RRS JOHN BISCOE

BRITISH ANTARCTIC SURVEY

OFFSHORE BIOLOGICAL PROGRAMME

CRUISE 4

(27 JULY - 29 SEPTEMBER 1983)

REPORT

by

R B HEYWOOD

CAMBRIDGE: BRITISH ANTARCTIC SURVEY: 1984

NATURAL ENVIRONMENT RESEARCH COUNCIL

High Cross, Madingley Road, Cambridge CB3 0ET

BRITISH ANTARCTIC SURVEY

OFFSHORE BIOLOGICAL PROGRAMME

CRUISE 4

(27 JULY - 29 SEPTEMBER 1983)

REPORT

by

R B HEYWOOD

CAMBRIDGE: BRITISH ANTARCTIC SURVEY: 1984

NATURAL ENVIRONMENT RESEARCH COUNCIL

High Cross, Madingley Road, Cambridge CB3 0ET

BRITISH ANTARCTIC SURVEY

OFFSHORE BIOLOGICAL PROGRAMME

CRUISE 4

(27 JULY - 29 SEPTEMBER 1983)

REPORT

by

R B HEYWOOD

INTRODUCTION

The period of greatest stress for the basically herbivorous krill, Euphausia superba, could be the mid-winter months when phytoplankton availability as a food source is negligible. Data from this period are clearly of importance to BIOMASS, the current international investigation on this species of potential commercial importance. However, computer literature searches indicated that no field observations had been made over the mid-winter period since the 2nd Discovery II Expedition of 1931 - 1933. Consequently, the OBP Cruise 4 was to be a winter expedition planned round a 30-day study of the distribution and abundance of krill (and other major zooplankton) around South Georgia, and a 30-day study of krill diet, feeding behaviour and swarm microstructure and organization. Concurrent studies of the physico-chemical oceanography and phytoplankton were also to be carried out to relate the zoological findings to horizontal and vertical variation in water masses and in abundance and composition of the plant community.

The plans had to be revised in the field because, although the South Georgia Zone Survey was curtailed to 25 days by a medical emergency, it was already clear that the densities in which krill were to be found around South Georgia were insufficient to support physiological and behavioural studies. The search for krill was continued in the

seas off Elephant Island (a preferred krill-fishing ground for Soviet and Polish factory trawlers in summer), in the Weddell-Scotia Confluence in longitude 51°00'W, and along a 2 × 440 nautical mile zig-zag transect across the Scotia Sea (Fig. 1). The concentrations of krill found remained low and consequently no detailed studies were carried out on krill. The Cruise was concluded with three small contingency projects in the South Georgia zone. These were a study of the ichthyoplankton of the reputed fish-spawning grounds between Cooper Island and Clerke Rocks, a study of ichthyoplankton along a transect crossing oceanic, slope and shelf areas near Cumberland Bay and a study on ichthyo- and zoo-plankton in Cumberland Bay East.

ACKNOWLEDGEMENT

Most research programmes were handicapped by equipment failure and bad weather. Some programmes were prevented or severely curtailed by the scarcity of krill. Yet the cruise was a remarkably happy one. In spite of the frustration and fatigue, the team spirit, morale and cooperation between scientists, officers and crew remained very high. My job as Chief Scientist was an easy one and I wish to record my grateful thanks and appreciation to all members of the OBP Winter Cruise 1983.

R B HEYWOOD

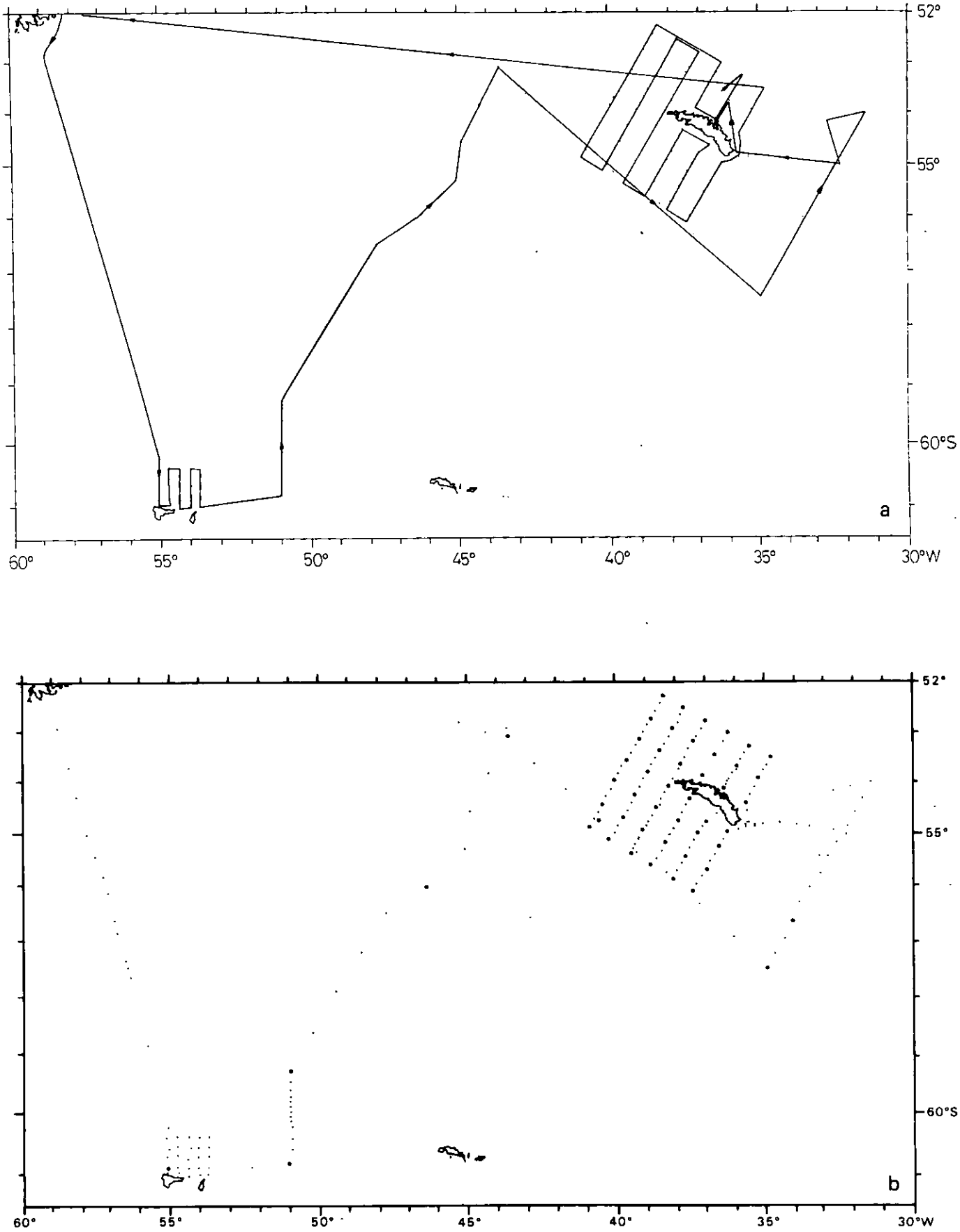

Fig.1. a. Cruise track of RRS John Biscoe, 27 July - 29 September 1984.

b. CTD (•) and XBT (·) positions.

