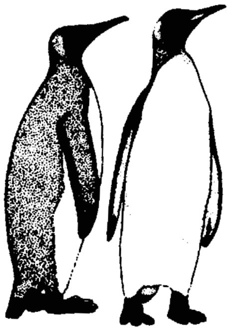

UNITED STATES
AMLR ANTARCTIC MARINE LIVING RESOURCES PROGRAM

AMLR 1996/97 FIELD SEASON REPORT

Objectives, Accomplishments and Tentative Conclusions

Edited by
Jane Martin

July 1997

ADMINISTRATIVE REPORT LJ-97-09

Southwest Fisheries Science Center
Antarctic Ecosystem Research Group

The U.S. Antarctic Marine Living Resources (AMLR) program provides information needed to formulate U.S. policy on the conservation and international management of resources living in the oceans surrounding Antarctica. The program advises the U.S. delegation to the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR), part of the Antarctic treaty system. The U.S. AMLR program is managed by the Antarctic Ecosystem Research Group located at the Southwest Fisheries Science Center in La Jolla.

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BACKGROUND

The long-term objective of the U.S. AMLR field research program is to describe the functional relationships between krill, their predators, and key environmental variables. The field program is based on two working hypotheses: (1) krill predators respond to changes in the availability of their food source; and (2) the distribution of krill is affected by both physical and biological aspects of their habitat. To refine these hypotheses a study area was designated in the vicinity of Elephant, Clarence, and King George Islands, and a field camp was established at Seal Island, a small island off the northwest coast of Elephant Island. For eight consecutive austral summers, shipboard studies were conducted in the study area to describe variations within and between seasons in the distributions of nekton, zooplankton, phytoplankton, and water zones. Complementary reproductive and foraging studies on breeding seals and penguins were also accomplished at Seal Island.

Because Seal Island was found to be unsafe due to landslide hazards, research at the field camp was significantly curtailed. Beginning this season, the AMLR study area was expanded to include a larger area around the South Shetland Islands, and a new field camp was established at Cape Shirreff, Livingston Island (Figure 1). Descriptive surveys of the pelagic ecosystem were conducted in the expanded AMLR study area, and studies on the reproductive success and feeding ecology of pinnipeds and seabirds were initiated at Cape Shirreff.

As in the past, research on the ecology of Adelie penguins was conducted at Palmer Station during the austral spring and summer.

SUMMARY OF 1997 RESULTS

Shipboard surveys were conducted on two legs in the AMLR study area between mid-January and late March 1997. Two major water zones were identified: Drake Passage and Bransfield Strait. A prevailing southwest to northeast flow was seen across the AMLR study area, with an eddy-like feature northwest of Elephant Island. The flow was most intense at the shelf-break near the 56°W meridian. Surface waters temperatures exceeded 4°C for the first time in eight years of AMLR surveys. The richest phytoplankton regions were found close to the continental shelf running in a northeasterly direction to the north of the South Shetland Islands and also in Bransfield Strait waters. The lowest phytoplankton concentrations were found in the northwest portion of the study area, including the northernmost new stations near Livingston Island, and in Weddell Sea waters in the southeastern portion of the study area.

The 1997 bioacoustic surveys revealed a discontinuous band of high krill density on the north side of the South Shetland Islands. The band tended to be north of the frontal zone running parallel to the archipelago, spreading onto the shelf near Elephant Island. Other areas of high density were mapped on the shelf near Livingston Island and in deeper water in the Bransfield Strait. A preliminary estimate of krill density was higher than the last five field seasons. Krill sampled with the Isaacs-Kidd Midwater Trawl (IKMT) demonstrated three size modes centered on 26-30 millimeters (mm) (1+ age group), 34-41mm (2+), and 49-52mm (3+). The female maturity stage composition suggested a prolonged 1996/97 spawning period, extending from mid-December through March. Moderate catches of krill larvae in mid-March suggested only moderate spawning success, despite the long duration of the spawning season. Excellent recruitment success of the 1994/95 year class (2+) was associated with above average sea-ice conditions during winters 1994 and 1995, and reflects early seasonal spawning activity and overwintering survival associated with such sea-ice conditions. Winter 1996 was characterized by average sea-ice conditions. Lower recruitment success of the 1995/96 year class (1+) supports the hypothesis that winter sea-ice extent affects larval survival and recruitment even when krill spawning is relatively early. Salp biomass concentrations in the Elephant Island area during 1997 were the largest observed since 1993 and 1994. Competition by salps for food resources may have reduced krill spawning efforts, while predation by salps on krill eggs and larvae may have greatly reduced their numbers.

On Seal Island, chinstrap penguins started fledging at a similar time compared to past seasons; the average fledging weight was slightly higher than those recorded in the last seven seasons. The estimated number of Antarctic fur seal pups was the second highest since the 1993/94 season. At the new Cape Shirreff camp, seabird studies were initiated by observing numbers and distributions of the seabird populations. Surveys of the area found 19 chinstrap penguin colonies, 6 gentoo penguin colonies, and 5 mixed chinstrap/gentoo penguin colonies. An initial 1000 chinstrap penguin chicks were banded for future demographic studies, and fledging weights were also recorded.

At Palmer Station, there was an 18.3% decrease in Adelie penguin population size relative to last season, which agrees with the predicted effects of a low ice year on overwinter survival. Breeding success of Adelie penguins was also down slightly, creching 1.47 chicks per pair or 0.14 chicks less than were creched last season. Conversely, there was a slight increase in the proportion of two-chick broods compared to last year. Also, the average fledging weight of sampled Adelie penguin chicks increased by 80 grams as compared to last season.

Using newly procured trawl equipment, seven bottom trawls were made at stations northwest of Robert and Nelson Islands, and west of Elephant Island. These trawls were conducted as part of a feasibility study for future surveys of finfish stock abundances. Four species dominated the trawl catches: *Notothenia coriiceps*, *Gobionotothen gibberifrons*, *Chaenocephalus aceratus*, and *Champsocephalus gunnari*. Overall, the new trawl equipment and the set-up aboard the R/V *Yuzhmorgeologiya* worked well.

