UNITED STATES AMLR ANTARCTIC MARINE LIVING RESOURCES PROGRAM

CRUISE REPORT
AMLR 8901

Objectives, Accomplishments and Tentative Conclusions

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April 1989

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U.S. Antarctic Marine Living Resources (AMLR)
1988-89 Field Season Cruise Report
Cruise AMLR 8901
(National Ocean Service Cruise SU-88-02)

Vessel: NOAA Ship SURVEYOR

Operating Area: (see Figure 1)
Antarctic Peninsula including:
South Shetland Islands
Bransfield and Gerlache Straits
Scotia Sea
South Georgia

Description: Observations (both remote and direct) of krill, the early life stages of fish, marine birds and mammals were made in the Scotia Sea region of Antarctica and South Georgia. Post-cruise analyses of these observations will help form the basis for advice given to the United States delegation to the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR).

Itinerary:
Depart Seattle 4 December 1988
Return Seattle 10 April 1989
113 days at sea; 15 days in port

				Days At Sea	Days In Port
Seattle to Valparaiso, Chile	04 Dec	-	24 Dec	21	
Port call in Valparaiso	25 Dec	-	26 Dec		2
Valparaiso to Punta Arenas	27 Dec	-	01 Jan	6	
Port call in Punta Arenas	02 Jan	-	03 Jan		2
Leg I	04 Jan	-	02 Feb	30	
Port call in Punta Arenas	03 Feb	-	06 Feb		4
Leg II	07 Feb	-	04 Mar	26	
Port call in Punta Arenas	05 Mar	-	07 Mar		3
Punta Arenas to Valparaiso	08 Mar	-	12 Mar	5	
Port call in Valparaiso	13 Mar	-	15 Mar		3
Valparaiso to San Diego	16 Mar	-	02 Apr	19	
Port call in San Diego	03 Apr				1
San Diego to Seattle	04 Apr	-	10 Apr	6	
				113	15

Cruise AMLR 8901 (NOS Cruise SU-88-02, Leg I)

DESCRIPTION

Leg I

The scientific party, with the exception of of a bird observer who was aboard the SURVEYOR on the southbound transit from Seattle, joined the ship during her first inport in Punta Arenas, Chile. The SURVEYOR departed Punta Arenas on 4 January 1989, crossed Drake Passage and made Seal Island (northeast of Elephant Island) on 7 January. Three of the Seal Island party, and all of their provisions, were put ashore and the ship departed for Bransfield and Gerlache Straits. Ice seal studies and gear testing were conducted for the next 7 days, interrupted by a 4-hour call at Palmer Station (U.S. National Science Foundation). On 14 January the SURVEYOR returned to Seal Island, the remainder of the party was put ashore, and the ship departed for South Georgia. From 17 January through 28 January plankton tows, bottom trawls and CTD casts were conducted on the shelf waters surrounding South Georgia; a 2-hour call was made at Bird Island (British Antarctic Survey) and an 8-hour call was made at Grytviken, an abandoned Norweigian whaling station and the site of a British Army garrison. The SURVEYOR returned to Punta Arenas on 2 February. Sea surface temperature and salinity were recorded continuously throughout the cruise; air and surface water CO_2 content were also monitored continuously; Seabeam data were collected whenever adequate horizontal control was available and a reasonable trackline could be established.

Leg II

The scientific party, with the exception of one person who remained aboard from Leg I, joined the ship during the 3-6 February 1989 port call at Punta Arenas, Chile. The SURVEYOR departed Punta Arenas on 7 February but returned to port that night to await the arrival of Captain Robert Smart. Captain Smart relieved the Commanding Officer, Captain William Stubblefield, who returned to the States due to a family illness. On 9 February the SURVEYOR departed Punta Arenas but spent 10 February at anchor at Port Williams, Chile awaiting the clearance of a gale force low pressure system from Drake Passage. On 11 February the SURVEYOR began the transit across Drake Passage. The Seabeam system was operated along the Shackleton Fracture Zone and the ship arrived at Seal Island on 14 February. Scientific operations and health, safety, and sanitation conditions on Seal Island were inspected. After departing Seal Island, the MOCNESS deployment procedure was tested. Because of the difficulty of deployment and retrieval from the stern, the MOCNESS was not used; direct krill sampling was conducted using the Bongo plankton net. Between 15 February and 20 February Seabeam, acoustic surveys, and marine bird and mammal observations were conducted around Elephant Island. Bongo net tows were completed at predetermined stations. At 2200 hrs, 20 February, operations were terminated and the SURVEYOR steamed to Chile's Teniente Marsh Base where oil containment gear was brought aboard for transport to Palmer Station; the gear was to be used in the salvage of BAHIA PARAISO, the Argentine vessel that grounded near Palmer Station. The SURVEYOR departed Palmer Station on 22 February and completed three krill sampling stations in Gerlache Strait. The vessel then transited to Elephant Island where the acoustic survey was continued on 23 February. On 1 March, personnel, gear and equipment were removed from Seal Island for transport back to Punta Arenas. The SURVEYOR arrived in Punta Arenas, Chile on March 4.

OBJECTIVES, ACCOMPLISHMENTS, AND DISPOSITION OF SAMPLES

1. Resupply Seal Island camp, Leg I.

1.1 Objectives:

The abundance, demography, reproductive success and growth of chinstrap penguin and fur seal colonies on Seal Island have been monitored for the last three seasons. This effort is part of the United States commitment to the Convention for the Conservation of Antarctic Living Marine Resources and undertaken by NOAA's Antarctic Marine Living Resources program.

The objective was to offload personnel and provisions for the 1988/89 field season. Trash and spoiled drums of fuel were also to be retrograded via ship; this material was left over from the previous season when weather forced a hasty recovery of the field party.

1.2 Accomplishments:

The ship anchored approximately 0.6 miles from Seal Island and a reconnaissance party went ashore to check landing conditions and the status of the camp site. Male fur seals were cleared from the beach landing area and equipment left on the site was found to be secure and in good condition; an observation blind located on the far side of the island had suffered only minor damage from winter rock slides and would provide adequate sleeping accommodations until the camp could be erected.

Ship's divers were brought ashore to steady boats landing through a 2-3' surge on the beach; the entire scientific party was also brought ashore to assist as porters. Cargo was transferred using a 19' Zodiac Mark V, a 12' Zodiac Mark II, and the ship's motor whale boat; cargo from the whale boat was lightered ashore by Zodiac. Approximately 17,000 pounds of cargo was transferred ashore over a period of 16 hours. Mike Geobel, Harriet Huber and Steve Osmek remained ashore.

1.3 Problems, Suggestions and Recommendations:

The Zodiac Mark V was demonstrated to be the ideal craft for this operation; an entire pallet of cargo could be lowered into the boat by ship's crane, ferried ashore and then broken down at the waterline and smaller pieces hand-carried up to the camp. The flat bottom Zodiacs were ideal for beach landing and the higher freeboard of the larger Zodiac prevented it from being swamped by the surge. The ship's divers contributed greatly to the efficiency of the operation by guiding the boats onto the beach and launching them again after being unloaded.

We experienced problems, however, with both 45 HP motors that were purchased for the Zodiac Mark V. One motor had a broken part in its fuel supply system. The equipment was supplied by the project and the ship carried no spare parts or repair manuals. The motor was declared inoperative. The second motor was fouled by contaminated gas. The fuel lines and carburetor were cleared and the motor ran without subsequent problems. It is recommended that spare parts and repair manuals be brought aboard in the future with project-supplied outboard motors.

2. Conduct ice seal studies, Leg I.

2.1 Objectives:

The objective was to collect tissue samples from ice seals (i.e., crabeater seals, Ross seals and Weddell seals) hauled out on sea ice in the bays adjacent to Bransfield and Gerlache Straits. These tissues would be later analyzed for reproductive condition by age and correlated with estimates of available forage.

2.2 Accomplishments:

Ice seal sampling was conducted for 5 days, targeting primarily on crabeater seals (See Figure 1). Ovaries, jaws, stomachs, urine and blood samples were to be obtained from specimens collected by John Bengtson, Lisa Ferm and Ordinary Seaman Beej Whiteaker from a small boat operating in the ice. No problems were encountered with the weather or in finding seals. A sufficient number of specimens were taken for the purposes of the study.

2.3 Disposition of Samples and Data:

Tissue samples were frozen and retained aboard the SURVEYOR for transport to Seattle. Dr. John Bengtson, of NOAA's National Marine Mammal Laboratory, will take possession of the sampies for analyses and curation.

2.4 Problems, Suggestions and Recommendations:

A Zodiac Mark II was used to collect specimens. The boat was light enough to maneuver among the ice floes and yet of sufficient size to accommodate 3 people and their sampling equipment. The boat had to enter the ice to find seals and the ship was required to stand close by during periods of reduced visibility. This posed a dilemma for the Command, however, acting under instructions not to enter areas of scattered glacial and sea ice. It is recommended that if ice seal sampling is required on future cruises, the Command be authorized to proceed with caution.

3. Conduct pelagic survey for young fish at South Georgia, Leg I; submitted by Valerie Loeb.

3.1 Objectives:

A small net sampling program was performed in conjunction with bottom trawl operations in order to quantitatively describe the distribution and abundance of pelagic larval and juvenile fishes in the South Georgia shelf area. Bongo net tows at each trawl station were intended to provide larval fish composition and abundance data directly comparable to those resulting from the 1988 AMLR South Georgia sampling efforts. Additional tows using a 6' Isaacs Kidd Midwater Trawl (IKMT) were intended to catch larger, more active pelagic juvenile stages which may not be adequately sampled by the bongo nets. The information resulting from this type of sampling program can be used to assess between year differences in spawning stock distribution and reproductive effort, and may eventually be useful in tracking year class success of dominant fish species.

3.2 Accomplishments:

Ninety quantitatively useful pelagic net tows were made during the 17-28 January sampling effort at South Georgia (see Figure 2). The IKMT was towed at Stations 1-13 but, due to technical difficulties, was omitted in subsequent sampling efforts (see Section 3.5). Seventy-seven (77) successful bongo net tows were made at 47 stations. These consisted of "deep" oblique tows at 47 stations and "shallow yo-yo" tows at 30 of the 47 stations. The depth range fished by the "deep" tows was bottom depth related, and generally was from 60-90m and 140-180m, respectively, at shallow (< 150m) and deep water stations. The "shallow yo-yo" tows were fished up and down two to three times within the upper ca. 30m in an attempt to sample the abundant near-surface larval fish assemblages reported by British Antarctic Survey ichthyologists.

3.3 Disposition of Samples and Data:

The bongo frames were fitted with 333-micron and 505-micron mesh nets. Entire 505-micron net samples were immediately preserved in formalin for subsequent ichthyoplankton analyses at Moss Landing Marine Laboratories. Approximately 600 larval fishes were rough sorted from the 333-micron bongo net and IKMT samples; these larvae were preserved in isopropyl alcohol and stored separately for use in age determination analyses by Dr. Richard Radtke, University of Hawaii. The remaining samples were then preserved in formalin. The IKMT samples will be sent to Moss Landing Marine Laboratories for finer sorting and subsequent catch analysis when larval fish identification information has been provided by Dr. Radtke. The 333-micron bongo net samples will probably be sent to Dr. John Wormuth, Texas A&M, for eventual zooplankton composition analysis.

3.4 Tentative Conclusions:

The bongo net samples collected at South Georgia during the AMLR 8901 cruise appear to be quite different from those collected in the same areas and time period during 1988. The most obvious difference is the relative paucity of larval fish in 1989: the 34 bongo samples collected in 1988 yielded from 0-235 larvae with an average of 36 larvae/tow; in contrast, a maximum of 68 larvae/tow was counted in the 1989 samples, with positive samples yielding an average of only 8 larvae/tow. Although species identifications have not been made, the general impression is also of reduced species diversity in 1989 vs. 1988. If these impressions are supported by the results of statistical analyses, there may be serious implications with respect to the 1988/89 year class success of fisheries impacted stocks.

3.5 Problems, Suggestions and Recommendations:

Although the bongo net larval fish sampling operations could be effectively done from the SURVEYOR, the pelagic juvenile sampling program was restricted by both deck space and winch limitations. Ideally such a program should involve higher speed tows (e.g., > 3 kts) with larger nets (e.g., 12' IKMT or Rectangular Midwater Trawl) and the appropriate winch facilities. The strain placed on the winch by the 6' IKMT resulted in time consuming and laborious recoveries and threatened severe damage to the winch motor.

4. Conduct benthic survey for fish and invertebrates, Leg I; submitted by James McKenna.

4.1 Objectives:

This research involved a quantitative survey of the population of pre-recruited demersal fish in the South Georgia area. The primary objective was to describe the link between larval and adult Antarctic fish standing stock by determining the population size of pre-recruited juvenile fish. By evaluating the abundances of larval and pre-recruited juveniles this year we eventually may be able to make predictions of future recruitment success in this valuable commercial fishery.

4.2 Accomplishments:

Standard benthic trawls (15 minutes bottom time, at 2.5-3.0 kts) were successfully completed at 42 stations around South Georgia at bottom depths between 50m and 250m (see Figure 2). The biomass and number of individuals of each species caught at each station were recorded. Individual fish lengths (total and standard) were also recorded. Otoliths from over 1000 fish were collected for age and growth work; selected specimens were also preserved for reference collections (see Section 8).

