped away.

The bay west of Longing Gap appeared to be fairly full of ice, so rather than try to force a way in we returned to Prince Gustav Channel, along a line 2 miles south of our earlier track on day 065. A southwest-northesst survey line from near Cape Longing to Cape Broms was completed in rapidly worsening weather. As we crossed Prince Gustav Channel the wind increased to force 6, and there was by now considerably more ice in the channel than during our earlier work here. Although in such a sheltered position no swell could build up, the ship's position was still quite hazardous at night because of the quantity of rapidly drifting ice. Luckily an area where we had soundings, some 3 miles south of Persson Island, looked reasonably clear, and we stopped for the night on dynamic positioning at 64°15'S, 58°25'W. Despite the now gale-force northerly wind (maximum gust 72 knots), the evening was fine and mainly clear, with spectacular clouds over the mountains to the west.

Fig. 7. Sparker and 3.5 kHz profiles, Larsen-A. Locations on Larsen fold-out.

A. sparker profile (Line 21) on iceberg-furrowed shelf area

B. 3.5 kHz profile on iceberg-furrowed shelf area

C. 3.5 kHz profile, slope

D. 3.5 kHz profile, hummocky channel floor.

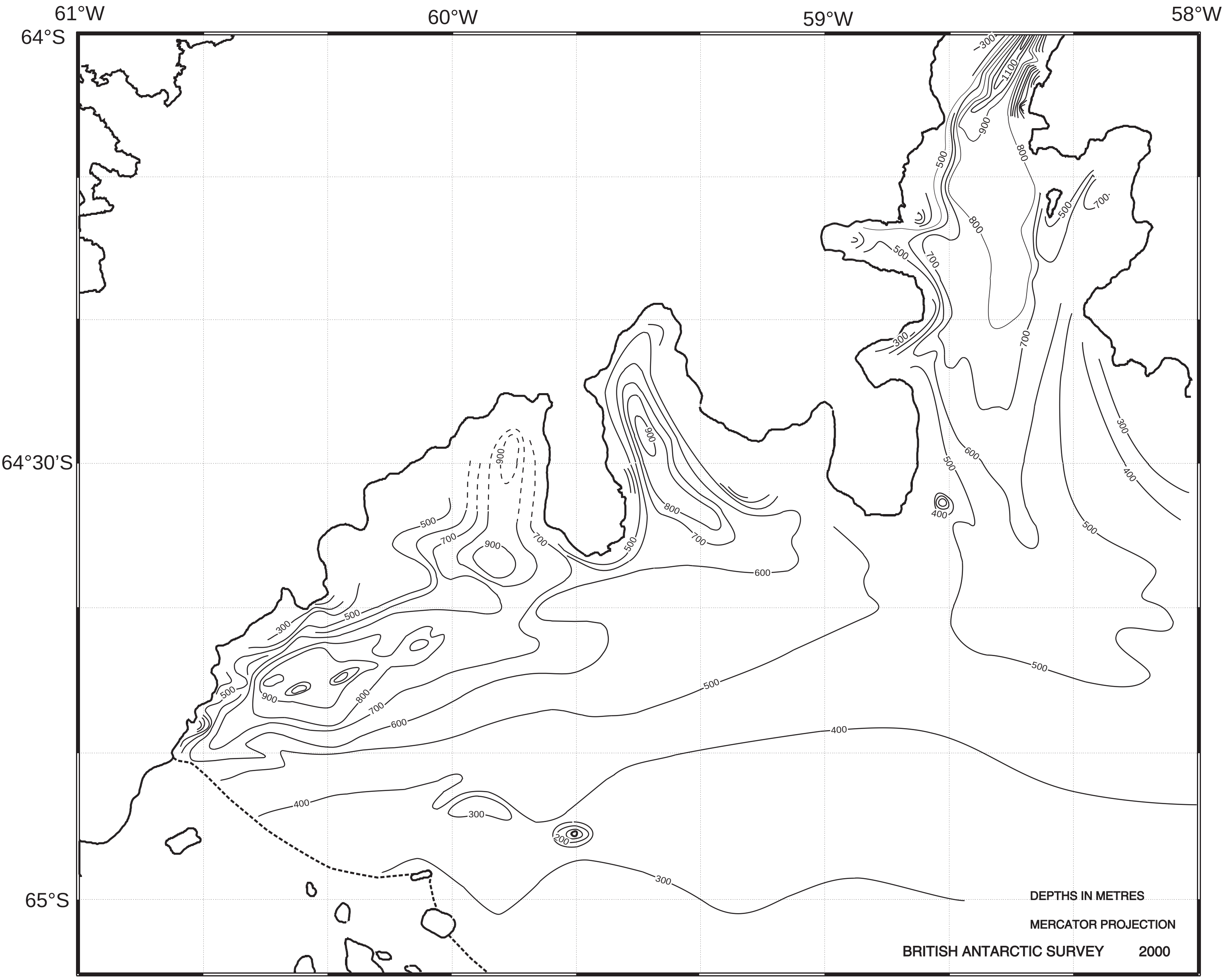

61°W
60°W
59°W
58°W
64°S
64°30'S
65°S
DEPTHS IN METRES
MERCATOR PROJECTION
BRITISH ANTARCTIC SURVEY 2000

Fig. 8. Bathymetry of northern Larsen Ice Shelf - Prince Gustav Channel area. Compiled from soundings of RRS *James Clark Ross* (2000), MV *Arctic Sunrise* (1997), RV *Polar Duke* (1991) and published charts.

The only areas which remained to be surveyed (Fig. 8) were the bay east of Longing Gap, and the south side of James Ross Island out to the 1902 ice edge and beyond. We had hoped to run a sparker line south of James Ross Island, but on day 071 there was too much ice (and still too much wind) to permit this. We were able to get under way at 1325, having lost 17 ½ hours waiting on weather. The wind had dropped to about 25 knots. We made very good progress on a southeasterly 3.5 kHz survey line, then turned south for 5 miles and took one vibrocore (VC275, 5.3 m) before running back on a parallel line, heading for Longing Gap. Unfortunately the wind got up again from the north and the Captain considered it prudent to stop again at 6.45 pm. We had just reached one of our earlier tracks, so when conditions eased just before 1 a.m. the ship could move along this line and take two cores in the drape in the central part of the channel. By dawn there was only a light breeze from the SW, so after completing VC276 and 277 (4.7 and 3.9 m) we ran up towards Longing Gap at 9 knots.

Again we were able to get right up to the ice front (actually 4 cables off), but the seabed there was rather too hummocky for successful coring. VC278 was sited at the entrance to the bay in a tiny sediment pond, and recovered 3.7 m. Poor visibility, and rain turning to snow flurries, encouraged us to leave for the open sea. As we headed east the ice began to thin out and we increased speed to 11-12 knots. Rather than stop to core, we decided to make as much progress as possible before nightfall. Snow Hill Island (our last sight of the Antarctic) was only just visible at 12 miles range. VC279, about 30 miles inboard of the shelf edge, recovered only 0.7 m although 1.6 m was cored and the (double) core catcher was inverted; coring diamicts is not easy. Although ice conditions had now eased to thin stringers of pack with large (1-2 miles) pools of open water in between, it was again decided to stop overnight in calm but misty weather, and another 7 hours were lost.

Some of the cores from the northern Larsen area were split on board (see section 7.10). Three representative core logs are shown in fig. 9.

3.3 Outer Continental Shelf and Slope

Because of (i) the time lost to weather, (ii) the likelihood of difficult ice conditions in that area, it was decided not to attempt the Seymour Island work. Instead we spent an extra day on the Quaternary of the outer shelf and slope. After the overnight stop the ship got underway at first light, steamed east to the shelf edge (the exact position of which was not previously charted) and took a vibrocore 3 miles inboard of the edge. VC280 obtained somewhat better recovery at 2.5m.

Two 3.5 kHz survey lines (speed 8-10 knots because of fog) were then run over the slope, to map any southward extension of the sediment drift cored on JR04 (Gilbert et al. 1998). The southern line revealed a smooth, acoustically opaque, concave-up slope profile. On the northern line, the pattern of sub-bottom reflectors showed turbidites and thin debris flows from the base of the slope at 2600 m up to about 1800 m . These probably constitute the right-bank levee of the large channel mapped by Gilbert et al. (1998).

We attempted a vibrocore (VC281) at 1980 m on the slope. This depth, although within the design limits of the system, proved too much for the pressure vessel containing the rig electronics, and it imploded at 1950 m (see Skinner, 2000). Problems were also experienced with the corer winch spooling, but the rig was recovered to deck just after 11 pm. It was lifted inboard

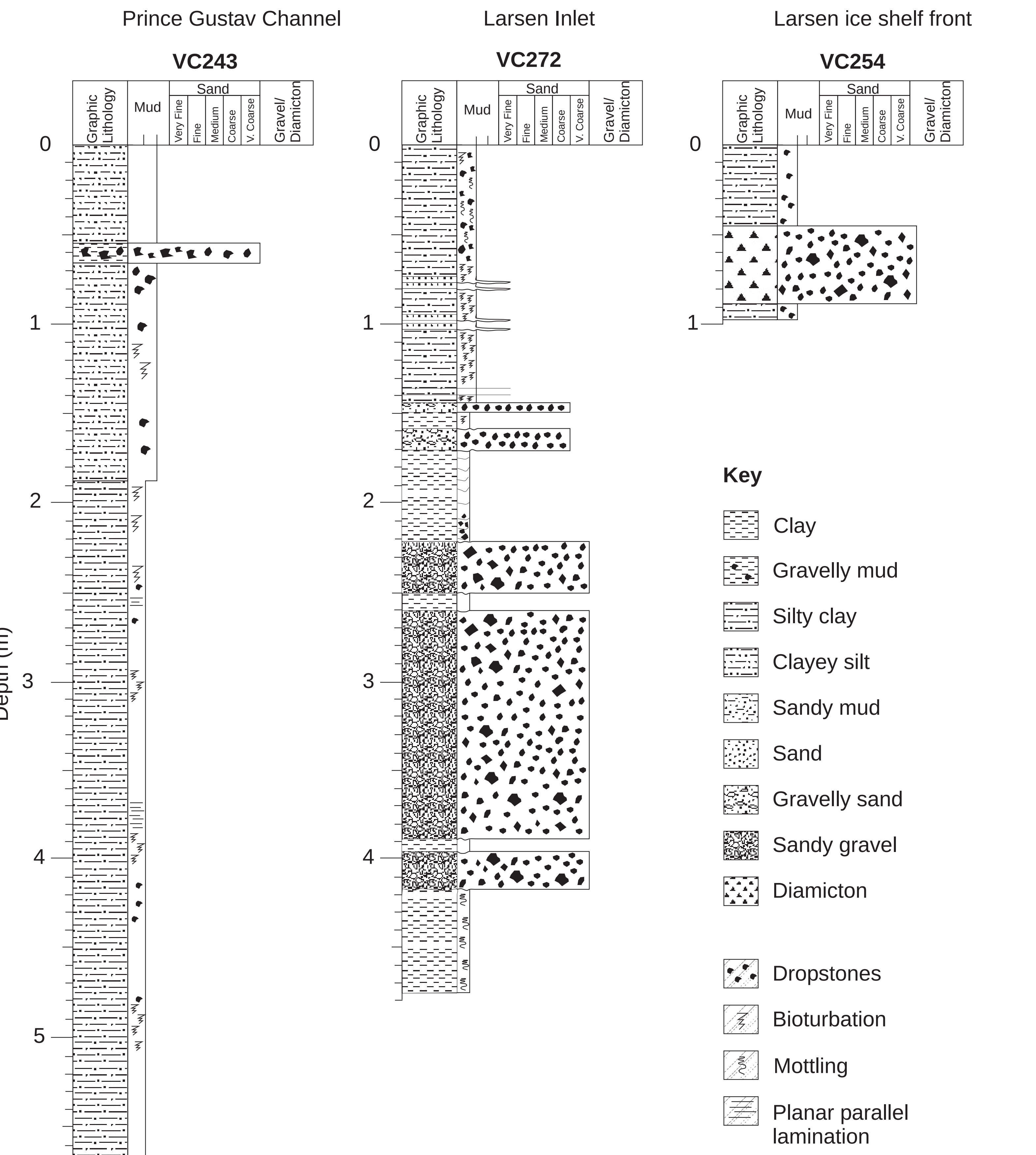


Fig. 9. (J. Evans) Representative core logs from Prince Gustav Channel (VC243), Larsen Inlet (VC275) and Larsen-A (VC254).

from the transom (luckily in flat calm conditions) so that the electronics unit could be replaced. The ship got under way slowly northwestwards, stopping again in the middle watch to return the rig to its pre-deployment position. VC282 (3.9 m) was a final vibrocore near the shelf edge.

3.4 Northern Weddell Sea

On the morning of day 074 we set off northeastward for Powell Basin and the start of the deep-water piston coring programme. The magnetometer was streamed at 9 a.m. when we were at last reasonably clear of ice, and a small diversion was made to map the upper part of Gilbert et al's large channel (some 55 km wide and 1000 m deep on the upper slope!). We made fast progress in daylight to the southwest side of Powell Basin, though the magnetometer had to be recovered at dusk because of ice.

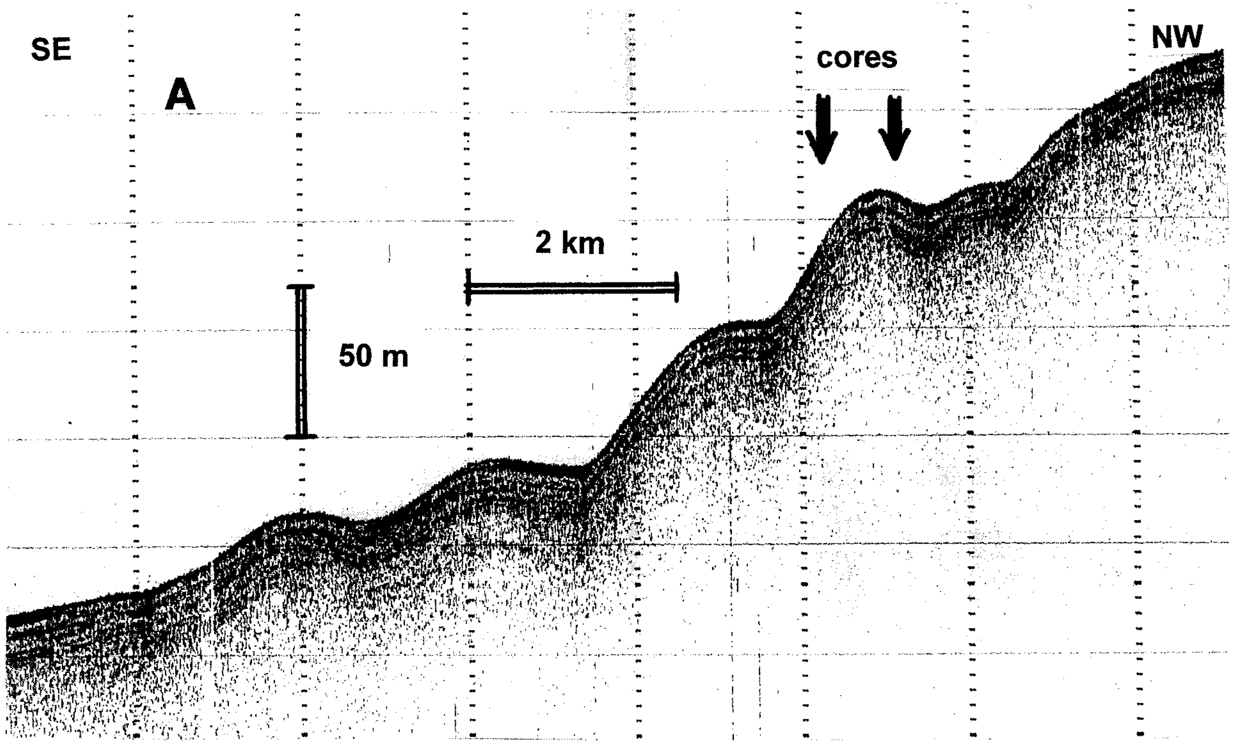
North-west Powell Basin contains an area of migrating sediment waves, partially mapped by B/O *Hesperides* in 1993 using swath bathymetry (Howe et al. 1998). We planned to conduct a 3.5 kHz survey of the waves, on tracks 2 miles apart and oriented 109°/209°, at right angles to the wave crests. An approach from the south close to a Shackleton 801 line revealed waves as expected (fig. 10A). By this time the easterly wind was increasing to force 6-7. The survey could only be conducted at 6 knots (the same speed being requested for upwind and downwind legs), and care had to be taken on the turns to prevent excessive rolling. Despite the rough sea conditions we obtained reasonable data from the 3.5 kHz, enabling individual wave crests to be mapped for 8-10 miles. At the end of the fourth line (forenoon of day 075) two core sites were chosen on the gentle and steep sides of one sediment wave. Although the wind had moderated slightly, the sea state was confused and very marginal for coring, and those on deck got fairly wet. At PC283 (4 barrels, gentle side) two of the core liners partly imploded, which may have a detrimental effect on core quality. After recovery the corer was immediately rebuilt with 3 barrels for PC284 on the steep side of the sediment wave, while the ship shifted 0.7 miles in D.P. mode. We recovered 7.2 and 7.8 m at the two sites, surprisingly little given the soft consistency of the mud.

Overnight we ran two more lines across the wave field, then headed ESE for a third core in the turbiditic area of Powell Basin. Again the liner in the third barrel (of 4) partly imploded and we only recovered 4.2 m at PC285. The magnetometer was streamed and the ship headed for the next core site in Jane Basin. Intermittent fog kept ship speed down to about 10 knots. The plan was for a new west-east magnetics/3.5 kHz line across the southern edge of the South Orkney plateau followed by a 40-mile southwest-northeast line along Jane Basin. At 7.30 pm. in thick fog we approached a dense concentration of ice, which forced us to recover the magnetometer and divert some 25 miles to the north of the intended track. It was therefore decided to head straight for the core site, to avoid losing any more time. The magnetometer was streamed again at dawn on day 077.

PC286 was a repeat of GC027 obtained from *Discovery* in 1985. Coring was a success with 9.4 m recovered and no imploded liners. A slacker piston fit was used at this and all subsequent sites. The ship then conducted an STCM calibration while still on D.P. (it is easier to spin the ship at 30°/minute first to starboard then to port while on station than to steam in a figure of eight, particularly when there is ice about).