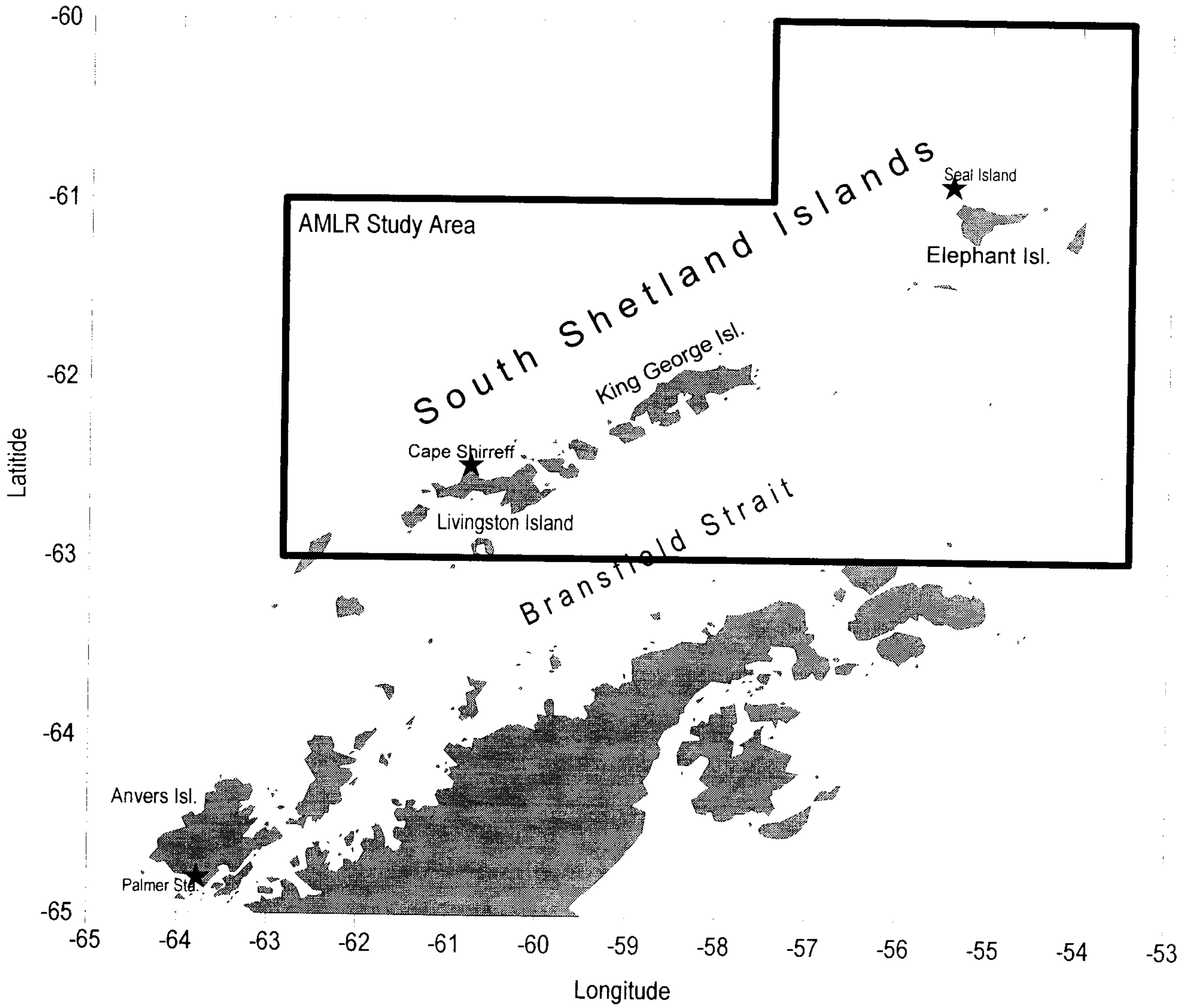

Figure 1. Locations of the U.S. AMLR field research program: AMLR study area, Cape Shirreff, Seal Island, and Palmer Station.

OBJECTIVES

Shipboard Research:

1. Map meso-scale (10's of kilometers) features of water mass structure, phytoplankton biomass and productivity, and zooplankton constituents (including krill) in the AMLR study area.
2. Estimate the abundance and dispersion of krill in the AMLR study area.
3. Conduct acoustic and net sampling surveys in Admiralty Bay, King George Island to describe krill demographic characteristics.
4. Collect continuous measurements of ship's position and heading, water depth, sea temperature, salinity, water clarity, chlorophyll, air temperature, barometric pressure, relative humidity, wind speed and direction, and solar radiation.
5. Provide logistical support to three land-based field sites: Copacabana field camp (Admiralty Bay, King George Island); Cape Shirreff (Livingston Island); and Seal Island.
6. Conduct bottom trawls at selected sites in the area around the South Shetland Islands as a feasibility study for future surveys.

Land-based Research:

Cape Shirreff
1. Weigh chinstrap penguin chicks at fledging.
2. Band 1000 chinstrap penguin chicks for future demographic studies.
3. Reconnoiter, census, and map seabird distributions as a requisite for designing future seabird studies.
4. Observe and assist with ongoing Chilean studies of Antarctic fur seals to plan future collaborative research.

Seal Island
1. Weigh chinstrap penguin chicks at fledging.
2. Record the presence of known-aged and previously-instrumented or handled seabirds and pinnipeds.
3. Record the abundance of Antarctic fur seals.

Palmer Station
1. Determine Adelie penguin breeding population size.
2. Determine Adelie penguin breeding success.
3. Obtain information on Adelie penguin diet composition and meal size.
4. Determine Adelie penguin chick weights at fledging.
5. Determine adult Adelie penguin foraging trip durations.
6. Band 1000 Adelie penguin chicks for future demographic studies.
7. Determine Adelie penguin breeding chronology.

DESCRIPTION OF OPERATIONS

Shipboard Research:

This year's cruise was conducted aboard the chartered Russian research vessel (R/V) *Yuzhmorgeologiya*. The ship departed for Leg I four days later than originally planned due to a delay in the arrival of the main AMLR cargo shipment. Despite the delay, all original objectives for Leg I were completed. Following Leg I, the ship was delayed 23 days in Punta Arenas due to the failure of the main engine. After repairs were completed, Leg II was conducted for 14 days with an abbreviated research plan, which included logistical support for the field camps, a very curtailed survey (Survey D), and bottom trawling.

Itinerary

Leg I:	Depart Punta Arenas	19 January 1997
	Exchange Personnel at Copacabana Camp	22 January
	Net Stations AB1 and AB2	23 January
	Acoustic Transducer Calibration	23 January
	Net Stations AB3 and AB4	24 January
	Cape Shirreff Operations	24-26 January
	Large-area Survey (Survey A)	27 January - 10 February
	Transfer Personnel, Cape Shirreff to Seal Island	10-11 February
	Arrive Punta Arenas	14 February

Leg II:	Depart Punta Arenas	13 March
	Seal Island Operations, CTD/IKMTs (Survey D)	16-18 March
	Copacabana Operations/Calibration	18 March
	Cape Shirreff Operations/Calibration	19 March
	Bottom Trawling, CTD/IKMTs (Survey D)	20-24 March
	Arrive Punta Arenas	26 March

Leg I.

1. The R/V *Yuzhmorgeologiya* departed Punta Arenas, Chile via the eastern end of the Strait of Magellan. Personnel were exchanged at the Copacabana field camp in Admiralty Bay, King George Island (M. Becker disembarked, W. Trivelpiece embarked).

2. Acoustic data and four net samples (Stations AB1, AB2, AB3, AB4) were collected in Admiralty Bay to describe krill demographic characteristics, complementing diet studies on Adelie penguins in the area (Figure 2).

3. Three acoustic transducers were calibrated in Ezcurra Inlet, King George Island. The transducers, operating at 38 kilohertz (kHz), 120kHz, and 200kHz, were hull-mounted and down-looking. Standard spheres were positioned beneath the transducers via outriggers and monofilament line. The beam patterns were mapped, and system gains were determined for all three transducers.

4. Building supplies and field team personnel were transferred to shore at the new Cape Shirreff field camp site.

5. A large-area survey of 106 Conductivity-Temperature-Depth (CTD)/carousel and net sampling stations, separated by acoustic transects, was conducted in the vicinity of Elephant, Clarence, King George Island, and Livingston Islands (Survey A, Figure 3). Acoustic transects were conducted at 10 knots, using hull-mounted 38kHz, 120kHz, and 200kHz down-looking transducers. Operations at each station included: (a) vertical profiles of temperature, salinity, oxygen, photosynthetically available radiation (PAR), light transmission, and fluorescence; (b) collection of discrete water samples at standard depths for analysis of chlorophyll-a concentration, primary production rates, inorganic nutrients, dissolved oxygen, photoadaptational state of phytoplankton, phytoplankton cell size and species composition, and phytoplankton biomass; and (c) deployment of an IKMT to obtain samples of zooplankton and micronekton.

6. A portable Acoustic Doppler Current Profiler (ADCP) was deployed at 5 meters (m) below the water surface at 99 of the large-area survey stations. The position and orientation of the instrument were recorded simultaneously, and the raw ADCP data were pre-processed aboard ship. The equipment was owned by the Korean Ocean Research and Development Institute (KORDI) and operated by Don Hyug Kang. Copies of data sets were retained by the AMLR program.

7. Field team personnel were transferred from Cape Shirreff to Seal Island.

8. Twenty-seven days of continuous underway measurements of ship's position and heading, water depth, sea temperature, salinity, water clarity, chlorophyll, air temperature, barometric pressure, relative humidity, wind speed and direction, and solar radiation were recorded.

Leg II.

1. The R/V *Yuzhmorgeologiya* departed Punta Arenas, Chile via the eastern end of the Strait of Magellan and arrived at Seal Island. The field team, equipment, and retrograded material were recovered from the island.

2. Sixteen CTD/IKMT stations, separated by acoustic transects, were conducted around Elephant Island (Survey D, Figure 4). Acoustic transects were conducted at 10 knots, using hull-mounted 38kHz, 120kHz, and 200kHz down-looking transducers. A Sea-Bird Seacat (with pH and oxygen sensors) was used for the CTD casts, but with no attached water-sampling bottles. Operations at each station included: (a) vertical profiles of temperature, salinity, dissolved oxygen, and pH; and (b) surface water samples (obtained by bucket) for measurement of pH, oxygen, and alkalinity.

3. Personnel (M. Becker and L. Taylor), equipment, and trash were recovered from Copacabana camp in Admiralty Bay; the camp was closed for the winter.