A total of 4667 individuals, representing 18 species, was captured in the South Georgia area. The total fish biomass caught was 844 Kg. An additional 156 fish of 10 species were caught at four stations sampled in the Antarctic Peninsula region during the first week of the cruise.

The South Georgia fish catch varied greatly between stations. The largest single catch was 138 Kg at station 28 (southeast corner of the island; Figure 2). The average catch per tow (South Georgia region) was 21 Kg, 118 individuals.

A quantitative index of epibenthic invertebrate abundance in each benthic trawl was calculated for each station. This index will be used to investigate possible correlations between the abundance of various fish species and groups of benthic invertebrates. It also serves as an indicator of the bottom type over which sampling occurred.

4.3 Disposition of Samples and Data:

All quantitative data were digitized using DBASE III or Lotus 1-2-3 software. Copies were recorded on 5 1/4" floppy disks (IBM format) and distributed to the cruise leader (Roger Hewitt) and the principal investigators (Valerie Loeb, James McKenna). Copies of the original data sheets were made and distributed in the same fashion.

A reference collection of amphipods and isopods was taken from the benthic invertebrate catch by Kathleen McKenna (Environmental Protection Agency, Narragansett, RI).

4.4 Tentative Conclusions:

Adult as well as juvenile stages were effectively collected by the benthic trawl. The size range of fish caught was 4 - 69cm. The great numbers of large individuals (e.g., >50cm) caught, suggest that net avoidance was not a problem.

The numerically dominant species was the humped rockcod (*Notothenia gibberifrons*). The painted notie (*Nototheniops larseni*) and the yellowfin notie (*Nototheniops nudifrons*) ranked second and third in abundance, but due to their small size did not contribute a major proportion of the biomass. Two less abundant but large species of icefish (South Georgia icefish, *Pseudochaenichthys georgianus*; blackfin icefish, *Chaenocephalus aceratus*) ranked second and third in biomass, respectively.

The humped rockcod is of commercial interest. It contributed 41% of the total biomass and 30% of the individuals caught by the benthic trawl. The size of individuals caught ranged from 5.7 - 50cm. The population was dominated by individuals < 25cm, but individuals of the smallest size classes were less abundant than those of intermediate sizes. This may indicate that the younger stages were in unfished nursery areas. Small individuals were relatively more abundant at shallow stations, indicating that higher concentrations of juvenile stages may be in waters < 50m. Unfortunately, such depths could not be sampled during this survey. An alternative possibility is that there are indeed few pre-recruits this year and that the population may decline in the future due to exploitation.

The painted and yellowfin noties are small fish and have little commercial value. Although they were numerically abundant their biomasses represented small proportions of the total catch (7% and 1%, respectively).

The blackfin and South Georgia icefish are both commercially important species. Most of the individuals collected during this survey were large (>30cm). The absence of small individuals in both bottom trawls and pelagic tows suggests that there may be a decline in their population abundance in the future.

Historically the two most important commercial species in the South Georgia region were the marbled rockcod (*Notothenia rossii*) and the mackerel icefish (*Champsocephalus gunnari*). The marbled rockcod population has been over-exploited for a number of years. Fifteen individuals, all > 44cm in length, were caught during this survey. There are no signs of recovery of this species. The mackerel icefish has shown signs of decline in recent years. It represented a moderate proportion of the catch in this survey. More detailed data analyses are required to determine if the stock size is continuing to decline.

There is evidence that the demersal fish community around South Georgia has changed over the past three years of AMLR groundfish investigations. The abundance of South Georgia icefish and the complete absence of the grey rockcod (*Notothenia squamifrons*) in 1989 suggests a continuation of the faunal changes seen between the 1986 and 1988 surveys.

Few pre-recruit size fish (e.g., <= 11cm) were collected at depths between 50m and 250m, and those were mostly yellowfin and painted noties, which attain most of their adult size by ca. 11cm. Juveniles were rare, represented by five species (blackfin icefish, narrowhead rockcod, humped rockcod, smalleye morey cod, *Parachaenichthys georgianus*), and were collected at shallow water stations (ca. 50m).

4.5 Problems, Suggestions and Recommendations:

The Christensen Benthic Trawl designed for this project by Chris Christensen, University of Rhode Island, worked extremely well. Two of these nets, complete with doors and bridles, and parts for a third net will be stored at the Southwest Fisheries Center.

An electronic scale designed to operate on a fishing vessel should be brought on future cruise of this type and used to weigh all fish. Fish processing could have been enhanced with electronic fish measuring boards connected to a microcomputer should be used to quickly measure the size of fish collected.

Extensive sampling of inshore stations, particularly those < 50m deep, is necessary to determine if the juvenile fish are actually absent or concentrated in shallow water nursery areas. A wheeled bongo or some other quantitative sampling device to sample epibenthic larvae/juvenile fish should be used in conjunction with the ongoing fish project. Benthic sampling should also be continued with more quantitative gear such as a benthic sled.

5. Monitor air and surface water CO_2 content, Leg I; submitted by Lee Waterman.

5.1 Objectives:

The first objective of this project was to make direct CO_2 measurements in surface waters with a Siemens infrared gas analyzer and a Weiss-design equilibrator. Few measurements have heretofore been made in the southern ocean high latitudes. Most measurements have indicated that the area between 50^{o}S and 70^{o}S to be one of low pCO_2 (markedly undersaturated) and a sink for the exchange of CO_2 between ocean and atmosphere.

The second objective was to visit Palmer Station, Antarctica to make a site inspection and to confer with HMC Dennis Hampton, U.S. Navy Medical Corps, who is voluntarily collecting air samples for the NOAA/ARL/GMCC flask sampling network. Air samples have been collected at this site since 1979.

The third objective was to visit the British Antarctic Survey station at Bird Island, South Georgia in an effort to start/restart air sampling as part of the NOAA flask sampling network.

5.2 Accomplishments:

The shipboard measurement system was fully operational before departure from Punta Arenas. A nearly complete record of both atmospheric CO_2 concentrations and pCO_2 in the surface ocean was obtained along the entire Leg I track. The measurement program produces a 23-minute continuous record of these values for each hour of operation. Both minute values and hourly means are logged on magnetic tape. An analog strip-chart record was also obtained beginning with the second day of observations.

Palmer Station was visited on the morning of 10 January. The usual flask sampling site, about 100m east of the clean air facility building was inspected. A pair of air samples was collected by Dennis Hampton with Lee Waterman as observer. A couple of alternate sampling sites to be used in severe weather and/or when the wind is coming from a westerly direction were discussed. The practice of retrograding the samples each time a ship calls at the station was also discussed.

The British Antarctic Survey station on Bird Island, South Georgia was visited on the afternoon of 26 January. Nick Lund and Tim Barton were given detailed instructions on the use of the P3 flask sampling apparatus using the short-form manual and diagrams obtained from Palmer Station. Possible sampling locations were discussed. They do not believe that it will be a problem to obtain the samples from ridge areas surrounding about half the station site and overlooking the beach. The four cases of flasks intended for 1989 sampling have arrived at the station and are sufficient for fortnightly collections. Nine cases of other flasks, apparently unused, were removed to the ship. They will be off-loaded in Seattle and sent to Boulder, Colorado. While hauling flask cases to the beach Lee Waterman sustained a small bite on the left leg from a female fur seal.

5.3 Disposition of Samples and Data:

Data tapes and strip-charts from the infrared analyzer measurement program and the flask samples of atmospheric air will be sent to the NOAA Air Resources Laboratory, Carbon Cycle Group, Boulder, Colorado.

5.4 Tentative Conclusions:

While a cursory examination of pCO_2 values support the idea of a sink for atmospheric carbon dioxide, some areas of supersaturation were observed. The sudden changes from low to high pCO_2 values and vice-versa are probably indicative of crossing from one water mass to another. While the measurements are a preliminary assessment of the Scotia Sea, they should not be construed as representative of the whole southern ocean.

5.5 Problems, Suggestions and Recommendations:

The participation of the NOAA Air Resources Laboratory on this expedition was contingent on the installation of a new delivery system for clean surface sea water. The system installed was an all plastic pump and pipe combination with a new intake on the starboard side in Compartment 2.

The new water system proved to be inadequate within the first few days of Leg I; the intake was placed too high on the ship's hull and consequently was at or near the water surface under all but the most ideal conditions of no roll and full fuel tanks. As soon as the fuel in the compartment 2 tanks was used, the intake came completely out of the water and the pump lost suction. This was temporarily remedied by pumping fuel back into the forward tanks. However, even with full fuel tanks, a small rolling motion caused the pump to lose suction. Altogether about 20 hours of pCO_2 data were lost from forced shutdowns.

The problem of an adequate, uniterruptable seawater supply was solved by connecting the new plastic line to the ship's general saltwater service for the duration of Leg I. It appears that this arrangement added about 0.5^{o}C to the temperature correction which must be made to the pCO_2 data.

It should also be noted that the thermosalinograph installed as part of the new scientific seawater supply system was placed in line after the pump instead of on the suction side. This arrangement gives inaccurate temperature readings inasmuch as the readout is the sum of the in situ surface water temperature and the warming from the pump. Bucket temperatures, taken 2-4 times daily were used to arrive at the total temperature correction for the pCO_2 monitoring.

6. Seabeam data collection and preliminary interpretation, Leg I and Leg II; submitted by David Sandwell, Chris Small and Keith Klepeis.

6.1 Objectives:

The primary objective was the acquisition of Seabeam bathymetry data in the vicinity of the Antarctic Peninsula and Scotia Sea. In particular, we were interested in high resolution sonar mapping of plate boundaries in this region (Figure 3). Although the ALMR program is mostly biological and unrelated to geophysical surveys, we hoped to collect Seabeam data on an opportunistic basis with little or no impact on the primary program. Because of the potential importance of this Seabeam data, we were able to obtain salary and travel support from a variety of institutions outside of NOAA (NASA Geodynamics Program, NSF Division of Polar Programs, Texas Advanced Technology Research Program and University of Texas Dept. of Geological Sciences). NOAA (Office of Charting and Geodetic Services) offered to process and distribute the Seabeam data. During the two legs of the Cruise we hoped to accomplish the following:

> Determine the continuity, morphology and tectonic structure of the poorly surveyed Shackleton Fracture Zone (FZ). This major tectonic feature (800 km long) is a northwest tending, strike-slip/compressional boundary separating the Scotia and Antarctic Plates (Figure 3). The large Shackleton FZ ridge is also of oceanographic interest because it acts as a barrier to the Antarctic Circumpolar Current.
>
> Obtain multibeam bathymetric coverage of the Bransfield Strait and South Shetland Islands. This poorly surveyed area of back-arc extension contains active and dormant volcanos as well as a ridge-transform-transform triple junction of the Antarctic, Drake and Scotia Plates (Figure 3). Moreover, recently German scientists discovered higher order hydrocarbons (Whiticar et al., 1985) near King George Island so this area may become economically important over the next 40 years.
>
> Follow a GEOSAT altimeter profile during the transit from Seal Island to South Georgia Island (Leg I). Seabeam data along this satellite ground track could be used to "sea truth" the marine gravity measurements made by GEOSAT.

6.2 Accomplishments:

The data acquired during the two legs of the cruise greatly exceeded our expectations. A number of factors worked in our favor. First, the SURVEYOR is a stable platform that is ideal for Seabeam surveys in high sea states. Second, during both cruise legs, the Seabeam equipment and SURVEYOR crew collected excellent data without any significant loss of time. Third, other project scientists, with higher priority projects, allowed us to modify and extend transit paths in order to optimize Seabeam mapping of tectonic features. Finally the survey grid, designed for the krill acoustic research, was nearly optimal for our geophysical surveys. Seabeam coverage is nearly complete along the Leg I and Leg II tracklines shown in Figure 4. The data having geophysical importance include:

Three Seabeam transits along the Shackleton FZ. The first transit (Leg I - south, dotted line in Figure 4), extends along the crest of the Shackleton FZ from the 200 mile limit of Chilean waters to the Pacific-Scotia-Antarctic Triple Junction. After gaining permission to collect data in Chilean waters, the second and third transits (dashed line in Figure 4) follow the entire length of the Shackleton and delineate the northern part of the Shackleton ridge and deep trenches on both sides of the ridge.

Six Seabeam transits along the northern side of the Bransfield Basin (Legs I + II). More than ten small volcanos (100 - 700 m) were charted by Seabeam along a narrow zone of geologically recent volcanism extending from Bridgeman Island in the northeast to Deception Island in the southwest. Away from this zone the volcano population is relatively low.

Semi-random Seabeam surveys of the margins and seafloor surrounding King George Island and Elephant Island were acquired during the Krill acoustic surveys (Leg II, dashed line in Figure 4). The intersection of the Shackleton FZ with the northeastern margin of Elephant Island is particularly well surveyed.

On the Leg I, northbound transit from Elephant Island to South Georgia, Seabeam data was collected along the South Scotia Ridge and then along a trackline of GEOSAT altimeter data. The GEOSAT coincident Seabeam line will be used by scientists at the Naval Research Lab to determine the resolution capabilities of the GEOSAT gravity data.