3.5 Scotia Sea and Falkland Trough

The next four cores (PC287 to 290) formed a transect across the Scotia Sea from Discovery Bank at 60°18' S to a repeat of PC078 (JR04) at 55°33' S. All were obtained without any problems. Although we were plagued by fog until the afternoon of day 078, there was by



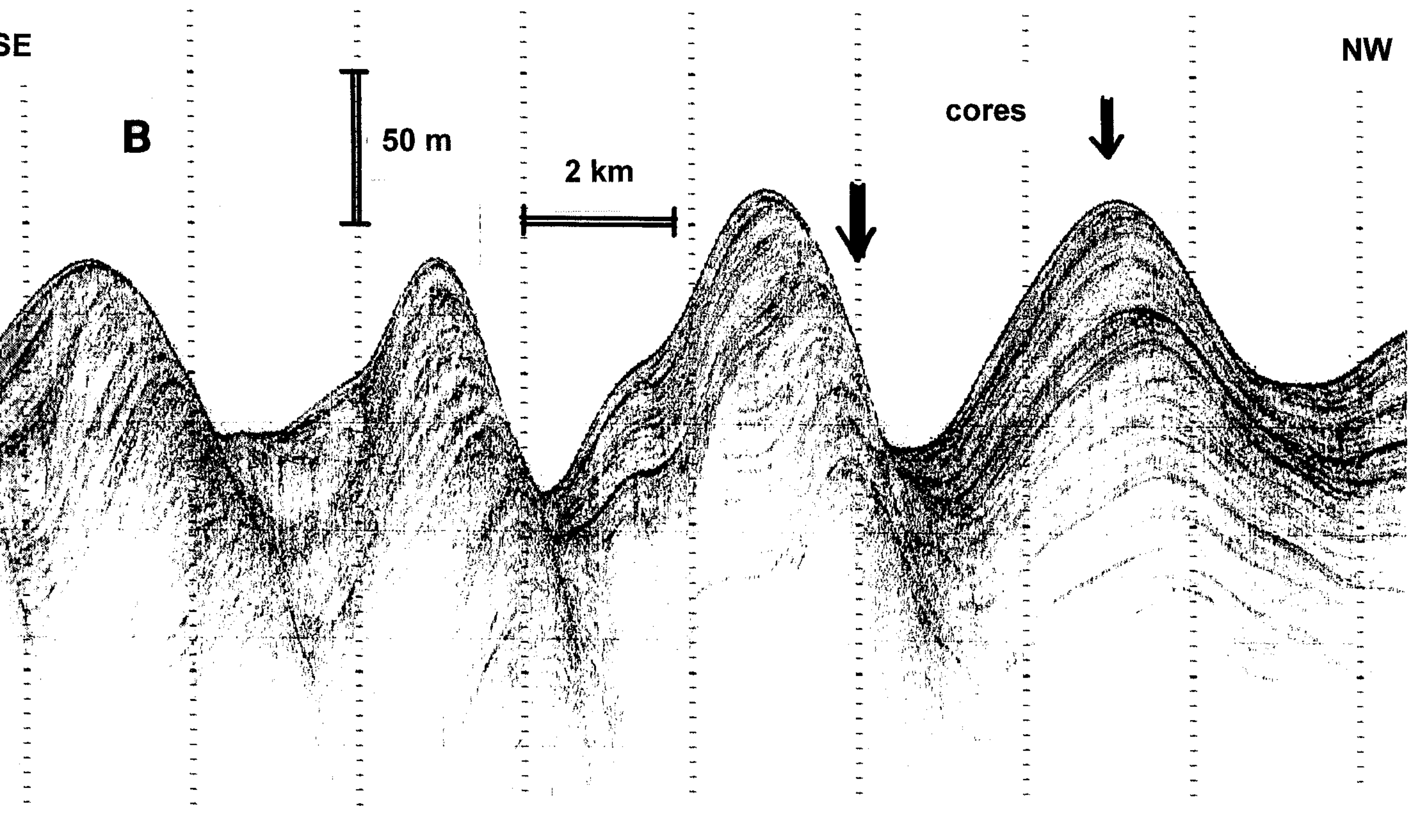


Fig. 10A. 3.5 kHz profile, sediment waves in Powell Basin. Location on fig. 1.

Fig. 10B. 3.5 kHz profile, sediment waves in the eastern Falkland Trough. Location on fig. 1.

now much less ice around so it was considered safe to leave the magnetometer out overnight. After PC288 we cut 2 m off the trigger chain, reducing the free-fall distance to 4 m; this had the desired effect of increasing recovery, i.e. getting sediment into the top barrel (Table 1).

Although we had received our last weather forecast of the season from Rothera on day 078, synoptic charts were still arriving by fax from Bracknell each weekday. The weather did not look particularly threatening as we steamed north across the North Scotia Ridge early on day 081 to begin a detailed survey of sediment waves in the eastern Falkland Trough. These waves had been interpreted by Cunningham & Barker (1996) as being formed by Weddell Sea Deep Water, so should form an interesting comparison with Powell Basin. Our tracks were parallel to a *Discovery* line at 141°/321°, at right angles to the wave crests. The first track 3 miles northeast of the *Discovery* line revealed magnificent sediment waves 50-100 m high and with crests 4-5 km apart, strongly asymmetric in the southeast and less so to the northwest (fig. 10B).

Two core sites were chosen, one on a wave crest and one on the steep side of an adjacent wave. We ran part of the second survey line before returning to core. The first station went very smoothly (PC291, 6.5 tons pull-out, 11.2 m recovery). On the steep side of the wave we expected a condensed section with stiffer, possibly sandy sediments, so the corer was rebuilt with 3 barrels while the ship shifted 1.8 miles southeastwards. From recovery of the corer inboard to readiness for the next station took only 32 minutes - a tribute to the effectiveness of the coring crew. At PC292 we got the corer stuck in the seabed. A straight pull of 7.6 tons failed to dislodge it (the SWL of the wire is 7.84 tons). We spent 3 1/4 hours moving the ship around the core site on D.P., maintaining the wire tension at 5-8 tons and pulling at 5-10° off the vertical, attempting to waggle the corer out. It finally came free at 8.46 pm at a tension of 8 ½ tons. All the barrels were still straight and recovery was 5.1 m. The stressed pennant wire was put aside for recycling.

Overnight we finished the second survey line and ran two more lines farther northeast, Sediment wave height decreases northeastwards. The intention was then to run a sparker profile 3 miles southwest of the Discovery track, to see if basement topography had any effect on the location of sediment waves. At 0630 the wind was northeasterly force 4, but an hour and a half later it had increased to force 6 and the sea was too rough to see any signal from the sparker at all (not even the seabed). We therefore recovered the sparker and ran the line with the 3.5 kHz instead, while the wind continued to increase. At 8 knots ship speed we obtained a reasonably good record, despite the beam sea, until just before 10 am when aeration under the hull transducer wiped out the echo. The ship was requested to heave to. Half an hour later the wind was force 10 from the NNE and the barometer was dropping like a stone. We remained hove-to for the rest of the day, with the wind gusting to 62 knots and the after deck frequently awash. About 3 pm the wind dropped to force 7 briefly and started to back, the barometer rose again equally rapidly and a cross swell started to develop. Our hove-to course was approximately northeastwards until 7 pm then northwestwards. The 3.5 kHz was turned back on at 4 pm and the PES at 10 pm.

Not until just after midnight on day 083 were we able to start making reasonable progress to the west. There was still a big swell from the north, and insufficient time remained to wait until conditions improved enough to take the planned third core at a site away from the waves, or to run any more survey lines. A course was laid for the last core site in the western Falkland Trough and the magnetometer streamed at 8.15 am. During the day and a half's steaming, all the BGS electronics equipment except the magnetometer was packed up, and a start made on report writing. We also enjoyed the end-of-cruise dinner and party, a credit to the catering department.

The magnetometer (which had been producing increasingly noisy data) was recovered for the last time a few miles before the last core site and we came on station at 1 pm on day 084. The site (PC293) was a repeat of KC097 obtained on cruise JR09B, on a small sediment drift in the western Falkland Trough. Fortunately for the nerves of the coring team, the pull-out this time was only 4 ½ tons and recovery was 10 m. No damage or loss was sustained to any of the piston coring equipment at any of the 13 stations.

BGS had requested time on station in deep water to pay out most of the umbilical cable (weighted with the rig stripped of its electronics) so that it could be spooled back on to the winch correctly. This operation commenced as soon as the piston corer had been brought inboard and took 2 hours, followed by some time to lift the rig inboard of the transom and secure it. A third STCM calibration was then carried out in D.P. mode. There was just time for a 7-mile excursion to the southern edge of the sediment drift, before starting the run home to Stanley with a complete 3.5 kHz crossing of the drift 3 miles west of the core site.

The 3.5 kHz profiler, PES, non-toxic seawater supply and ocean logger were turned off at 8 am on Saturday March 25th (day 085). We had Cape Pembroke abeam at 0810 and secured alongside FIPASS at 0905. Then began an extremely busy day of demobilisation (in the rain). By 6 pm all the BGS and RVS equipment had been removed from the after deck, dismantled and stowed in its containers, and the containers placed in the forward hold. The labs were cleared in readiness for the next part of the cruise. By 10 am on Sunday 26th, securing for sea had been completed and the technical staff were able to enjoy a well-earned run ashore (in the rain).

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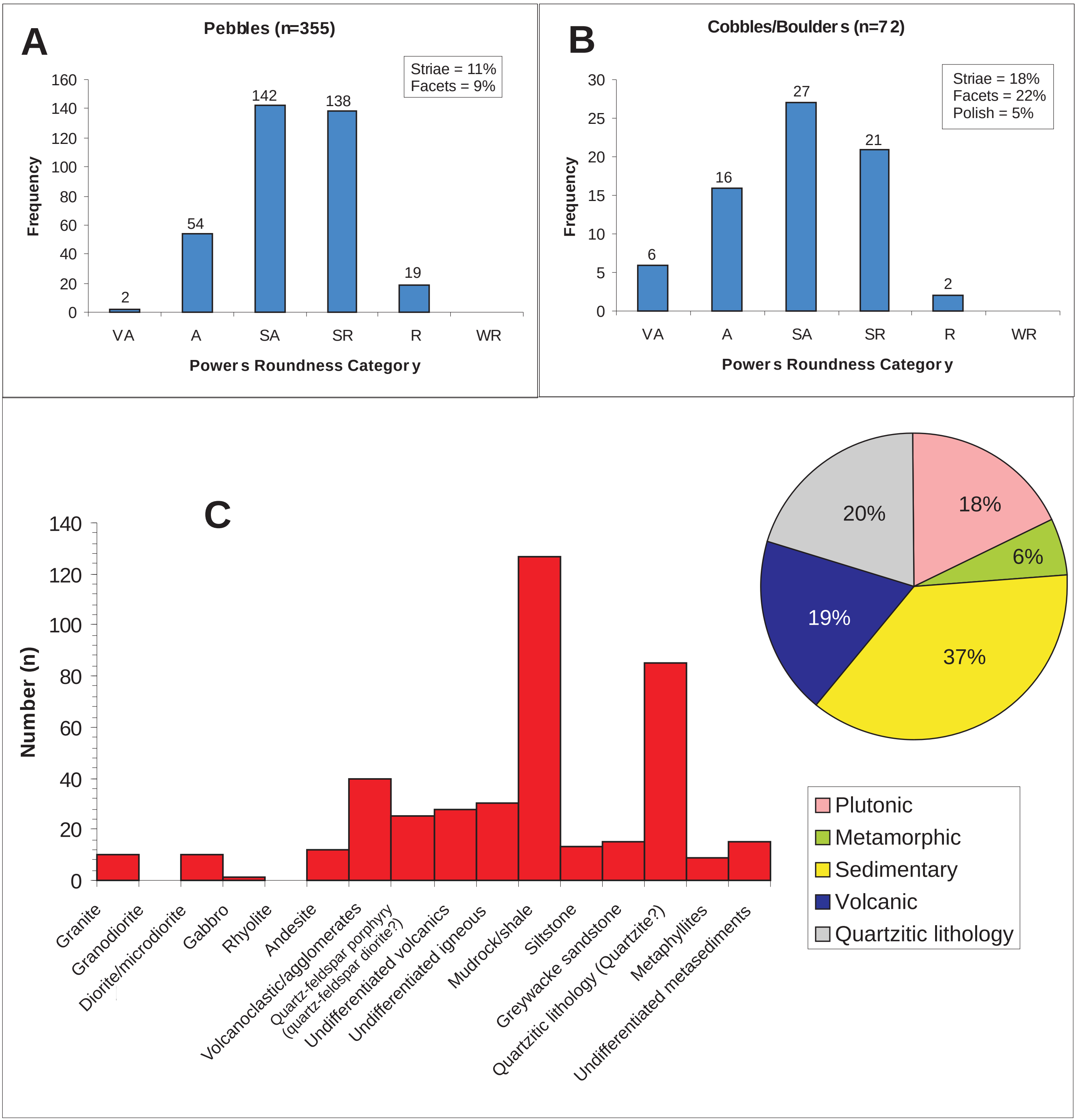


Fig. 11. A. Powers roundness for clasts collected from the surface of the Larsen Ice Shelf: pebbles.
B. Powers roundness for clasts collected from the surface of the Larsen Ice Shelf: cobbles and boulders.
C. Petrographic types (all clast sizes).

4. ICE SHELF ROCK DEBRIS (COC, JE)

Debris bands melting out on the surface of the Larsen Ice Shelf along its front (adjacent to the Drygalski Glacier) were sampled. Shape analysis (Powers Roundness) and petrographical identification were conducted on pebbles (n=355) and cobbles + boulders (n=72) to determine the relative proportion of subglacial vs. rockfall debris and to investigate the provenance of clasts by comparing them to published geological sources on the Antarctic Peninsula.

4.1. Shape analysis

The objective of this work is to provide information on contemporary debris transport paths and subsequent deposition in the Larsen Ice Shelf system. Debris that falls onto a glacier surface by rockfall from valley or fjord walls is typically angular in shape. By contrast, subglacial debris tends to be more rounded as a result of its comminution during transport. Subglacial clasts are also commonly striated and faceted, and they may be polished. Almost 80% of the pebble-size fraction falls into the Powers categories of subangular and subrounded, and striated and faceted clasts account for 11% and 9% respectively (fig.11A). A similarly high proportion of subangular and subrounded clasts is recorded in the boulder and cobble sizes (67%). Striated and faceted clasts comprise 18% and 22% respectively of this size range (fig. 11B). These data indicate that a significant proportion of debris transport through the Larsen Ice Shelf system occurs at the ice/bed interface (cf. Boulton 1978). Few very angular and rounded/well rounded clasts occur. Angular clasts account for 15% of the pebble-sized fraction and 22% of the cobble-boulder fraction, and these testify to formation by frost-shattering on valley walls up-ice and relatively passive supraglacial transport to the sample site.

4.2. Petrographical analysis

Clasts were categorised according to their petrography and main lithological grouping (fig. 11C). The clasts comprise 37% sedimentary, 19% volcanic and 18% igneous lithologies. A further 20% of clasts are thought to be quartzite, although further detailed petrographical analysis will be needed for firmer identification. Metamorphic clasts are rare (5.7%).

In more detail, sedimentary clasts are dominated by mudrock/shale (n=127) and less common siltstones (n=13) and greywacke sandstones (n=15) derived from the Trinity Peninsula Group outcropping widely throughout the Antarctic Peninsula (Fleming & Thomson 1979). Igneous clasts comprise granite (n=10) and diorite/microdiorite (n=10), quartz-feldspar porphyry (or possibly quartz-feldspar diorite?; n=25) and other undifferentiated rock types (n=30) that probably derive from the suite of intrusive rocks outcropping across the interior of this region of the Antarctic Peninsula. Volcanic clasts are dominated by volcaniclastics and agglomerates (n=40), andesites (n=12) and other undifferentiated rock types (n=28) derived from the Antarctic Peninsula Volcanic Group outcropping close to the present day ice shelf margin. Metamorphic clasts comprise metaphyllites (n=9) and other metasediments (n=15) belonging to the Trinity Peninsula Group (Fleming & Thomson 1979). The ?quartzites have no documented source in this region of the Antarctic Peninsula, suggesting the identification of the lithology may be incorrect.

5. COLLECTION OF PLANKTON SAMPLES (KED, MK)

5.1. Collection of Antarctic subpolar and polar planktonic foraminifera for DNA and morphometric analysis

5.1.1. Objectives

Using a molecular approach, we have found that many morphologically defined species of planktonic foraminifers represent several distinct genetic types (genotypes). We are in the process of charting the global distribution of the genotypes in order to understand the mechanisms, which have led to their divergence. The distribution patterns show us that identical genetic types may occur in very distant parts of the ocean and also that specific genotypes of the same morphospecies may be adapted to different environmental conditions. As part of our high latitude investigation, planktonic foraminifers were collected from the Antarctic subpolar and polar water masses during cruise JR19 in 1997. The pilot study showed that there is a surprisingly high level of genetic variability within the three morphospecies of Antarctic subpolar and polar of planktonic foraminifers. In addition, their distribution pattern indicated that individual genotypes may be associated with specific Antarctic water masses.

Our objectives for cruise JR48 were to sample the Antarctic water masses to determine the genotype population structure and also to compare the distribution pattern with that found during cruise JR19.We took digital video images of each specimen prior to processing for DNA analysis. This will enable us to carry out digital morphometric analysis on the planktonic foraminiferal shells to characterise the specific genotypes morphologically.

5.1.2. Methods

Specimens for DNA analysis were collected from the ship's uncontaminated sea water supply (6-m depth) to the preparation laboratory. The water was run continuously and coarse filtered (>1500 μm) near the intake. For sampling, water was filtered through a 63-μm screen at a flow rate of ~15 litres/min and the retained plankton washed off with clean seawater into glass picking dishes. On several occasions, a coarser screen (125 μm) was used when the finer screen became clogged due to high algal concentrations in the plankton. Following sampling, the screen was cleaned by flushing with a powerful fresh water spray to remove all adherent particles and dried. The time (GMT) was noted at the beginning and end of the sampling periods (~1.5 hrs). Bulk samples were also collected (~1.5 hrs) following sampling for genotyping to provide foraminiferal assemblage abundance counts and specimens for later scanning microscopy.

Specimens for genotyping were picked from the sample and kept in fresh seawater until processed. The largest specimens were selected as they are more easily crushed and the morphology is most likely to resemble the mature form of the shells found in sediments. The species identification, coiling direction and cytoplasmic colour were recorded for each specimen. Specimens were then individually cleaned, placed into a microtube on the tip of a fine brush and crushed in 20 μl of lysis buffer. The Pasteur micro-crushers were then decontaminated in 0.1 M HCl, washed in fresh water and individually dried. After crushing, the microtubes were sealed, labelled and incubated in a drying oven for ~1 hour at 60ºC. One half of the samples were then stored in the ship's freezer at –80ºC and the second half of the samples were stored at ambient temperature to be transported to Edinburgh for immediate analysis.

Digital images of most specimens were taken prior to their transfer into the microtubes. The specimens were first placed onto a glass slide with a printed scale (equally spaced vertical lines) attached to the bottom. A digital camera connected to the stereomicroscope and a video monitor were then used to save images of the foraminifers on videotape. The maximum magnification was used for filming the specimens and for each specimen, the printed scale was brought into focus to allow us to assess eventual variations in the zoom settings of both the microscope and the camera. The identity of each specimen was indicated by voice, as the camera also records sound during filming.

In order to investigate whether a different assemblage of planktonic foraminifera occurred in the different water masses at greater depths in the water column, some of the pumping stations were accompanied by 100m vertical net samples. The plankton net used had a mesh size of about 85 µm, and it was lowered using a weight of about 6 kg attached to its end. All nets were taken while the ship was stationary (maximum incline of 20º off vertical). The amount of water filtered through the net during a single deployment was ~39 m^3.