4. The hull-mounted transducers were calibrated in Ezcurra Inlet, Admiralty Bay and also while at anchor at Cape Shirreff, Livingston Island. Similar methods to the first calibration were used to calibrate the 38kHz and 120kHz transducers, but rough seas precluded the calibration of the 200kHz transducer.

5. Equipment and materials were delivered to the new Cape Shirreff field camp, while trash and retrograded equipment were removed. The camp was closed for the winter.

6. Seven bottom trawls were conducted using the AMLR program's new trawl gear at stations northwest of Robert and Nelson Islands, and west of Elephant Island. The R/V *Yuzhmorgeologiya* returned to Seal Island to secure the camp for the winter.

7. Similar to Leg I, 14 days of continuous underway measurements were recorded.

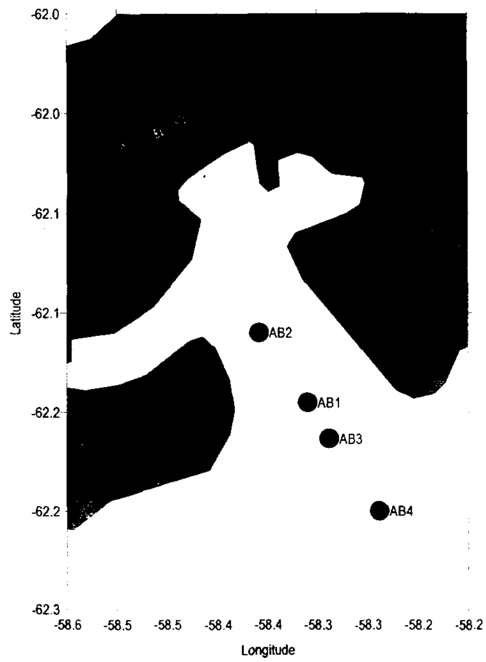

Figure 2. Admiralty Bay Stations: AB1, AB2, AB3, AB4.

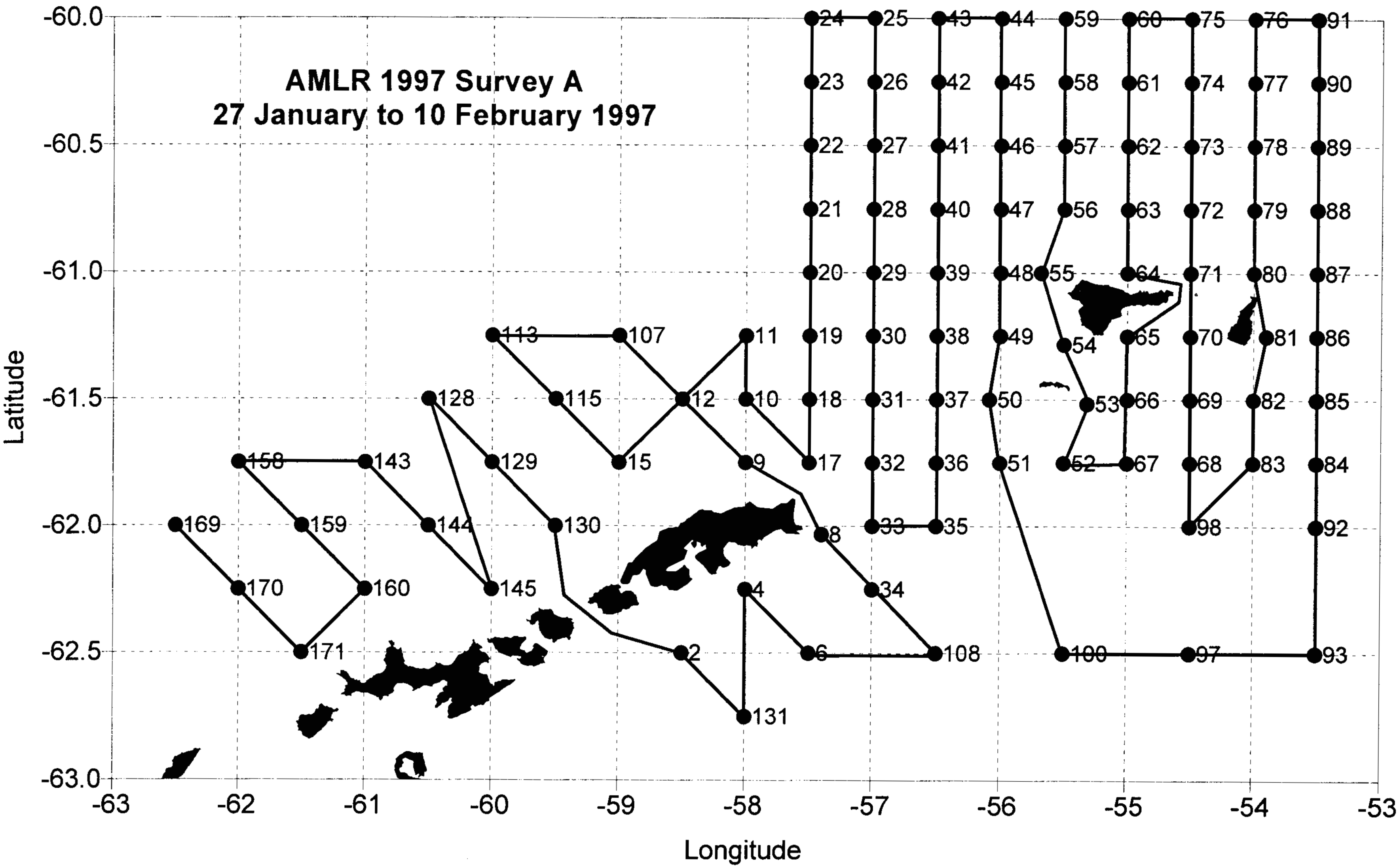

Figure 3. The large-area survey (Survey A), conducted on Leg I in the vicinity of Elephant, Clarence, King George, and Livingston Islands.