6.3 Disposition of Seabeam and Navigation Data:

We thank the NOAA officers and staff, especially Captain Christian Andreasen (NOS, Charting and Geodetic Services, Rockville, MD) for their efforts to keep these Seabeam data unclassified. Seabeam data from Legs I and II data will be forwarded to the NOAA Office of Charting and Geodetic Services for final post processing, reproduction and distribution to Dr. Larry Lawver, University of Texas Institute for Geophysics, Dr. Eddie Bernard, Pacific marine Environmental Laboratory, Dr. Roger Hewitt, Southwest Fisheries Center, the National Geophysical Data Center in Boulder Colorado and mapping agencies of other countries (e.g. Chilean government).

In addition, paper plots of Seabeam data produced during Legs I and II will be given to Dr. Lawver in Punta Arenas on March 5. Over the next two months (March 15 to May 9) Dr. Lawver and others will use these data to aid his geophysical surveys in the Powell Basin, North Bransfield Basin, King George Basin and Central Bransfield Strait aboard the R/V Polar Duke. One of the primary objectives of his two month is to measure the rate of heat flowing from the seafloor by lowering a long temperature probe (~3 m long) into flat lying sediments. Our Seabeam coverage of these basins will enable them to locate flat sedimented areas and avoid rocky rear volcanos.

6.4 Tentative Conclusions:

Shackleton Fracture Zone

As shown on previous charts, the Shackleton fracture zone is a continuous topographic feature extending for over 800 km from Diego Ramirez Island to Elephant Island. While the Shackleton is a continuous feature, its morphology and tectonic structure seems to be divided into three segments. The northernmost segment extends from Diego Ramirez Island to the intersection of the extinct Drake spreading ridge with the Shackleton FZ (160 km). Along this segment, the Shackleton consists of a ridge rising 1000 - 2000 m above the surrounding seafloor. Approximately 15 km to the southwest of the ridge is a deep, parallel trough. Earthquake focal mechanisms from this area as well as the trough-to-ridge signature suggest that this northern part of the Shackleton was produced by a combination of strike-slip faulting and underthrusting of the Antarctic Plate beneath the Scotia Plate.

The southernmost part of the Shackleton FZ between Elephant Island and the intersection of the extinct Scotia ridge (350 km) has a similar ridge and trough morphology. The ridge axis depth is mostly about 1600 m although there is a short segment where the ridge rises to within 800 m of the surface. In contrast to the northern segment, the southern segment has a deep trough (~4000 m) which lies to the northeast of the ridge. Between the ridge axis and the trough axis is a very steep escarpment having slopes as high as 30 deg. Our preliminary interpretation is that the southern part of the Shackleton ridge also formed by a combination of strike-slip faulting and underthrusting; however, along the southern segment we think the Scotia Plate is underthrusting the Antarctic plate.

Between the northern and southern segments of the Shackleton FZ lies 300 km long segment where the ridge and trough signatures are less apparent and sometimes absent. This segment of the Shackleton FZ is generally deep > 3000 m and has disorganized topography. To understand the tectonics of this segment would require more complete Seabeam coverage both on and off the Shackleton FZ. One interesting observation is that this complicated section is bounded on the northwest by the extinct Drake spreading ridge and on the southeast by the extinct Scotia spreading ridge.

Elephant Island

Elephant Island is located in a tectonically complex setting where the Shackleton FZ intersects the continental margin of the Antarctic peninsula and forms part of a triple junction along with the South Scotia Ridge and the axis of the North Bransfield Rift Basin. As stated above, Seabeam coverage in the vicinity of this intersection is excellent. We have produced a preliminary bathymetric map of this region that illustrates several interesting features. The map includes a prominent bathymetric low that represents the shelfward extension of the deep trough lying to the northeast of the Shackleton FZ. The trough is paralleled on either side by two high, linear ridges. The southern ridge is an extension of the Shackleton ridge and is several hundred meters higher its northern counterpart. An extrapolation of the lineament defined by the Shackleton trough intersects Cape Yelcho on the northern margin of Elephant Island. It is approximately at this point on the island where several interesting geological features have recently been described by others (e.g. Dalziel, 1984) and, we believe, may bear a relationship with the FZ.

The rocks on Elephant Island are thought to represent pre-Middle Jurassic basement of the Scotia Metamorphic Complex. They have been interpreted to be fore-arc rocks associated with the subduction of Panthalassic crust beneath the Antarctic continent and have recently been uplifted at a rapid rate. Two geological terrains have been delineated on the island (Dalziel, 1984; 1989), separated by a structural as well as a metamorphic transition that subparallels the onland extrapolation of the FZ. The northern terrain consists of low temperature blueschists and greenschists and the southern terrain is a high temperature, albite-epidote-amphibolite facies that is highly deformed. We believe that the boundary between the two terrains represents the onland extension of the Shackleton FZ and that the uplift of these rocks is directly related to differential movement along the fault. The intersection of a major active plate boundary with Elephant Island represents an excellent opportunity to study the processes involved in the uplift of fore-arc terrains.

North Bransfield Basin

Northern Bransfield Strait is an extensional basin tectonically situated between the now defunct Drake plate to the west of the South Shetland Islands and the continental margin of the Antarctic Peninsula. There is some debate over the exact age of the basin. Barker had recently proposed (Barker, 1982) that sea floor spreading initiated 1.3 million years ago--3 million years after east-directed subduction of ocean crust beneath the South Shetlands ceased. If this is correct it makes the basin difficult to explain in terms of normal back-arc spreading processes. Lawver (1989) suggests that the extension is not related to subduction but is primarily due to plate motion caused by the 110 degree bend as the Shackleton FZ sweeps around Elephant and adjacent islands to join with the South Scotia Ridge.

We have completed a Seabeam survey that includes six transects in the area between the shelf margin of the South Shetlands and the axis of the Bransfield Basin. We have located a long, linear string of volcanos between Deception and Bridgeman islands and note that these are very much off axis features. By further defining the position of these volcanos and the axis of the basin, we will be able to test the hypothesis that observed volcanism is not due to normal seafloor spreading processes but is associated with normal faults produced by the general extensional regime.

7. Conduct underway seabird and marine mammal observations, Leg I; submitted by Dawn Breese.

7.1 Objectives:

The first objective was to conduct marine bird and mammal censuses on the SURVEYOR's southbound transit from Seattle to Punta Arenas. As a gross indicator of the marine bird and mammal food base, flying fish were to be censused as well. Birds were to be identified to the lowest possible taxa, and age and sex were determined when possible. These observations will contribute to studies of long-term variability in bird and marine mammal distributions.

The second objective was to conduct censuses of marine birds and mammals on Leg I with an emphasis on Drake's Passage and Bransfield Strait, and between fishing operations around South Georgia to compare to the previous work and database of co-investigator Dr. Richard Veit.

7.2 Accomplishments:

Standard 300m wide transects were searched from the flying bridge for marine birds and mammals at various times during daylight hours.

Southbound Transit: Between 5-23 Dec 1988, and 27 Dec 1988 - 1 Jan 1989 the SURVEYOR transited between Seattle, Washington and Punta Arenas, Chile with a port call in Valparaiso, Chile. Thirty-eight censuses were conducted for a total of 93 hours of effort. Eighty-four species of birds and 23 sightings of 9 species of marine mammals were recorded. Marine mammal sightings broke down as follows; 2 mysitcetes, 11 odontocetes, and 10 pinnipeds. Three additional species of marine mammals were seen while "off-effort": sperm whales, killer whales, and southern right whale dolphins.

Leg I: The SURVEYOR left Punta Arenas, Chile 4 Jan 1989 and returned 2 Feb 1989. Twenty-six censuses were conducted for a total of 45.5 hours of effort. Forty-one species of birds and 67 sightings of 9 species of marine mammals were recorded. Marine mammal sightings break down as follows: 14 mysticetes, 4 odontocetes, and 49 pinnipeds. One additional species, the killer whale, was seen while "off-effort."

7.3 Disposition of Samples and Data:

All seabird census data will be entered into a computer and analyzed by Dr. Veit at UC Irvine. He will keep the original census data, and I will keep a copy at my home in Santa Cruz.

All marine mammal sightings have been documented in the SURVEYOR's Marine Mammal Log and will go to the NMFS NMML in Seattle via the ship's Marine Mammal officer, Ensign Chris Meinig. I will also keep a copy for my records to compare to work in the future.

7.4 Tentative Conclusions:

Southbound Transit: The north and equatorial Pacific Ocean was relatively devoid of both marine birds and mammals. Many of the seabird species which occur in the northern hemisphere were breeding in the southern hemisphere.

Sightings increased in the southern hemisphere. The influence of breeding islands (such as San Felix, San Ambrosio, Juan Fernandez, and Mocha Island, all off Chile) was apparent on bird distributions. Marine mammals were more common with sightings of typical southern species such as dusky Dolphins and southern right whale dolphins.

The inside passage along the southern Chilean coast SE of Chiloe Island was a haven for two species of seabirds not seen in significant numbers elsewhere. Hundreds of Grey-headed Albatross, and thousands of petrels of the genus *Procellaria* were seen. Due to the characteristic black tip ("nail") to an ivory yellow bill, I believe this petrel is either Parkinson's Petrel (*Procellaria parkinsoni*) or Westland Petrel (*P. westlandica*). Neither Harrison (1983) nor Araya et al. (1986) show any records in Chile for Parkinson's. Araya et al. (1986) shows one record for Westland some 600km to the north of Chiloe Island. The protected and rich waters (as indicated by the numerous fishing boats) of the inside passage may be a significant feeding and/or resting area for these two species.

Two sightings of little shearwater (*Puffinus assimilis*) are both new range extensions for the species. There is one previous published record (that I am aware of) for the South American Pacific Ocean from 1970 by Jehl (Harrison, 1983) 2 miles west of Chiloe Island (Araya et al. 1986). On 23 December 1988 one was seen approximately 180 miles NW of Valparaiso (near 30^{O} 12.0'S / 74^{O} 26.2'W), and on 27 December 1988 another was seen after leaving Valparaiso Harbor (near 33^{O} 09.1'S / 71^{O} 53.8'W).

Leg I: Major flocks of feeding and/or resting birds were encountered on four censuses. On 14 January, while SE of King George Island, the ship steamed for several miles parallel to an extended line of approximately 500 Antarctic fulmars and 250 cape petrels which were on the water feeding. On 17 January during the transit to South Georgia, coincident with reaching the shelf break, we encountered roughly 1500 prions (*Pachyptila* species) in less than five minutes. On 20 January north of South Georgia between sampling stations 13 and 14 we passed approximately 650 prions sitting on the water. On 24 January near the northeast end of South Georgia we passed an iceberg with a flock of over 2000 Wilson's storm petrels feeding on krill concentrated at the berg edge.

Two penguin sightings are of interest. On 5 January an Adelie was seen in the Beagle Channel near Isla Solitario (54^{O} 57.6'S / 67^{O} 07.8'W) 3km north of Navarino Island, Chile. There are few records for Adelie's north of the Antarctic convergence, and the presence of this bird is considerably north of its normal range. On 8 January a group of 15 juvenile emperor penguins was seen in Bransfield Strait near 62^{O} 24.1'S / 57^{O} 49.3'W. This sighting supports Harrison's (1983) contention that juveniles may wander north more than currently realized.

Significant numbers of marine mammals were seen around the Antarctic Peninsula, especially in Bransfield Strait and in Flandres Bay. Between 6-8 January in the Bransfield Strait area over 60 minke whales were recorded. On 10 January in Flandres Bay six humpback whales were observed feeding for approximately an hour. The whales were in three distinct pairs. They were seen lunging parallel to the surface all right side down and in formation where whales were side by side and one whale slightly ahead of the other. This method of feeding has been observed by B. Tershy and myself for fin whales in the Gulf of California, and B. Wursig and others for bowhead whales in the Arctic. No bubble net feeding was observed.

On 15 January during the transit from Seal Island to South Georgia two beaked whale sightings (one of 3 individuals, and one single) were made by the officers on watch. Their immediate descriptions (recorded into the SURVEYOR Marine Mammal Log) indicate a strong probability that in both cases they were Arnoux's beaked whales.

The highest density of Antarctic fur seals was seen 17 January while we were off the west end of South Georgia (near the Willis Islands). Within the 300m transect, I counted 95 (average group size 3.5) in three hours. At the time we were close to the large colony on Bird Island, where an estimated 5000 breeding females hauled out this year (John Croxall, pers. comm.).

On 27 January, the evening before our visit to the abandoned whaling station at Grytviken, a spectacular gathering of minke whales was seen. Just after sunset a mother/calf pair was observed, and within 10 minutes, two more were seen. Within half an hour and the approaching darkness, the sea was covered with whales. Everywhere we looked in a 2 mile square area, there were charging, porpoising minke's. There were sub-groups of 2-3 in an aggregation of what appeared to be at least 100 whales.

7.5 Problems, Suggestions and Recommendations:

The seabird census work would benefit by having two observers. Coverage would be better with two people to see high flying species (like tropicbirds, frigatebirds and terns), and smaller hard to see species (such as storm petrels).