SCIENTIFIC COMPLEMENT

D G BONE	Technician, gear
DR I EVERSON	Senior zooplankton Biologist
P J FITZGERALD	Engineer, electronics (to Rio de Janeiro)
DR R B HEYWOOD	Oceanographer, Chief Scientist
G L M HUGHES	Head of Computer and Electronics Section, BAS
DR D J MORRIS	Physiologist
A W NORTH	Fish Biologist
M N PILCHER	Technician, zooplankton
DR J PRIDDLE	Phytoplanktologist
J M ROSCOE	Technician, electronics
R LIDSTONE-SCOTT	Technician, bird studies (South Georgia Zone Survey only)
P J WARD	Zooplankton Biologist
J R WARREN	Technician, electronics
DR J L WATKINS	Krill Biologist
M G WHITE	Senior Fish Biologist
M J WHITEHOUSE	Technician, chemistry
V R WOODLEY	Technician, chemistry

CRUISE REPORT

Itinerary

21 June - 10 July	Passage to Rio de Janeiro
11 July - 13 July	Rio de Janeiro, rest and relaxation for crew
14 July - 24 July	Passage to South Georgia, preparation of OBP equipment
25 July - 26 July	Preparation of OBP equipment
27 July - 21 Aug	South Georgia Zone Survey
21 Aug - 25 Aug	Passage to Port Stanley, Falkland Islands
26 Aug - 29 Aug	Port Stanley, rest and relaxation for crew, refuel
30 Aug - 1 Sept	Passage to Elephant Island
2 Sept - 5 Sept	Elephant Island Grid and a meridional section across the Weddell-Scotia Confluence
6 Sept - 11 Sept	Scotia Sea transects
12 Sept - 15 Sept	Ichthyoplankton study off Cooper Island
16 Sept - 18 Sept	Ichthyoplankton study along transect off Cumberland Bay
19 Sept - 29 Sept	Cumberland Bay East study
30 Sept - 2 Oct	OBP gear cleaned and stowed
3 Oct - 10 Oct	Passage to Montevideo

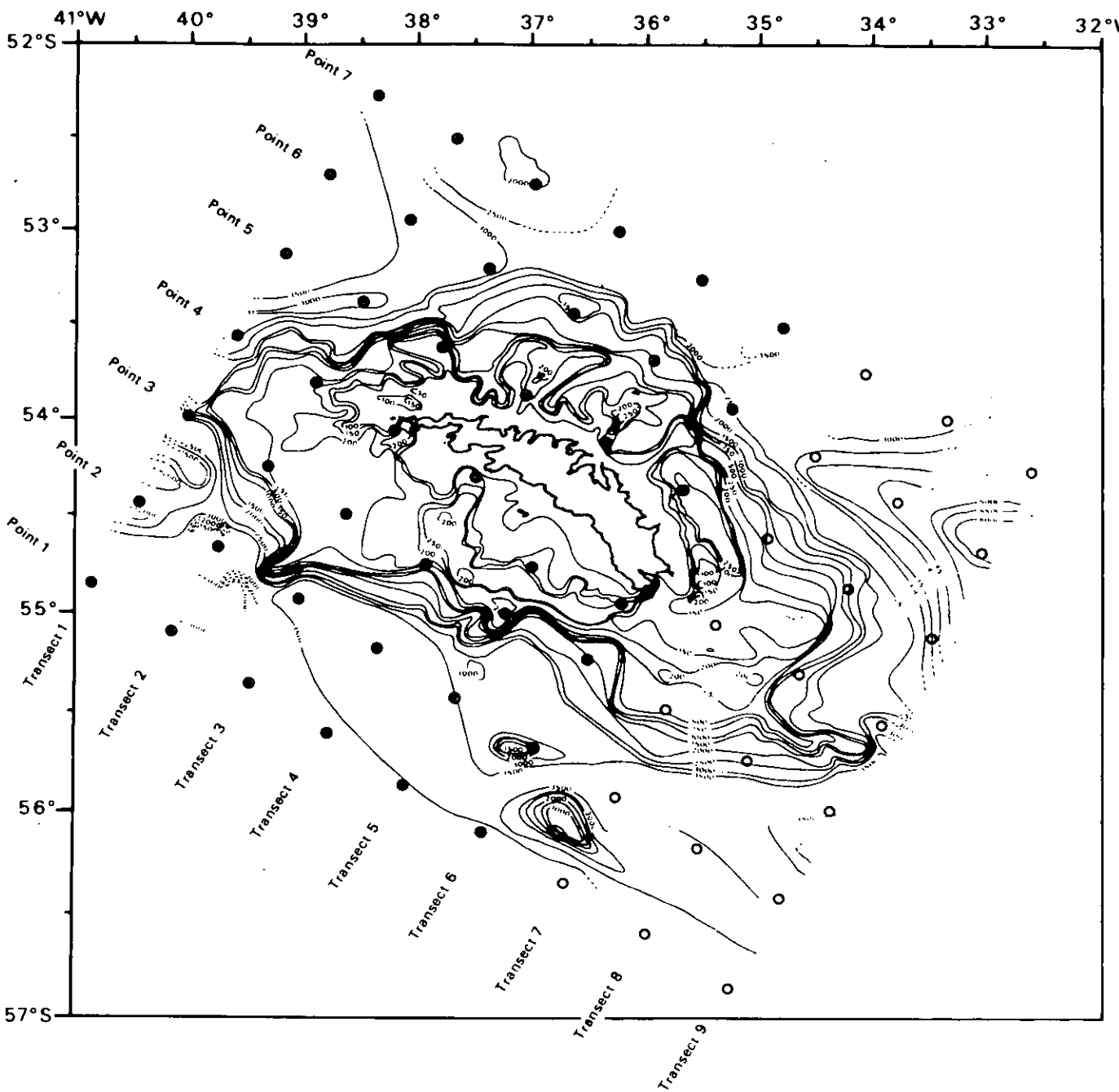

Fig. 2. South Georgia Zone Survey standard stations, worked (●) and not worked (○) during the Winter Cruise

NARRATIVE

21 June. RRS John Biscoe sailed from Southampton with Fitzgerald, Heywood, Hughes and Warren on board. Several pieces of new and modified OBP equipment had not been available for UK-based sea trials. Fitzgerald and Hughes were seconded from the Common Services (Computing and Electronics) Section to commission this equipment with Heywood and Warren, and to write or correct any computer programmes required, during the passage to Rio de Janeiro.

22 June - 10 July. Vessel on passage to Rio de Janeiro. Unexpected problems with both a new and an upgraded (electronics) Grundy Environmental Systems conductivity-temperature-depth (CTD) profiler monopolized, and increased considerably, the workload of the OBP team. Only one profiler could be made to work to acceptable limits after 12 days of painstaking examination, experimentation and adjustment. Arrangements were made for Fitzgerald to fly from Rio de Janeiro to San Diego, California, to discuss the CTD problems with the manufacturers.

New SIPPICAN MK9 expendable bathythermograph equipment and NEIL BROWN acoustic current meters were commissioned successfully but scheduled work on the new SIMRAD hydro-acoustic equipment, Navigation-event logger and Horizontal-oceanographic-data logger was not completed. The necessary software development was prevented by lack of time and by the cutting out of overheated microcomputers and floppy-disk drivers in the non-air-conditioned laboratories during passage through the tropics. Consequently the period of Hughes' secondment was extended until the vessel reached South Georgia.

11 - 13 July. Vessel alongside at Rio de Janeiro. The remainder of the OBP team flew in and joined the vessel on 12 July.