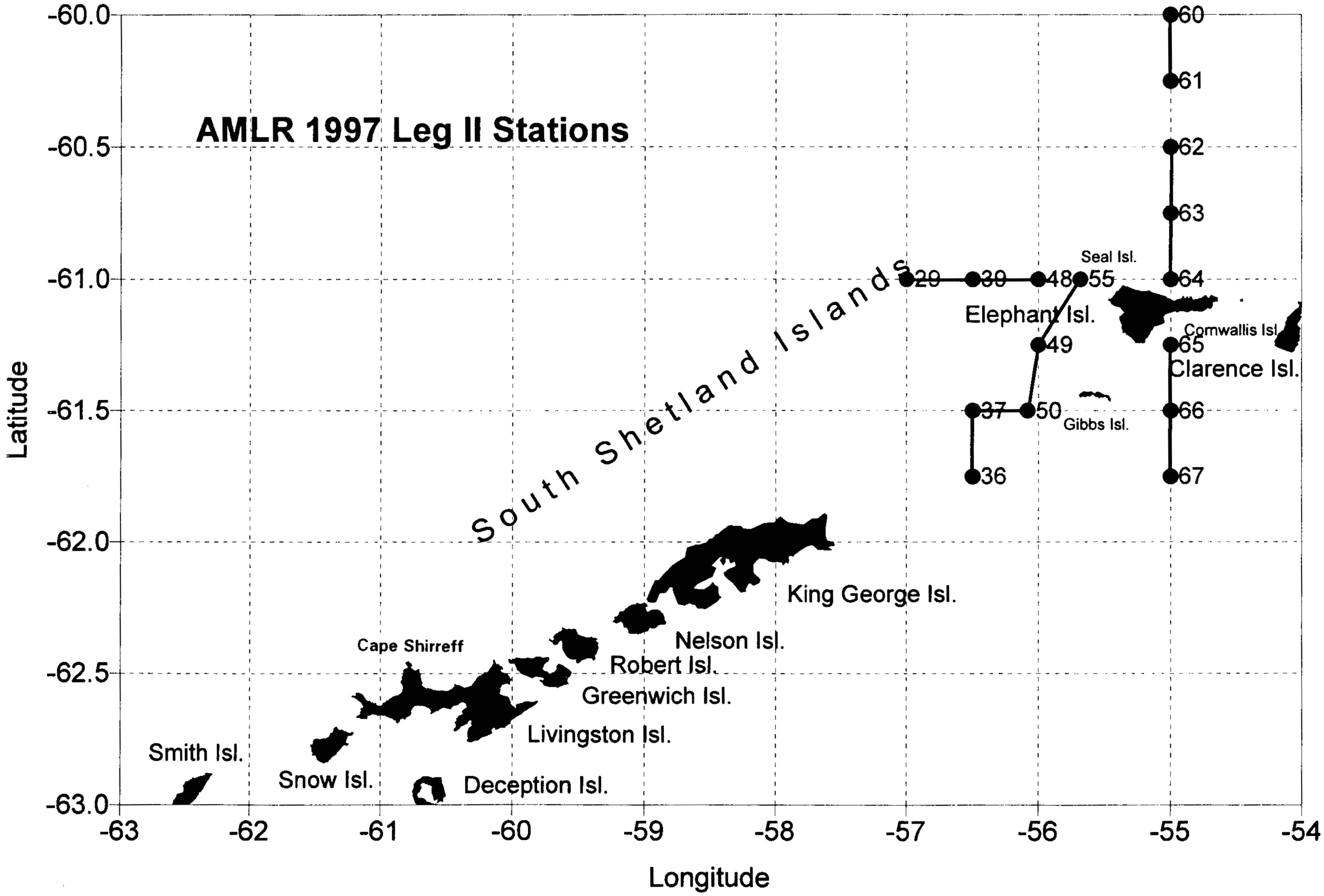

Figure 4. Sixteen CTD/IKMT stations and acoustic transects (Survey D), conducted on Leg II in the vicinity of Elephant Island.

Land-based Research:

Cape Shirreff

1. A six-person field team (W. Cobb, R. Holt, D. Marks, M. Stiehr, T. Stiehr, and W. Trivelpiece) arrived at Cape Shirreff, Livingston Island, on 25 January 1997 via the R/V *Yuzhmorgeologiya*.

2. Approximately 100 Zodiac loads of building materials were transferred from the R/V *Yuzhmorgeologiya* to Cape Shirreff. These materials were used for construction of four structures at the new field camp.

3. All breeding colonies of chinstrap and gentoo penguins in the Cape Shirreff rookery were censused in early February; colonies were marked with numbered wooden stakes and their positions plotted on a map of the region.

4. Nesting territories of brown skuas were located; 16 chicks and 3 adults were banded in these territories.

5. One thousand chinstrap penguin chicks were banded in early February for future demographic studies.

6. Fledging weights of 214 chinstrap penguin chicks were recorded 18-26 February.

7. The field team assisted Chilean colleagues in the capturing and weighing of Antarctic fur seal pups.

8. Three field team members (W. Cobb, R. Holt, and D. Marks) embarked the R/V *Yuzhmorgeologiya* on 10 February for transport to Seal Island. Refuse from the Cape Shirreff camp was also transported to the ship for disposal in Chile.

9. Due to uncertainties in the schedule of the R/V *Yuzhmorgeologiya*, three field team members (M. Stiehr, T. Stiehr, and W. Trivelpiece), as well as two Chilean personnel, were recovered from Cape Shirreff on 8 March by the National Science Foundation (NSF) R/V *Polar Duke* for transport back to Chile.

Seal Island

1. A four-person field team (W. Cobb, R. Holt, D. Marks, and J. Sterling) arrived at Seal Island on 11 February 1997. The team dismantled a small fiberglass structure, observation blinds, and antenna towers, and packaged the materials for removal from the island. Other routine maintenance at the Seal Island camp, including reinforcing walls exposed to rock falls, was also conducted.

2. Fledging weights of 217 chinstrap penguins were recorded 14-18 February.

3. Opportunistic resights of previously-banded chinstrap and macaroni penguin chicks were conducted.

4. A count of Antarctic fur seal pups in two study areas on the island was conducted on 14 February.

5. Opportunistic resights of previously-tagged fur seals were conducted.

6. The field team, supplies, and equipment were recovered from Seal Island on 16 March, and the camp was closed for the winter on 21 March.

Palmer Station

1. Field work at Palmer Station was initiated on 28 September 1996 and terminated on 15 April 1997.

2. One hundred Adelie penguin nests on Humble Island were observed from clutch initiation to creche to determine breeding success.

3. Breeding population size was determined by censusing the number of breeding pairs of Adelie penguins at 54 sample colonies during the peak egg-laying period (14-15 November).

4. The proportion of one and two Adelie penguin chick broods was assessed at 54 sample colonies between 7 and 8 January. Chick production was determined by censusing Adelie penguin chicks on 25 January at 54 sample colonies when approximately 2/3 of them were in the creche stage.

5. Fledging weights of Adelie penguin chicks were obtained at beaches near the Humble Island rookery between 2 and 18 February.

6. One thousand Adelie penguin chicks were banded as part of continuing demographic studies at selected AMLR colonies on Humble Island.

7. In conjunction with diet studies, adult Adelie penguins were captured and lavaged as they approached their colonies to feed chicks on Torgersen Island.

8. Thirty-six Adelie penguins breeding at the Humble Island rookery were fitted with radio transmitters; radio receivers and automatic data loggers recorded presence/absence data for these animals.

SCIENTIFIC PERSONNEL

Cruise Leader:

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David A. Demer, Southwest Fisheries Science Center (Leg II)

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Phytoplankton:

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Wesley A. Armstrong, Southwest Fisheries Science Center (Leg I)
Alistair Hobday, Scripps Institution of Oceanography (Leg II)
Matthew Nelson, San Diego State University (Leg I)
Dawn Outram, Moss Landing Marine Laboratories (Leg I)
Charles F. Phleger, San Diego State University (Leg I)
Kimberly Puglise, Moss Landing Marine Laboratories (Legs I and II)
Jeremy Sterling, University of California at Santa Cruz (Legs I and II)
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Vanesa Lopez, University of California at Santa Cruz (Leg I)
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Donna L. Patterson, Montana State University
John Carlson, Montana State University
Peter Duley, Montana State University
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Electronic Technician:

Jeffrey Hill, Pacific Marine Center (Legs I and II)

DETAILED REPORTS

1. Physical oceanography; submitted by Anthony F. Amos (Leg I), Andrea Wickham (Leg I), and Charles Rowe (Leg II).

1.1 Objectives: The physical oceanography component of the AMLR program provided the means to identify contributing water masses and environmental influences within the study area, as well as to log meteorological and sea surface conditions annotated by the ship's position. The instrumentation and data collection programs served as host to the other scientific components of the program. AMLR 97 is the eighth field season for the collaboration of physical measurements with biological studies.

1.2 Accomplishments: The large-area survey was expanded this year to include stations extending to the north of Livingston Island; some of the original 91 large-area survey stations were dropped.

CTD/Carousel Stations: One hundred and six CTD/carousel casts were made on Leg I (Survey A). For Leg II, 16 CTD casts were conducted at certain large-area survey stations (Survey D). Four hundred and ninety eight water samples were collected from the carousel bottles for analyses during Leg I (out of a total of 1166 water samples collected). Water from these were analyzed for micronutrient concentration, phytoplankton, chlorophyll-a, and dissolved oxygen by the phytoplankton group, and for salinity by the Russian scientific team. Salinity samples were analyzed aboard using a Guildline Autosal to verify the depth that each bottle tripped and to provide calibration data for the CTD conductivity sensor. The difference between the salinity measured by the Autosal and the CTD sensor was about 0.005, confirming the high accuracy of the CTD. Additional sensors on the CTD (fluorometer, transmissometer, and PAR sensor) functioned well, but problems were encountered with the dissolved oxygen sensor. Comparisons between dissolved oxygen data from the sensor and those from water samples (run aboard by the phytoplankton group with Winkler titration method) indicate that the sensor values were 18% lower than the water samples. This difference will be accounted for in the final analysis by applying a correction to the coefficients used in the calculation of dissolved oxygen from the raw oxygen current and temperature data provided by the sensor.

Underway Environmental Observations: Twenty-seven and 14 days of continuously acquired weather, sea temperature, salinity, water clarity, chlorophyll, and solar radiation data were collected during Legs I and II, respectively. Augmented with navigational data from a portable Global Positioning System (GPS) system and the ship's gyro compass output, these data provided complete coverage of surface environmental conditions encountered throughout the AMLR study area.