For the seabird work hand held binoculars are adequate, but to strengthen the marine mammal observations a pair of 25x150 power, mounted binoculars would be a great asset. The SURVEYOR has the mounts already in place and should have a set of these glasses prior to future cruises with bird and marine mammal observers aboard.

Due to problems with the thermosalinograph I was not always able to obtain measurements of sea surface temperature and salinity during the southbound transit. A flow-through fluorometer, to measure chlorophyll levels for primary productivity assessment, would also be advantageous to compare patterns of primary productivity with bird distributions.

7.6 Literature Cited:

Araya, B., G. Millie, M. Bernal. 1986. *Guia de campo de las aves de Chile*. (Field Guide to the Birds of Chile; in Spanish). Editorial Universitaria. Santiago. 386 pp.

Harrison, P. 1983. Seabirds, an identification guide. Houghton Mifflin. Great Britain. 448 pp.

8. Collect otoliths for age and growth studies, Leg I; submitted by James Brennan and David Shafer.

8.1 Objectives:

Antarctic fishes are a unique group of animals with specialized biological adaptations and population dynamics for survival in the Antarctic. Unfortunately, there is a paucity of information describing the population characteristics and biology of these animals. Various life history characteristics of these fish species make them susceptible to over-exploitation, especially slow growth rates. Many of these species have become targets of large scale commercial fisheries, which have already exceeded optimum yield estimates. For the effective use and proper management of any fishery resource, and a better appreciation of the basic biology of fish populations, information describing age, growth, recruitment, fecundity, and mortality is essential. This information may be obtained from collections of a representative size range of individuals and bony structures, such as otoliths, for age determination and stock differentiation.

In the process of conducting a pre-recruit survey for fish surrounding South Georgia, ancillary data were taken on an opportunistic basis by scientists David Shafer and Jim Brennan in addition to the prescribed data acquisition proposed for Leg I. These additional data included sex, stage of maturation, otoliths, and brain tissue from a subsample of the total fish catch. These data will greatly enhance the abundance/length-frequency database originally proposed for the pre-recruit survey, by providing critical information describing population gender proportions, age at maturity, population age structure, growth, and mortality. In addition, specimens were collected and preserved in 5% formalin for reference collections.

8.2 Accomplishments:

Otoliths are calcium carbonate concretions located in the membranous labyrinth of fishes. Otoliths are the aging structure of choice because they are not resorbed, they typically grow isometrically relative to fish growth, and they are easily acquired. Otolith shapes are species-specific with certain morphological characteristics that may be useful for stock differentiation. In addition shapes and relative sizes of otoliths may provide useful information about feeding habits of marine mammals, birds, and fishes. A total of 1048 pairs of saggital otoliths was collected from 19 species, representing 6 families from two distinct geographic areas; Bransfield Strait and South Georgia. Of the 19 species, adequate numbers of otoliths were collected for age determination from 11 species including:

Trematomus newnesi
Chaenocephalus aceratus
Nototheniops nudifrons
Muraenolepis microps
Parachaenichthys georgianus
Pseudochaenichthys georgianus
Artededraco mirus
Pagothenia hansoni
Champsocephalus gunnari
Notothenia gibberifrons
Nototheniops larseni

We believe that adequate samples of *N. gibberifrons* were collected from the two geographic sampling areas to attempt stock differentiation using computer-aided shape analysis techniques. For each of these samples, total length (TL), standard length (SL), sex, and stage of maturity were recorded. Otoliths were stored in labelled envelopes for future analysis, time/funding permitting.

8.3 Disposition of Samples and Data:

Otolith samples will be divided between David Shafer and Jim Brennan and transported to their respective institutions for future collaborative analysis with Drs. Richard Radtke and Gregor Cailliet. An additional number of otoliths will be dissected from frozen samples of *P. hansoni*, *N. gibberifrons*, and *N. larseni* to complete size ranges for these species during transit to Punta Arenas. Brain samples have yet to be dissected from a size-range of frozen *N.gibberifrons* collected from South Georgia. Brain samples will be processed for lipofuscin assays at the University of Hawaii. Lipofuscin, a metabolically-derived aging by-product, may accumulate as a function of free radical and oxidative metabolic activity of an organism and may be used as a measure of physiological age. Fishes acquired for reference collections will be inventoried and divided into 3 collections for Moss Landing Marine Laboratories, the University of Hawaii, and the University of Rhode Island. These samples will be stored and shipped back to Seattle, Washington on the NOAA Ship SURVEYOR and subsequently distributed to the respective institutions.

8.4 Problems, Suggestions and Recommendations:

Sex and stage of maturity determinations should be an integral part of the data collection, especially when proposing to target a particular age/size group. We also suggest that an otolith collection and population-dynamics regime should be integrated into the sampling protocol.

9. Conduct hydroacoustic survey for prey organisms and krill growth and molting studies, Leg II; submitted by Michael Macaulay, Kendra Daly, Patricia Morrison.

9.1 Objectives:

This research involved a quantitative hydroacoustic survey of the population of krill (*Euphausia superba*) and other targets. The primary objective was to describe the distribution and abundance of concentrations of acoustically detectable targets. An additional component (conducted by K. Daly) was concerned with the growth rate and molting rate of juvenile krill. This survey will provide data directly comparable to those resulting from the 1988 AMLR survey in this area. The information from this program can be used to assess between year differences in the distribution and abundance of krill. The growth rate data will provide information on the basic biology of *E. superba* for comparison with other areas of their distribution.

9.2 Accomplishments:

A total of 224 hours of quantitative data was recorded. The 200 kHz signal was analyzed in real time and both 120 kHz and 200 kHz data were recorded for subsequent analyses. The sampling depths were from 6-10 m below the surface to 250 m or bottom whichever occurred first. The analysis of the 120 kHz data and other aspects of the distribution of krill will be done at Seattle.

Less than the full proposed survey was completed due to unavoidable disruptions of the ship operations. The major portion of the King George Island - Bransfield Strait area was surveyed along with important elements of the northern Elephant Island survey area before the break to transport supplies to Palmer Station. Upon return to the sampling area, the southern Elephant Island area was surveyed with a modified sampling grid to fit available time.

Following the survey, attempts were made to conduct a series of radial transects around Seal Island to relate the distribution of prey organisms to the predator populations being studied on the island. Weather and the presence of a large fishing fleet prevented some operations, but we were able to document the distributions outside the area being intensively fished. Of the twelve days spent sampling, 10 were spent on the survey and 2 on special studies.

Two live krill experiments were completed during this cruise. These experiments were designed to determine molting frequency and daily growth rates of *E. superba*. Molting and growth rates are affected by temperature and food concentration, therefore short term shipboard experiments reflect the previous environmental and feeding history of individuals during the intermolt period. Krill were collected with Bongo nets, sorted and held in seawater incubators at ambient temperature and food concentration.

9.3 Disposition of Data:

The hydroacoustic sampling was done with two frequencies, 120 kHz and 200 kHz. These two frequencies have been used on each of the AMLR surveys to date. The method of data analysis is echo integration. This method requires the periodic sampling of the ensonified population for determination of length-frequency. The length frequency data are then used to calculate target-strength from established equations. The resulting target-strength is then used to convert measurements of volume scattered sound into estimates of biomass. The methods used, both hardware and software, are the same as has been used in previous surveys. The data are also recorded digitally so that other post-cruise analyses can be performed. The resulting files of data will be made available to other investigators in the form of MS-DOS format ascii files. All data will be available from Dr. Michael Macaulay, University of Washington.

Animals for the first experiment were collected on the north side of King George Island on 18 February. 83% were juveniles, 20-45 mm in length, and 17% immature females, 27-43mm in length. Animals for the second experiment were collected in Gerlache Strait on 22 February. These also appeared to be predominantly juveniles and about the same size range. During both experiments, molting occurred at night. Final measurements and analyses will be completed at the University of Washington.

9.4 Tentative conclusions:

The distribution of krill in the survey area was much less this year than either of the previous two years. The presence of a large concentration ("super-swarm") in the Elephant Island - Seal Island area was confirmed both by the large number of fishing vessels and the similarity of the size and magnitude of patches in the surrounding area. These features closely duplicated the conditions found in this area in 1981. On the whole, krill were present near shore, predominantly in the Elephant Island area, and low to absent in the Bransfield - King George Island area.

9.5 Problems, Suggestions and Recommendations:

The SURVEYOR performed well as a hydroacoustics platform. However, the inability to obtain quantitative stratified net tows and to fish larger nets for obtaining biological samples for length-frequency is a serious drawback. The very low abundance of krill in the survey area made it more important to obtain biological samples where these could be obtained from MOCNESS samples in discrete layers. The effect of the lack of these samples or the difficulty in estimating length-frequency from the samples obtained on the hydroacoustic data will be to lower the reliability of the estimate of biomass in terms of absolute abundance. The relative abundance will be less affected by this problem. The reduced ability to obtain individual krill prevented further work on growth of juvenile krill.

10. Conduct net sampling for krill and zooplankton in association with acoustic survey in Bransfield Strait, King George Island and Elephant Island areas, Leg II; submitted by John H. Wormuth and Valerie Loeb.

10.1 Objectives:

Net sampling (MOCNESS and bongo nets) performed in conjunction with the hydroacoustic survey program were intended to provide vertically stratified and integrated information on the distribution and abundance of krill, zooplankton and ichthyoplankton populations over the survey area. Krill abundance and length frequency information is intended to ground truth acoustically determined biomass estimates. The krill, zooplankton and ichthyoplankton distribution, abundance and population structure information will be used for evaluating interannual variability of basic elements of the Antarctic pelagic ecosystem. MOCNESS (Multiple Opening and Closing Net and Environmental Sensing System) was to be the primary net system used to provide vertical distribution information as well as integrated 0-180m and 0-360m water column composition and abundance information. Bongo net samples were to provide accessory data on the krill and zooplankton assemblages in the upper ca. 180m and to provide additional data for our AMLR net intercomparison studies.

10.2 Accomplishments:

Because of limited space below the towing beam on the Surveyor, MOCNESS could not be utilized, and all sampling was done with the smaller bongo net. Bongo net samples were collected at ca. 30km intervals along the acoustics transects (Figure 5). A total of 81 stations was sampled between 15-28 February. The samples from these open oblique tows are statistically comparable to bongo net samples collected during the 1987 and 1988 AMLR cruises.

10.3 Disposition of Samples and Data:

The bongo frames were fitted with 333-micron and 505-micron mesh nets. The 333-micron net samples will be sent to Texas A&M University for analysis of the zooplankton components (copepod species, euphausiid species, amphipods, chaetognaths, etc.). The 505-micron net samples will be sent to Moss Landing Marine Laboratories for krill population and ichthyoplankton studies. While at sea, krill and sample splits were removed from some 333 micron net samples by K. Daly and M. Huntley; the appropriate information derived from the removed material will be supplied to J. Wormuth. One larval squid was removed by M. Vecchione from a 505 micron net sample; 10 larval fishes were removed from the 333 micron mesh samples, and preserved in alcohol for larval fish otolith work by R. Radtke, University of Hawaii.

10.4 Tentative Conclusions:

The overall krill catch appears to be small relative to the 1987 and 1988 AMLR surveys. In general, the numerical and biomass dominance by salps, the extreme patchiness and low densities of krill over the survey area, and the low abundance of large (mature) krill individuals conform with the results of the hydroacoustic survey. However, relatively small or zero krill catches persisted despite strong acoustic traces in the vicinity of ca. 20 trawlers actively engaged in krill fishing north west of Seal Island on 26-28 February. These large discrepancies between krill catch and strong acoustics traces suggest that the bongo nets were not adequately sampling the krill populations during that time. While acknowledging small net avoidance by krill, the catches resulting from these latter tows were definitely smaller than those from previous bongo net tows taken in acoustically detected krill layers, and may result from poor fishing qualities of the stern-towed bongo nets during this cruise. Time/Depth Recorder (TDR) traces during the prevailing rough water conditions indicate erratic vertical net movement, especially during upward, fishing, resulting from high amplitude surges by the stern of the ship; such motion definitely could enhance net avoidance and result in meager krill catches. Additionally, the possible surge-related backwashing could have reduced overall catch size during rough sea sampling.

Zooplankton other than salps, small euphausiid species and amphipods were extremely rare in comparison to previous AMLR surveys. With the possible exception of juvenile and late stage larval fish, this low abundance was probably a real, wide spread phenomenon and not due to enhanced net avoidance due to the surging bongo net. Low zooplankton abundance may reflect the reported late onset of springtime conditions in the area (Wayne Trivelpiece, pers. comm.). The low ichthyoplankton abundance (ca. 20 larvae in 81 samples) contrasts strongly with 1988 when 103 bongo samples yielded 1265 larval fish (mean = 12 larvae/tow) and mirrors what was found during the 1989 leg 1 cruise off of South Georgia Island. As with the other zooplankton components, this could have resulted from prolonged harsh winter conditions and consequent poor larval fish survival.

10.5 Problems, Suggestions and Recommendations:

Limited deck space and inadequate A-frame capabilities precluded the use of larger-size nets such as the MOCNESS except during ideal weather conditions. Although bongo net sampling could be performed from the aft boom on the Surveyor, the operations were greatly affected by sea conditions. Wind speeds > 25 knots and sea swell heights > 8 feet appear to have reduced the quality of the tows, as evidenced by the erratic TDR traces and poor catches.