Sea-ice samples were taken at two stations. In both cases, the ice was placed into a clean container and mixed with two parts of filtered (62 µm) sea water collected at the same place and time as the ice. The temperature of the seawater was in both cases below 0ºC. The ice was allowed to melt in the open container stored in the laboratory in the ship's ambient temperature. The meltwater from the ice was then passed through a 62-µm screen and the residue was searched for foraminifers.

5.1.3. Results

5.1.3.1. Drake Passage transect

Samples were collected from 26 stations along this transect (fig. 12, table 2). The sampling area covers all the regional water masses between the Falkland Islands and the Antarctic Peninsula (fig 13). The weather conditions throughout the transect remained good, permitting picking of specimens directly from the seawater and also the use of the video camera. Bulk collections were made from 6 stations along the transect for later scanning electron microscopy and relative abundance counts.

A total of 283 specimens were individually processed for DNA analysis and the species collected included *Globigerinoides ruber, Globigerina bulloides*, *Turborotalita quinqueloba*, *Neogloboquadrina pachyderma* sinistral and dextral, *Globigerinita uvula* and *Globigerinita glutinata* (Table 3). Each specimen was identified and its coiling direction and cytoplasmic colour noted. When numbers of *N. pachyderma* specimens were plentiful, the tests were filmed using digital video imaging and a total of 52 specimens from three stations were recorded.

Summary of sampling stations:

Stations 1 and 2: Continental shelf close to the Falkland Islands. Planktonic forams very rare, mixed with benthic forams and mineral particles brought to the surface.

Station 3: Continental shelf but farther off shore from the Falkland Islands resulting in higher abundance of subpolar planktonic forams though with relatively few *N. pachyderma* dextral.

Stations 4 and 5: Continental shelf. However, *N. pachyderma* was more abundant with mixed coiling.

Station 6: Falkland Trough (~1000 m water depth). Many benthic with very few planktonic forams accompanied by a large diatom bloom.

Station 7: Above Burdwood Bank. Very shallow (~100 m). Benthic forams abundant with a large diatom bloom. Planktonic forams rare.

Stations 8 and 9: Southern edge of the continental shelf deepening towards the continental slope. Planktonic forams abundant.

Stations 10 and 11: Leaving the continental slope into Drake Passage, crossing the Subantarctic Front (drop in SST from 8ºC to 6ºC) but north of the Polar Front. Abundant planktonic forams of subpolar assemblage.

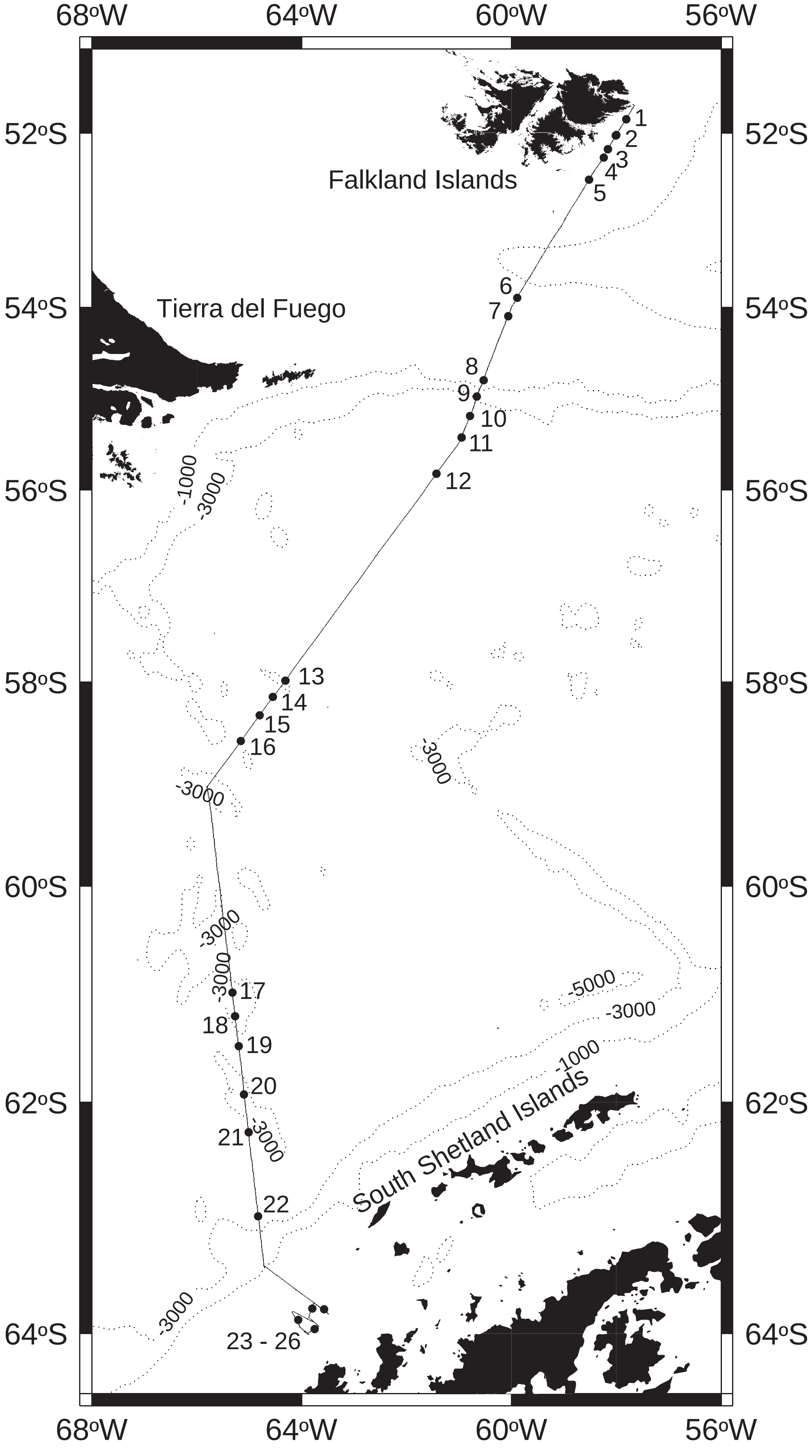


Figure 12. The ship's track with the 26 sampling stations in the Drake Passage transect. The position of the ship at the beginning of the sampling interval is shown for each station.

Station 12: North of the Polar Front, water depth (> 4000 m). Abundant planktonic forams, some benthics. Assemblage dominated by *T. quinqueloba* and *G. uvula*.
Stations 13 and 14: Middle of Drake Passage towards the edge of the Polar Front in a mixed zone. Abundant planktonic forams with the assemblage dominated by *T. quinqueloba* and *G. uvula* with *G. bulloides* becoming more rare.
Stations 15 and 16: Close to Polar Front but still to north of it. Abundant planktonic forams with the assemblage dominated by *T. quinqueloba* and *G. uvula* with *N. pachyderma* sinistral becoming more abundant.
Station 17: Southern part of Drake Passage towards the Antarctic Peninsula. The SST dropped to 3ºC and remained at this level for the rest of this transect indicating that the Polar Front had been crossed. Abundant planktonic forams dominated now by *G. uvula*. Also radiolarians were observed in this sample.
Stations 18 to 20: South of Polar Front yet assemblage has a low abundance of *N. pachyderma* sinistral. The assemblage was completely dominated by *G. uvula*. Radiolarians still present.
Station 21: Southern part of Drake Passage, approaching the continental slope off the Antarctic Peninsula. Flocculent algal bloom with virtually no planktonic forams.
Station 22: Continental slope off the Antarctic Peninsula. Flocculent algal bloom with virtually no planktonic forams.
Stations 23 and 24: Continental shelf off Anvers Island. Planktonic forams abundant, the assemblage still dominated by *G. uvula*, but *N. pachyderma* sinistral is more common.
Stations 25 and 26: Continental shelf off Anvers Island. Bloom of small algae clogging the net. Very rare *G. uvula*, no other planktonic forams.

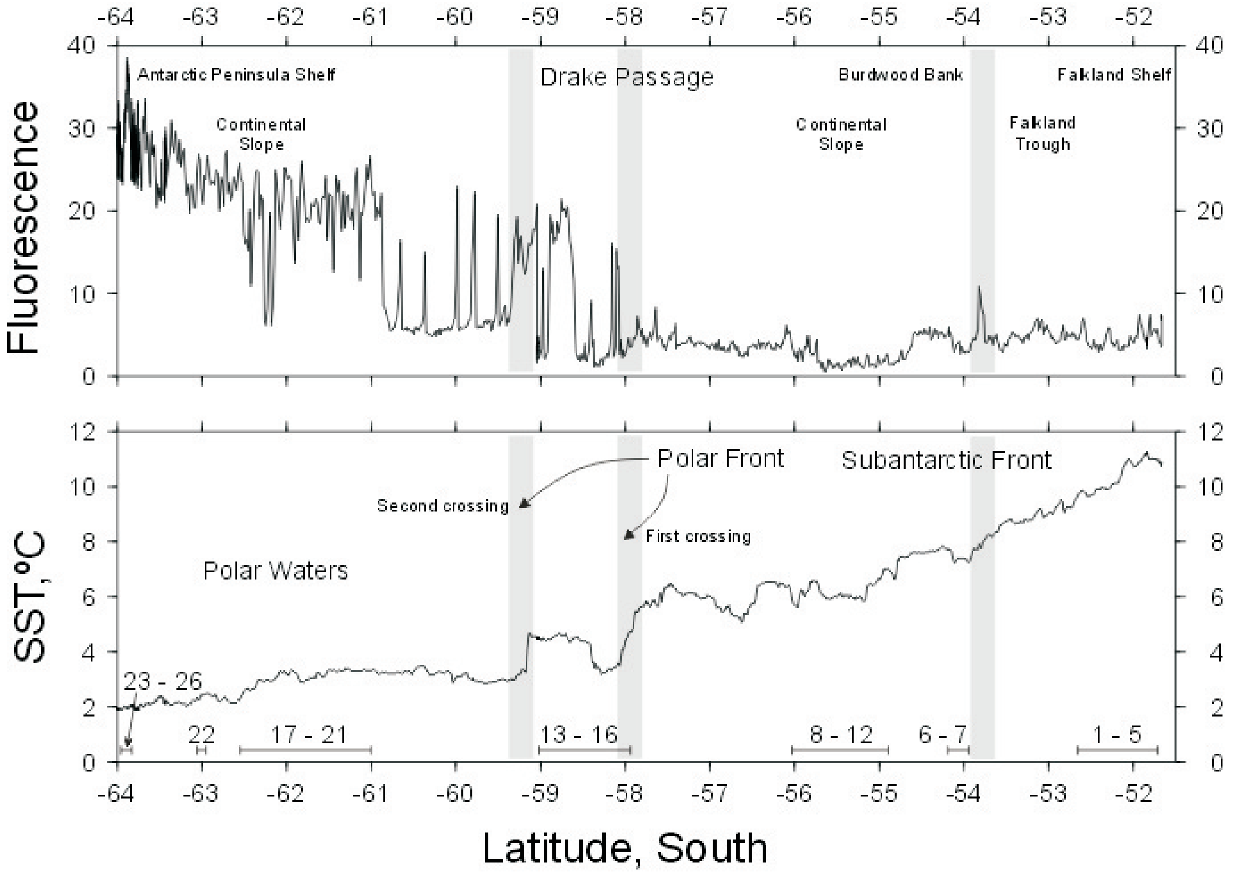
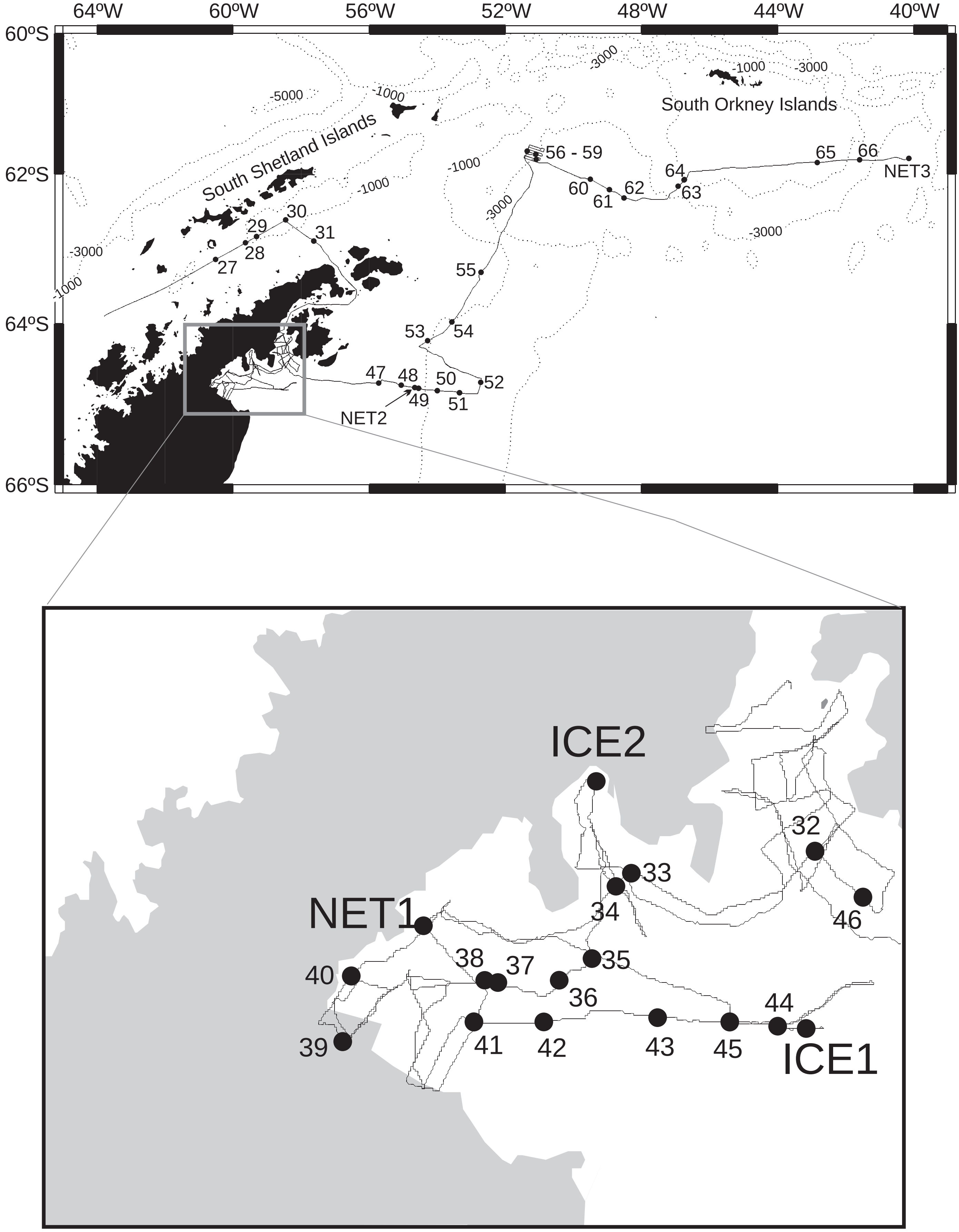


Figure 13. Sea surface temperature (SST) and fluorescence variation as recorded by the ship's oceanlogger during the Drake Passage transect. The positions of the major fronts are shown in both plots by shaded rectangles. The Subantarctic Front is here defined by the drop in SST below 8ºC, the Polar Front is indicated by an SST drop from above 4ºC to below 3ºC. The numbers at the bottom of the SST plot indicate the position of the sampling stations, legend in the fluorescence plot indicates the position of major geographical features on the sea floor.


64ºW
60ºW
56ºW
52ºW
48ºW
44ºW
40ºW
60ºS
62ºS
64ºS
66ºS
South Shetland Islands
South Orkney Islands
-5000
-3000
-1000
27
28
29
30
31
47
48
49
50
51
52
53
54
55
56 - 59
60
61
62
63
64
65
66
NET2
NET3
ICE1
ICE2
NET1
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5.1.3.2. Antarctic Peninsula and Northwestern Weddell Sea

A summary of the locations of the sampling stations in this area is shown in Figure 14 and table 2, the numbers of processed specimens are summarised in Table 3.

Bransfield Strait

Stations 27 – 31. Compared with the Drake Passage transect, the algal concentration within the plankton was high and often associated with mono-specific diatom blooms. A number of benthic forams were observed in the samples. The planktonic foraminiferal assemblage was dominated by *G. uvula* with low abundance of the other morphospecies. A limited number of specimens were taken for genotyping (n=17).

Prince Gustav Channel and the Northern Larsen area

Stations 32 – 54. The concentration of algae within this region was very high, necessitating the use of the 125µm screen. The low numbers of specimens within the surface waters and low salinity were suggestive of a melt water lens at the surface. Therefore we deployed a plankton net twice in this area to a depth of 100 m, to determine whether the planktonic foraminifera occurred in larger numbers below the surface layer. The very low abundance of specimens within the nets confirmed that the planktonic foraminifera were rare within the entire water column. When present, the foraminiferal assemblage was completely dominated by *N. pachyderma* sinistral. In total, 76 specimens were processed for genotyping.

To confirm the genetic identity of the foraminifera reported from Antarctic Sea Ice, we sampled the sea ice on two occasions. The first ice sample was obtained from a large ice floe freshly cleaved by the ship. Several pieces of the coloured ice were collected by scooping from the main deck. One living and 7 empty shells were obtained from this sample. The second sample was from freshly forming ice collected from the surface in Larsen Inlet. This ice did not contain any foraminifera.

The northwestern Weddell Sea

Stations 55 – 60. These waters had very few particles retained within the 125-µm screen and no foraminifera. However, clogging from micro particles prevented the use of the finer screen.

Stations 61 – 66. In these waters it was possible to use the 62-µm screen, as there were less algae in the plankton. The planktonic foraminifera were still rare in the upper water column as confirmed by a plankton net collection to 100 m. The assemblage was dominated by *N. pachyderma* sinistral and 17 specimens of planktonic foraminifers were processed.

Figure 14. The ship's track with the sampling stations around the Antarctic Peninsula and the northwestern Weddell Sea. The position of the ship at the beginning of the sampling interval is shown for each station. The area of the Prince Gustav Channel and the northern part of the former Larsen Ice Shelf is enlarged to show the positions of the sampling stations in this region with better resolution.