1.3 Methods:

CTD/Carousel: For the large-area survey on Leg I (Survey A), water profiles were collected with a Sea-Bird SBE-9/11 PLUS CTD/carousel water sampler. CTD profiles were limited to 750m depth (or to within a few meters of the ocean floor when the depth was 750m, or less). A Data Sonics altimeter was used to guide the CTD/carousel to within 5m of the bottom on the shallow stations. A Sea-Bird dissolved oxygen sensor, Seatech 25-centimeter beam transmissometer, Biospherical Instruments PAR sensor, and a Seatech *in situ* fluorometer (interfaced with the CTD/carousel unit) provided additional water column data on each station. Downtrace and uptrace CTD data for each station were recorded separately on Bernoulli drive removable cartridges (two 150 Mbyte drives). Data were collected at 24 scans/second on the downtrace and 6 scans/second on the up. All carousel bottles were fired during the upcast.

Raw CTD data were corrected for time-constant differences in the primary and oxygen sensors. Parameters were then derived and binned to produce 1-meter by depth averaged files for analysis. A sorted printout of the carousel bottle tripping sequence was produced so that sampling strategies could be adjusted immediately after the CTD/carousel unit was retrieved on deck. At each station, the current underway data were recorded to a disk and then transferred to the CTD computer; a log sheet was printed containing all the current meteorological and surface-water conditions. The log sheet included a diagram of the ship's heading and wind direction on-station and a map inset showing the location of the station.

For Leg II's abbreviated large-area survey (Survey D), CTD casts were conducted with a Sea-Bird Seacat (model SBE-16), which was deployed to a maximum depth of 250m. The Seacat unit included pH and oxygen sensors, but did not have attached water sampling bottles.

Underway Data: A GPS system (model Trimble NAVPAC II) was used to acquire navigational information without modifying the cable. The cable was run from the computer laboratory to an obstruction-free region near the port lifeboat station; nearly error-free operation was provided during both legs. A new Coastal Environmental Company Weatherpak system was installed and used as the primary atmospheric data acquisition system this year. All of these systems produced serial data, as did a Sea-Bird SBE-21 thermosalinograph for sea temperature and salinity data. The PAR sensor, transmissometer and flow-through fluorometer units produced analog data signals; they were sent to a new Fluke "Data Bucket" DVM/multi-channel data acquisition system, which itself outputs an RS232 message. A GTEK multi-port card was used to acquire all these data with the Data World computer.

1.4 Results and Tentative Conclusions:

Oceanography: As in past years, we classified and grouped stations with similar vertical temperature/salinity (T/S) characteristics. In previous field season reports, we called these station groups "water types," but to avoid confusion with the strict oceanographic designation of the same name, we will henceforth call them "water zones." Five water zones have been identified, designated I through V. It should be noted that the water zones are based on the T/S curves from the surface to 750m (or to the bottom in water shallower than 750m). For example, Water Zone I has the following characteristics: warm, low salinity surface water; a strong subsurface temperature minimum (called "Winter Water" at approximately -1 °C and a salinity of 34.0 ppt.); and a distinct T/S maximum near 500m (called "Circumpolar Deep Water" or CDW). Water Zone I is the oceanic water of the Drake Passage. In the Bransfield Strait and south of Elephant Island, Water Zone IV dominates. Water Zone IV has the following characteristics: bottom waters around -1 °C; and subsurface extrema that are far less prominent, although a slight "crook" in the curve is characteristic. In between, there are transition zones where adjacent water zones mix.

The composite T/S scatter diagram for all stations of Surveys A and D are shown in Figures 1.1a and 1.1b, respectively. An extraordinary feature of AMLR 97 was sea-surface temperatures exceeding 4 °C to the northwest of Elephant Island on Leg I (see Figure 1.1a). While the much-reduced station coverage on Survey D obviously prevents meaningful comparison with Survey A, the lower surface temperatures of Leg II are apparent (see also Figure 1.5a). In Figure 1.2, each panel shows the envelope (in grey) encompassing the T/S curves of all stations grouped by water zones (I through V). The depth-averaged mean of each water zone is shown as a solid black curve. The map insets show the location of those stations which display the T/S curve characteristic of its water zone. This makes it easier to envision the locations of the five water masses in the AMLR study area. Although considerable care has been taken to classify each station by water zone, these data are still preliminary as some stations are transitional. This particularly applies to Water Zone II, which is characterized by the evidence of isopycnal mixing of the CDW with shelf water. No data from Survey D can be included in Figure 1.2.

In Figures 1.3a and 1.3b, T/S curves have been plotted for each station in the AMLR study area for Survey A (Leg I) and Survey D (Leg II), respectively. The two major water divisions can clearly be seen for Survey A only, due to the limited coverage and depth of the Seacat unit used on Survey D. A dotted line is shown to delineate the border of Water Zone I from the other zones (the approximate boundary of the major front in the AMLR study area). Water Zone I dominates the area north of Livingston Island, which are new stations occupied for the first time during Leg I. Some transition stations and Water Zone IV stations are seen on the South Shetland continental slope and shelf here. New stations added in the Bransfield Strait fall into Water Zone IV, except for the extreme southeast where some influence of modified CDW can be seen. These have been classified in the Weddell Sea influenced Water Zone V. In Figure 1.3b, the Survey D stations are not deep enough to reveal the CDW and also show some "spikiness" (Station D63) due to the slower recording rate of the Seacat unit.

The dynamic topography of the region is shown in Figure 1.4. The implied flow at the surface relative to 500dbar is illustrated by streamlines with arrows pointing in the direction of flow. As usual, the major feature was the prevailing southwest to northeast flow across the entire AMLR study area. With the expansion of the large-area survey to include stations by Livingston Island, the dominance of this feature becomes readily apparent, as was the eddy-like feature northwest of

Elephant Island. This dynamic topographic high was a quasi-permanent feature of the flow in the AMLR study area and has been present on all AMLR cruises on both legs. A similar pattern was revealed by referencing the surface to 200m, so it is assumed that these patterns are reasonably representative of the mean flow in the upper water column. The flow was particularly intense at the shelf-break around the 56°W meridian. Parallel flow was seen south of King George Island in the Bransfield Strait, while another topographic high was seen between Elephant and Clarence Islands. There was also northward flow of some intensity along the eastern margin of the AMLR large-area survey grid. With the exception of the eddies, flow throughout the region was in a northeasterly to northerly direction.

The near surface temperature, salinity, and chlorophyll-a fluorescence for Survey A (Leg I) and Survey D (Leg II) are plotted in Figures 1.5a-1.5c. Data are from the underway environmental data system, rather than from the CTD, to increase the resolution. Temperatures measured by the Sea-Bird thermosalinograph have been corrected using the CTD surface values to correct for warming which occurred in the pipe leading from the intake at the bottom of the ship's hull (Figure 1.5a). This year on Leg I, surface waters exceeded 4°C for the first time in the eight years of AMLR (those years when surface conditions were monitored continuously). During "warm" years like 1993, temperatures above 3°C were occasionally found in the same region on Leg I, and more frequently on Leg II. This year, the condition was reversed with the record-setting temperatures on Leg I and much cooler surface temperatures on Leg II. Of course, Leg II was considerably reduced in scope and only encompassed the last several days of March, when the atmosphere began to cool down approaching the austral autumn. Consequently, 1997 looks like it might be an anomalous year for AMLR. It should be noted that the Leg II contours are biased in a N/S orientation due to the limited aerial coverage, but they do show the cooler trend. Salinity shows a typical trend for both legs, although the distortion caused by the paucity of data on Leg II applies here also (Figure 1.5b). The boundary of the Water Zone I oceanic water with the other zones approximately follows the 33.9 PSU isohaline, running from southwest to northeast. The oxygen data are not presented here in horizontal profile because of the problems experienced with the Beckman dissolved oxygen sensors.

Vertical profiles of oceanographic parameters along the 55°W meridian line for Survey A (Stations A60-A67) and Survey D (Stations D60-D67) are shown in Figures 1.6a-1.6f and Figures 1.7a-1.7d, respectively. This line was chosen because of interest in this meridian by the international community. Several CCAMLR nations have conducted research cruises along this line both this year and in previous seasons. All parameters showed a change in the water column properties marking the frontal boundary at Station 63, near 60°45'S. The abrupt excursions in Survey D salinity and density are due to the inadequate compensation for differing time-constants in the Seacat unit used on Leg II (Figures 1.7b and 1.7c). Some further filtering can be done to minimize this effect. The oxygen data on Survey A along this transect appear to be reliable, although they are not corrected here. Oxygen maxima in the winter water temperature minimum were more prominent than last year. Further analysis of the oxygen values obtained on Survey D (Figure 1.7d) needs to be done to compare with Survey A data and the water sample data. The Seacat unit did not have a fluorometer or transmissometer.