11. Growth and development of larval *Euphausia superba* in relation to environmental conditions, Leg II; submitted by Mark Huntley.

11.1 Objectives:

The goals of this project were to assess the rates of growth and development of the larval stages of *Euphausia superba* in relation to environmental conditions. The environmental conditions to be assessed were (1) temperature and (2) chlorophyll-a. Development rates were to be assessed by direct measurement on live larval krill collected throughout the study area. Growth rates could be determined by combining this information with carbon, nitrogen and dry weights of fresh-frozen larvae.

This project is important to understanding krill recruitment. Recent research has demonstrated that growth rates of larval krill in the western Bransfield Strait region are strongly influenced by prevailing levels of available food (Huntley and Brinton, submitted MS). Development rates in the phytoplankton-rich Gerlache Strait were estimated to be more than double those in the nearby Bransfield Strait waters. Survival of larvae in food-poor Drake Passage waters was thought questionable.

Knowledge of larval development rates in the AMLR study area would greatly expand our understanding of environmental controls on recruitment to the large krill population known to exist there.

11.2 Accomplishments:

Environmental conditions: Measurements of chlorophyll-a and temperature at the surface were made at 202 stations throughout the study area. Particulate chlorophyll-a was measured in triplicate 250-ml water samples filtered through 934-AH glass fiber filters, extracted in 10 ml 100% methanol at -20 C in the dark for at least 12 h. Surface temperature was measured with a bucket thermometer suspended at the sea surface for several minutes.

Larval krill: Larval krill appeared to be absent from the zooplankton at all 81 stations where bongo nets were towed in the upper 200 m, with the exception of one station north of King George Island, where a single Stage 1 Furcilia larva was identified in the contents of one bongo tow. Hence, no experiments could be conducted with live larvae, nor could animals be fresh-frozen for later determination of carbon, nitrogen or dry weights. Some samples of copepods and other zooplankton were collected and fresh-frozen for later measurement, but the samples were inadvertently removed from the freezer and the samples were destroyed.

11.3 Disposition of samples and data:

Environmental conditions: All chlorophyll-a samples were analyzed on shipboard using a Turner Designs fluorometer. The spatial distribution of chlorophyll-a concentration is shown in Figure 6. The spatial distribution of surface temperature is shown in Figure 7.

Larval krill: Cursory visual inspection of the contents of all zooplankton tows revealed a marked absence of larvae. However, this is no substitute for the exhaustive microscopic analysis of samples. Dr. John Wormuth and Dr. Valerie Loeb have agreed to turn over any samples containing larval krill - from both 1988 and 1989. This will allow comparison of stage-frequency distributions (and hence development rate of field populations) between this year and other years for which we have data.

11.4 Tentative Conclusions:

Environmental conditions: A strong frontal zone, only several miles wide and ~30 miles long, was located northeast of Elephant Island. The front was evident in spatial distributions of both chlorophyll-a and temperature (Figs. 10.1 & 10.2). The front was characterized by high chlorophyll-a concentrations and a steep (4 C) temperature gradient. High abundances of juvenile Euphausia superba in this area, indicated by (1) bioacoustic data, (2) bongo net catches and (3) implied by the presence of more than a dozen fishing vessels, may have been causally linked to the front.

Larval krill: The striking absence of larval krill from waters near the Antarctic Peninsula at this time of year is no cause for concern. A similar situation prevailed in this same region in the austral summer of 1983-84 (Brinton et al., 1986), yet adults in 1986-87 - many of which would have been spawned in 1983-84 - were remarkably abundant. I conclude that a significant spawning must have taken place somewhere during 1983-84, but we simply did not detect it.

There is good evidence that *E. superba* larvae which are spawned in, or find their way into, coastal embayments have higher rates of growth and survival than those in relatively food-impoverished offshore waters (Huntley and Brinton, submitted MS). There were abundant larvae in the Gerlache Strait during 1986-87, but none were found there during the 1989 AMLR cruise. This suggests that, although Gerlache Strait may generally be a productive coastal region, it is not consistently used by *E. superba* as a spawning location. The bulk of our knowledge to date suggests that *E. superba*, because it is truly nektonic and because it has a reasonably lengthy spawning season (8-10 weeks; L. Quetin and R. Ross, pers. comm.) can seek out "ideal" spawning locations from among the many coastal embayments scattered along the Antarctic Peninsula coastline. Once spawned, the distribution of larvae will to a great degree be determined by local physical circulation.

11.5 Problems, Suggestions and Recommendations:

The AMLR program should continue to have a component project focussed on the distribution, abundance and growth of larval *Euphausia superba*. Recruitment to the krill population cannot sensibly be predicted or monitored without studies on larvae, which do not enter the fishery for at least two years.

A complete suite of climatological, hydrographic and standard biological measurements should be an integral part of the AMLR database. No modern study of marine biological resources can responsibly purport to investigate variations in the distribution and abundance of living organisms without this basic environmental information. The El Nino phenomenon is an excellent example of a process with enormous effects on marine living resources which - but for the availability of simple climatological and hydrographic measurements - would have defied interpretation. Henceforth, the AMLR database should include information on

(1) seasonal and interannual climatic conditions,
(2) hydrography, and
(3) basic water column biology.

Efforts should be made to cooperate and collaborate with entities which may already be collecting such data; if unavailable, then AMLR should undertake to collect them.

11.6 Literature cited:

Huntley, M. and E. Brinton. Mesoscale variation in growth and development of larval Euphausia superba near the Antarctic Peninsula, 1986-87. Submitted to Deep-Sea Research.

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12. The Distribution of marine birds and mammals in the Drake Passage and Bransfield Strait in relation to the abundance, distribution and characteristics of krill swarms, Leg II; submitted by Dennis Heinemann, Richard R. Veit, and P. Michael Payne.

12.1 Objectives:

Many species of Antarctic marine birds and mammals are completely or largely dependent on krill as a food source. In addition, in some areas (e.g. South Georgia), predator densities are high enough to have a major impact on krill stocks. Organizations responsible for or interested in the conservation and management of Antarctic living resources (e.g. CCAMLR) have proposed the use of predator populations as indirect monitors of the health of krill stocks and of the Antarctic environment in general. Despite the importance of the relationship between these predators and krill to our understanding of Antarctic ecology and the effective conservation and management practices of these organisms, we know very little about the linkage between these predators and their prey.

Our studies of the relationship between seabird and fur seal distributions in relation to krill distributions in the Bransfield Strait region and around South Georgia have shown that the spatial correlation between krill specialists and krill is very weak. In part this is due to biases inherent in the sampling techniques that we had available to us, but, more importantly, we believe it is due to the cryptic, ephemeral, and mobile nature of krill swarms which makes their detection by predators difficult. The result is that predators often do not find large patches of krill and are rarely able to maintain contact through space and time with patches that they have found. In addition, we have found little correlation between the numbers of birds feeding at a krill patch and the biomass of the patch. Finally, we suspect that differences in the spatial and temporal scales over which the population dynamics of these predators and prey operate further attenuates and complicates the correlation between them. For example, it is likely that because the range covered by krill stocks and they circulate through broad areas of the Southern Ocean is much larger than the foraging ranges of many nesting seabirds. Therefore, annual changes in krill availability on the scale of the foraging ranges of the seabirds, and the potentially large effects those changes could have on the reproductive success of the latter, may be due to fluctuation in the circulation pattern of the krill stocks and have little to do with changes in the size or condition of the stock.

Understanding the linkage between seabirds and krill is important for three reasons. First, it is necessary to the interpretation of changes in the population- and tropho-dynamics of seabirds, in view of their proposed use as indicators of the health of krill stocks and the ecosystem. Second, it is required to predict what the effect of changes in the condition, size and/or range of krill stocks will be on seabird populations. Third, understanding this linkage is critical to our understanding of the ecology of the key species, krill, in the Antarctic ecosystem. Fourth, a mechanistic understanding of how birds exploit krill is of general interest in the context of foraging theory. Our studies have been efforts to begin to uncover the nature of the relationship between foraging marine birds and mammals, and their major prey, krill.

This survey was designed to meet three goals. The first goal was to obtain a finer spatial resolution to our measurement of the association and correlation between the distributions of krill specialists and krill, than we were able to achieve in our previous studies. This was accomplished by coordinating our sampling with the hydro-acoustic survey being conducted by Dr. Michael Macaulay, and later interfacing the two data sets. In our previous studies, resolution in the hydro-acoustic data set was limited to krill density estimates in one nautical mile intervals along a trackline, which limited the predator survey data the same resolution. Because patches of krill and predators were most often much less than 1 nm in diameter, apparent associations between predators and krill may have been spurious because the patches may have been widely separated within the mile intervals. We were able to largely eliminate this problem, because in the current hydro-acoustic survey krill densities were integrated over 1 min intervals, which correspond to 200-300m intervals of trackline. In addition, other differences in the hydro-acoustic survey techniques, such as transducer depth and integration depth intervals, should help to eliminate additional sampling problems that occurred in our previous studies.

The second goal was to determine the relationship between the characteristics of krill swarms (e.g. size and depth) and the composition and number of seabirds associated with the swarms.

Our third goal was to map the distribution of marine birds in the Drake Passage and Bransfield Strait. We were especially interested to find whether birds concentrated at oceanographic features such as slopes or fronts, and to compare the pattern we observe this year with those seen on previous cruises.

12.3 Accomplishments:

We conducted marine bird strip-transect surveys during every day of the leg, except when we were in enclosed waters (e.g. Beagle Channel), or at anchor. Observations were made from dawn to dusk, except during net tows. Normally observations were conducted from the flying bridge, but in fog or rain we moved to the bridge wings, bow or wheelhouse. We used 3 strip-transect protocols. For general observations we counted all birds seen in a 90deg arc from dead ahead to the beam and within 300m of the ship. When visibility was less that 300m or we were forced onto the bow or into the wheelhouse, we used a 100m wide strip. The primary survey protocol (special observations), which was used whenever the hydro-acoustic survey was being conducted, consisted of counting those birds that were on the water or feeding within 50m of the trackline and 100-300m ahead of the ship. The strip was centered on the trackline to give the greatest spatial congruence with the hydro-acoustic data, and the counting zone was centered 200m ahead of the ship to minimize the effects of ship-avoidance. One observer was used for General Observations and another for Special Observations. All data were entered directly into a Husky Hunter 208K hand-held, weather-proof microcomputer. At the end of each day the data were error checked, corrected and stored on floppy disks.

We collected 176 h of survey data over the 14.5 days that we were able to work; this amounted to 275 man/hours of sampling effort. We collected 53 h of general observations during the two crossings of the Drake Passage, and approximately 120 h of general observations and 106 h of special observations in the Bransfield Strait area. During these periods we covered 611, 1112, and 752 nm of trackline, for a total of 1723 nm of trackline, or 956 km2, surveyed during the leg.

We recorded 37 species of seabirds during the cruise, 26 on the Drake Passage crossings and 29 in the Bransfield Strait area. The distribution within the Bransfield Strait area of all species combined is shown in Figure 8. The most abundant species were Chinstrap Penguins, Antarctic Fulmars and Cape Petrels, all of which are krill specialists (100, 85 and 85% krill in their diets, respectively). The three largest concentrations of birds we saw were all close to the shelf-break to the north and northwest of Seal Island (Figure 8). A steep horizontal temperature gradient coincided with the shelf break near one of these concentrations (M. Huntley pers. comm.). During the Surveyor's intensive sampling of one very large krill swarm over the shelf to the north of Elephant Island, we observed that birds were concentrated only at a few isolated patches, despite the widespread distribution of krill within the upper 50m of the water column. This observation suggests that krill within a large swarm must be driven toward the surface by aquatic predators before they become available to many seabirds (e.g. especially the surface feeders), or that species that breed on the nearby islands, such as the abundant Chinstrap Penguin, did not need to come as far off shore as we were sampling because they encountered sufficient quantities of krill closer to shore.

These data will be matched with the digital representation of the krill density estimates from the hydro-acoustic survey when the latter are made available by Dr. Macaulay later this year. Already, we have evidence that the comparisons will show Chinstrap Penguins to be sensitive to the density and/or depth of krill concentrations. Figure 9 shows the number of Chinstrap Penguins recorded during special observations during a one hour period on the 28th of February between Elephant and Clarence Islands in relation to the target strength of the krill detected as a function of depth. We are confident that the krill patch displayed in Figure 9 consists of krill rather than other organisms because it was clearly reflected by pulses from the 120Khz and 200Khz transducers (M.Macaulay pers. comm.). Penguins were found in relatively large numbers, although not in every time interval, during the beginning and end of the hour. At that time krill swarms or dispersed krill were found in the top 50m of the water column. However, penguins were largely absent during the middle of the hour when krill were much less dense above 75m depth.

12.3 Disposition of Samples and Data:

All data are stored on floppy disks. One set will be kept by each of the principal investigators, Drs. Heinemann and Veit, at the Manomet Bird Observatory and the University of California at Irvine, respectively.