14 - 24 July. Vessel on passage to South Georgia. OBP equipment was removed from the hold and installed in the laboratories. Cases of consumables, spares, etc. were laid out in the 'tweendecks hold for ready access, even in bad weather. The weather started to deteriorate shortly after sailing. On 15 July, a crewman fell into the Bowthrust compartment and the vessel was hove-to for several hours while he was

extricated, examined and x-rayed for broken bones. After direct consultation with a BAS doctor in Cambridge over the satellite telephone, the vessel continued on passage to South Georgia. The weather worsened, and the vessel lay hove-to for most of the period 17 July - 19 July and steamed at 6 knots throughout 20 July.

Hughes completed the software for the Navigation-event logger which was commissioned on 19 July. A second successful trial of the CTD was carried out on 22 July. However, the OBP preparations were seriously curtailed by the bad weather. Deck apparatus (nets, etc.) could not be removed from the hold and assembled, and sea trials could not be held. A planned transect of physical oceanographic stations east of South Georgia had to be cancelled because of the time lost when the vessel was hove-to. The Guildline Autosal laboratory salinometer broke down on 23 July. It was to remain unserviceable throughout the Cruise although Roscoe would spend many hours working on it.
The new SIMRAD microprocessing equipment was brought into service also on 23 July and the hull-mounted 120-kHz transducer was found to be suspect.

25 - 26 July. Vessel alongside at Grytviken in calm and sunny weather. A friendly and hospitable reception was extended by the military garrison and the officers and crew of HMS Brilliant. Nets were assembled and the final preparations for the South Georgia Zone Survey (SGZS) were completed. Hughes worked on software problems until he disembarked a few minutes before the vessel sailed at 1500 GMT 26 July for net trials in Cumberland Bay East and Cumberland Bay West. The tests were successful and the RMT samples provided samples of fish larvae, mysids and copepods for an on-going subsidiary project of inshore research. A series of temperature-depth profiles were also obtained for this project by expandable bathythermographs (XBT).

27 - 28 July. The weather deteriorated as the vessel headed out towards the first station of the South Georgia Zone Survey. Eventually the vessel was forced to heave-to in gale-force winds and heavy swell. The station (Grid Point (GP) 0507, Fig. 2) was worked during a temporary lull when the wind fell to 40 knots. Both sets of equipment used (RMT, CTD) failed to work properly under the marginal

conditions, and laboratory equipment was also affected adversely by the violent movements of the ship. Further station work was impossible and the vessel steamed for the shelter of Cumberland Bay East, passing down the line of the SGZS transect 5 (Fig. 2) to permit an acoustic survey of the major zooplankton and a recording of surface (3-m depth) water temperature, salinity and chlorophyll fluorescence. Temperature-depths profiles were recorded at 10-nautical-mile intervals by XBT.

29 - 30 July. The OBP team were fully occupied in repairing equipment damaged in the storm while the vessel sheltered in Cumberland Bay East. Faults were found in the towed RMT net transducer, in the connecter between transducer and sea cable, in the sea cable and in the slip-rings of the transducer winch! Hughes spent the day of 29 July on board correcting faults which had been discovered in CTD and Horizontal-physical-oceanography-data logger software. The vessel spent the evening of 29 July in Rosita Harbour. On 30 July the repaired RMT equipment was tested in the relatively sheltered waters of this bay whilst outside the winds gusted up to 80 knots.

31 July - 21 August. The South Georgia Zone Survey was restarted with the working of GP 0405 station at 1300 GMT on 31 July, and was continued until 0113 GMT on 19 August when the work had to cease because of an emergency medical case. The crewman, previously injured in a fall into the Bowthrust compartment, suddenly collapsed with severe internal pains and it became essential to obtain the services of the Grytviken garrison Medical Officer. The station at GP 0505 was worked while the vessel waited for first light before entering Cumberland Bay; the garrison was at war-alert readiness and radio communication was limited by the mountains surrounding Grytviken. The crewman's condition had improved by the time of the medical examination which was inconclusive. The Medical Officer recommended that the man should stay on board under surveillance and the SGZS continue, but the vessel should steam for Port Stanley and its hospital facilities if his condition deteriorated again. Stations at GPs 0506, 0507 (repeat) and 0607 were worked successfully before the crewman collapsed again and the vessel had to steam for Port Stanley.

Working conditions were marginal throughout most of SGZS. Winds were above gale force for the greater part of each of 11 days, and above 20 knots for the greater part of nine more days. Four working days were lost when wind and a cross-swell forced the vessel to heave-to. The minimum air temperature recorded was -5.4°C but temperatures were below 0°C on only six days, and no serious icing-up of the vessel occurred. The vertically-deployed equipment was particularly prone to damage when being lowered to or raised from the sea surface under these weather conditions. The glass liner of the CTD conductivity cell had to be replaced on one occasion. Four Niskin waterbottles, two thermometer carriers, nine reversing thermometers, and the photomultiplier tube of the profiling nephelometer were broken beyond repair.

However, 42 of the 63 SGZS stations had been worked successfully before the vessel had to leave for Port Stanley. At each station, oblique, multiple RMT 1 + 8 (RMT 1 + 8M) hauls had been made from 250 m to 10 m, 500 m to 250 m (and 1000 m to 500 m at each end-of-transect station). The CTD had been deployed with a profiling nephelometer and self-recording profiling acoustic current meter. Water samples for chemical and phytoplankton analyses had been obtained by rosette-fired water bottles. Net phytoplankton samples had been obtained for each station also. Surface (3 m) water temperature, salinity and chlorophyll-fluorescence had been measured continuously, and acoustic surveys made of the major zooplankton, along 1620 nautical miles of inter-station transect. Eighty-three XBT profiles had been obtained at 10-nautical-mile intervals between the stations. Ornithological observations had been made while the ship was underway in daylight hours (Fig. 3).

22 - 25 August. Vessel on passage to Port Stanley. Hove-to throughout 22 August. The plans for the remainder of the Cruise were revised because, although the survey had been curtailed, it was clear that the densities in which krill were to be found around South Georgia were insufficient to support the proposed physiological and behavioural research. The search for higher densities of krill would continue in the vicinity of Elephant Island and elsewhere in the Scotia Sea. Several versions of the original physiological and behavioural research proposals were drawn up for selection according to the time

CRUISE 4 SOUTH GEORGIA ZONE SURVEY

GRID POINT	ACTIVITY	EVENT NO	TIME TABLE SCHEDULED Start	Finish	h:mm	gmt ACTUAL Start	Finish	h:mm
			7.August.1983					
26								
54 55.9'S	RMT		0615	0815	2:00	0855	1040	
39 03.4'W	reposition ship		0815	0830	0:15	1040	1420	
	STD		0830	1130	3:00			
	Vert.Phyto.net				-			
	reposition ship		1130	1145	0:15			
	ECHOsurvey/ Horizon.Oceanog.		1145	1445	3:00	1443	1758	Steaming at 10kts
	Bird obs		1215	1225	-			
	XBT		1245		-			
	Bird obs		1315	1325	-			
	XBT		1345		-			
	Bird obs		1415	1425	-			
G0501 27								
55 21.8'S	RMT (deep)		1445	1745	3:00	1830	2130	RMT
39 29.5'W	reposition ship		1745	1800	0:15			
	STD		1800	2100	3:00	2132	0056	STD U73 XBT
	Vert.Phyto.net				-	2232	2242	PHYTO 676
	steaming between transects		2100	0300	6:00	0055	0400	Steaming at 5kts
			8.August.1983					
28								
55 36'8S	Meuston nets		0300	0330	0:30			
38 47.6'W	RMT (deep)		0330	0630	3:00	0436	0740	
G0401	reposition ship		0630	0645	0:15			
	STD		0645	0945	3:00	0810	1130	
	Vert.Phyto.net				-			
	reposition ship		0945	1000	0:15			
	ECHOsurvey/ Horizon.Oceanogr.		1000	1300	3:00	1198	1459	Steaming at 10kts
	Bird obs		1030	1040	-			
	XBT		1100		-			
	Bird obs		1130	1140	-			
	XBT		1200		-			
	Bird obs		1230	1240	-			
G0402 29								
55 10.9'S	RMT		1300	1500	2:00	1535	1730	
38 21.3'W	reposition ship		1500	1515	0:15			
	STD		1515	1815	3:00	1811	2104	
	Vert.Phyto.net				-			
	reposition ship		1815	1830	0:15			
	ECHOsurvey/ Horizon.Oceanogr.		1830	0030	6:00	2139	0040	Steaming at 5kts
	Bird obs		1930	1940	-			
	XBT		2030		-			
	XBT		2230		-			
			9.August.1983					