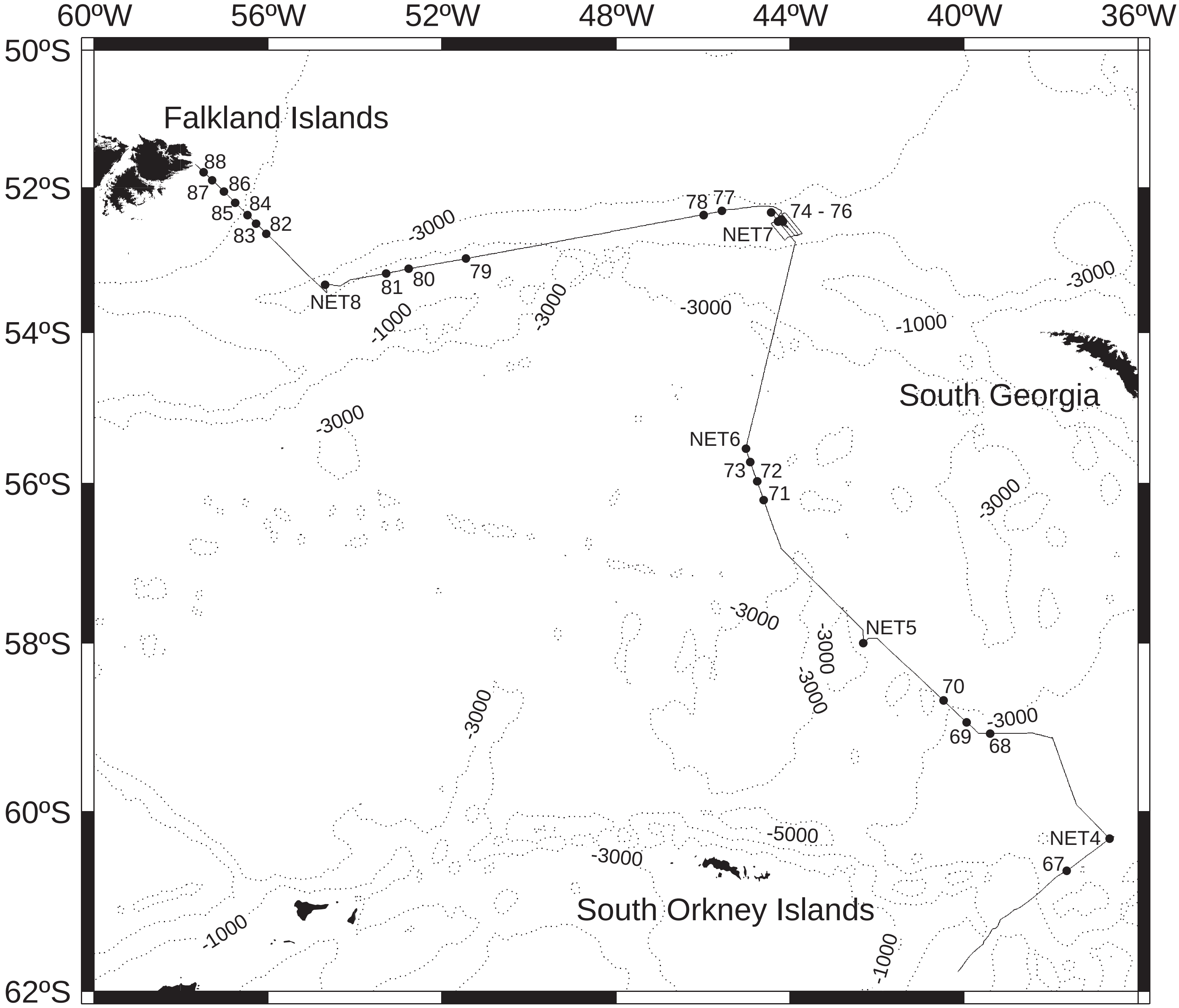


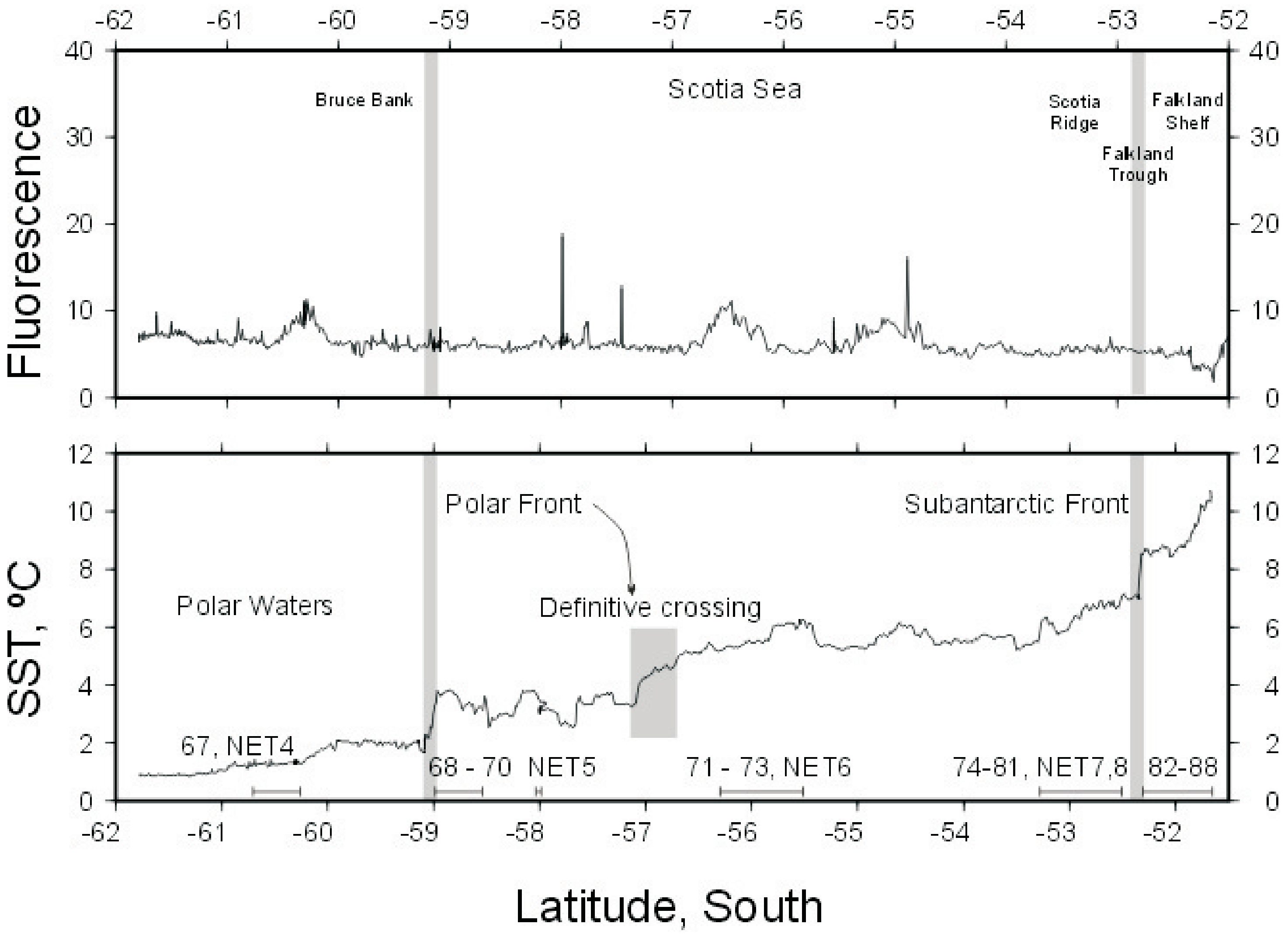
Figure 15. The ship’s track with the sampling stations in the Scotia Sea transect. The position of the ship at the beginning of the sampling interval is shown for each station.

Figure 16**.** Sea surface temperature (SST) and fluorescence variation as recorded by the ship’s oceanlogger during the Scotia Sea transect. The Polar Front was first approached at 59ºS latitude, then the ship was probably going parallel to the front to cross it definitely at 57ºS. For more details see Figure 13.

5.1.3.3. The Scotia Sea transect

Samples were collected from 22 pumping stations and five vertical net stations along this transect (Figure 15, Table 2). The sampling area covers all the regional water masses between the South Orkney Islands and the Falkland Islands (Fig 16). The weather conditions throughout the transect remained good, apart from one day, permitting picking of specimens directly from the sea water and also the use of the video camera. Bulk collections were made from 7 stations along the transect for later scanning electron microscopy and relative abundance counts. In addition, the relatively low abundance of foraminifera at many of the stations allowed us to generate quantitative counts for an additional seven stations while sampling for genotyping (Table 3).

A total of 296 specimens were individually processed for DNA analysis and the species collected included *Globigerinoides ruber*, *Globigerina bulloides*, *Turborotalita quinqueloba*, *Neogloboquadrina pachyderma* sinistral and dextral, *Globigerinita uvula* and *Globigerinita glutinata* (Table 3). In addition, we collected a single specimen of *Globorotalia inflata* in NET6. As we became more accustomed to the usage of the video equipment during the cruise, we were able to collect digital images of virtually all the processed foraminifers during this transect.



Summary of sampling stations

Station 67 and NET4. Still in polar waters, northeast of the South Orkney Islands, above Discovery Bank. High concentration of diatoms, but planktonic forams relatively rare, *N. pachyderma* sinistral was the only species present. As confirmed by a 100-m vertical net (NET4), this description applies to the whole water column.

Station 68. Still high concentration of diatoms, SST slightly higher, probably recording the crossing of the Polar Front. Planktonic forams dominated by *N. pachyderma* sinistral, although the first *T. quinqueloba* was encountered here.

Stations 69-70 and NET5. The higher SST indicates that the ship was going more or less parallel to the Polar Front. Dramatic decrease in the amount of algae retained in the sieve. The planktonic foraminifer assemblage included more abundant *T. quinqueloba* and *G. glutinata*. Net 5 showed that a generally low concentration of plankton prevailed in the entire water column

Stations 71-73 and NET6. Definitely north of the Polar Front. Planktonic forams much more abundant, typical subpolar assemblage dominated by *T. quinqueloba* and *G. glutinata*, with *N. pachyderma* sinistral and also *G. bulloides*. Different type of diatoms, reminiscent of those encountered at Station 16. We have noted that more of the spinose planktonic forams retained spines here than at most other stations. The assemblage recovered from a 100-m vertical net (NET6) was generally similar, but it also yielded several specimens of *G. glutinata* and one specimen of *G. inflata* (both are transitional to subpolar species).

Stations 74-81 and NET7-8. SST permanently above 6ºC. Low concentration of algae, planktonic forams abundant with typical subpolar assemblage. *N. pachyderma* dextral still very rare. Two 100-m vertical nets were taken, confirming that the assemblage is the same throughout the water column.

Stations 82-88. Approaching the Falkland continental shelf, water depth decreasing from 1500 m to 50 m, SST rising from 8 to over 10ºC. Higher concentration of algae and also of small copepods towards the shelf edge. Planktonic forams initially abundant then decreasing in abundance towards the shelf edge. Typical subpolar assemblage, *N. pachyderma* dextral remained very rare, with *N. pachyderma* sinistral more abundant despite the high SST.

5.2. Collection of *Neogloboquadrina pachyderma* sinistral for Mg/Ca analysis

5.2.1. Objectives

Accurate estimates of past sea-surface temperature variations are crucial for a better understanding of the dynamics of Earth's climate. One of the most promising new techniques is Mg/Ca thermometry. This method is based on the observation that the amount of Mg incorporated into the calcite shells of planktonic foraminifera seems to be governed mainly by ambient temperature. However, to obtain reliable results, the Mg/Ca thermometer must be properly calibrated. Although the optimum approach is the study of the Mg/Ca ratio in planktonic foraminifera grown in laboratory cultures under controlled conditions, the analysis of living planktonic foraminifera provides invaluable additional data. This is very much the case for the cold-water species, which have never been kept in laboratory cultures due to logistic problems (the laboratory must be *in situ* as planktonic foraminifera do not reproduce in cultures and fresh specimens must be supplied continuously).

The purpose of this sampling is to provide a basis for the calibration of a Mg/Ca thermometer on *Neogloboquadrina pachyderma* sinistral, a cold water planktonic foraminifer occurring in large numbers in deep-sea sediments from high latitudes. The samples were requested by David Lea and Peter von Langen from the University of California at Santa Barbara. The sampling strategy was based on two considerations: a) to obtain a data set covering the entire SST range where the species occur (~9°C to the freezing point of sea water), and b) to collect at least 10 specimens from each station, and preferably much more from at least a few of the stations for duplicate analyses.

5.2.2. Methods

For a more detailed account on the sampling stations and on the collection procedures, please refer to section 5.1. The specimens were taken from samples representing water masses of different temperature. Only samples where at least 10 individuals of the planktonic foraminifer *Neogloboquadrina pachyderma* sinistral could be collected were selected. The specimens were identified among the plankton in a sample and transferred on a tip of a brush into a small glass dish filled with fresh water from the ship's supply. The ship produces fresh water by low-temperature (low pressure) evaporation. After being rinsed for several minutes, the specimens were then transported onto a glass slide, cleaned, dried, and finally stored in micropalaeontological slides. Water samples were occasionally taken from the ship's uncontaminated water supply filtered through the plankton net.

5.2.3 Results

A total of 18 pumping stations and 2 vertical plankton net samples yielded sufficient numbers of *N. pachyderma* sinistral shells. These stations cover the entire SST range where this species is commonly found and thus should provide a good basis for the Mg/Ca calibration. Most specimens contained cytoplasm and could thus be considered living when collected. Empty shells have been recorded separately, as these could theoretically derive from a different water mass and/or could have grown earlier in a different SST. The SST value for the pumping stations was taken as an average value for the entire sampling interval (data in one-minute intervals), with the standard deviation and the minimum and maximum values recorded (Table 4).

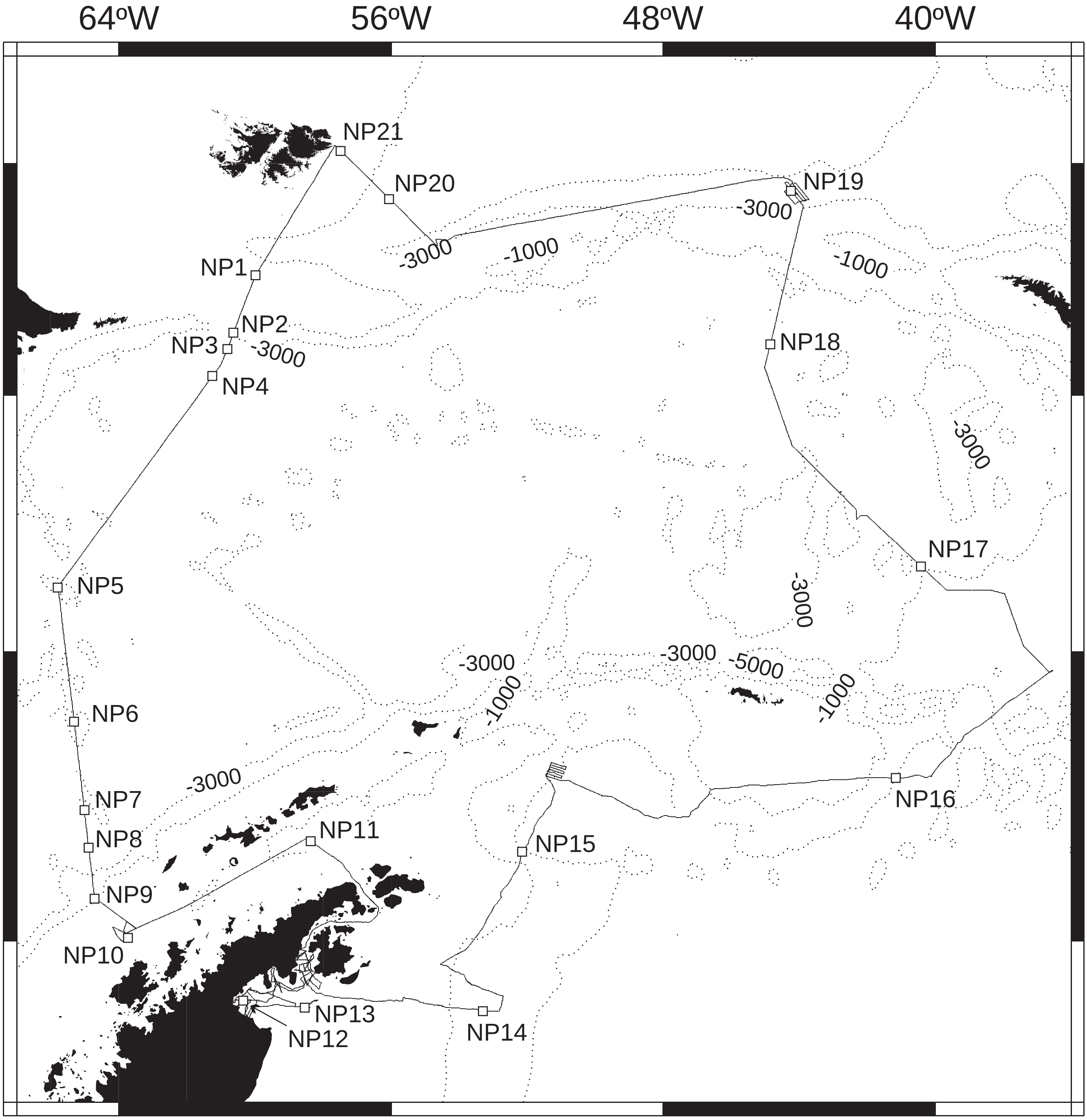
5.3. Collection of nannoplankton samples

5.3.1. Objectives

The purpose of collecting nannoplankton samples was to provide material for studies of the distribution of living coccolithophores in Antarctic waters. The samples were requested by Jeremy Young from the Natural History Museum in London. There are only a limited number of previous reports on the occurrence of this group in the southern high latitudes and the prime interest is to test whether there is a simple predictable pattern in their distribution. We were asked to collect nannoplankton filter samples along a semi-regular sample transect across all the different fronts and water masses. In addition, it was desirable to collect a water sample for immediate transfer to London for culturing. Mainly due to logistic problems, southern ocean coccolithophores have never been studied in laboratory cultures.

5.3.2. Methods

The sampling locations were selected so as to cover the major different water masses on both sides of the Antarctic Peninsula. At each location, a small glass container was filled with uncontaminated



64ºW
56ºW
48ºW
40ºW
52ºS
56ºS
60ºS
64ºS
NP1
NP2
NP3
NP4
NP5
NP6
NP7
NP8
NP9
NP10
NP11
NP12
NP13
NP14
NP15
NP16
NP17
NP18
NP19
NP20
NP21
-3000
-1000
-5000

sea water from the ship's supply filtered through a plankton net used for the collection of planktonic foraminifera.

For every sample, a 0.45-µm cellulose nitrate membrane filter (13 mm diameter) was transferred using fine tweezers into a Millipore Swinnex-13 filtration unit. A 30-ml syringe was filled with the collected pre-filtered seawater until the maximum volume (about 33 ml), the syringe was fitted with the filtration unit and the water was expelled. This procedure was repeated three times at each site so that the amount of water passed through the filter remained the same, about 100 ml. The filtration unit was then dismantled and the filter was transferred onto a 35-mm Millipore absorbent pad. The pad was placed into a small petri dish and dried at 60°C for 1-2 hours. Once dried, the petri dish was closed with a lock and placed in a fridge (about 5°C). All components of the filtration unit were thoroughly rinsed in fresh water, the syringe was filled and emptied at least five times after each use. To prevent damage during transportation, the dried filters and the absorbent pads were attached to each other and to the petri dish by a thin strip of tape. The samples were numbered consecutively with the prefix NP.