12.4 Tentative Conclusions:

We expect to be able to relate the distributions of patches of Chinstrap Penguins and krill swarms or concentrations on a very fine spatial scale. Because the hydro-acoustic equipment was unable to sample the water column above 10m depth, we will not be able to achieve this level of resolution for other non-diving species. The distribution of seabirds in the Bransfield Strait area appears to be similar to that which we recorded in 1985, and we will be able to compare the krill specialist versus krill correlations at scales of 1 nm and up between the two studies. The species composition of seabirds in the Drake Passage differed from data collected by Dr. Veit on crossing made from 1982-1985. Total bird density was lower, prions and Blue Petrels were much less numerous than in past years, and large numbers of diving-petrels, usually rare in Drake Passage, were seen.

12.5 Problems, Suggestions and Recommendations:

The SURVEYOR is nearly an ideal platform for this type of work. The officers and crew were extremely helpful in assisting in the collection of position and environmental data, and in providing custom-built equipment (e.g. a tray for the data-entry computer) to aid our surveying operations. In addition, the ship kindly provided access to its computing equipment and supplies (e.g. computer paper) for our use. In the future, we suggest that temporary modification of the flying bridge be made to reduce the problems created by strong winds coming from behind the beam, and rain. This would be desirable because we would not have to move to other viewing locations as much, thus eliminating an unwanted source of bias and variability in the data associated with variation in the height of the viewing position and the presence of visual obstructions.

13. Cephalopod Systematic and Taxonomic Studies, Leg II; Submitted by Michael Vecchione.

13.1 Objectives:

The objectives of this task were to (1) obtain morphometric measurements and photographs of freshly collected cephalopod specimens to determine changes that occur because of fixation and preservation and (2) collect specimens of Antarctic cephalopods, juvenile fishes, and decapod crustaceans for the U.S. National Collections at the Smithsonian Institution.

13.2 Accomplishments:

Specimens required to accomplish both objectives were to be collected using the MOCNESS system and midwater trawls which were to be used if time was available. Unfortunately, the MOCNESS system could not be deployed. Only one specimen, a postlarval *Brachioteuthis picta*, was collected using a bongo net. All ichthyoplankton collected on this leg are required for analyses, however, Dr. Valerie Loeb has agreed to provide a complete reference collection of Antarctic ichthyoplankton from material collected on previous Antarctic cruises.

13.3 Disposition of Samples and Data:

The single cephalopod specimen was retained by Vecchione for the Smithsonian collection. Dr. Loeb will send the ichthyoplankton reference collection to the Smithsonian.

ANCILLARY DATA COLLECTIONS AND CONTACTS

A continuous record of sea surface temperature and salinity was maintained and stored on floppy disk by Ensign Gary May. This record was subsampled every 10 minutes and a hard copy transcript was given to Lee Waterman of NOAA's Air Resources Laboratory. The data, on magnetic format, was released to the Chief Scientist.

CTD casts were obtained at 9 stations in Wilhelmina and Flandres Bays and at 48 stations in the waters surrounding South Georgia; replicate CTD's were taken at 2 South Georgia stations for a total of 59 casts. The instrument used was a Seacat SBE 19 manufactured by Sea-Bird Electronics, Bellevue, Washington. The data were recorded in situ and downloaded to a portable computer by the Chief Scientist.

An annotated position log was prepared by Lieutenant Commander Craig Berg, Operations Officer, and distributed to the scientific party in both hard copy and electronic formats. The log, containing over 1700 positions, will enable us to reconstruct the entire cruise and be of invaluable assistance in resolving discrepancies and ambiguities in the various field records.

Bridge weather logs were also reproduced by Ensign Julia Nichols and distributed to the scientific party.

An unsuccessful attempt was made to recover a dissolution experiment from a site on the Galapagos Rift for Dr. Lowell Fritz, Rutgers University.

Several contacts were made during the course of the cruise including: Dr. Tony Inderbitzen, National Science Foundation representative at Palmer Station; Chip Kennedy, head of Peninsula Operations for ITT's Antarctic Services; John Croxall, Senior Scientist for the British Antarctic Survey at Bird Island, South Georgia; and Major Phillip Jennings, Commander of the British Army garrison at King Edward Point, South Georgia. Captain Stubblefield presented ship's plaques to the Chilean Hydrographic Institute in Valparaiso, to Palmer Station, to the British Antarctic Survey station at Bird Island, and, in accordance with local custom, to the gravesite of Sir Ernest Shackleton, a well-known British Antarctic explorer.

INCIDENTS AND BREAKDOWNS

The cruise plan was designed to exploit the capabilities of the SURVEYOR and we were not disappointed; in fact, productivity exceeded expectations for all activities. Two shortcomings, however, did limit some of the work. The first was the failure of the clean salt water supply to operate uninterrupted in a seaway; presumably this was due to inappropriate placement of the intake pipe. The second limitation was imposed by only 750m of usable wire on the winch used to deploy the sampling nets instead of the 1000m originally requested. These were not serious impediments, however, and sampling procedures were easily adjusted.

The ice seal studies were conducted in a productive fashion without any adverse incidents. When the ship was tending the small boat in areas of concentrated bergy bits and sea ice, little risk to the ship was perceived as long as forward way was maintained. The Command, however, would have felt more comfortable if he had been specifically authorized to exercise personal judgement, risk notwithstanding. It is highly recommended that a policy on entering ice areas be established prior to future deployments.

In future seasons, the Antarctic Marine Living Resources program will very likely continue to sample all life stages of fish. This will require the use of plankton tows, MOCNESS samplers, midwater trawls, and bottom trawls as well as adequate deck machinery for their deployment, deck space for gear storage and staging, and lab space for sample processing and storage. In its current configuration the SURVEYOR is less than ideal for fish sampling. A J-frame with a least 20' of vertical deck clearance, a winch (or winches) with more pulling capacity, and additional lab space for sample processing and storage would greatly enhance the efficiency of operations. Practical solutions to these problems have been suggested in a memo from Izadore Barrett, Science and Research Director, to Sigmund Petersen, Director, Pacific Marine Center dated March 22, 1989.

A helicopter could not have been used to enhance the operations to any great extent. The only operations that could have employed a helicopter were the transfer of people and cargo at Seal Island and the ice seal studies. Both activities were conducted during the first 10 days of the cruise; people were also transferred on the last day of field operations. If small boat landing conditions were adverse, cargo could have been transferred to the island by helicopter assuming adequate visibility for flight operations. Because a time window was allowed for the transfer operations, other activities were conducted while waiting for workable conditions with little loss of productivity. A helicopter could also have been used in lieu of a small boat for the ice seal studies assuming adequate visibility and sufficiently stable ice floes for landing; however, little gain in productivity would have been realized. Fog was encountered with limited visibility during 30% or more of the time spent on both of these activities. Neither of the Cruise Leaders nor the Command is of the opinion that the marginal gains realized from a helicopter early in the cruise would be worth the costs of deployment for the full cruise. The loss of deck space to a helicopter and associated equipment, on a vessel already limited by useful staging areas, would further inhibit operations. And finally, the loss of ship stability, imposed by the addition of a helicopter and its fuel, would reduce the endurance of the SURVEYOR and require shorter cruise legs.

SCIENTIFIC PARTY

Leg I

Cruise Leader:
  Dr. Roger Hewitt, Southwest Fisheries Center
Seal Island resupply and ice seal studies:
  Dr. John Bengtson, National Marine Mammal Laboratory
  Lisa Ferm, National Marine Mammal Laboratory
  Harriet Huber, National Marine Mammal Laboratory
  Mike Goebel, National Marine Mammal Laboratory
  Steve Osmek, National Marine Mammal Laboratory
Ichthyofauna survey at South Georgia:
  Dr. Valerie Loeb, Moss Landing Marine Laboratories
  James Brennan, Moss Landing Marine Laboratories
  David Shafer, University of Hawaii
  James McKenna, University of Rhode Island
  Kathleen McKenna, Environmental Protection Agency
  Chris Christensen, University Of Rhode Island
  Stephen Berkowitz, Texas A&M University
CO_2 sampling:
  Lee Waterman, NOAA Air Resources Laboratory
Seabeam transects:
  Chris Small, University of Texas Institute for Geophysics
Bird and Marine Mammal Observations:
  Dawn Breese, University of California at Irvine

Leg II

Cruise Leader:
  Dr. Rennie Holt, Southwest Fisheries Center
Acoustic krill survey:
  Dr. Michael Macaulay, University of Washington
  Kendra Daly, University of Washington
  Pat Morrison, University of Washington
  Dr. Adrian Madirolas, INIDEP, Argentina
Direct krill sampling:
  Dr. John Wormuth, Texas A&M University
  Dr. Chul Park, Texas A&M University
  Dr. Valerie Loeb, Moss Landing Marine Laboratories
Krill growth rate:
  Dr. Mark Huntley, Scripps Inst. of Oceanography
  Daniel Gross, San Diego CA
Bird and mammal observations:
  Dr. Dennis Heinemann, Manomet Bird Observatory
  Dr. Richard Veit, University of California at Irvine
  Michael Payne, Manomet Bird Observatory
Cephalopod observations:
  Dr. Michael Vecchione, National Systematics Laboratory
Seabeam transects:
  Dr. David Sandwell, University of Texas
  Keith Klepeis, University of Texas

ACKNOWLEDGEMENTS

Leg I

The scientific party extends its heartfelt appreciation to the Captain, officers and crew of the NOAA Ship SURVEYOR for their professional attitude and integrity without which this cruise would not have been the resounding success that it was. This was the first time that a NOAA vessel had worked in the Antarctic; short preparation time, last minute personnel changes and deployment of unfamiliar gear only added to the challenge. In particular, Captain William Stubblefield set the stage with a "can do" attitude for the project. Commander Ron Jones extended us the full hospitality of the SURVEYOR. Lieutenant Commander Craig Berg mustered the ship's resources to make our plans become a reality. Chief Boatswain King Claggett helped us rig our gear, develop our deployment procedures and loaned us hardware. Chief Engineer Brian Yelland repaired our equipment and made sure that the deck machinery responded to our somewhat excessive demands. Chief Steward Boyd Quinanola graciously accepted our excess specimens and prepared them for the table. Mark Bailey, Karen Dunning, and Laurie Baker from the Survey Department pitched in and willingly became competent biological technicians. The deck officers adjusted to very different sampling protocols and record keeping requirements. Wally Heblich and Mike Conway, the winchmen standing arduous port and starboard watches during the second half of the cruise, were always alert, competent and helpful. Brenda Houston, Carol Carroll and James Gray, our stewards, couldn't have been more considerate. And the entire crew made us feel welcome from the first night we met them in Punta Arenas to the last day of the cruise. This was much more than we expected and we owe our success partly to the extraordinary weather, partly to the capabilities of the ship, but mostly to the exceptional people that work aboard the SURVEYOR.

Leg II

The scientific party are extremely grateful for the dedication and professional devotion of the Captain, Officers and crew of the SURVEYOR. Because of their attitude and eagerness to assist all aspects of the scientific work, the cruise was completed successfully. It was a pleasure to work with this Command. All officers and departments provided support in a timely and courteous manner. We would especially like to thank OSD S. Dudley and DU R. Gladden who completed several trips to Seal Island to remove the scientific party and all supplies and equipment. It was a delicate operation which required a great deal of skill and perseverance. Finally, the success of the cruise was made possible by LCDR C. Berg's initiative and organization. We have never had the pleasure of having the assistance of an Operations Officer who was more eager to ensure that the science was accomplished in the most efficient manner possible.

FIGURES

1. Leg I trackline and ice seal study areas, Scotia Sea and Bransfield Strait.
2. Trackline and station sites, South Georgia.
3. Tectonic diagram of the Scotia Sea region.
4. Seabeam tracklines for Leg I and Leg II.
5. Leg II trackline and bongo sampling stations.
6. Spatial distribution of chlorophyll-a.
7. Spatial distribution of surface temperature.
8. Spatial distribution of bird density.
9. Spatial correlation of chinstrap penguins and acoustic echos from krill.

Figure 1. Leg I trackline and ice seal study areas, Scotia Sea and Bransfield Strait.