Fig. 3. Part of the actual detailed schedule used to control the intensive, multidisciplinary South Georgia Zone Survey. The vessel's speed was reduced to 5 knots during hours of darkness to reduce the risk of collision with pack ice and small berg fragments.

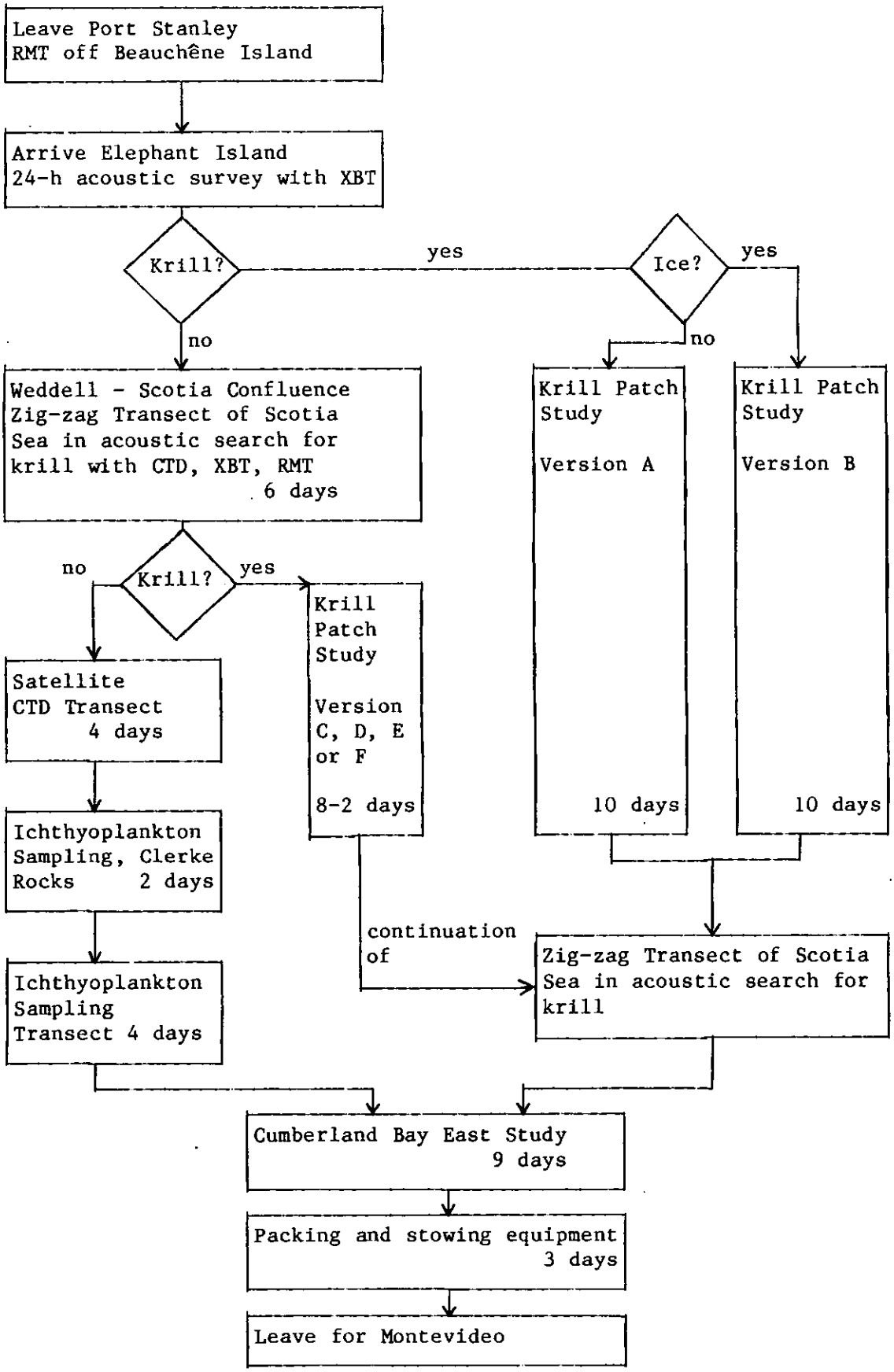

Fig. 4a. Schedule and contingency plans for Phase 2 of the Winter Cruise, OBP Cruise 4.

Krill Patch Study

Components: Mapping of patch by hydroacoustic survey between 9 CTD stations in a grid pattern.
Microstructure of patch examined by using the large Longhurst-Hardy Plankton Recorder and foredeck pump sampler from 0100 to 0500 GMT and from 1300 to 1700 GMT, with CTD, XBT (and video and still cameras if calm and krill above 150 m).
Feeding of krill by examining samples from RMT 1+8M hauls taken every 4 h from 100-250 m, 250-350 m and 350-500 m strata.
Association with ice examined by diving under large floes to observe and collect krill and ice algae.

Versions:

		A	B	C	D	E	F
Day number for	Mapping	1,3,5,7	1,3,5,7	1,3,5	1	1	-
	Microstructure	2,4,6	2,4,6	2,4	2,3,4	2,3,4	1,2
	Feeding	8,9,10	8,9	6,7,8	5,6	-	-
	Ice association	-	10	-	-	-	-

Fig. 4b. Detailed plans for Krill Patch Study.

remaining available after krill had been found in sufficient densities (Fig. 4).

26 - 30 August. RRS John Biscoe lay at anchor off Port Stanley and crew and scientists enjoyed periods of relaxation ashore. Watkins used the time to calibrate the underwater stereo camera unit and to determine exposure settings. Heywood and Roscoe worked throughout the night of 29 August to analyse 250 water samples using the precision laboratory salinometer on board HMS Herald, by kind permission of Captain R Browne. The samples had been collected during the South Georgia Zone Survey to calibrate the CTD sensor but had not been analysed because the OBP laboratory salinometer was unserviceable. R Lidstone-Scott disembarked to wait ashore for a passage to Bird Island, courtesy of the Royal Navy. RRS John Biscoe sailed for Elephant Island after refueling during the morning of 30 August.

31 August. Vessel was diverted to Beauchene Island where a Russian fishing fleet had been reported active. Many hydro-acoustic traces were recorded in the area but very little material was obtained in a multiple series of RMT hauls. Presumably the Russians were catching 'fin'-fish, which swim too fast for the RMT.

1 September. XBT profiles and a conveniently timed satellite navigation fix determined the position of Polar Front to within 1.5 nautical mile centered on 57° 12.6' S, 54° 39.3' W. The sea surface temperature fell from 2.6°C to -0.2°C.