Two samples of living plankton were collected during cruise JR48b. The uncontaminated seawater from the ship's supply was passed through a 62-µm screen into a nannoplankton net with collection bottle on the end. The exact times of the pumping were recorded, and the water flow through the net was estimated by measuring the time a 1-l bottle was filled (Table 5). The content of the collection bottle was transferred into a 250-ml plastic container, filled only to 200 ml to allow for gas exchange. The containers were then sealed and stored refrigerated (about 5°C).

5.3.3. Results

A total of 21 filter samples and 2 culture samples were collected, their locations with the corresponding oceanographic data are shown in Figure 17 and Table 5. The cellulose nitrate filters broke on several occasions. This was immediately recognised by the much lower pressure needed to expel the water through the filtration unit. In these cases, the filter was replaced and the sampling repeated.

Figure 17. The ship's track showing the positions of the 21 nannoplankton filter samples collected.

6. **DREDGING** (PFB)

This part of Cruise JR48 was intended to dredge the crest of the North Scotia Ridge between 57°W and 48°W (mainly Davis Bank), to determine the onset of the Antarctic Circumpolar Current (ACC) from examination of dredged sediments. It comprised 5 days in the work area (3.5 days for about 20 dredge stations plus 1.5 days passage between stations) and 2 days passage there and back from Port Stanley. Potential dredge sites had been picked on available bathymetric and seismic profiles (about 45 crossings in all). The sites were widely distributed, and it was assumed that sediments at several (but by no means all) of them would yield information on palaeo-depth and palaeo-current changes, and would fix the time of onset of the ACC.

PES and 3.5 kHz profiles would be obtained throughout, and the PES would also be used with a pinger on the dredge wire (usually 150 m above the dredge mouth) to monitor and control dredge position with respect to the seabed. Wire tension would be recorded digitally during dredge stations using the Seametrix system, and displayed on a potentiometric recorder.

The ship sailed from Port Stanley at 1 pm on 27th March (Julian Day 087) and left Port William at 3 pm after boat drill. Because the weather was favourable it was decided to head for the eastern end of the area; initial progress was good, but the wind later came round to ahead, slowing the ship to 7 kts. After a minor diversion to pass through two other potential sites the ship arrived at the most easterly site at about 8 pm on Day 088, but could not maintain the ship's head in DP mode because of strong wind, a confused swell and surface currents. The vicinity of the site, on an isolated seamount, was surveyed overnight while waiting for an improvement in the weather, to increase the options for dredging. Finally the originally chosen, west side was dredged in daylight on Day 089 (Station DR 168), but not in DP mode, and with ship movement unpredictable. Despite good indications from the wire tension and pinger records, the dredge returned virtually empty: a weak link had sheared, closing the bag.

Of the next two sites, traversed on passage, one was rejected and the other could not be attempted because bad weather precluded ship movement in the required direction (to the northwest). The required direction of movement at the next site (to the southwest) was feasible, however, and DR 169 was dredged late on Day 089 in improving weather, recovering about 200 kg of a range of sandstones that included visible macrofossils.

The weather continued to improve, and DR 170 was dredged (in DP mode) up the WSW lower flank of a steep-sided cleft. It recovered about 100 kg of mainly pebble-sized angular fragments, not easily examined immediately because of a ubiquitous dark coating, but too well-sorted and similar-looking to be glacial erratics. Immediate dredging of the upper part of the same slope (DR 171) yielded 100 kg of much larger samples of a metamorphic rock, much fresher-looking and the likely outcrop source of much of the debris dredged from below.

These two stations were complete by 9 am on Day 090 and the next site, on a major scarp striking 070°, was about 30 miles away. However, it was not dredged until about 5 pm because of the need for stops to examine the bow thruster. Before the site was reached we were told this would be the final station, as the bow thruster had failed, requiring slow (<8 kts) ship passage back to Port Stanley and examination by diver. The dredge station (DR 172), undertaken using main engines alone, was complete by 7 pm and yielded 100 kg of fine-grained dark mudstone and brown calcareous mudstone with visible macrofossils.

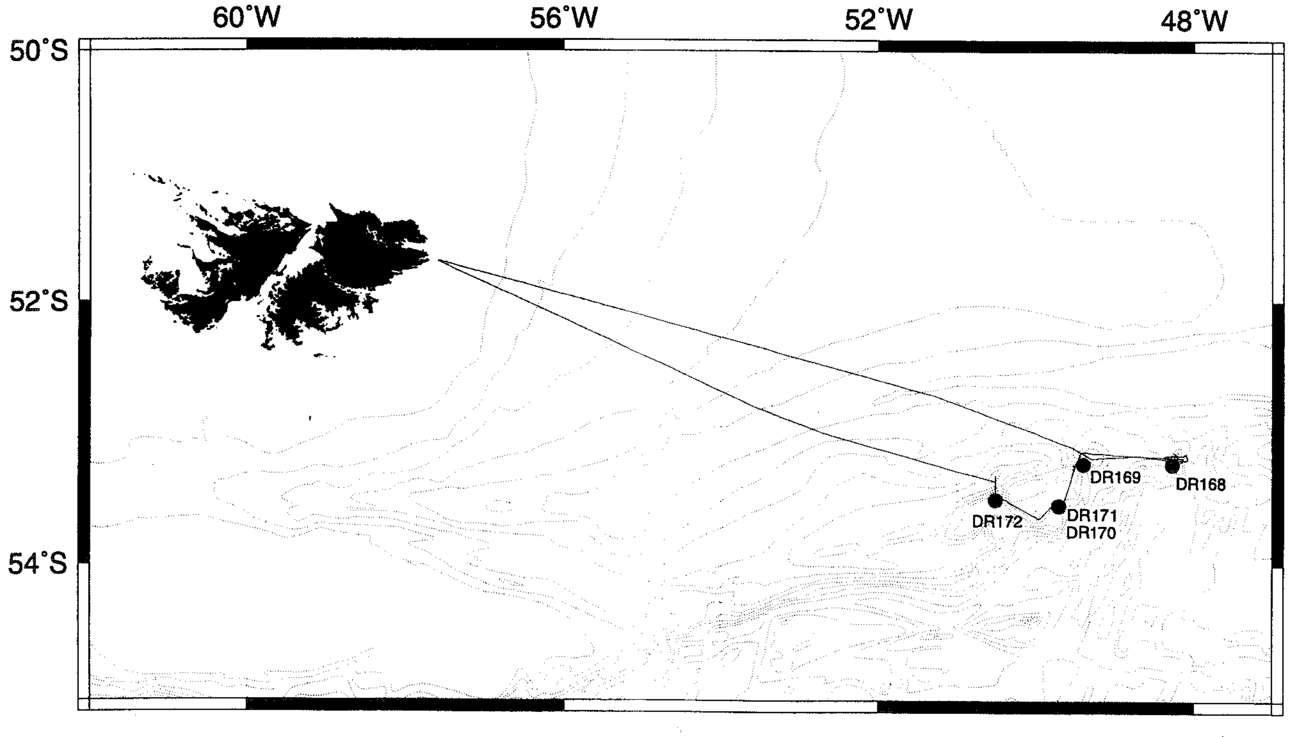
The ship headed WNW in continued good weather, and arrived in Port Stanley at 9am on Day 092. The dredging programme had lost more than three days out of five as a result of the bow thruster failure, and could not achieve its main objective. Progress in the first two days had been good. The successful dredges had greatly refined our views of the structure of Davis Bank, focussing future attention on particular parts of it, and the weather had improved from initially bad conditions. The material recovered will be useful in refining the history of Scotia Sea evolution and in regional tectonic reconstruction, but (though not yet examined in detail) is most unlikely to provide any information about the onset of the ACC.

Dredge locations are listed in table 6 and plotted in Fig. 18.

	START			END		
Dredge	Lat S	Long W	Depth (m)	Lat S	Long W	Depth (m)
DR 168	53 15.35	48 16.8	2300	53 15.2	48 16.7	2100
DR 169	53 14.65	49 30.2	2650	53 15.1	49 30.3	2250
DR 170	53 33.3	49 43.1	1500	53 33.6	49 42.8	1200
DR 171	53 33.55	49 42.7	1200	53 33.7	49 42.6	1050
DR 172	53 23.55	50 30.95	1150	53 23.3	50 31.0	1000

Table 6. End positions of dredge paths along the sea bed. Dredge stations (including such tasks as securing dredged rocks before the ship got under way) took between 2 hours (shallow sites) and 4 hours (deep sites).

Fig. 18. Track chart showing dredge stations. Contours at 500 m intervals.



7. EQUIPMENT REPORT (CJP, PM, JE, AB)

7.1 Navigation, including Dynamic Positioning

The following GPS units are installed on the ship:

Leica GPS	Bridge navigation only
Ashtec G12	Dynamic positioning (2 of these)
Trimble	Primary scientific logging
Ashtec ADU2	Secondary scientific logging
Glonass	Tertiary scientific logging

The Leica, Ashtec G12, Trimble and ADU2 all use a differential signal; this effectively means that the position can be accurate to within 5 metres. However, when the differential signal is lost, the accuracy is around 50 metres. The Glonass uses a different constellation of satellites (Russian System) but is only accurate to within 50 metres. To achieve a regular (1/minute) printout of GPS positions in the UIC room, Mark Preston wrote a short PC program to sub-sample the 1-second Trimble data. We lost the differential GPS for several hours on the night of 088-89 because of a fault in the “western” communications satellite. The “eastern” satellite was used instead, but could only see 3 or 4 of the GPS satellites we were using.

The Dynamic Positioning worked very well and was used at all core sites and most of the dredge stations. It was essential for the vibrocore sites, which were in shallow water and where the corer was on the seabed for 15-30 minutes. Although the ship generally took only a few minutes to settle on station, some delays were experienced due to GPS dropouts; the longest was half an hour, at VC254 early on day 067. Working in ice-infested waters, it was extremely useful to be able to move the ship to avoid drifting ice and to know exactly how far from the original position we were. Either the aft gantry or the midships gantry could be made the reference position, depending on which was being used.

7.2 Precision Echo Sounder and 3.5 kHz profiler

Both these instruments were run using the hull transducers for almost the entire cruise, except while on station or while stopped/hove-to in bad weather, and worked well. The PES signal was output to a Waverley thermal linescan recorder and an Elonex computer. The Waverley record was used to measure depths manually, during periods when the Simrad 500 on the bridge was not logging depths (in water over 2000 m deep, over steep slopes or in fairly bad weather). The real-time record on the computer screen was used to measure pinger-bottom separation while coring or dredging.

The performance of the 3.5 kHz profiler was very much better than on previous JCR cruises; since its overhaul last summer, it is better than it has ever been since the ship was new. The full range of power output is now available and the overload warning light does not come on. The Raytheon linescan recorder required only paper changes and occasional cleaning of the stylus belt. The quality of the records was good even in rough sea conditions; the 3.5 kHz was defeated by aeration under the hull only in the force 10 storm on day 082.

We look forward to swath bathymetric data and high-resolution, digital acoustic data from the TOPAS sub-bottom profiler system, next season.

7.3 Level ABC data logging/processing

The instruments logged were as follows:

Instrument	mnemonic	measures	sample rate
Trimble	gps_nmea	position-(differential gps)	1 sec
Ashtec	gps_ash	position,pitch,roll	1 sec
Glonas	glonas	position	1 sec
Gyro	heading	heading	1 sec
STCM (old)	stcm	magnetic field components	1 sec
STCM (new)	new_stcm	magnetic field components	1 sec
TSSHRP	tsshrp	heave, roll, pitch	1 sec
Magnetometer	magnet	total magnetic field	1 sec
EA500	sim500	water depth	variable
Ocean Logger	oceanlog	sea surface temperature, salinity, fluorescence	5 sec
Anemometer	anemom	wind speed and direction	1 sec
Emlog	em_log	speed through water	2-3 sec
Winch	winch	wire out, tension etc	5 sec

The ABC system functioned well throughout the cruise. The Level A's suffered from a master clock jump on two occasions, but resetting all of the Level A's fixed this problem. The GPS_ASH level A had a meltdown but was soon rebuilt and operational again.

The Level B crashed twice during the cruise, on the first occasion there was 2 minutes of data loss and on the second 5 minutes. The Level C worked throughout the cruise without any problems

Data processing

The level C data stream 'bestnav' was generated. This represents the best navigation data available at any time. Note that the Doppler log was not functioning during this cruise. Simrad EA500 echosounder data and proton magnetometer data were edited to remove noise and sub-sampled to a 1 minute interval using the Geosoft processing package. When adequate Simrad data were not available, 5 minute depth values recorded manually from the PES were inserted into the record. Carter corrections were applied to the echo sounder data and an IGRF correction was applied to the magnetics before the two datasets were combined with the navigation into a standard MGD77 format file.

Notes:
1) The MGD77 file is in the new year 2000 compliant format, and may not run correctly in some older software applications.
2) The IGRF applied to the magnetic data was the predicted value based on the 1995 upgrade of the coefficients. The anomaly values should be recalculated in due course using the 2000 values.

7.4 Ocean Logger and non-toxic seawater supply

This equipment was used for most of the cruise, apart from short periods when the seawater pumps became choked with ice (in the Larsen area, days 067 and 070) or tripped because of aeration in bad weather (days 082 and 089). The probe was used in the mid position (protruding 0.5 m below the hull) and the filters were cleaned once per day, usually between 8 and 8.30 am. The meteorological instruments (anemometer, barometer, air temp. thermometer) worked all the time except a brief period when the anemometer froze up.

7.5 STCM

Both the old and new STCM's were recorded continuously during the cruise. The old STCM worked well except for one period when it started logging at irregular intervals of 2 or 3 seconds rather than its normal 1 second. A reboot cleared this problem. The main difficulty was in recovering the data from the ABC system. The PC controlling the old STCM is currently not year 2000 compatible. This means that the year value on the PC has defaulted to 1980. Also, the day logged onto the ABC system from this instrument only increases intermittently, so it is possible to have several sets of 24 hours' worth of data all with the same day value as follows:

True days	STCM day
57-61	40
62-63	41
64	42
65-67	43
68-72	44
73	45
74-81	46
82-83	47
84-90	48
91	49
92	50

An upgrade to a more modern PC is obviously urgently required !

The jury is still out on the new STCM. It is still not performing anywhere near as well as the old one with far more noisy records. The most likely problem is once again the positioning of the instrument. A radical new site is required, possibly on the monkey island above the bridge.

The calibration coefficients derived on JR39 worked well again this year, at least for the old STCM but the total field anomaly has bulk shifted by about +3000nT. Four new calibration turns were carried out during the course of the cruise:

Day	Time	Lat	Long
057	20:15 - 20:42	51° 11'S	57° 48'W
078	00:27 - 00:59	61° 47'S	40° 14'W
084	20:49 - 21:04	53° 21'S	54° 41'W
092	10:05 - 10:25	51° 42'S	57° 49'W

Once again the STCM gave excellent results on long straight runs. As yet however it is of little use in periods when the ship turns frequently, as when passing through ice. It should be noted that this is the first year that an adequate roll and pitch record has been available on the JCR . The TSS heave- roll-pitch monitor was returned for repair earlier in the season, and now seems to be working correctly for the first time ever. Having this information available should improve the quality of the STCM record.

7.6 BGS Sparker (from Skinner 2000)

The EG&G sparker source was operated at 1-1.5 kJ depending on water depth. Firing period varied from 0.7-1.5 sec (slower in deeper water). A 10 m, 7 channel, Teledyne hydrophone was used, normally with channels 2 to 5 selected and summed. The data were digitally recorded using the BGS CODA Digital Acquisition System, and output to a Waverley 3710 thermal linescan recorder after processing. All the BGS sparker and sidescan equipment was sited on the port side of the UIC room. For more details including the aft deck layout, see Skinner (2000).

After initial noise problems, the system ran well on lines 14, 15, 16 and 17. Some 50 Hz noise continued (also seen on deep-tow boomer records acquired on this ship) but not enough to degrade the record significantly. On line 18 the record began to deteriorate and could not be tuned. The hydrophone was replaced, but with no effect on the data. The earth chain link from deck to sea was seen to be sparking and was repaired, but again with no improvement in the record. The sparker was then brought in and it was found the earth lead connection had worked loose. This was repaired and the line continued as line 18B.

There were no problems with the sparker system on lines 19-22. We attempted a sparker line in the Falkland Trough sediment wave area, but rapidly worsening weather conditions made it impossible to obtain any signal, so the equipment was recovered after half an hour.

Table of Sparker Lines

Line no	SOL time Z	Lat.	Long.	EOL time Z	Lat.	Long.
14	0515/061/00	60°06.7'S	65°32.4'W	0730/061/00	60°28.9'S	35°27.1'W
15	0732/061/00	60°29.2'S	65°27'W	0925/061/00	60°49.6'S	65°21.7'W
16	0928/061/00	61°50.3'S	65°21.6'W	1107/061/00	61°10.8'S	65°16.8'W
17	1108/061/00	61°11.0'S	65°16.8'W	1245/061/00	61°31.1'S	65°11.8'W
18	1246/061/00	61°31.3'S	65°11.8'W	1337/061/00	61°41.8'S	65°02.9'W
18a	1354/061/00	61°57.5'S	65°05.6'W	1540/061/00	62°06.7'S	65°03'W
18b	1612/061/00	62°13.2'S	65°01.4'W	1743/061/00	62°32.0'S	64°56.9'W
19	1909/063/00	64°12.5'S	58°45.0'W	2101/063/00	64°08.5'S	58°32.2'W
20	2106/063/00	64°08.6'S	58°31.9'W	2255/063/00	64°16.0'S	58°24.8'W
21	1945/067/00	64°56.8'S	60°19.2'W	2111/067/00	64°50.5'S	60°12.8'W

22	2112/067/00	64°50.5'S	60°12.8'W	2225/067/00	64°44.7'S	60°18.6'W

7.7 BGS magnetometer (from Skinner 2000)

A Barringer M123 marine proton magnetometer was used. The fish was towed from the port quarter and the magnetometer itself was located in the centre of the aft bench in the UIC room. The deck cable was routed through the cable entry on the port (inboard) side of the winch control room. This proved to generate less noise in the data than the original route through the port side of the UIC room. Digital data were recorded to the ABC system via a BCD-ASCII converter supplied by BGS. The magnetometer level A was modified at the start of the cruise to communicate with the BCD-ASCII converter.

Magnetometer noise levels were extremely high during the cruise, plus or minus 5 nT with large numbers of huge spikes. Although it was possible to recover a reasonable record during processing, this was only because the oceanic anomalies of interest are large with a long wavelength so that heavy low pass filtering can be applied to the data. Although one output power transistor failed and had to be replaced during the trip, the main problem appears to be somewhere in the cable or fish : changing to the spare cable produced no improvement. Severe 60 Hz noise was seen on some occasions.

Both the BGS magnetometer and the RVS magnetometer more usually employed on the ship are now over a quarter of a century old. Over the last 5 years their performance has been mediocre at best and they have required a lot of attention. A modern instrument should be acquired and permanently installed on the ship.