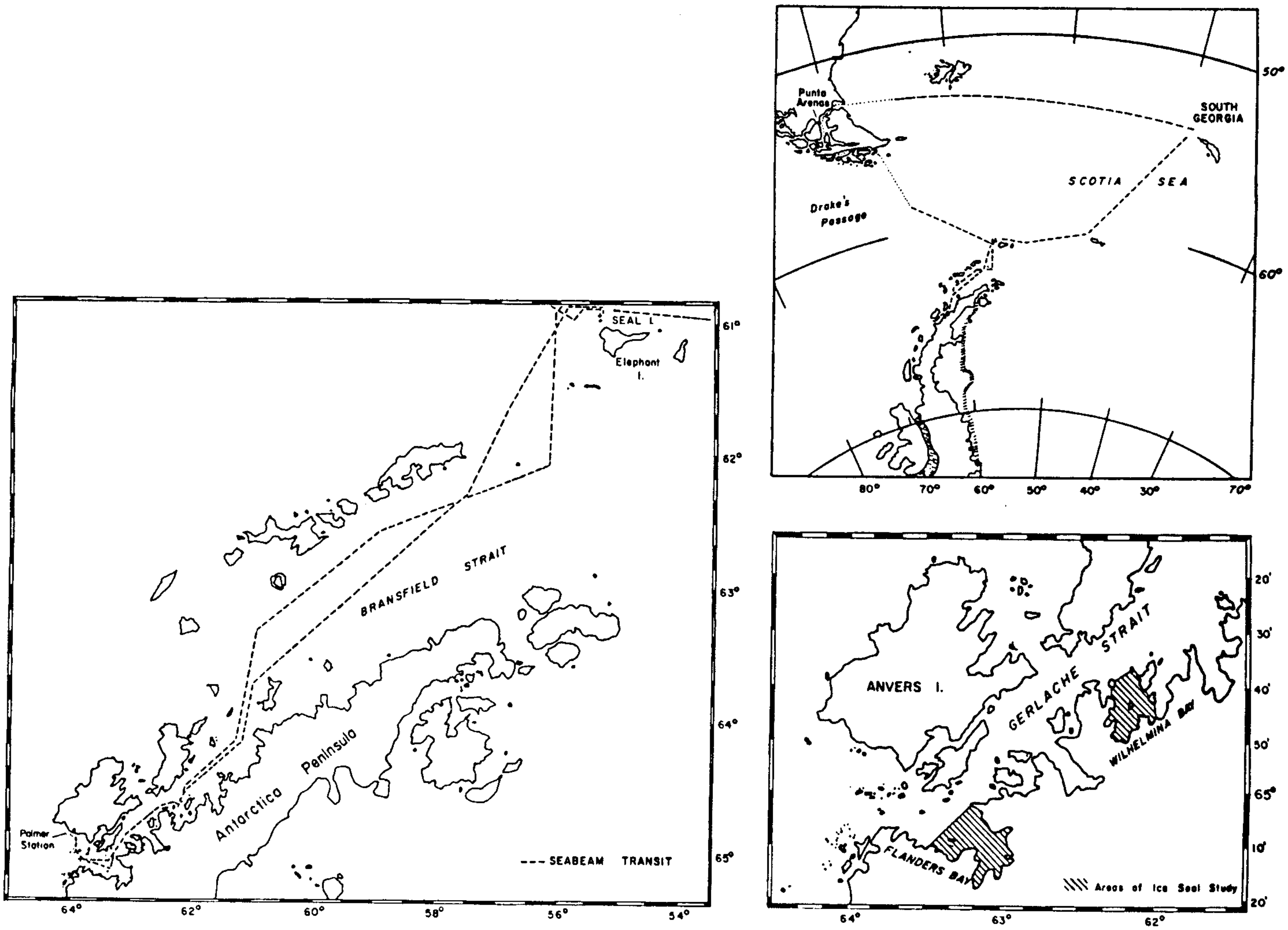

Figure 2. Trackline and station sites, South Georgia.

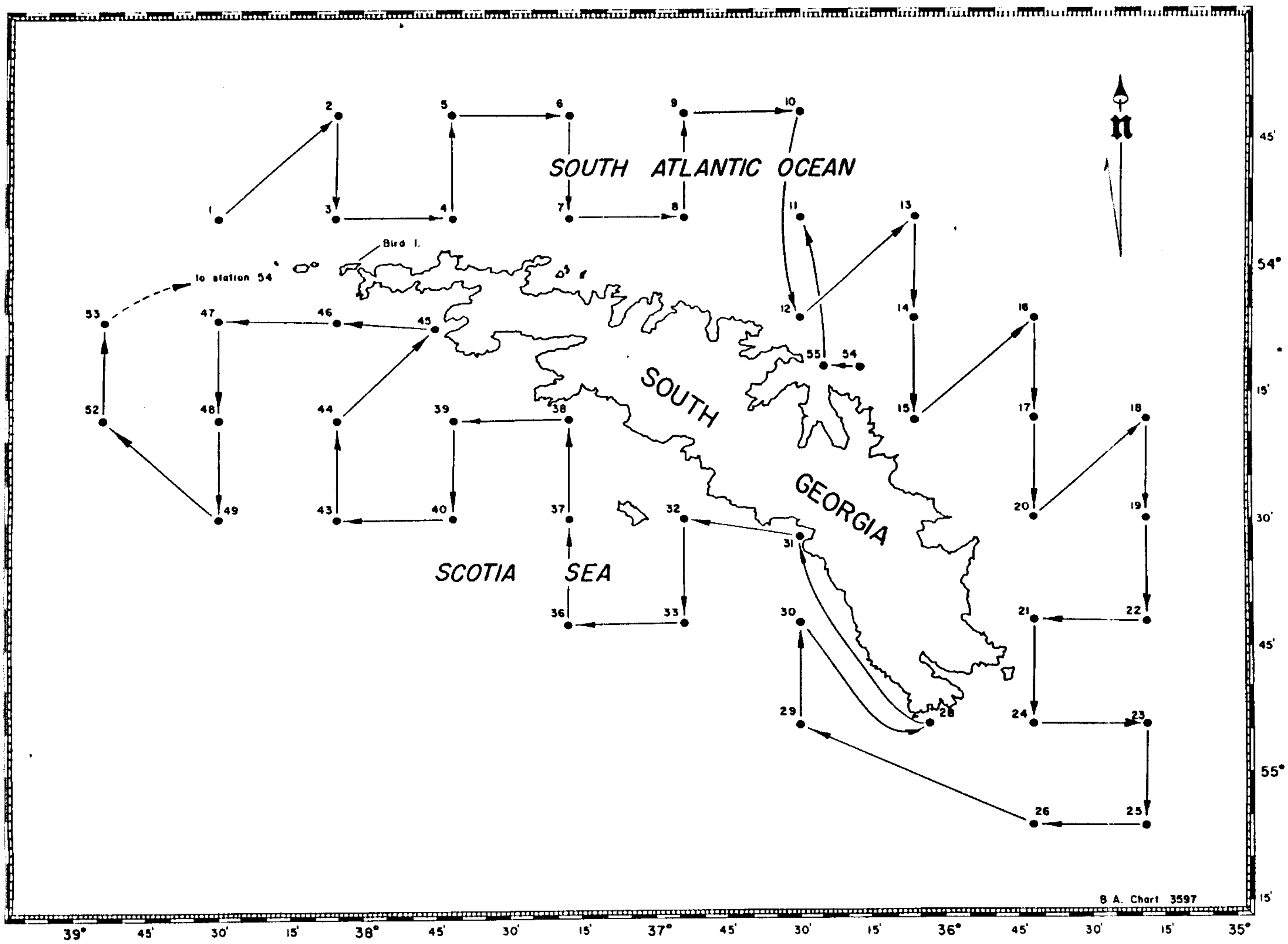

Figure 3. Tectonic diagram of the Scotia Sea region. The major tectonic features are: the Shackleton Fracture Zone (a strike-slip/compressional boundary between the Antarctic, Scotia and Drake Plates), the South Scotia Ridge (a strike-slip boundary between the Scotia and Antarctic Plates) and the north Bransfield Basin (a spreading ridge boundary between the Antarctic and Scotia Plates). Elephant and Seal Islands formed at the triple junction of these major tectonic boundaries.

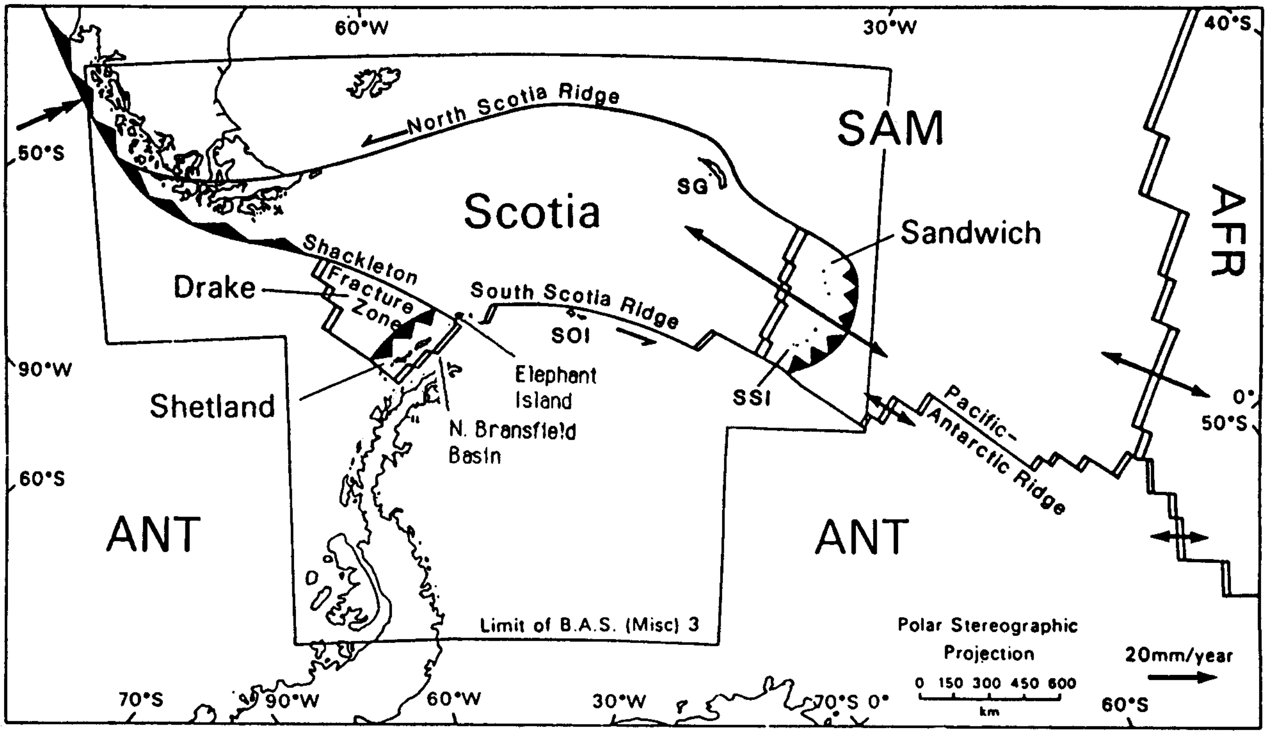

Figure 4. Tracklines for Leg I (dotted line) and Leg II (dashed line). Seabeam coverage is complete along all deep-water tracks (>500m). Significant surveys include: 3 transects along Shackleton FZ with Seal and Elephant Islands, and a trackline following an ascending GEOSAT altimeter profile.

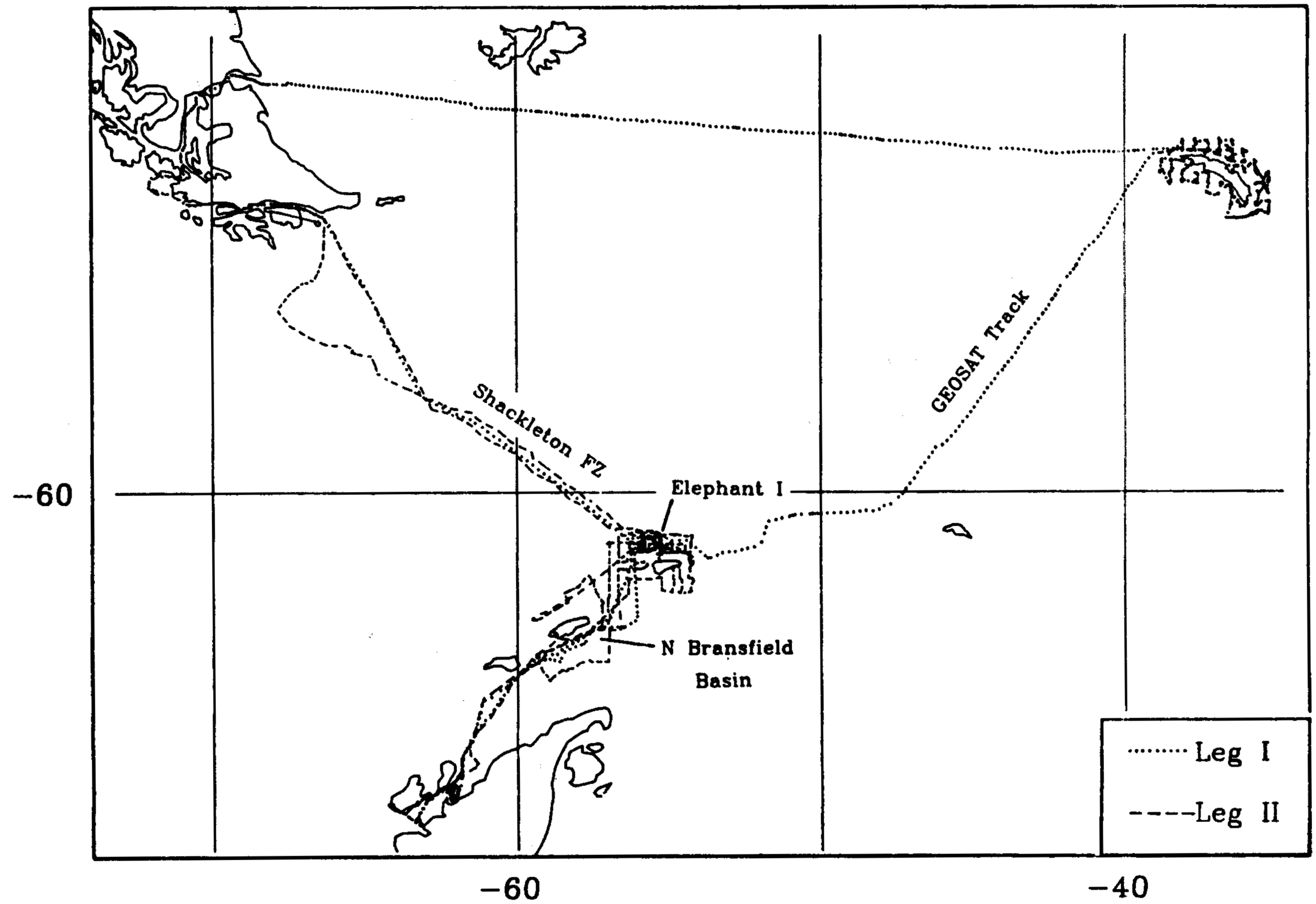

Figure 5. Leg II trackline and bongo sampling stations.