2 - 3 September. The pack-ice had retreated south of Elephant Island and the OBP team was able to echosurvey and XBT profile a 160 square nautical mile grid extending to within 6 nautical miles of the north coast of the island. Few acoustic traces were recorded and trawls within the grid produced only a small number of krill. The team also worked a station at 60° 52' S, 55° 08' W, a position used for a standard time station by West German expeditions, and by the Anglo-German Joint Biological Expedition during 1 - 4 February 1982. Winter profiles were obtain by CTD and current meter but the RMT caught few krill. Afterwards the vessel steamed east towards the Weddell-Scotia Confluence.

4 - 5 September. The absence of pack-ice allowed the OBP team to work the same meridional transect of the Weddell-Scotia Confluence as the Anglo-German Joint Biological Expedition in 5 - 6 February 1982. This consisted of four stations spaced at 30-nautical-mile intervals across the Scotia Arc from 60° 45' S to 59° 15' S in longitude 51° 00' W. XBT profiles were taken at 5-nautical-mile intervals between the stations to supplement the CTD data. Again, in contrast to the 1982 summer, RMT catches were small and contained no krill.

6 - 13 September. An acoustic search was carried out along zig-zag transects across the Scotia Sea (Fig. 1). Aimed multiple RMT 1 + 8 hauls were made whenever promising acoustic-traces were recorded but the catches were small and consisted of mainly salps with moderate numbers of Euphausia tricantha but few krill, Euphausia superba. XBT profiles were obtained at regular intervals along the transects and CTD profiles wherever the RMT was deployed until the equipment was damaged. The weather had steadily worsened and on 11 September the temperature sensor was broken while the CTD was being deployed under gale force conditions. The CTD was to remain unserviceable for the remainder of the cruise in spite of long hours of strenuous effort by Roscoe and Warren. The vessel was hove-to throughout 12 and 13 September.

14 - 15 September. The weather rapidly improved and the ichthyoplankton of the fish spawning grounds between Clerke Rocks and Cooper Island were sampled in relatively calm weather. Two stations were worked alternately throughout a 48-h period, using the multiple RMT 1 + 8. Near-surface samples were obtained by deployment of a frame-net from the foredeck at noon each day and on two separate occasions during each night. The hauls produced fish eggs at an advanced stage of development, fish larvae with yolk sacs, and a clear indication of marked diurnal vertical migration. A moderate number of krill were caught lying just above the sea bed, a stratum not suitable for fishing with a mid-water trawl. One attempted 'skim' of the sea bed produced 20 large fish specimens, a considerable number of octopus - and a large quantity of mud! XBTs and waterbottle casts were used to monitor the physico-chemical environment, and the phytoplankton was sampled by vertical net.

16 - 18 September. The second fish project was designed to study in greater detail the variation in abundance and composition of ichthyoplankton and -nekton observed on transition from the continental slope and shelf stations of the South Georgia Zone Survey. The OBP team worked a transect of three stations running up the continental slope between, and including GPs 0505 and 0506. Each station was sampled by RMT 1 + 8 throughout a 24-h cycle to eliminate change through diurnal migration. The physico-chemical environment and the phytoplankton were monitored as previously and additional XBT profiles were obtained at 5-nautical-mile intervals between stations. The video camera and stereo still-camera units were used on 16 September after krill and mysids had been caught in a RMT haul.

Weather conditions remained reasonable with winds only infrequently above 20 knots during the period of the fish projects but the vessel had to steam through dense fog to start the final project of the Cruise - the Cumberland Bay East study.

19 - 29 September. The fog persisted for most of 19 September and the scheduled intensive zig-zag acoustic-survey with XBT profiles was deferred because of the risk of running aground on the shoals lining many areas of the Bay. Waterbottle casts were made for water chemistry and phytoplankton analyses, and XBT and current meter profiles were measured at three stations along the centre line of the Bay. The zooplankton was then sampled for six consecutive days by oblique, multiple RMT 1 + 8 hauls along the central transect. The surface water was sampled by the 1-m frame net deployed from the foredeck. Nets were deployed at approximately 6-h intervals to give adequate cover of both day and night periods, and still leave sufficient interval time for the preliminary analysis of each catch. The routine was interrupted on two occasions and three sets of samples were lost. On the evening of 22 September RRS John Biscoe had to stand by HMS Herald which had suffered a major power failure while surveying in Cumberland Bay West, and later escort her into the relative safety of the open sea after she had regained power. On 24 September RRS John Biscoe was hove-to for over 12 h while the wind gusted to speeds over 60 knots. The video and stereo camera units were deployed on several occasions between RMT hauls.

Heywood and Roscoe were able to spend the greater part of 20 - 22 September on board HMS Herald, again analysing salinity samples taken for the calibration of the CTD. They were able to repay the kindness and hospitality of Captain Browne by analysing samples taken by the Royal Navy survey ship for a similar purpose.

On completion of the 6-day RMT series the OBP team attempted, but failed, to study the microstructure of the zooplankton populations within the Bay, by a 24-h series of hauls taken first with the large, and second with the small versions of Longhurst-Hardy Continuous Plankton Recorder (LHPR). The Large-LHPR series was curtailed by the vessel being forced to heave-to throughout the night of 26/27 September and most of the following day. The Small-LHPR series was terminated when it was discovered that teeth were being stripped off the drive belt of the gauze feed mechanism.

The deferred acoustic survey and XBT profiling of the Bay were carried out under calm and sunny conditions on 29 September and the vessel tied-up alongside the King Edward Point jetty at 1530 GMT.

30 September - 2 October. The video and stereo-camera units were used to film animals at night, attracted to the vessel by a light hung over the stern. Most of the OBP equipment was dismantled and stowed in the 'tweendecks hold. On 1 October all acids, alkalis, alcohols, oxidants and other dangerous chemicals were removed from the BAS store on King Edward Point and taken on board at the request of the military commander who was concerned that they might be accidentally misused by his men. North disembarked on 2 October to take passage to Bird Island on a Royal Navy vessel and RRS John Biscoe sailed at 2000 GMT.

3 - 4 October. Vessel steamed against gale force winds to reach SGZS grid point 0507 and had to heave-to there for 6 hours before the last waterbottle casts and current profile of the Cruise were taken. Both the hydrographic wire and CTD cable were run off their drums down to the last layer before being thoroughly oiled for storage as they were rewound. The vessel then set course for Montevideo. On 4 October the chemicals removed from the King Edward Point store were poured overboard and their containers jettisoned in 4000-m-deep water. (The majority of the compounds were neutralized on contact with sea water

and the remainder were diluted almost immediately to non-toxic concentrations). Afterwards a very deep RMT provided material for OBP biochemical projects and the opportunity to oil the wire for stowage. The vessel then continued towards Montevideo in deteriorating weather conditions.

5 - 10 October. Weather remained bad until 7 October. Remainder of OBP gear was packed and stowed in the hold or in the waterbottle annex. Certain equipment in urgent need of repair, log books and computer printout were packed for air freightage to UK (RRS John Biscoe did not return to UK before 11 March 1984). All laboratories were cleaned out and washed down. Vessel tied alongside in Montevideo at 1230 GMT 10 October.

13 - 14 October. OBP team flew to UK or Chile (White only).

The cruise statistics are presented in Table 1.