Underway Data: Data were recorded at 1-minute intervals covering over 8,000 nautical miles (n.mi.) of cruise track. Only a few periods of data loss were encountered, mostly due to problems with the Fluke Data Bucket or the modified underway program. During Leg I, the mean wind below 60°S was 12.2 knots, which was even calmer than last year. The few days on Leg II spent below 60°S were much windier, with a mean wind of 19.6 knots. The maximum wind of 42.5 knots on Leg I was higher than last year, but high winds occurred only once at the beginning of that leg. For 21 days, the maximum wind speed did not exceed 30 knots. A maximum wind of 43.7 knots was experienced on Leg II. There were no storms during Leg I, and we did not have to abandon any stations due to weather. Air temperatures were below freezing for only a few hours during Leg I, but there were a few days of freezing temperatures on the abbreviated Leg II with a low of -2.3°C.

1.5 Disposition of Data: The CTD/carousel, underway, and weather station data have been stored on 150 Mbyte Bernoulli disks and 100Mbyte "Zip" diskettes. The raw data were taken to the University of Texas Marine Science Institute in Port Aransas, Texas. Final analysis will be under the direction of Anthony F. Amos. Copies of the CTD/carousel 1-meter averages (Leg I only) and modified 1-minute underway data (Legs I and II) have been distributed on diskettes to the phytoplankton and acoustics groups. Copies of the printed log sheets and plots were provided daily to the phytoplankton group. Special logs listing time, position and weather conditions for each scientific event were provided to the phytoplankton and zooplankton groups.

1.6 Acknowledgments: Special mention must go to the Russian crew who prepared, launched, and recovered the CTD/carousel unit. We also are most grateful to Chief of Expedition, Oleg Pivovarchuk, for his overall leadership and attention to our needs and rapid response to our problems. Oleg and Valeriy also did double duty running hundreds of salinity samples for the physical oceanography group. Jeffrey Hill (Electronic Technician) was a great help in setting up the salinometer and CTD/carousel; he also took care of the various repairs and software problems. We also thank the phytoplankton group for collecting salinity water samples from each station.

1.7 Problems and Suggestions: The new Sea-Bird SBE-9/11 PLUS CTD operated well with the exception of some puzzling noise on the last two stations (huge excursions of the conductivity salinity signal in high temperature gradients). The problem seemed to be related to the pump or plumbing which ensures that high gradients do not cause erroneous output. We have had correspondence with Sea-Bird on the problem, but have not received satisfactory explanation from them. Similarly, difficulties with two new oxygen sensors have not been solved as of this writing. I doubt that the problem was with the sensors themselves, but suspect something went awry with the flow of water through the sensor's membranes, perhaps associated with the pump problem. We have passed on the information to AERG, so the CTDs can be sent to Sea-Bird for recalibration, at which time they will be able to do some trouble-shooting. The Sea-Bird carousel water sampler worked splendidly, and we are very pleased with this addition to the AMLR equipment.

One significant point, however, is the use of the frame supplied by Pacific Marine Center (PMC) to hold the water-sampling bottles, carousel, and CTD. To work best, the Sea-Bird CTD should be mounted horizontally, and not vertically as is necessary with the PMC frame. The reason being that the critical CTD sensors (temperature and conductivity) will experience a similar water-flow whether being lowered (downtrace) or raised (uptrace). In the configuration used during AMLR 97, on the uptrace there was considerable entrainment of water by the great bulk of the carousel, water sampling bottles, and auxiliary sensors. While we use the downtrace CTD data as our primary data source, the bottles must be tripped on the uptrace. Outputs from the CTD and the auxiliary sensors are used to compare with the data from analyses of water samples collected in the bottles. Due to time-constants and the entrainment of water by the CTD, these values could be erroneous. The frame made by Sea-Bird for their carousel and CTD minimizes this problem by allowing the CTD to be mounted horizontally in its original frame. Almost all users of this equipment in the oceanographic community use it in this configuration.

The Sea-Bird Seacat CTD unit used on Leg II functioned well, but the data cannot be used in place of the Sea-bird SBE-9/11 PLUS used on Leg I. The depth was limited to 250m, and it does not have the precision of the 9/11. Also, it is prone to produce erroneous excursions in the calculated salinity and density.

The new Coastal Climate Weatherpak system, which measures wind conditions, air temperature, humidity, and barometric pressure, worked well and was a welcome replacement for the system used on past AMLR cruises. A problem experienced in the first few days was due to the placement of the Weatherpak in too close proximity to the ship's stack gases, which gave erroneously high air temperature readings. The Weatherpak was re-positioned forward of the bridge and worked satisfactorily after that. Other components of the underway system performed well with a minimum of downtime. The problem of spikes appearing on the salinity output from the thermosalinograph was solved by Valeriy with an ingenious plumbing job. We had no bubble problems on AMLR 97.

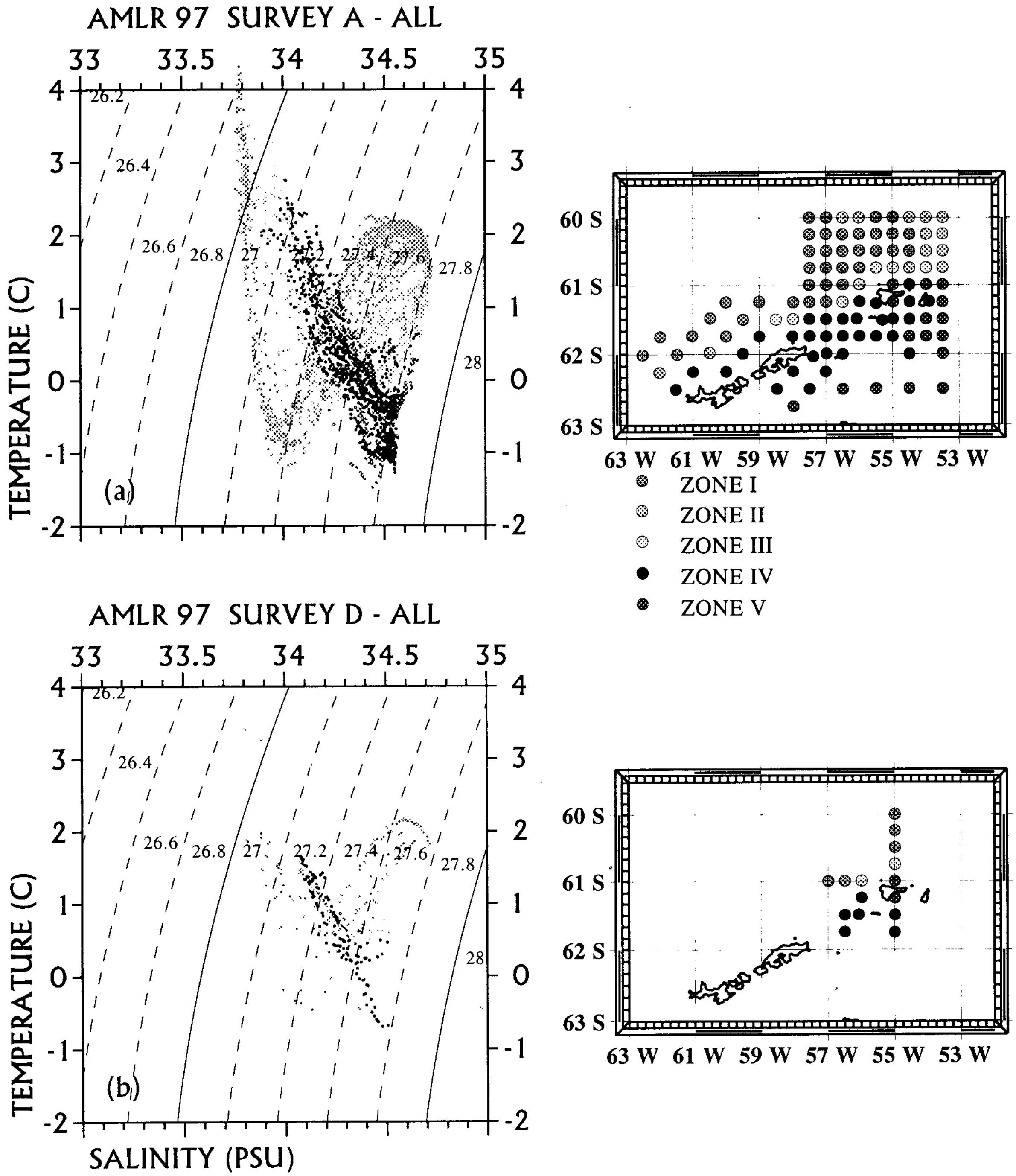


Figure 1.1 Composite Temperature/Salinity (T/S) diagram for all stations from the large-area surveys. (a) Survey A, Leg I; (b) Survey D, Leg II. Symbols on inset maps show station locations shaded by water zones of similar T/S characteristics.