7.8 BGS Vibrocorer and Rock drill (from Skinner 2000)

The coring programme used the BGS rockdrill with the option of vibrocoring by interchange of barrels and selection of different computer functions. Deployment was over the stern of the vessel via a combined signal/power/hoist umbilical cable on a dedicated winch system. All functions were PC controlled and a monitor display allowed the operators to observe progress and vary the coring parameters. The data on seabed operation were recorded for each site (example in fig. 19).

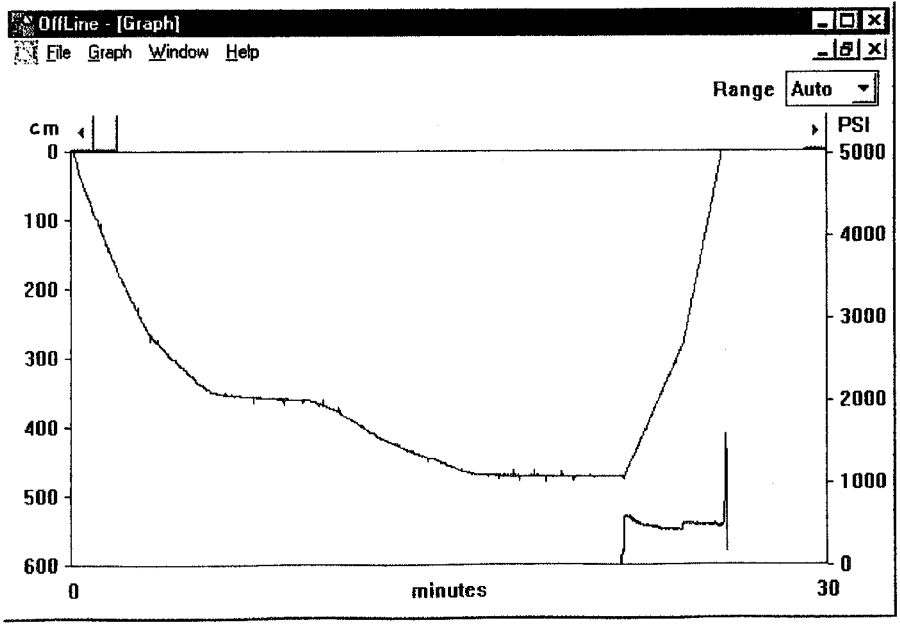


Fig. 19. Example of vibrocoring graph (VC 241).

Fig. 19. Example of vibrocoring graph (VC 241).

In rockdrilling mode, the tool collects a core of 49 mm diameter in a double-walled core barrel. The speed of rotation can be varied from 0-600 rpm and either one or two flush pumps can be used. Penetration and oil pressure are normally monitored, as being the most useful for interpretation of the drilling. Additional sensors fitted include pitch and roll to check the stability of the frame on the seabed. Two different bits were used on this cruise: a stepped profile, surface set bit and a soft matrix impregnated diamond bit. Upon full penetration or refusal to drill further, the drill function is switched off and the barrel is retracted into the frame. Within the inner core barrel, the core is retained by a core spring during recovery. The core is extracted by removing the bit and reaming shell from the bottom end of the outer barrel, withdrawing the top water swivel and disconnecting the inner core barrel. The core is then removed from the inner barrel into plastic guttering, using controlled water pressure.

In vibrocoring mode the tool can collect up to 5.2 m of soft sediment in an 88 mm i.d. polycarbonate liner, which is also used for sample storage after cutting to length, applying and taping endcaps. Although the vibrocoring barrel is 6 m long, the whole length cannot be used in conjunction with the rockdrilling equipment, because of the necessary precaution of avoiding the vibration head striking the rotary kelly on the base of the frame. During vibrocoring, a vertical vibration force is delivered to a hardened steel cutting shoe. After full penetration or refusal, the vibration is switched off and the barrel retracted into the frame before recovery from the seabed.

The umbilical winch gave some problems during two deployments (VC 277-278), with symptoms of a sluggish joystick control and a tendency to "fall back" when hauling in. The fault was traced to a blocked filter on the dynex control, which was cleaned and replaced, thereby curing the problem. The new umbilical cable performed well at temperatures down to -14°C, and the Lebus grooving fitted to the drum allowed tidy spooling except at the deepest site (1980 m). After the last piston core site in 3000 m of water, the cable was paid out down to the last layer and spooled correctly.

The rig suffered terminal failure of a seabed electronics unit; the pressure case imploded under hydrostatic pressure at 1950 m (at VC281). A sapre unit was fitted within about 2 hours, to allow continuation of coring at the next site. It is possible that operation in very cold weather, combined with metal fatigue, could have lowered the pressure rating.

7.9. RVS Piston Corer

The piston corer was assembled to 9 or 12 m length (3 or 4 barrels). The barrel stands supplied were the type which are fixed to the ship's rail (as on the *Charles Darwin*) rather than bolt down to the deck (as on the *Discovery*, and normally on the *JCR*). Four barrel stands were welded on to the rail for this cruise. The davits were positioned to lift on the second and third barrels. No loss or damage was sustained to any of the piston coring equipment during the 13 stations. At the first few stations, sections of the core liners were found on recovery to be partly imploded. It was at first thought this was because some of the batch of liners had manufacturing defects (liners from the same batch had imploded during a previous cruise on *Charles Darwin*). From PC 286 onwards the piston was made a slack fit in the liner, and this cured the problem (or we were luckier with the liners).

Based on experience on previous cruises, a free-fall wire length of 7.5 or 9 m (2 m longer than the Driscoll recommended length for 3 and 4-barrel corers) was used. Recovery was still less than expected at the first few stations; seemingly 2 or 3 m of water was entering the core barrel before the sediment surface was reached. Before station PC289 we cut 2 m off the trigger chain, reducing the free-fall distance to 4 m. Recovery improved after this was done.

For one station in the Larsen-A area (GC251) the corer was rigged as a 3 m gravity corer, but recovered only a core-catcher sample. Because the forward davit did not reach the first barrel, at this station the corer was brought inboard using the wire from a small auxiliary winch on the midships gantry attached to an eye on the bucket.

Wire speeds were 60 m/min for veering to near the seabed (a pinger was attached to the wire 100 m above the core head), 22 m/min for final veering, 6-8 m/min for pull-out and 75 m/min for hauling in. Pull-out forces were 4.5-6.5 tons except PC292 where the corer got stuck (see Narrative). The pennant wire probably exceeded its safe working load (SWL) at this station, so was not re-used. No problems were encountered with the miships gantry, winches, wires, core bucket or davits. After the traumatic experiences with the traction winch on cruise JR19, it was a great relief to see everything working so smoothly.

The RVS Risk Assessment for piston coring lists the use of appropriate weak links to protect the wires. The SWL of the ship's coring wire is 7.84 tons, but no 8-T weak links were supplied. The 13 mm pennant wire was supposed to act as a weak link, but neither its SWL, yield load nor breaking load were known. This information must be supplied for future cruises.

7.10. Core processing

Vibrocores and piston cores were sawn into 1 m sections and labelled on the core bench on the aft deck. Core lengths were transported to the core laboratory where the end caps were sealed to the core liner with tape. They were then stored in individual cardboard boxes in the scientific cold room. Core catcher samples were sealed in polythene bags and labelled, and stored in the scientific cold room. A representative number of vibrocores were selected and split in the Wet Laboratory (no piston cores were split). Cores were split longitudinally, using a router to split the core liner and a cheese wire to split the sediment. The sediment surface of the archive half was cleaned with an electro-osmotic knife. The core was described visually, carefully logging lithologies and grain size, sedimentary structures and contacts, sediment colour (with the aid of a Munsell colour chart), bioturbation and iceberg rafted debris. Three representative core descriptions from Prince Gustav Channel, Larsen Inlet and the Larsen-A region are illustrated in Figure 9. Smear slides were taken at selected points within each core and analysed using a microscope. Each split core section was covered in cling-film and sealed inside lay-flat polythene tubing, and returned to the scientific cold storage.

7.11. RVS Dredge

Everything worked smoothly at the 5 dredge stations, the first four of which were done from the aft gantry and the last from midships. A pinger was attached to the wire 150 m above the dredge. At DR169 the bag became so full of rocks that it partly broke away from the frame on one side; it was subsequently sewn back together with wire for re-use.

8. ACKNOWLEDGEMENTS

This was one of the most challenging cruises ever undertaken by RRS *James Clark Ross*. We thank all the officers and crew for a memorable, scientifically productive and enjoyable cruise. In particular, none of the work in the northern Larsen area would have been possible without the navigational and ship-handling skills of Captain Jerry, Graham, Robin and Justin. The extra hours on the bridge were greatly appreciated. We thank the engineers for keeping the ship going in conditions where any problems with ship speed or manoeuvrability could have been very serious. We are grateful to the crew for their willing and competent help with mobilisation, demobilisation and corer and dredge deployments. John Summers, Dave Peck and Doug Trevett drove and maintained the ship's winches with their usual high level of skill, and Doug also attended to the non-toxic seawater supply. Steve Mee the Sparky kept us in touch with the outside world, and he and Mark Preston installed and calibrated the heave-roll-pitch sensor for the DP at the start of the cruise. Last but not least of the ship's staff, Hamish and the galley crew kept us well-fed and entertained.

Fortunately Mark Preston (electronics), Andy Barker (computer support) and Spence the doctor were seldom called upon to mend our equipment or ourselves. We are grateful for their assistance with scientific watchkeeping and help on deck. We also thank Spence for compiling the weekly web pages. BAS Operations, Logistics and Travel (John Hall, Ian Collinge, Kath Nicholson and Pat Grassick) got us and all our equipment to the ship without a hitch. Myriam Booth made sure things went as smoothly as possible in Stanley, including arranging a team of divers to attend to the broken bow thruster. Sarah Dobson and Nick McWilliam at the BAS Mapping and Geographic Information Centre located and processed the satellite images of the Larsen Ice Shelf, which were invaluable when planning ship tracks in that area.

The BGS vibrocorer/rockdrill and sparker operated very efficiently, thanks to careful preparation and operation by the BGS technical team of six led by Ali Skinner. We are particularly grateful for their swift, professional and uncomplaining response to the frequent changes of plan necessary while working in unsurveyed areas. Any technical problems which did arise were fixed in time for the next core station. Graham Tulloch's attention to core curation was appreciated, and we thank Eileen Gillespie for her help in collecting rock debris from the Larsen Ice Shelf. We thank Richie Phipps for operating the RVS corer so successfully; it was a pleasure to watch the coring team at work on the starboard deck during deployments and recoveries.

Dr R del Valle of the Instituto Antartico Argentino kindly supplied the digital bathymetric data obtained by the Greenpeace vessel *Arctic Sunrise*. We thank him, and also the contributors to the GEODAS bathymetry database.

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Acronyms

BAS	British Antarctic Survey
BGS	British Geological Survey
DGPS	Differential Global Positioning System
DP	Dynamic Positioning
FIPASS	Falklands Interim Port And Storage Services
GC	Gravity core
GEODAS	GEOphysical Data System (National Geophysical Date Center, USA)
HRPT	High-resolution picture transfer
IAA	Instituto Antartico Argentino
ICM	Institut de Ciencies del Mar
PC	Piston core
PES	Precision Echo Sounder
RD	Rockdrill
RVS	Research Vessel Services
SWL	Safe Working Load
VC	Vibrocore

10. CRUISE STATISTICS (REH)

This section is for the coring cruise only.

Total cruise time		27.6 days
Rock drilling	0.4 days	
Vibrocoring	2.9 days	
Piston coring	1.7 days	
Total station time		5.0 days
Sparker profiling		0.9 days
Mechanical failures and maintenance		0.4 days
Waiting on weather/ice etc.		2.0 days
Underway data collection (PES and 3.5 kHz)		19.3 days

Of which 1.6 days were spent in very slow steaming at night in unsurveyed waters.

Magnetometer time	8.7 days
STCM time	27.6 days (whole cruise)
Ocean logger time	26.5 days (including time on station, when data are meaningless)

11. CREW LIST

Scientific Party

Dr Carol J. Pudsey	BAS	Principal Scientist
Dr Jeff Evans	BAS	Marine geologist
Dr Peter Morris	BAS	Geophysics database manager
Dr Peter Barker	ex BAS	Geophysicist/dredging
Dr Colm O'Cofaigh	University of Bristol	Glacial geologist
Miss Ruth Hale	University of Southampton	CASE student
Dr Kate Darling	University of Edinburgh	Molecular biologist
Dr Mike Kucera	University of California	Micropalaeontologist
Mr Mark Preston	BAS	Electronics engineer
Mr Andy Barker	BAS	Computer support
Mr Richie Phipps	RVS	Mechanical engineer (coring)
Mr Ali Skinner	BGS	BGS Team Leader
Mr Dave Wallis	BGS	Electronics engineer
Mr Neil Campbell	BGS	Mechanical engineer
Mr John Derrick	BGS	Mechanical engineer
Mr Graham Tulloch	BGS	Survey technician
Ms Eileen Gillespie	BGS	Survey technician
Dr Spencer Cheung	BASMU	Doctor
Mr Keith Gillon	JNCC	Seabird observer

BAS = British Antarctic Survey, BASMU = BAS Medical Unit, BGS = British Geological Survey, JNCC = Joint Nature Conservancy Council, RVS = Research Vessel Services.

Ship's Company

Jerry Burgan	Master	Colin Lang	Bosun
Graham Chapman	Chief Officer	Dave Peck	Bosun's Mate
Robin Kilroy	2nd Officer	Martin Bowen	Seaman
Justin McCarthy	3rd Officer	Kelvin Chappell	Seaman
Steve Mee	Radio Officer	George Dale	Seaman
Duncan Anderson	Chief Engineer	Keith Dickson	Seaman
Colin Smith	2nd Engineer	Luke Trussler	Seaman
Robert (Rag)Macaskill	3rd Engineer	Erwin (Scanner) Allen	Motorman
Keith Connor	3rd Engineer	Angus Macaskill	Motorman
Keith Rowe	Electrician	Richard Parsley	Motorman
John Summers	Deck Officer	Danny McManamy	Chief Cook
Doug Trevett	Deck Engineer	Tracey Macaskill	2nd Cook
Hamish Gibson	Catering Officer	Lee Jones	Senior Steward
		Simon Hadgraft	Steward
		Graham Raworth	Steward
		Michael Weirs	Steward

APPENDIX

Table 1. JR48 core sites

Core	Latitude S degrees	minutes	Longitude W degrees	minutes	corr.depth (m)	Time on station	Cored (m) or corer length	recovery (m)	Comments
RD230	59	2	65	47.6	613	17.50-22.54/059	2.4 total (3 sites)	~ 0.2	basalt pinnacle, Drake Passage
VC231	63	26	64	43	1067	22.30/060-00.25/061	2.76	3.00	upper slope
RD232	63	53.7	63	47.6	416	18.46-20.12/061	3.06	0.75	
RD233	63	53.7	63	47.5	415	20.55-22.15/061	3.06	0.75	outcrop on shelf
RD234	63	54.1	63	46.6	416	00.36-02.20/062	2.29	0.5	
PC235	62	38.2	58	28.6	1628	17.05-20.00/062	9	6.18 + TC	Bransfield Strait
VC236	64	15.9	58	24.8	328	23.35/063-01.50/064	4.83	5.27	P G Channel (Rohss bay)
VC237	64	13.39	58	28.67	816	03.49-05.10/064	5.22	6.00	P G Channel (centre)
VC238	64	9.52	58	31.23	875	06.12-07.50/064	5.22	6.00	P G Channel (pond)
VC239	64	8.66	58	31.87	857	08.40-10.25/064	5.22	5.50	P G Channel (drape)
VC240	64	11.69	58	42.32	481	11.50-13.25/064	4.4	5.30	P G Channel (Sjogren)
VC241	64	9.69	58	17.95	499	17.55-19.15/064	4.71	4.84	P G Channel (Rohss bay)
VC242	64	22.62	58	31.14	767	23.43/064-01.00/065	5.22	5.8	P G Channel (Sjogren)
VC243	64	13.5	58	18.3	649	04.42-06.30/065	5.22	5.86	P G Channel (Rohss bay)
VC244	64	17.56	58	34.68	757	09.15-11.20/065	3.95	4.86*	P G Channel (Sjogren)
VC245	64	33.3	59	20.3	850	19.30-21.38/065	5.22	5.60	Larsen Inlet, south
VC246	64	41.8	59	27.5	574	23.45/065-01.03/066	1.26	1.56	Larsen-A, distal
VC247	64	41.6	59	26.6	571	03.50-04.45/066	2	2.47	Larsen-A, distal
VC248	64	44.64	59	36.37	564	07.30-08.26/066	1.9	1.87	Larsen-A, distal
VC249	64	44.66	59	36.32	564	08.45-09.40/066	2.4	2.67	Larsen-A, distal
VC250	64	45.12	59	53.5	612	11.37-12.35/066	0.7	0.71	Larsen-A
GC251	64	52.07	60	36.71	482	16.15-17.10/066	3	cc sample only	Larsen-A (ice margin)
VC252	64	52.07	60	36.71	482	17.10-18.00/066	0.66	0.52	Larsen-A (ice margin)
VC253	64	47.1	60	39.4	534	22.00-23.13/066	2.68	bag sample	Larsen-A (Drygalski Glacier)
VC254	64	50.02	60	32.29	625	00.33-02.22/067	1.39	0.99	Larsen-A, proximal
VC255	64	48.9	60	30.28	552	03.25-04.32/067	1.72	1.00	Larsen-A, proximal
VC256	64	46.64	60	25.75	899	05.30-07.10/067	3.44	2.87	Larsen-A, proximal
VC257	64	45.44	60	21.99	922	08.15-10.30/067	3.3	3.30	Larsen-A, proximal
VC258	64	38.23	60	14.4	457	15.05-16.15/067	1.6	1.50	Larsen-A (Cape Worsley)
VC259	64	45.2	60	7.5	722	23.30/067-00.44/068	1.93	1.90	Larsen-A, trough
VC260	64	48.6	60	14.63	585	02.45-04.50/068	1.3	1.50	Larsen-A, slope
VC261	64	54.7	60	17.47	348	06.35-07.25/068	0.42	0.6	Larsen-A, shelf