Table 1. Cruise statistics

Time from Rio de Janeiro to Montevideo	88 days
Time vessel engaged in research	54 days

Stations worked

Events	total
CTD - current meter profiles with waterbottle casts	52
Current meter profiles with waterbottle casts	3
Current meter profiles only	8
XBT profiles	230
Vertical phytoplankton net hauls: 10 µm mesh from 50 m	50
35 µm mesh from 100 m	27
Vertical zooplankton net hauls	7
Multiple RMT 1 + 8 net series	120
Surface frame net hauls	46
Neuston net hauls	16
Large LHPR hauls	6
Small LHPR hauls	6
Pump net trials	1
Video and still camera trials	8
Acoustic survey mileage	3275
Horizontal surface (3 m) environment profile	2000
Bird observations - 10-minute periods	474

PRELIMINARY SCIENTIFIC FINDINGS

Oceanography

The physico-chemical conditions are summarized in Fig. 5. The surface isotherms present a good general picture of the Surface Water layer, which was homogeneous to depths of 100 - 150 m throughout the region. Two water mass regimes occupied the research area. The Polar Front Zone was less than 20 nautical miles wide in the eastern Drake Passage, and its northern limit, the Polar Front, was sharply defined by the 2.0° C isotherm, which extended almost vertically to below 760 m (the depth limit of the XBT). Mixing over the ridge of the Scotia Arc broadened the Polar Front Zone as the water flowed eastwards. The Polar Front was not clear here and the position given in Fig. 5 was where the surface 2.0° C isotherm was first detected on passage from South Georgia to the Falkland Islands. Temperatures, salinities and silicates recorded for the Surface Water layer in the Polar Front Zone ranged from 1.70 to 0.00° C, from 34.10 to 34.05‰ and from 21 to 32 μmol dm^{-3} respectively. A tongue of ~2° C water intruded under the Surface Water layer to occupy the depths between 300 and 1100 m as far south as the 0.0° C surface isotherm, which sharply delineated the position of the Antarctic Convergence. Here the heavier Surface Water layer (σt 27.50 to 27.46) of the Antarctic Circumpolar Current sank below the Surface Water layer (σt 27.31 to 27.28) of the Polar Front Zone. Temperatures recorded for the Surface Water layer near the Weddell-Scotia Confluence, and near the ice-edge, were as low as -1.06° C. However, salinities of 34.14 to 34.16‰ and silicate concentrations of 47 to 65 μmol dm^{-3} indicated that mixing with Weddell Sea water was localized and not extensive in the research area. The positions of the ice edge were obtained from American Navy-NOAA satellite photographs.

R B HEYWOOD

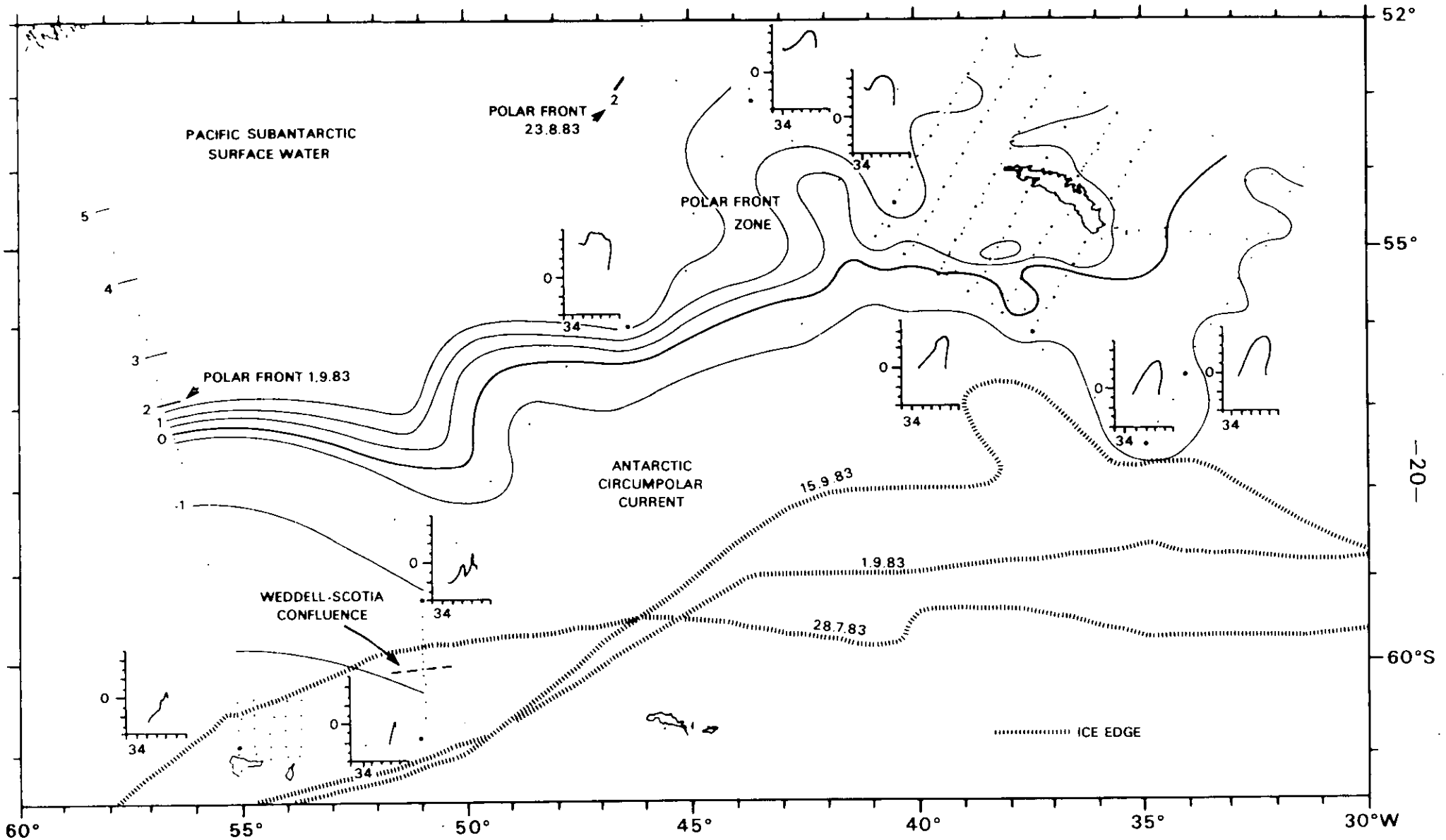

Fig. 5. The physical environment of the research area during the Winter Cruise.

Phytoplankton and microplankton

Phytoplankton biomass was estimated by the quantity of particulate chlorophyll a determined by fluorometry of acetone extracts of filtered material from water-bottles and from the pumped surface seawater both at CTD stations and whilst the ship was under way. Forty-three vertical profiles were taken on the South Georgia Zone Survey (SGZS) (grid point 0507 covered twice) and a further thirteen were obtained during the remainder of the cruise, mostly on the transect Elephant Island - Shag Rocks - South Georgia. Forty-five additional surface water samples supplemented the detailed information from the CTD stations.

Chlorophyll concentrations were low, rarely exceeding 500 ng dm^{-3} near the surface at oceanic stations. Vertical profiles indicated mixing to a depth of at least 100 m. Amounts of chlorophyll a integrated over the whole water-column for stations of the SGZS varied from 15.8 to 41.1 mg m^{-2} and corresponding figures for phaeopigments were 7.1 to 32.3 mg m^{-2}. The proportion of total pigment present as phaeopigments exceeded 0.5 at six stations (14%) and was less than 0.3 at nine stations (21%), giving an overall impression of a population with many moribund cells and dead material. Highest values of chlorophyll a concentration during this period were found in the northerly parts of transects 5 and 6 and in a curved band situated south of the island.