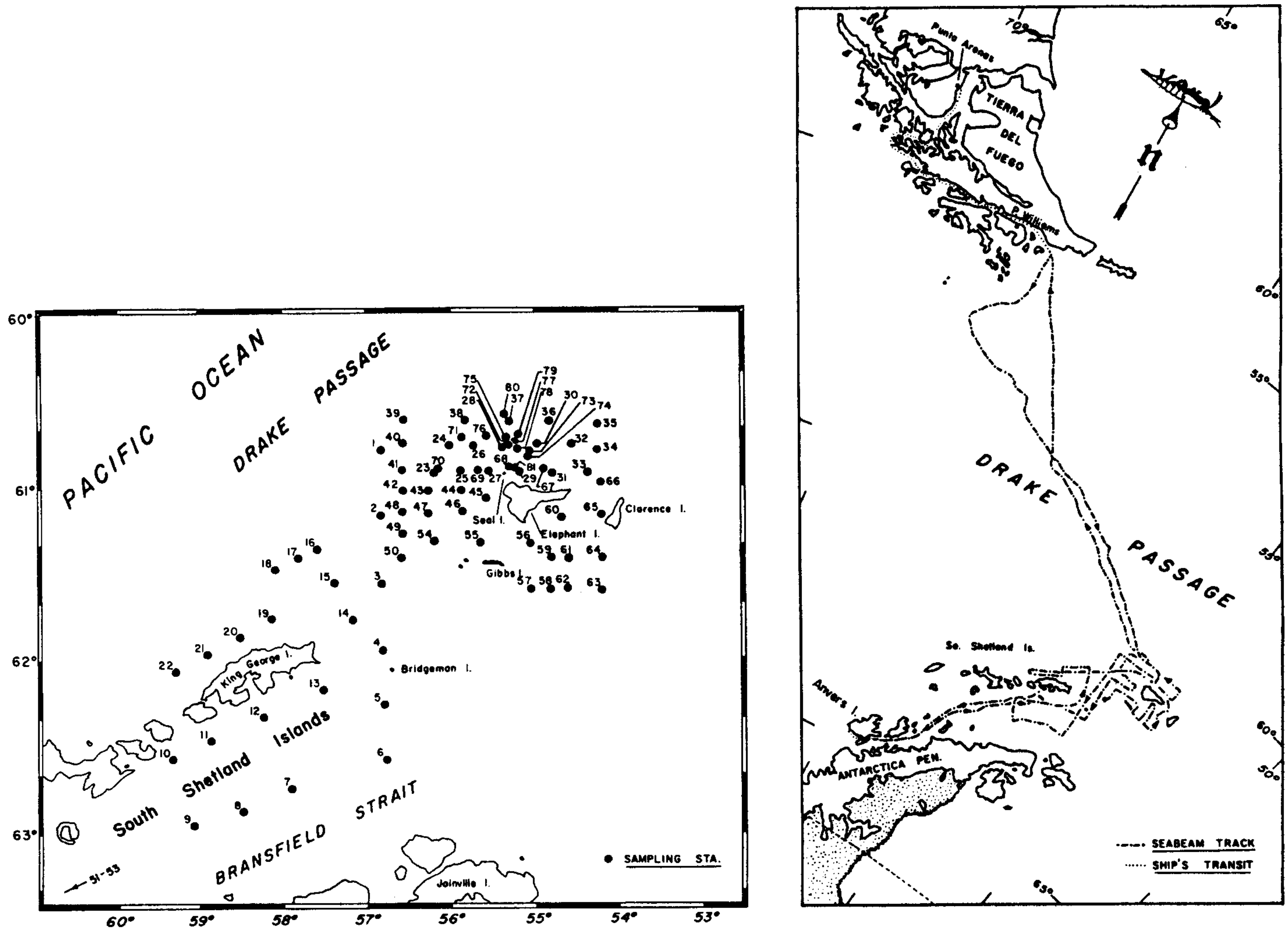

Figure 6. Spatial distribution of chlorophyll-a.

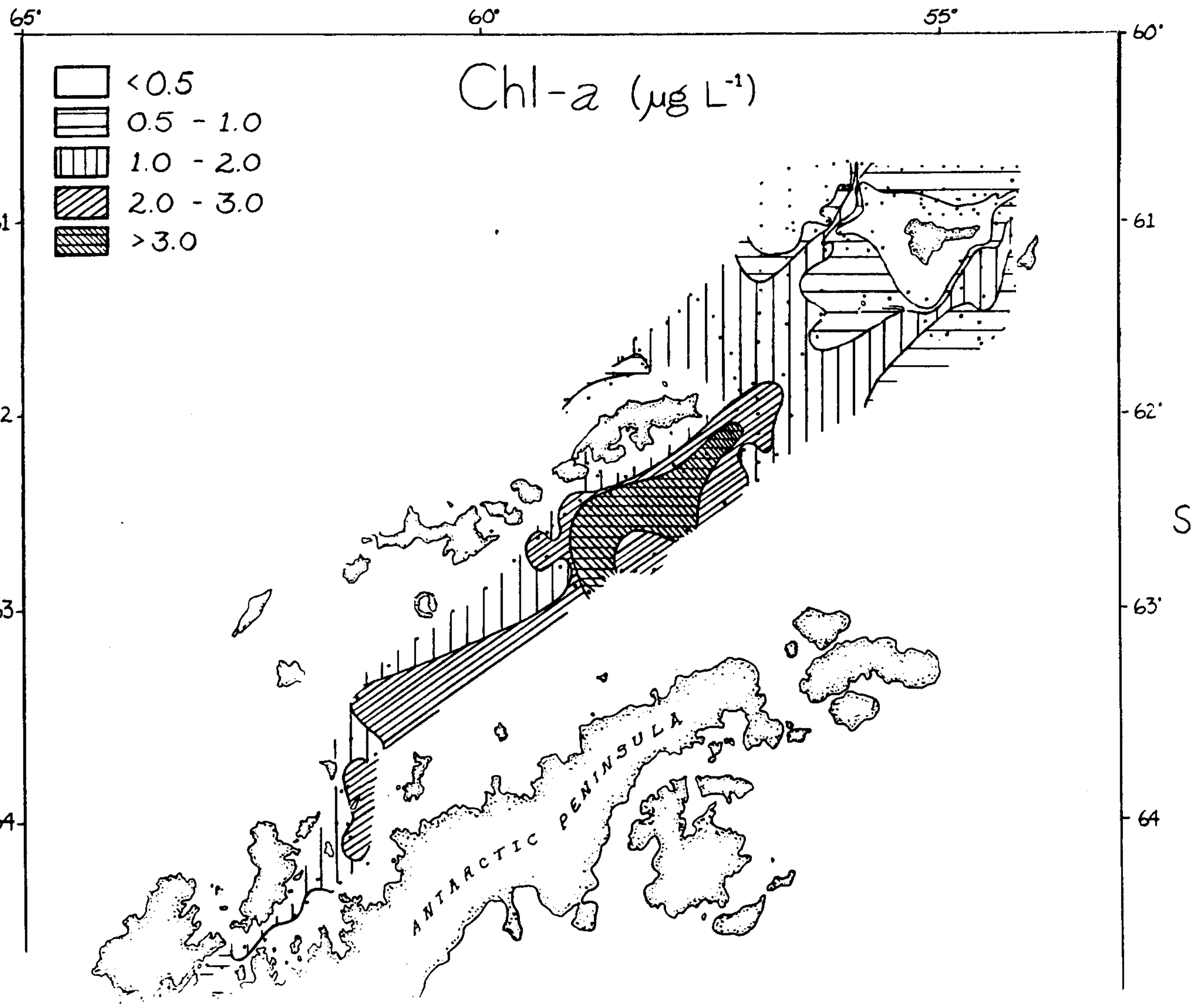

Figure 7. Spatial distribution of surface temperature.

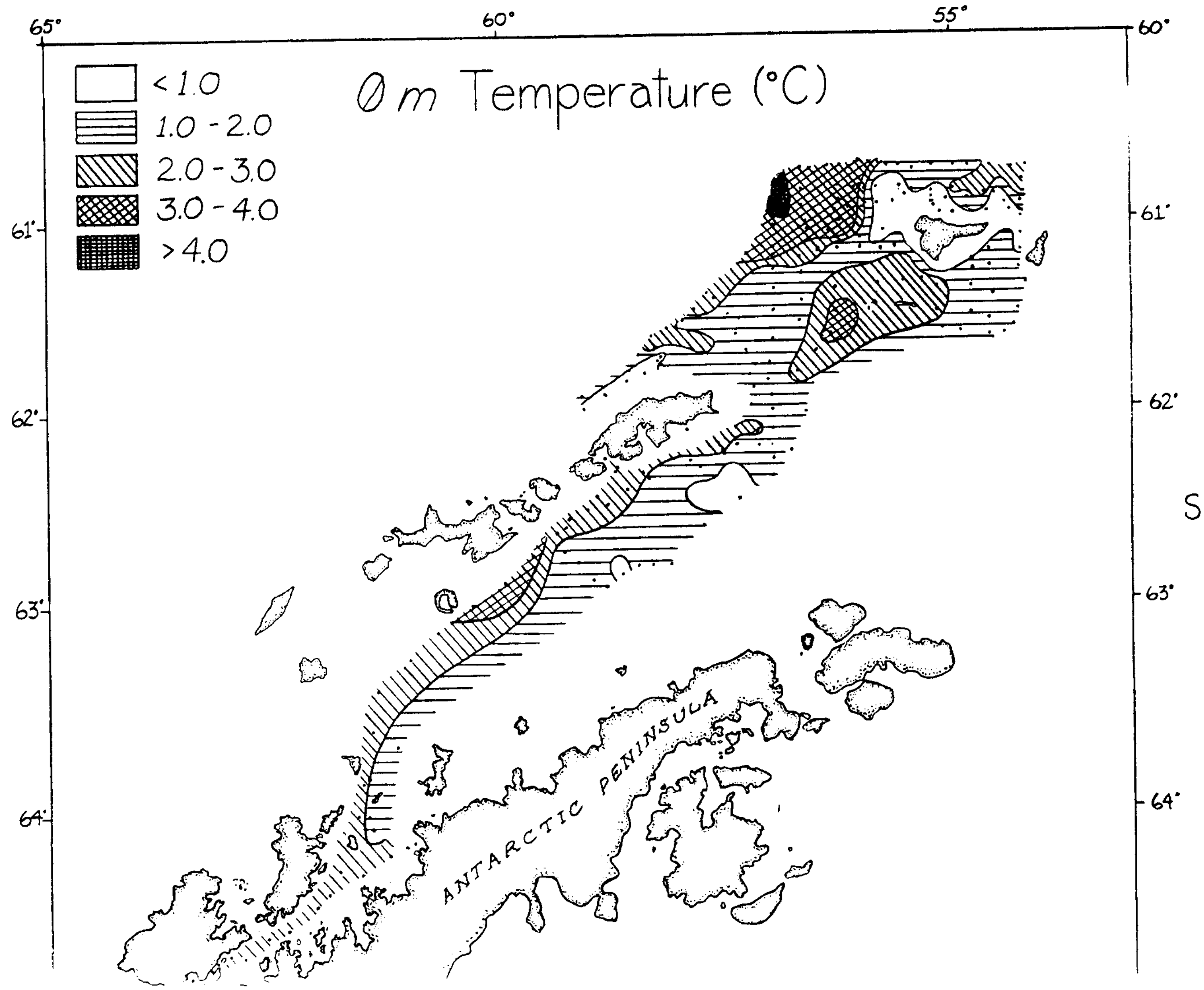

Figure 8. Distribution of total bird density in Bransfield Strait and Drake Passage, 15 February - 1 March 1989. The highest concentrations of birds were located at the shelf break north of Elephant and King George Islands; the largest of these was near the inshore end of a submarine canyon.

Figure 9. Numbers of chinstrap penguins and target strength of echo returns from krill during a one-hour period on February 28 between Elephant and Clarence Islands. Chinstrap penguin numbers are shown for three-minute intervals as bars at the top of the figure. The horizontal lines below the penguin bar graph represent the surface, 50m and 100m depths. The amount of krill is proportional to the amount of black on the echo-gram shown below the bar graph. Solid black areas represent dense krill swarms, and "stippled" areas represent dispersed krill; white areas had no detectable krill.