Table 1. JR48 core sites

Core	Latitude S		Longitude W		depth	Time on station	Cored (m)	recovery	Comments
	degrees	minutes	degrees	minutes	(m)		or corer length	(m)	
VC262	64	57.36	60	14.52	321	08.32-09.55/068	1.51	1.92	Larsen-A, shelf
VC263	64	49.6	60	0.2	455	11.44-13.00/068	2.63	3.09	Larsen-A
VC264	64	50.2	58	34.8	401	19.50-20.35/068	3.5	4.00	shelf, draped
VC265	64	44.9	54	8.17	502	23.00/068-01.00/069	2.55	3.12	shelf, draped
VC266	64	45.5	58	17.01	490	03.10-04.43/069	5.22	5.37	shelf, draped
VC267	64	48.57	58	27.41	442	06.17-08.35/069	3.75	4.12	shelf, draped
VC268	64	49.72	58	48.39	377	10.30-11.50/069	0.82	0.87	shelf, hard, furrowed
VC269	64	38.82	59	54.96	676	17.15-18.37/069	0.95	0.88	Larsen-A, north
VC270	64	39.46	59	12.28	546	23.06/069-00.25/070	2.21	2.36	Larsen-A, distal
VC271	64	34.2	59	17.59	811	02.54-04.50/070	5.22	5.90	Larsen Inlet, south
VC272	64	31.82	59	24.21	886	05.56-07.34/070	4.97	4.86	Larsen Inlet, south
VC273	64	20.64	59	25.88	490	12.20-13.35/070	5	5.67	Larsen Inlet, north
VC274	64	27.17	59	29.86	905	15.06-16.48/070	1.8	1.66	Larsen Inlet, central
VC275	64	36.1	58	5.7	453	19.30-20.41/071	4.27	5.34	shelf, draped
VC276	64	25.93	58	18.46	451	04.51-06.25/072	3.91	4.70	shelf, draped
VC277	64	34.02	58	28.89	603	08.51-10.40/072	3.44	3.90	shelf, draped
VC278	64	22.05	58	45.68	653	13.00-14.43/072	2.85	3.70	E of Longing Gap
VC279	64	45.33	55	39.63	390	23.18/072-00.38/073	1.6	0.67	30 nm E of shelf edge
VC280	64	48.45	54	41.21	386	11.51-13.27/073	2.45	2.47	shelf edge
VC281	64	33.27	53	38.09	1934	23.05/073-02.54/074	0	0 (too deep)	mid-slope
VC282	64	17.69	54	32.11	310	08.52-10.06/074	3.1	3.90	shelf edge
PC283	61	41.5	51	20.2	2796	13.40-17.30/075	12	7.22 + bag +TC	Powell Basin, wave (crest)
PC284	61	41.63	51	18.82	2827	17.55-21.54/075	9	7.82 + 1.06	Powell Basin, wave (steep side)
PC285	62	3	49	48.98	3347	10.55-14.30/076	9	4.23 + 1.04	Powell Basin, flat
PC286	61	47.3	40	8.3	3467	21.10/077-00.27/078	12	9.35 + 0.54	Jane Basin (repeat core 27)
PC287	60	18.36	36	39.07	1998	16.42-18.58/078	9	5.78 + 0.54	Discovery Bank
PC288	59	8.52	37	57.88	2864	03.53-06.42/079	12	8.87 + 1.16	Mooring VI, Bruce-Discovery basin
PC289	58	0	42	18.47	3097	19.36-22.29/079	12	9.45 + 1.13	NE of Pirie Bank (repeat core 82)
PC290	55	33	45	0.9	3826	14.50-18.00/080	12	10.22 + 1.08	N Scotia Sea (repeat core 78)
PC291	52	28.42	44	16	3351	15.25-18.10/081	12	11.21+ 0.95	E Falkland Trough (wave crest)
PC292	52	29.75	44	14.1	3404	19.00/081-01.23/082	9	5.12 + 1.14	E Falkland Trough (steep side)
PC293	53	20.98	54	41.01	3046	15.50-18.30/084	12	9.97 + 0.46	W Falkland Trough (repeat core 97)

Table 2. List of pumping stations, vertical plankton net stations and ice sampling stations taken during cruise JR48. The position of the ship at the beginning and the end of each pumping period is shown with corresponding oceanographic data (Fl = fluorescence, Depth = water depth, Sal = salinity). Also shown is the type of screen (Mesh) used for the collection of each sample.

No.	Date	Day	Start GMT	End GMT	Latitude S	Long. W	Depth m	SST °C	Fl	Sal ‰	Mesh µm	Remarks
Continuous pumping stations												
1	2/26	57	20:30		-51.841	-57.812	-73	11.3	4.2	33.7	62	
	2/26	57		22:05	-52.023	-58.001	-65	10.8	4.3	33.7		
2	2/26	57	22:08		-52.031	-58.009	-64	10.9	4.8	33.7	62	
	2/26	57		23:05	-52.190	-58.159	-85	10.1	4.3	33.8		
3	2/26	57	23:05		-52.190	-58.159	-85	10.1	4.3	33.8	62	
	2/26	57		23:57	-52.287	-58.239	-121	9.9	5.6	33.8		
4	2/26	57	23:57		-52.287	-58.239	-121	9.9	5.6	33.8	62	
	2/27	58		1:35	-52.545	-58.518	-151	9.7	4.1	33.7		
5	2/27	58	1:35		-52.545	-58.518	-151	9.7	4.1	33.7	62	bulk sample
	2/27	58		2:48	-52.751	-58.721	-182	9.3	5.0	33.8		
6	2/27	58	9:57		-53.895	-59.891	-151	7.7	4.3	34.1	62	
	2/27	58		11:05	-54.086	-60.052	-105	7.3	3.7	34.1		
7	2/27	58	11:10		-54.101	-60.062	-106	7.2	3.4	34.1	62	
	2/27	58		12:07	-54.250	-60.162	-93	7.8	4.9	34.0		
8	2/27	58	15:16		-54.814	-60.531	-343	6.7	1.3	34.2	62	
	2/27	58		16:13	-54.992	-60.656	-2077	6.7	1.6	34.1		
9	2/27	58	16:15		-54.998	-60.660	-2291	6.6	1.8	34.1	62	bulk sample
	2/27	58		17:20	-55.207	-60.786	-4270	5.9	1.2	33.9		
10	2/27	58	17:23		-55.216	-60.793	-4256	6.0	1.8	33.9	62	
	2/27	58		18:27	-55.415	-60.938	-4093	6.1	1.2	33.9		
11	2/27	58	18:34		-55.436	-60.954	-4090	6.0	0.8	34.0	62	bulk - sieve clogged
	2/27	58		20:55	-55.815	-61.413	-4156	6.5	2.8	34.0		
12	2/27	58	21:00		-55.829	-61.430	-4166	6.3	4.8	34.1	62	
	2/27	58		22:37	-56.089	-61.758	-4112	6.4	4.6	34.0		
13	2/28	59	10:29		-57.984	-64.307	-3117	4.5	3.1	34.0	62	
	2/28	59		11:33	-58.150	-64.551	-3663	3.4	20.1	33.8		
14	2/28	59	11:35		-58.155	-64.558	-3663	3.4	16.0	33.8	62	bulk sample
	2/28	59		12:43	-58.332	-64.803	-3412	3.4	2.3	33.7		
15	2/28	59	12:47		-58.343	-64.817	-3332	3.4	1.1	33.7	62	
	2/28	59		14:22	-58.590	-65.159	-3181	4.5	3.0	33.8		
16	2/28	59	14:26		-58.601	-65.174	-2931	4.5	8.9	33.8	62	bulk sample
	2/28	59		17:24	-59.046	-65.812	-810	4.5	2.3	33.9		
17	2/29	60	10:16		-61.003	-65.322	-2781	3.4	22.9	33.7	62	
	2/29	60		11:19	-61.221	-65.270	-2941	3.3	20.1	33.7		
18	2/29	60	11:23		-61.235	-65.267	-2951	3.3	20.1	33.7	62	
	2/29	60		12:20	-61.433	-65.219	-3583	3.3	19.9	33.7		
19	2/29	60	12:37		-61.491	-65.205	-4018	3.4	21.2	33.7	62	
	2/29	60		14:47	-61.931	-65.098	-2262	3.3	18.9	33.7		
20	2/29	60	14:50		-61.942	-65.096	-2034	3.4	23.8	33.7	62	
	2/29	60		16:25	-62.265	-65.013	-4038	2.9	6.7	33.7		
21	2/29	60	16:30		-62.282	-65.009	-3977	2.9	21.2	33.7	62	bloom, not used
	2/29	60		18:00	-62.591	-64.933	-3388	2.2	22.6	33.8		
22	2/29	60	19:59		-63.005	-64.827	-2997	2.5	23.0	33.8	62	bloom, not used
	2/29	60		22:08	-63.036	-64.818	-1033	2.1	29.1	33.8		
23	3/1	61	10:32		-63.916	-63.740	-466	2.0	30.1	33.7	62	
	3/1	61		11:48	-63.965	-63.755	-564	1.9	27.5	33.7		

Table 2 Continued

24	3/1	61	11:48		-63.965	-63.755	-564	1.9	27.5	33.7	62	bulk sample
	3/1	61		12:54	-63.994	-63.910	-525	1.9	24.7	33.7		
25	3/1	61	12:59		-63.990	-63.920	-527	1.9	25.1	33.7	62	bloom, not used
	3/1	61		14:40	-63.974	-63.961	-416	2.0	24.7	33.7		
26	3/1	61	14:46		-63.969	-63.974	-416	2.1	28.5	33.7	62	bloom, not used
	3/1	61		16:24	-63.899	-64.087	-416	2.2	26.5	33.8		
27	3/2	62	10:31		-63.895	-63.793	-441	1.6	22.0	33.7	62	bloom
	3/2	62		11:21	-63.161	-60.514	-662	1.8	26.6	33.9		
28	3/2	62	13:27		-62.937	-59.637	-904	2.1	28.4	34.3	62	
	3/2	62		14:15	-62.853	-59.311	-1183	2.1	17.9	34.3		
29	3/2	62	14:19		-62.846	-59.285	-1218	2.0	25.4	34.3	62	
	3/2	62		16:25	-62.630	-58.459	-1673	2.3	20.3	34.3		
30	3/2	62	16:29		-62.628	-58.450	-1647	2.3	19.2	34.3	62	sieve clogged
	3/2	62		19:54	-62.637	-58.477	-1629	2.2	27.8	34.3		
31	3/2	62	19:54		-62.637	-58.477	-1629	2.2	27.8	34.3	62	bulk
	3/2	62		22:30	-62.913	-57.625	-244	0.3	26.1	34.5		
32	3/5	65	14:47		-64.488	-58.415	-541	0.0	37.6	32.7	62	
	3/5	65		18:28	-64.529	-59.269	-466	0.2	29.1	32.3		
33	3/5	65	19:20		-64.558	-59.347	-855	-0.3	19.3	31.9	62	bulk, flow decreased
	3/5	65		20:00	-64.556	-59.339	-850	-0.3	24.3	32.0		
34	3/5	65	20:30		-64.556	-59.339	-850	-0.5	49.9	32.3	125	flow restored
	3/6	66		1:36	-64.702	-59.458	-571	-0.2	34.5	32.2		
35	3/6	66	1:40		-64.702	-59.458	-570	-0.1	31.5	32.3	125	
	3/6	66		8:56	-64.744	-59.606	-564	-0.1	40.6	32.4		
36	3/6	66	8:56		-64.744	-59.606	-564	-0.1	40.6	32.4	125	
	3/6	66		11:43	-64.750	-59.892	-613	-0.2	38.0	32.3		
37	3/6	66	11:43		-64.750	-59.892	-613	-0.2	38.0	32.3	125	
	3/6	66		13:10	-64.747	-59.948	-648	-0.1	28.9	32.3		
38	3/6	66	13:10		-64.747	-59.948	-648	-0.1	28.9	32.3	125	
	3/6	66		16:30	-64.868	-60.612	-482	-0.4	44.1	32.7		
39	3/6	66	16:30		-64.868	-60.612	-482	-0.4	44.1	32.7	125	bulk
	3/7	67		0:20	-64.839	-60.544	-599	-0.5	45.4	32.8		
40	3/7	67	0:25		-64.836	-60.538	-624	-0.5	45.3	32.7	125	sieve clogged
	3/7	67		11:25	-64.735	-60.576	-689	-0.7	42.8	32.9		
41	3/8	68	11:43		-64.827	-60.000	-453	-1.0	54.2	32.6	125	
	3/8	68		13:36	-64.827	-59.788	-425	-0.8	26.2	32.6		
42	3/8	68	13:52		-64.826	-59.676	-437	-1.1	30.6	32.7	125	bulk
	3/8	68		15:26	-64.818	-59.147	-392	-0.9	19.9	32.7		
43	3/8	68	15:26		-64.818	-59.147	-392	-0.9	19.9	32.7	125	
	3/8	68		17:30	-64.842	-58.456	-413	-0.9	30.0	32.5		
44	3/8	68	17:30		-64.842	-58.456	-413	-0.9	30.0	32.5	125	bloom, sieve clogged
	3/8	68		19:14	-64.837	-58.584	-399	-1.0	32.7	32.9		
45	3/9	69	11:54		-64.826	-58.814	-378	-1.1	35.9	32.5	125	
	3/9	69		13:34	-64.716	-59.313	-539	-1.1	27.7	32.7		
46	3/11	71	16:38		-64.281	-58.434	-695	-0.9	45.4	33.0		
	3/11	71		21:05	-64.579	-58.187	-447	-1.0	45.4	32.8		
47	3/12	72	23:01		-64.755	-55.722	-384	-1.0	7.9	33.0	62	water off?
	3/13	73		1:09	-64.725	-55.646	-360	-1.0	6.7	33.2		
48	3/13	73	9:51		-64.781	-55.060	-374	-0.9	25.5	33.6	62	
	3/13	73		11:26	-64.818	-54.552	-394	-0.7	7.5	33.6		

Table 2 continued

49	3/13	73	11:26		-64.818	-54.552	-394	-0.7	7.5	33.6	62	bulk
	3/13	73		13:36	-64.809	-54.657	-382	-0.7	6.0	33.4		
50	3/13	73	13:41		-64.810	-54.621	-380	-0.7	6.3	33.4	62	
	3/13	73		14:59	-64.848	-53.995	-1474	-0.9	6.5	33.4		
51	3/13	73	14:59		-64.848	-53.995	-1474	-0.9	6.5	33.4	62	sieve clogged
	3/13	73		16:21	-64.877	-53.350	-2195	0.1	6.7	33.1		
52	3/13	73	16:21		-64.877	-53.350	-2195	0.1	6.7	33.1	62	
	3/13	73		18:26	-64.747	-52.727	-2596	-0.2	6.7	33.3		
53	3/14	74	11:00		-64.218	-54.280	-488	-0.4	13.5	33.7	125	
	3/14	74		13:00	-63.979	-53.569	-1052	-0.3	5.8	33.8		
54	3/14	74	13:00		-63.979	-53.569	-1052	-0.3	5.8	33.8	125	
	3/14	74		16:32	-63.329	-52.718	-456	0.7	21.1	34.0		
55	3/14	74	16:32		-63.329	-52.718	-456	0.7	21.1	34.0	125	
	3/14	74		19:05	-62.836	-52.153	-3034	0.4	25.4	33.8		
56	3/15	75	11:33		-61.727	-51.098	-2991	1.0	14.2	34.2	125	
	3/15	75		13:20	-61.685	-51.355	-2785	0.9	10.8	34.0		
57	3/15	75	13:20		-61.685	-51.355	-2785	0.9	10.8	34.0	125	
	3/15	75		17:07	-61.692	-51.337	-2802	0.8	12.0	34.0		
58	3/15	75	17:07		-61.692	-51.337	-2802	0.8	12.0	34.0	125	
	3/15	75		19:46	-61.694	-51.314	-2826	0.8	12.5	34.0		
59	3/15	75	19:46		-61.694	-51.314	-2826	0.8	12.5	34.0	125	
	3/16	76		1:41	-61.799	-51.089	-3047	0.6	15.6	33.9		
60	3/16	76	15:28		-62.072	-49.505	-3326	0.6	7.7	33.9	125	
	3/16	76		16:58	-62.218	-48.945	-3325	0.7	7.6	33.8		
61	3/16	76	16:58		-62.218	-48.945	-3325	0.7	7.6	33.8	62	
	3/16	76		18:31	-62.325	-48.538	-3343	0.7	8.6	33.8		
62	3/16	76	18:35		-62.329	-48.516	-3345	0.6	8.8	33.8	62	bulk
	3/17	77		0:44	-62.168	-46.920	-1412	1.1	9.2	33.9		
63	3/17	77	0:44		-62.168	-46.920	-1412	1.1	9.2	33.9	62	
	3/17	77		2:02	-62.086	-46.745	-1227	1.1	8.2	34.0		
64	3/17	77	2:07		-62.081	-46.736	-1192	1.1	8.3	34.0	125	
	3/17	77		11:00	-61.895	-44.433	-458	0.9	6.2	34.1		
65	3/17	77	14:35		-61.842	-42.834	-667	1.0	6.4	34.0	62	
	3/17	77		16:20	-61.809	-42.032	-763	0.9	6.3	33.9		
66	3/17	77	17:18		-61.806	-41.586	-2079	0.9	6.5	33.9	125	
	3/17	77		23:00	-61.788	-40.138	-3468	0.9	7.1	33.9		
67	3/18	78	13:02		-60.669	-37.632	-1515	1.2	6.2	33.8	62	
	3/18	78		14:24	-60.483	-37.132	-1550	1.3	8.7	33.8		
68	3/19	79	10:28		-59.084	-39.402	-2715	1.9	8.2	34.0	62	
	3/19	79		11:55	-58.954	-39.937	-2598	3.7	5.4	33.8		
69	3/19	79	11:55		-58.954	-39.937	-2598	3.7	5.4	33.8	62	
	3/19	79		13:35	-58.694	-40.472	-3336	3.4	6.1	33.9		
70	3/19	79	13:38		-58.686	-40.488	-3336	3.4	6.2	33.9	62	bulk
	3/19	79		15:00	-58.466	-40.935	-3223	2.6	6.6	34.0		
71	3/20	80	11:04		-56.208	-44.600	-3506	5.3	8.1	33.7	62	
	3/20	80		12:17	-55.968	-44.753	-3768	5.5	5.9	33.8		
72	3/20	80	12:17		-55.968	-44.753	-3768	5.5	5.9	33.8	62	bulk
	3/20	80		13:30	-55.721	-44.908	-3728	6.1	5.8	33.9		
73	3/20	80	13:30		-55.721	-44.908	-3728	6.1	5.8	33.9	125	
	3/20	80		15:00	-55.550	-45.015	-3826	6.2	6.0	33.9		