A lower algal biomass was encountered in the area around Elephant Island, with a minimum integrated amount of 6.48 mg m^{-2} chlorophyll a at 60°47'S. A rapid increase in biomass occurred along the short transect over the Weddell-Scotia Confluence with 49.41 mg m^{-2} chlorophyll a being recorded at 59°15'S. Standing crop along the remainder of the track to Shag Rocks and South Georgia was similar in magnitude to that found on the SGZS. The vertical homogeneity of chlorophyll profiles meant that surface chlorophyll a concentration was a useful indicator of integrated chlorophyll amount (coefficient of determination of linear regression for all offshore stations = 0.958).

Three inshore stations were worked in Cumberland East Bay and these all showed high algal biomass (59 to 80 mg m^{-2} chlorophyll a). The

character of the vertical profiles at these stations suggested that the population was starting the spring increase, with a pronounced near-surface maximum accounting for the major part of the algal biomass.

Evidence for earlier seasonal change in the offshore stations was obtained from grid point 0507 of the SGZS which was sampled three times during the cruise. The earliest sample (28 July) showed a preponderance of phaeopigment in the water-column, with a maximum at 100 m depth. A month later (20 August) the amount of chlorophyll *a* in the water column had increased, with slight maxima near the surface and at 30 m. The fraction of total pigment represented by phaeopigment had fallen from 0.79 to 0.35. The final samples taken on the 3 October were similar to the August event, but the near-surface chlorophyll maximum was more pronounced.

Detailed taxonomic information on the phytoplankton and microplankton will only be available when glutaraldehyde-fixed water samples are returned to the UK on RRS *John Biscoe*. Samples corresponding to the chlorophyll determinations are available for all CTD stations. An overall impression may however be gained from the shipboard examination of material for vertical net hauls, which were carried out at all but a few CTD stations. The most commonly used net was a 10-µm mesh, 50-cm mouth 5:1 net, hauled from 50 m depth to the surface (49 hauls). A similar net of 35-µm mesh was also hauled from 100 m depth at some stations (29 hauls).

Species composition appeared to be more or less uniform across the whole area, including the transect from Elephant Island. Conspicuous taxa at most stations were *Thalassiothrix antarctica* (Schim.) Karst., *Thalassiosira tumida* (Janisch) Hasle, *Chaetoceros* bulbosum (Ehr.) Heiden, *C. Criophilum* Cast., *C. dichaetum* Ehr., *Corethron criophilum* Cast., *Nitzschia kerguelensis* (O'Meara) Hasle, *Asteromphalus* sp. (?spp.), *Rhizosolenia hebetata* f. *semispina* (Hen.) Gran. In addition to these diatoms, the silicoflagellate *Distephanus speculum* was present in most samples. Dinoflagellates were uncommon and were encountered only rarely at deep-water stations. Of the heterotrophic microplankton, tintinnids and globigerinid Foraminifera were abundant in some samples and Radiolaria were usually present. Choanoflagellates were not seen.

Microscopic examination of the gut and feeding apparatus of Euphausia superba and of the gut of Antarctomysis ohlini and A. maxima showed that it was possible to recognise fragmented and whole diatom frustules and the tests of tintinnids in krill but none was found in the Antarctomysis. Estimates of plant pigments in the gut of krill were carried out on several animals for comparison with visual estimates of gut fullness made by D J Morris. Preliminary trials were undertaken of some methods for fluorometric determination of gut pigment content that did not involve dissection of the gut and it is hoped to develop these into a rapid method for assessment of the amount of algal material in krill.

J PRIDDLE

The Distribution of Krill, Euphausia superba Dana

The quantitative hydro-acoustic equipment on RRS John Biscoe had been augmented by the addition of a SIMRAD EK 400 and QD Digital Integrator. These were installed with the EK 400 operating at 38 kHz and 120 kHz using hull-mounted, downward looking, transducers, and interfaced to the QD Digital Integrator. The original EKS 120 system, operating at 120 kHz, was connected to a towed, upward-looking, transducer and interfaced to a QM MK II Analogue Integrator. With this combination it should have been possible to obtain data from the surface down to 500 m depth. However, early on in the cruise the hull-mounted 120 kHz transducer broke down. Replacement was impossible without dry-docking the ship and therefore a temporary rig was made by repositioning the upward-looking transducer in the towed fish to scan downwards. This arrangement could only be used at slow speed. Later in the cruise the conducting cable to the towed transducer broke down. Consequently the only comprehensive set of acoustic data is from the 38 kHz transducer.

Net hauls using the multiple RMT 1 + 8 combination net were made to provide data on the zooplankton for correlation with the acoustic findings. The standing stock density was low, provisionally estimated to be 2.5 - 3.0 mg m^{-2}, primarily due to the paucity of krill. During

the SGZS only half the nets fished caught krill and only 5% caught krill in any quantity. This was in marked contrast to the previous cruise (1981-82 austral summer) when krill were dominant in 40% of the catches and 73% of the nets fished caught krill.

Very few krill swarms were seen on the echosounder and this, coupled with the low net catches, suggested that there was a general scarcity of krill in the South Georgia area. A similar picture of krill abundance and lack of swarms was obtained on the search as far south as Elephant Island and elsewhere in the Scotia Sea.

I EVERSON

Krill swarm and macroplankton observations

An underwater television camera and a pair of 35-mm still cameras, mounted in a rectangular frame and lowered on the hydrographic wire of the ship, were to be used to provide information on krill swarm structure and density. Unfortunately, observations on krill were not obtained because of the almost complete absence of krill swarms in the cruise area. The camera system was deployed, however, to gain experience in its use and to confirm its suitability for the proposed work.

Stereo calibration and exposure tests were undertaken in Stanley Harbour so that the distance between animals could be calculated from stereo pairs of negatives. At present there is an error of up to 10 mm in the distance of objects between 60 and 150 cm from the cameras; with more refined calibration it should be possible to reduce this error significantly. The cameras were deployed 13 times from the ship either while at sea, at anchor or tied up. The cameras were used five times at a station off Cumberland Bay, where some krill and mysids were caught in the RMT 8 nets. Two very small swarm indications were seen on the echosounder but attempts to launch the cameras through the swarms were not successful. No krill were observed although quite a few salps were seen on the video and recorded on film. At the mouth of Cumberland Bay at a depth of 160 m

many moving flashes of light were seen just above the bottom; the animals were tentatively identified as bioluminescing copepods. A good view of the bottom fauna around Hobart Rock at a depth of 15-30 m was obtained on several occasions. The cameras were finally deployed at night at the surface while tied up at Grytviken. A lamp hung over the stern attracted a variety of amphipods, polychaetes including Tomopteris and a fish Notothenia rossii, which were all recorded on film.

A circular behaviour tank, to simulate a limitless environment, set up on the shelter deck for continuous observation of krill, was not used, except to test the equipment, as the few krill caught were not in good condition when removed from the nets.

J L WATKINS

Small scale distribution of krill and macroplankton

The failure to locate a krill patch meant that it was not feasible to deploy the Longhurst-Hardy plankton recorder and the plankton pump sampler as originally intended. However, opportunity to use the LHPR was taken at the end of the Cumberland Bay study. Oblique tows were made to complement RMT 8 and small LHPR hauls along the same transect. Unfortunately, gear problems and bad weather restricted the LHPR to four successful hauls. The mysids Antarctomysis maxima and Antarctomysis ohlini were the most abundant organisms caught with a maximum density of approximately 1-2 mysids per m^3 and usually found below 150 m in the LHPR samples.