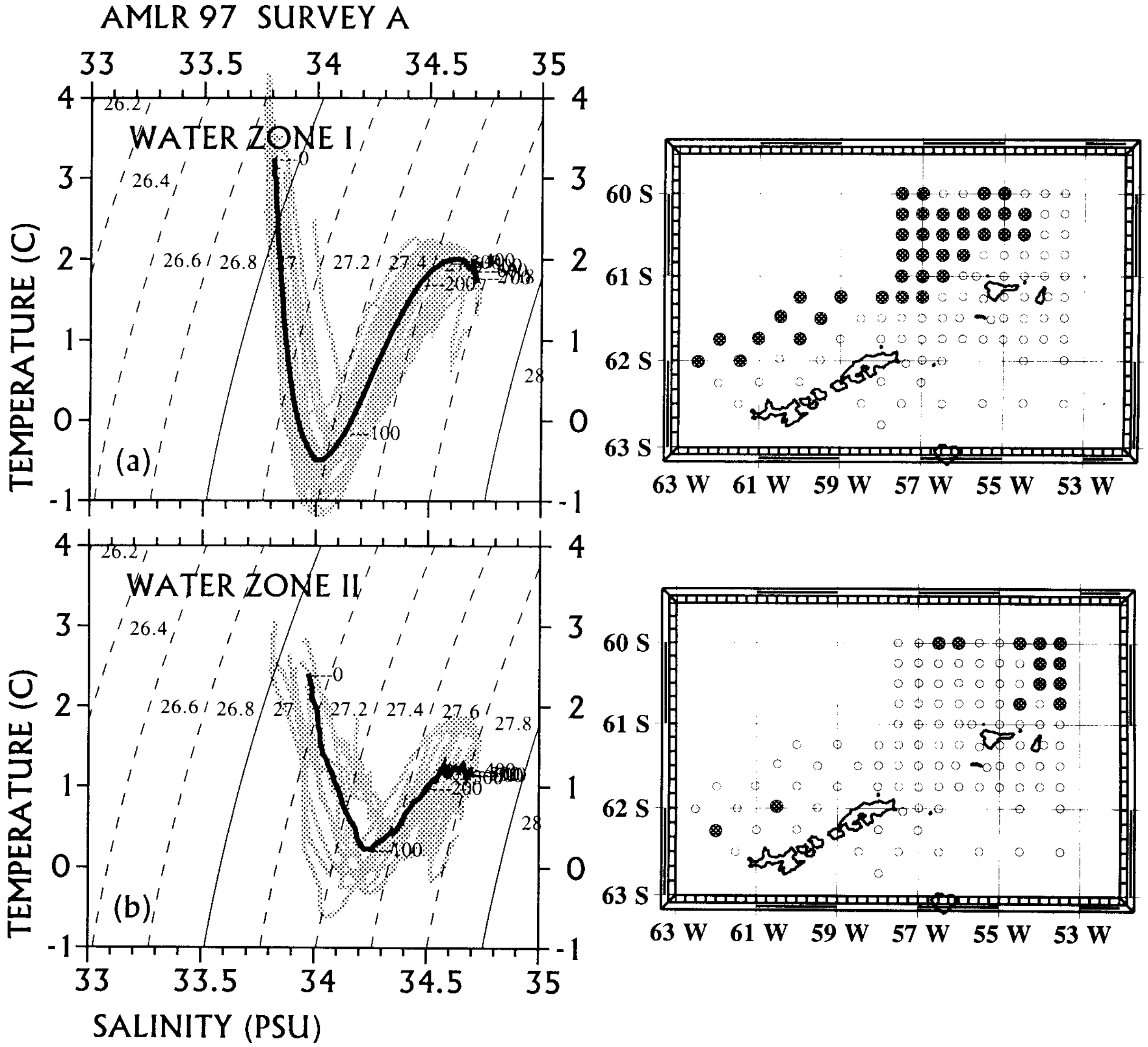


Figure 1.2 Temperature/Salinity (T/S) curves for various water zones in the AMLR study area. The gray area is the T/S envelope of all stations identified as having the water zone characteristics. The heavy black curve is the mean T/S curve for each water zone. Inset maps show the location and numbers of stations belonging to each water zone. (a) Survey A, Water Zone I; (b) Survey A, Water Zone II.

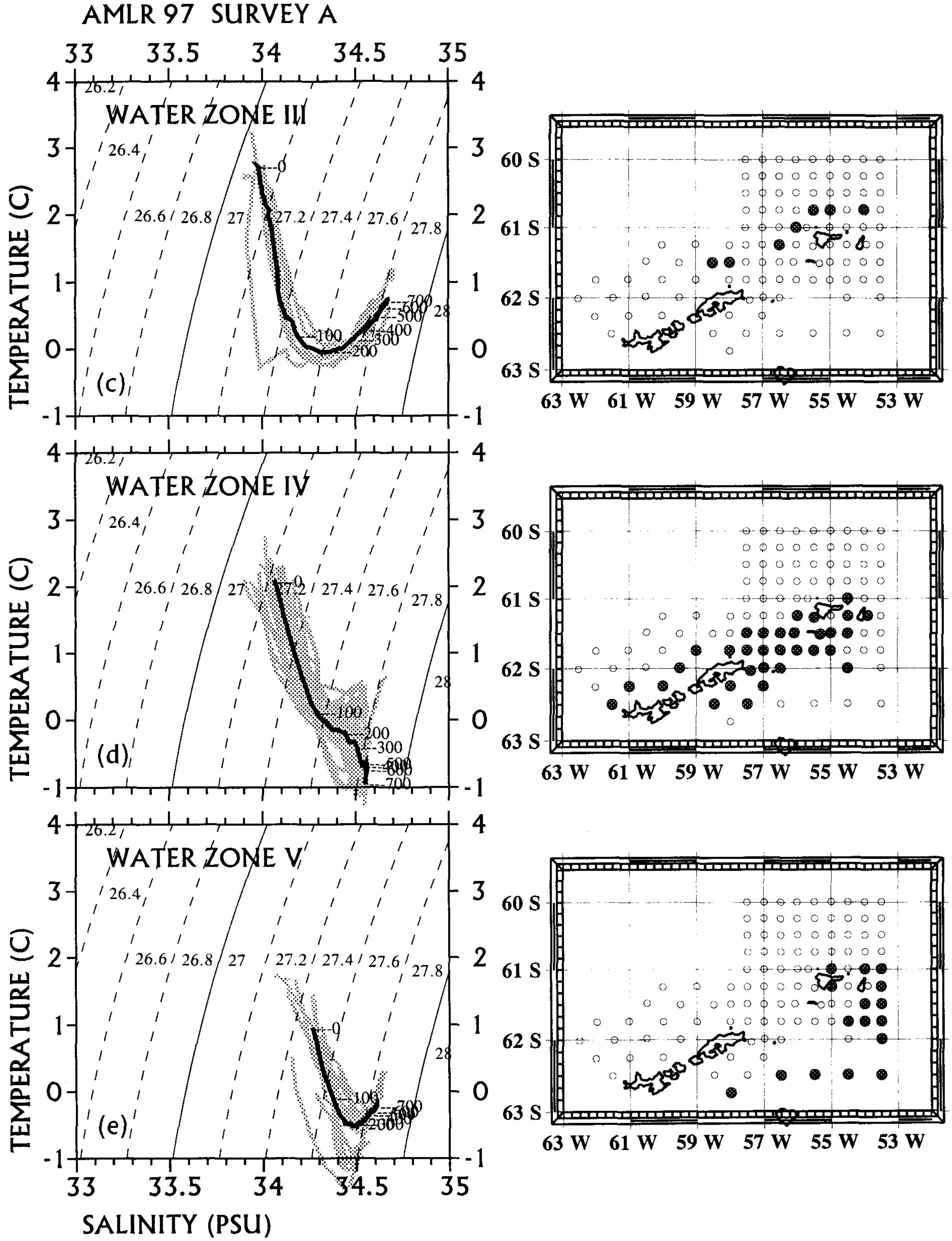


Figure 1.2 (cont.) (c) Survey A, Water Zone III; (d) Survey A, Water Zone IV; (e) Survey A, Water Zone V.