Table 2 continued

74	3/21	81	11:15		-52.549	-44.167	-3422	6.7	4.6	33.7	62	
	3/21	81		12:36	-52.346	-44.428	-3281	7.0	5.0	33.7		
75	3/21	81	12:36		-52.346	-44.428	-3281	7.0	5.0	33.7	62	bulk
	3/21	81		13:35	-52.448	-44.193	-3372	7.4	16.8	33.8		
76	3/21	81	13:45		-52.474	-44.158	-3352	7.1	5.0	33.9	125	
	3/21	81		15:22	-52.474	-44.266	-3351	7.0	5.8	33.8		
77	3/23	83	10:58		-52.328	-45.563	-3583	6.0	4.6	33.7	62	
	3/23	83		12:30	-52.381	-45.984	-3543	5.8	3.8	33.7		
78	3/23	83	12:30		-52.381	-45.984	-3543	5.8	3.8	33.7	62	bulk
	3/23	83		13:33	-52.419	-46.318	-3513	6.0	3.3	33.6		
79	3/24	84	6:10		-52.994	-51.443	-2547	8.6	4.7	34.0	125	
	3/24	84		10:32	-53.133	-52.769	-2376	8.8	6.2	33.9		
80	3/24	84	10:32		-53.133	-52.769	-2376	8.8	6.2	33.9	62	
	3/24	84		11:52	-53.195	-53.274	-2602	8.8	6.3	34.0		
81	3/24	84	11:52		-53.195	-53.274	-2602	8.8	6.3	34.0	62	bulk
	3/24	84		12:57	-53.236	-53.659	-2848	6.6	4.2	34.1		
82	3/25	85	3:53		-52.645	-56.032	-1529	8.1	6.3	33.9	62	
	3/25	85		4:53	-52.504	-56.267	-1325	8.0	5.6	34.0		
83	3/25	85	4:53		-52.504	-56.267	-1325	8.0	5.6	34.0	62	bulk
	3/25	85		5:45	-52.384	-56.468	-1162	8.2	5.5	33.9		
84	3/25	85	5:45		-52.384	-56.468	-1162	8.2	5.5	33.9	62	
	3/25	85		6:58	-52.212	-56.751	-840	8.6	3.1	33.9		
85	3/25	85	6:58		-52.212	-56.751	-840	8.6	3.1	33.9	62	
	3/25	85		8:06	-52.054	-57.009	-448	8.4	4.8	34.0		
86	3/25	85	8:06		-52.054	-57.009	-448	8.4	4.8	34.0	62	bulk
	3/25	85		9:15	-51.891	-57.286	-306	9.0	3.3	33.7		
87	3/25	85	9:15		-51.891	-57.286	-306	9.0	3.3	33.7	62	
	3/25	85		10:08	-51.776	-57.479	-147	9.8	3.7	33.6		
88	3/25	85	10:08		-51.776	-57.479	-147	9.8	3.7	33.6	62	
	3/25	85		10:56	-51.674	-57.656	-53	10.4	3.4	33.7		
Other stations												
ICE1	3/8	68	15:15		-64.816	-59.211	-414	-1.0	32.3	32.7	62	old ice
ICE2	3/10	70	12:50		-64.344	-59.431	-490	pump failure			62	new ice
NET1	3/7	67	15:50		-64.637	-60.240	-458	pump failure			85	
NET2	3/13	73	12:30		-64.808	-54.687	-386	-0.7	6.3	33.4	85	
NET3	3/17	77	22:15		-61.788	-40.138	-3468	0.9	7.1	33.8	85	
NET4	3/18	78	17:20		-60.306	-36.651	-1996	1.3	9.4	33.9	85	
NET5	3/19	79	21:20		-58.000	-42.308	-3097	3.2	6.2	34.0	85	
NET6	3/20	80	16:45		-55.547	-45.016	-3826	6.3	8.1	33.9	85	
NET7	3/21	81	17:10		-52.474	-44.266	-3352	7.0	4.3	33.7	85	
NET8	3/24	84	17:30		-53.350	-54.684	-3046	7.6	7.1	34.1	85	

Table 3. Summary of the numbers of specimens from each station that were processed for genotyping. Stn. refers to station number as listed in Table 2, an asterisk in the QC column indicates samples for which a quantitative assemblage count will be available.

Stn.	QC	*G. bulloides*		*T. quinqueloba*		*N. pachyderma*		*G. uvula*	Other species		Total
		S	D	S	D	S	D				
1		1	1	1							3
2								1			1
3		1	4	6	5	1	1				18
4		4	1	4		4	4				17
5	*										
6		2		2	4	3		1			12
7					1			1			2
8		7	6	3	9	17	3		?	1	46
9	*										
10		5	4	8	1	9	2	1	*G. ruber*	1	31
11	*										
12		10	2	7	3	8	1				31
13		4	2	4	6	10	6				32
14	*										
15		4	3			21					28
16	*										
17		2		4	6	12	2				26
18									*G. glutinata*	1	1
19		1				10	1				12
20		1				3					4
21											
22											
23				1		14	1	2	*G. glutinata*	1	19
24	*										
25											
26	*										
27											
28					1	2		4			7
29						2					2
30			1			5	2				8
31	*										
32	*					1					1
33											
34	*					2			*B. digitata*	1	3
35	*					3					3
36	*				1	12	2	1			16
37	*			2		8					10
38	*					14					14
39	*										
40	*										
41	*			4	1	9		1			15
42	*										
43	*										
44											
45	*					2					2
46	*										
47	*										
48	*					9					9
49	*										

Table 3. continued.

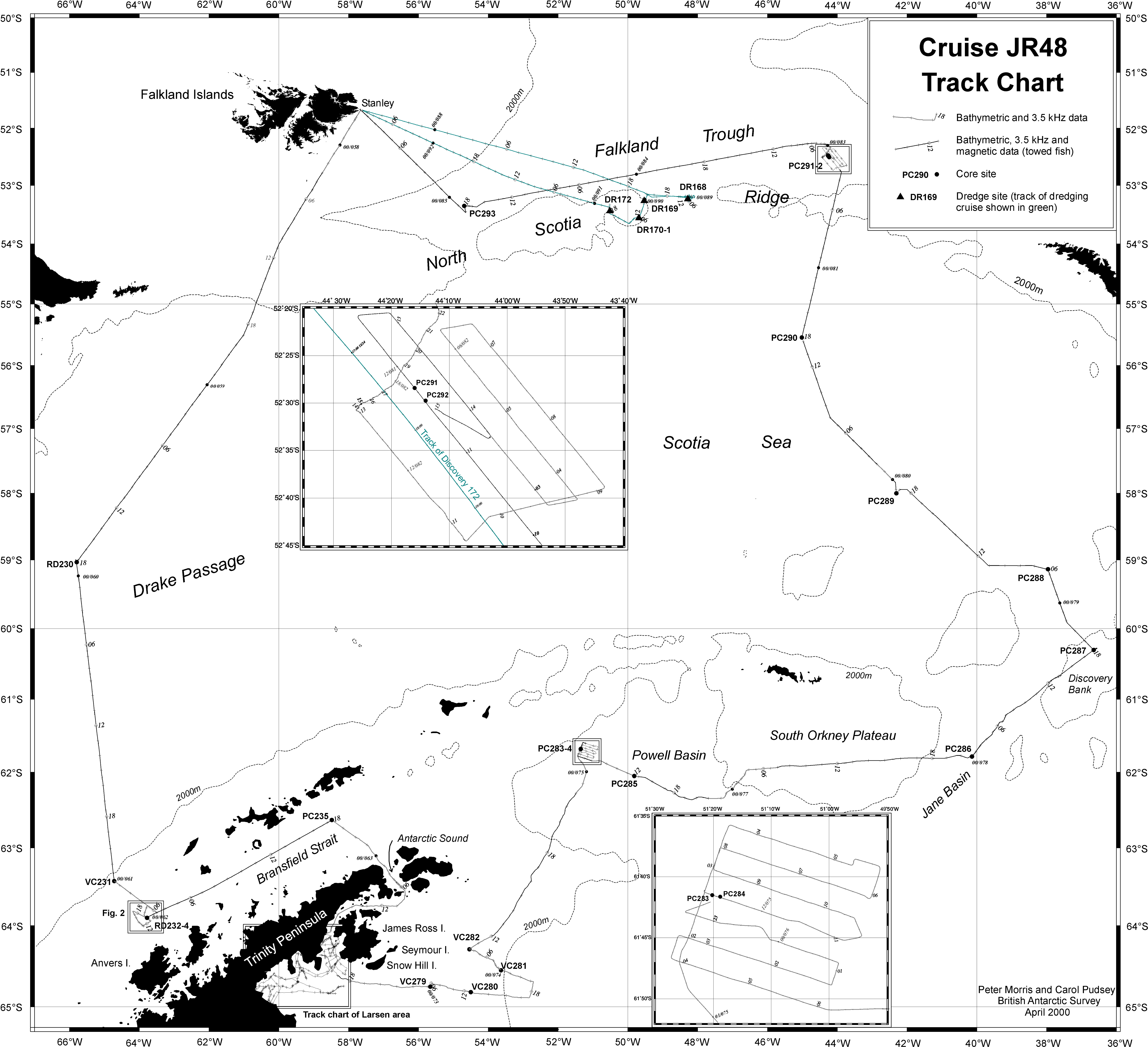
50	*							1			1
51	*										
52	*										
53	*										
54	*										
55	*										
56	*										
57	*										
58	*										
59	*										
60	*					1					1
61	*					5		1			6
62	*										
63	*					5					5
64	*										
65	*					5					5
66	*										
67	*					6					6
68	*						4				4
69	*			1	2	1	1				5
70	*										
71		3	2	5	5	9	1	2			27
72	*										
73		3	2	1		1					7
74		1	2	3	1	5	1				13
75	*										
76	*										
77		4	1	3	2	5	3	2			20
78	*										
79						1	11				12
80		7	3	2	3	9	5				29
81	*										
82		6	1	2	2	7	4	1			23
83	*										
84	*	2		2	2	6	7	1			20
85		3	1	4	2	6	5	1			22
86	*										
87		4	2	4		6					16
88		1		3	1	4					9
ICE1	*					1					1
ICE2	*										
NET1											
NET2	*					2					2
NET3	*										
NET4	*					10	3				13
NET5	*			1		3					4
NET6		5	3			11	1		*G. glutinata*	3	23
									G. inflata	1	1
NET7		3	2	1	2	5	1				14
NET8		5	3	3	1	7	9				28
Total		89	46	81	61	302	81	21		9	690

Table 4. Summary of continuous pumping stations and vertical plankton net samples that yielded enough specimens of *N. pachyderma* sinistral for Mg/Ca analyses. Also shown are the times of the collection of water samples and the actual numbers of shells available for analysis. More details about the stations can be found in Table 2.

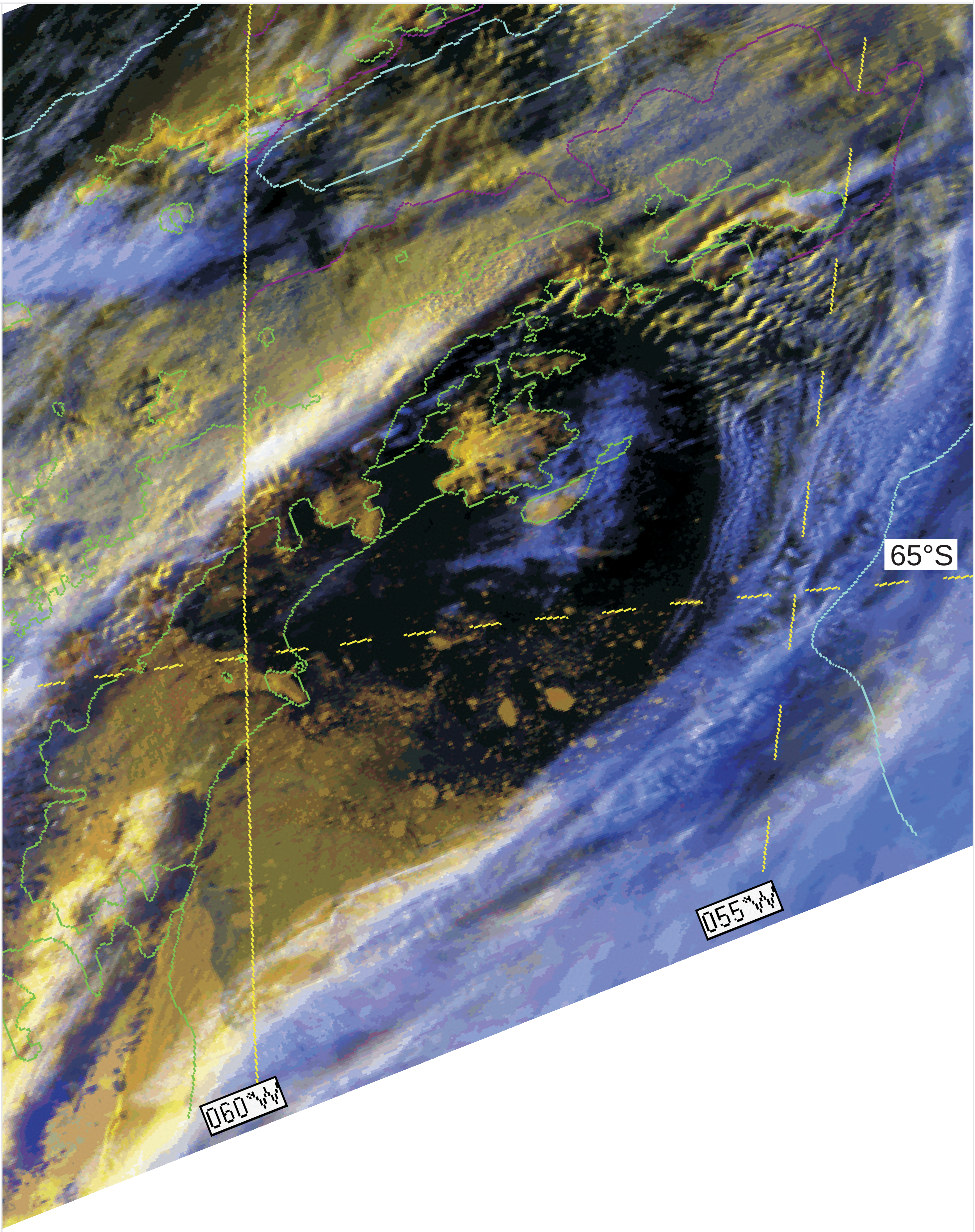
Stn.	Location	SST	sd	min	max	Water sample	*N. pachyderma* SIN		Remarks
		°C				Day GMT	Full	Empty	
13	Drake Passage	3.80	0.387	3.40	4.46	060 12:52	20		62 µm screen
18	Drake Passage	3.34	0.041	3.26	3.40		14		"
36	Larsen Ice Shelf	-0.19	0.125	-0.50	-0.03	066 13:06	12		125 µm screen
40	Larsen Ice Shelf	-0.78	0.303	-1.14	-0.21		28		"
41	Larsen Ice Shelf	-0.90	0.066	-0.98	-0.70		42	7	"
43	Larsen Ice Shelf	-0.74	0.115	-0.94	-0.53		19	3	"
45	Larsen Ice Shelf	-1.27	0.077	-1.40	-1.10		13		"
46	Larsen Ice Shelf	-1.01	0.036	-1.09	-0.78		25	3	"
63	South Orkney	1.11	0.043	1.02	1.23		13	2	62 µm screen
65	Jane Basin	0.95	0.028	0.89	1.01	077 18:12	13		"
67	Scotia Sea	1.27	0.051	1.12	1.41	078 15:07	80		"
68	Scotia Sea	2.43	0.638	1.80	3.78		49		"
69	Scotia Sea	3.62	0.214	3.13	3.86		59		"
76	Scotia Sea	6.90	0.233	6.53	7.24		33		"
77	Scotia Sea	6.02	0.086	5.80	6.12		32		"
84	Scotia Sea	8.49	0.160	8.15	8.70		135		"
85	Scotia Sea	8.69	0.091	8.44	8.83		19		"
87	Scotia Sea	9.35	0.261	8.94	9.78		8		"
NET4	Scotia Sea	1.3					143		85 µm screen
NET6	Scotia Sea	6.3					17		85 µm screen

Table 5. Times and positions of nannoplankton filter samples and culture samples taken during JR48, together with the corresponding oceanographic data extracted from the oceanlogger. Also shown is the mesh size of the screen through which the sea water was pre-filtered to remove larger particles and the water flow during the collection of the two culture samples.

No.	Date	Day	Time GMT	Latitude	Longitude	Depth m	SST °C	Fluorescence Relative units	Salinity ‰	Screen
Filter samples										
1	2/27	58	10:28	-53.980	-59.974	-115	7.4	3.1	34.1	62 µm
2	2/27	58	16:04	-54.963	-60.637	-1344	6.9	1.5	34.0	62 µm
3	2/27	58	17:30	-55.238	-60.809	-4221	6.0	1.4	34.0	62 µm
4	2/27	58	20:09	-55.693	-61.254	-4102	6.1	1.8	34.0	62 µm
5	2/28	59	17:20	-59.043	-65.808	-722	4.5	1.7	33.9	85 µm
6	2/29	60	10:19	-61.014	-65.319	-2811	3.3	23.3	33.7	62 µm
7	2/29	60	16:22	-62.255	-65.015	-3966	3.0	6.6	33.7	62 µm
8	2/29	60	18:50	-62.762	-64.894	-3173	2.3	23.2	33.8	62 µm
9	2/29	60	22:10	-63.442	-64.714	-1002	2.2	22.7	33.8	62 µm
10	3/1	61	11:37	-63.959	-63.731	-525	1.9	21.9	33.7	62 µm
11	3/2	62	20:25	-62.674	-58.369	-1558	2.0	24.7	34.4	62 µm
12	3/6	66	14:52	-64.753	-60.346	-911	-0.6	37.4	32.6	125 µm
13	3/8	68	18:55	-64.840	-58.542	-401	-0.7	39.3	32.5	125 µm
14	3/13	73	16:30	-64.883	-53.293	-2239	0.2	6.7	33.2	62 µm
15	3/14	74	19:09	-62.823	-52.140	-2998	0.4	24.7	33.8	125 µm
16	3/17	77	18:18	-61.813	-41.152	-2955	0.7	7.0	33.9	125 µm
17	3/19	79	13:25	-58.722	-40.418	-3245	3.1	6.1	34.0	62 µm
18	3/20	80	19:55	-55.159	-44.850	-3620	5.2	7.6	33.8	62 µm
19	3/21	81	18:59	-52.496	-44.238	-3438	7.0	5.0	33.7	62 µm
20	3/25	85	3:58	-52.634	-56.052	-1519	8.1	5.3	34.0	62 µm
21	3/25	85	10:12	-51.768	-57.493	-140	10.1	3.5	33.5	62 µm
Culture samples										
1	3/30	90	17:05	-53.512	-50.381		7.0	3.8	34.0	62 µm
	until		18:20	-53.419	-50.516		6.6	4.2	34.0	1l/16s
2	3/31	91	12:45	-52.865	-53.372		7.8	3.7	34.0	62 µm
	until		14:25	-52.788	-53.687		7.7	2.6	34.0	1l/28s



Cruise JR48
Track Chart
Bathymetric and 3.5 kHz data
Bathymetric, 3.5 kHz and magnetic data (towed fish)
PC290 Core site
DR169 Dredge site (track of dredging cruise shown in green)
Falkland Islands
Stanley
Falkland Trough
North Scotia Ridge
Scotia Sea
Drake Passage
Track of Discovery 172
PC291
PC292
PC291-2
PC293
DR168
DR169
DR170-1
DR172
PC290
PC289
PC288
PC287
PC286
PC285
PC283-4
PC283
PC284
RD230
VC231
RD232-4
Fig. 2
PC235
VC279
VC280
VC281
VC282
Discovery Bank
South Orkney Plateau
Powell Basin
Jane Basin
Bransfield Strait
Antarctic Sound
Trinity Peninsula
James Ross I.
Seymour I.
Snow Hill I.
Anvers I.
Track chart of Larsen area
2000m
Peter Morris and Carol Pudsey
British Antarctic Survey
April 2000


65°S
055°W
060°W