The pump sampler was not used quantitatively but two trials were conducted to observe the condition of the catch; about 50% of the copepods caught were still alive when removed from the collecting bucket.

J L WATKINS

Fish Biology

Fish samples were obtained throughout the cruise and preliminary analyses were carried out on more than 6000 specimens representing different stages of life history of 20 species. Most of the material was of post larval, coastal nototheniids but adult mesopelagic species were also obtained on the deeper routine zooplankton hauls outside the immediate neritic regions. Pelagic fish eggs, 4-5 mm diameter, were commonly sampled. The sampling was in four distinct but integrated phases.

The SGZS provided information on occurrence and distribution of species during winter for the OBP Data Base. About 2000 specimens were obtained from RMT hauls. The increase in routine sampling depth to 500 m (previously 250 m) produced ichthyonekton throughout the diurnal cycle. As recorded during previous SGZS, there was a marked separation between oceanic and neritic components as well as marked vertical movement associated with the diurnal cycle. However, the most important feature of the specimens was the fact that they were in their winter condition. Invaluable data will be obtained for the interpretation of life histories and growth patterns of many species found around South Georgia. Scales and otoliths may confirm the development of a winter growth ring in several species. The gonad index of species such as the common myctophid, Electrona antarctica, and the common, but rarely sampled, bathydraconid, Psilodraco breviceps will refine the knowledge of their spawning cycles and the interpretation of reproductive strategies. Large pelagic fish eggs were found throughout the water column and the morphology of the more advanced prehatching larvae showed that they were mainly Notothenia rossii and Notothenia neglecta. These observations complement the earlier work of land-based BAS fish biologists.

Samples taken over the shelf area between Clerke Rocks and Cooper Island demonstrated in fine detail the transition from oceanic to neritic communities. The area is reputed to be a spawning ground for several coastal species of nototheniid, most of which should hatch during September. SGZS data seemed to indicate marked diurnal movements and so the RMT 1 + 8 M was used to sample two stations at 6-h intervals throughout the 24-h cycle. The diurnal pattern was well

demonstrated and the area was shown to have high levels of neritic post-larvae compared with other regions of the South Georgia Zone. Quantities of eggs at an advanced stage of development were obtained indicating that early September was before the main hatch of Notothenia species in this year. Advanced Champsocephalus gunnari post larvae and early Chaenocephalus aceratus post larvae dominated the samples. Juvenile Patagonotothenia (Notothenia) larseni commonly occurred. Most species appeared to be feeding on copepods or mysids.

The transect across the slope was a preliminary study to an intensive fjord investigation (see Cumberland Bay East study). SGZS samples had indicated a marked change in ichthyonekton composition from the outer to inner shelf. It was not clear, however, if diurnal factors were involved since no time stations were worked during the SGZS. The three stations were chosen to represent outer (oceanic), mid (mixed) and inner (neritic) characteristics, and each was sampled at regular intervals throughout the diurnal cycle. The samples clearly demonstrated marked differences in ichthyonekton composition and abundance over the shelf, the fish gradually increasing in numbers and species diversity towards the coast. Biomass however could be the same or even higher at the oceanic end of the transect because of the presence of adult and sub-adult mesopelagic species such as the myctophids.

Samples of fish liver, gill, spleen and blood were collected as part of a joint programme with McMaster University, Hamilton, Canada, to study the haemopoetic processes in Antarctic fish. A small number of adult and juvenile fish were also deep frozen for calorific and lipid distribution studies.

M G WHITE

Cumberland Bay East study

The main study was preceded by an RMT 1 + 8 M haul in both Cumberland Bay East and Cumberland Bay West on 26 July, before the SGZS, with supporting XBT profiles. Specimens of overwintering larvae and post

larval fish, mysids and copepods were obtained. Many of the female Euchaeta antarctica were either carrying egg sacs, or had eggs present in their oviducts. Reproduction in this predatory copepod does not appear to be confined to the spring and summer, and may extend into and through the winter (see below).

The main study was confined to Cumberland Bay East and was an investigation into the occurrence, abundance and diurnal depth distribution of larval and post larval fish and major zooplankton, in relation to temperature and food abundance. An initial transect of three CTD stations and concomitant phytoplankton net hauls was worked along the main axis of the bay to obtain information on the physico-chemical environment and the abundance and composition of the phytoplankton. Bathymetric, XBT and acoustic surveys of the Bay were not carried out until the end of the study period because of fog limiting navigation during this initial period. During a 6-day period a series of 24 RMT 1 + 8 M net hauls were made along the centre transect. Two hauls were made in the daylight and two hauls were made in the darkness of each 24-h period. Each net was opened for 30 minutes, and the following strata fished:- near bottom (200-250 m) to 150 m, 150 - 70 m, 70 - 5 m. During each RMT haul, a 1-m^2 frame net was deployed from the foredeck and fished just below the surface for 30 minutes.

Fish material from the RMT 8 hauls was identified to species, measured and preserved for gut analyses in Cambridge. Zooplankton samples were identified to major species, the volume and wet weight measured and then preserved for size frequency analysis. The RMT 1 samples were preserved whole for analysis in Cambridge.

Vertical nets were deployed during daylight hours to catch copepod material for CHN analyses and calorific evaluation. These data will be used to assess the energetics of fish diet in relation to the available prey.

Samples of Euchaeta antarctica were measured, dried and then frozen in dessicator jars for CHN analysis in Cambridge in an ongoing study of the species begun in the 1981/82 summer. Similarly specimens of the mysid Antarctomysis ohlini obtained during the pre-SGZS sampling

period extended the available information on population structure to six months (October, December, January, February, March, July) and some general conclusions can now be drawn about the biology of these species at South Georgia.

P WARD (and A W NORTH)

Krill physiology and feeding studies

The limited supply of krill restricted experiments to ad hoc observations. In total 698 krill were assessed for fullness of alimentary tract, 34 krill were analysed for plant pigment levels in the gut and 86 krill were moult staged. Although limited, the data clearly indicated that krill could and did feed during the winter period, but at a reduced rate. In August, between 10 and 20% of the krill were feeding on phytoplankton and about 4% were moulting. In mid-September some 50% were feeding on phytoplankton and about 10% were moulting. This appeared to be a transitional step towards summer rates; in December-January 1981-82 approximately 90% of the krill were feeding on phytoplankton and 10% were moulting. This suggests that krill have a flexible overwintering strategy and can make use of food if it is available. Winter around South Georgia may not be as hard for krill as winter in higher latitudes or under ice.

As part of the feeding study the size distribution of particles obtained from water bottle samples was analysed on a Coulter Counter TA II. Particles were counted in triplicate using 15 size ranges between 2.8 and 72.4 μm. Twelve depth strata at each of 29 stations of the SGZS were investigated. Chlorophyll profiles were also determined for all these stations and nephelometer profiles were obtained at 10 of them, the nephelometer being calibrated against the particle size data.

A starvation experiment to determine the utilization of energy reserves was carried out on the carnivorous, pelagic amphipod, Parathemisto gaudichaudii. Fifty animals were starved for periods of either 9 or 13 days and then frozen at -60°C for biochemical analysis in Cambridge. Mortality after 9 days was 32% and 64% after 13 days.

Additional material collected for general biochemical analysis included euphausiids (approximately 450 specimens), midwater Crustacea (approximately 150 specimens), gelatinous zooplankton (approximately 450 specimens) and miscellaneous Crustacea and Mollusca.

D J MORRIS