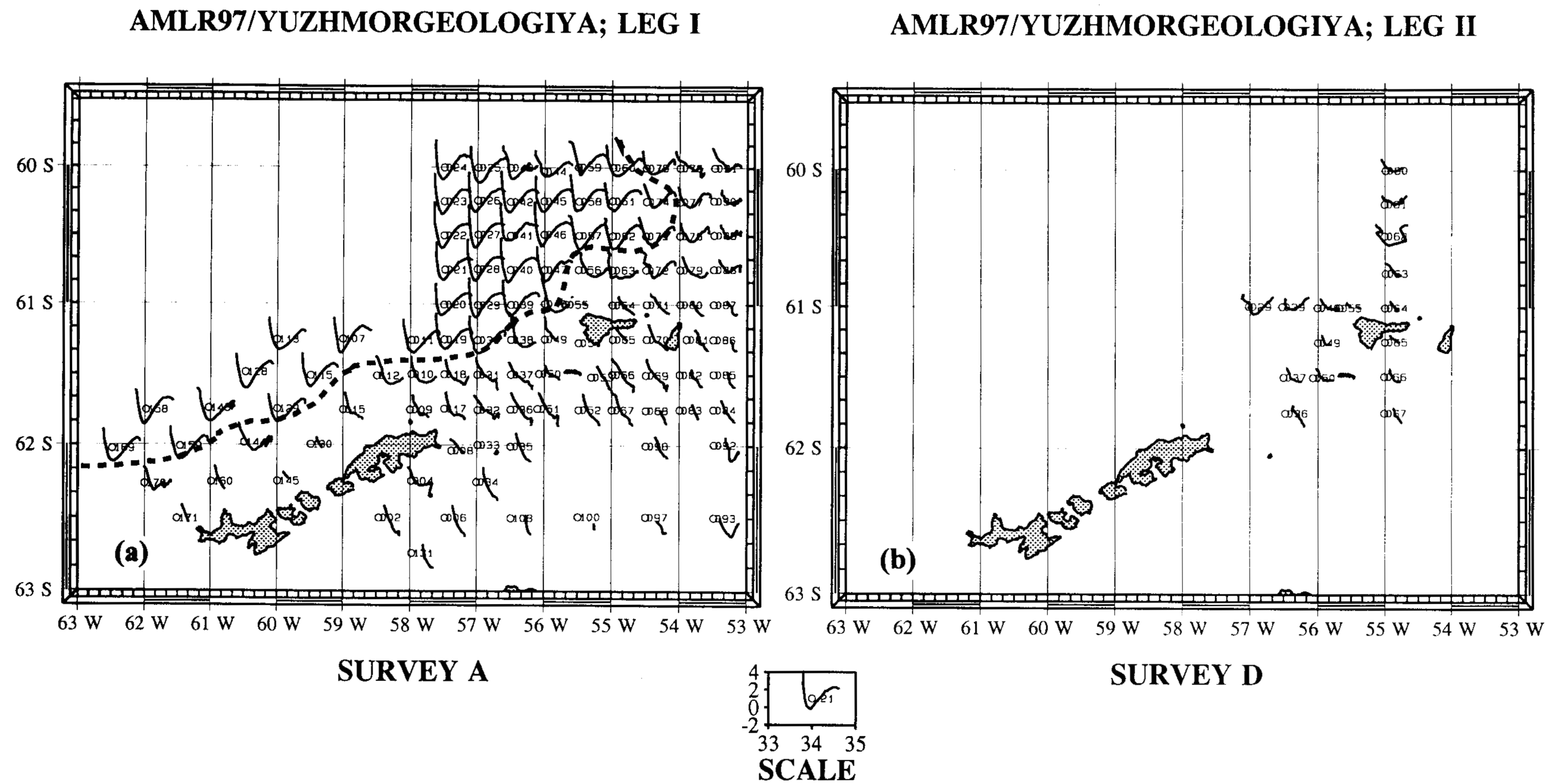


Figure 1.3 Temperature/Salinity (T/S) curves for individual stations plotted at the station location. The circle representing station location is plotted at S=34, T=+0.5 (see scale inset). Dashed lines show divisions between Water Zone I and the rest of the water zones. (a) Survey A, Leg I; (b) Survey D, Leg II. Note: Leg II Seacat CTD stations were limited to 250m.

AMLR97 - LEG I, SURVEY A
DEPTH = 500m; DYNAMIC HEIGHT (Dyn. cm)

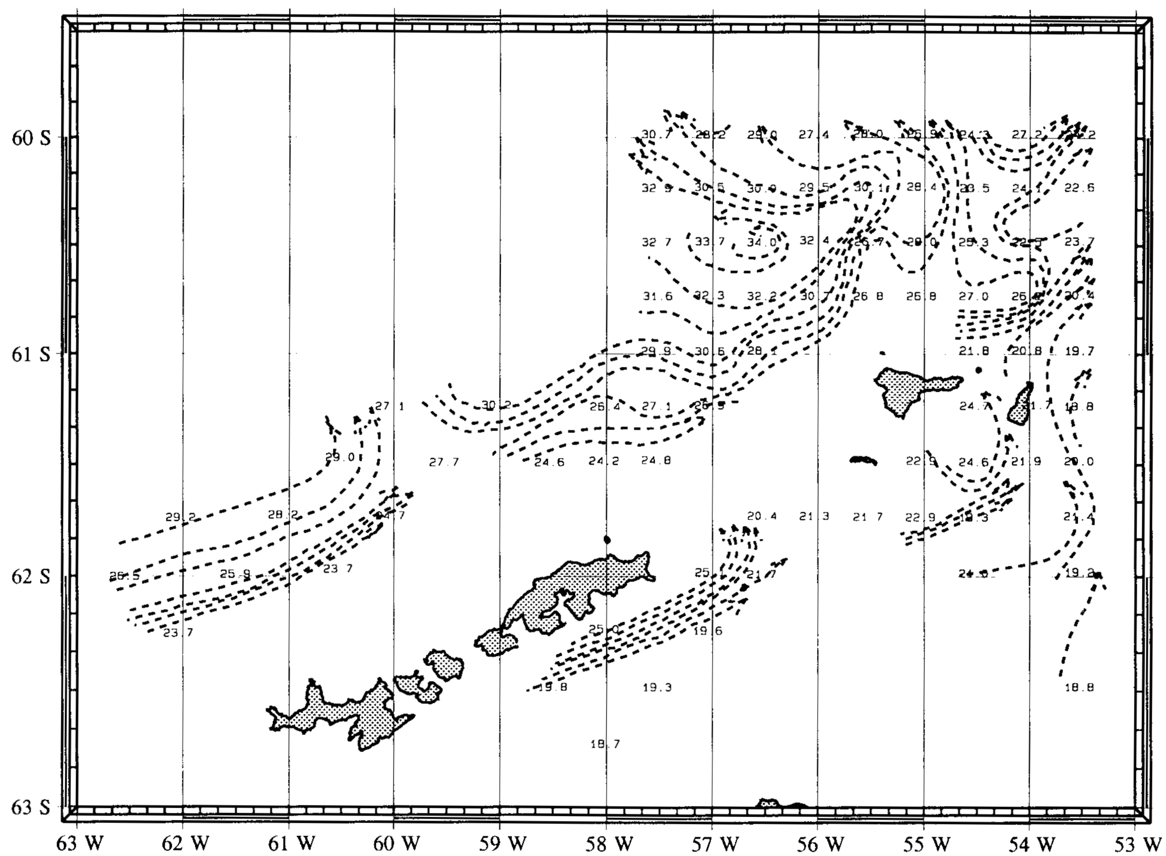


Figure 1.4 Dynamic topography of the AMLR study area during Survey A. Dynamic height with respect to 500db at the surface (dyn.cm.).

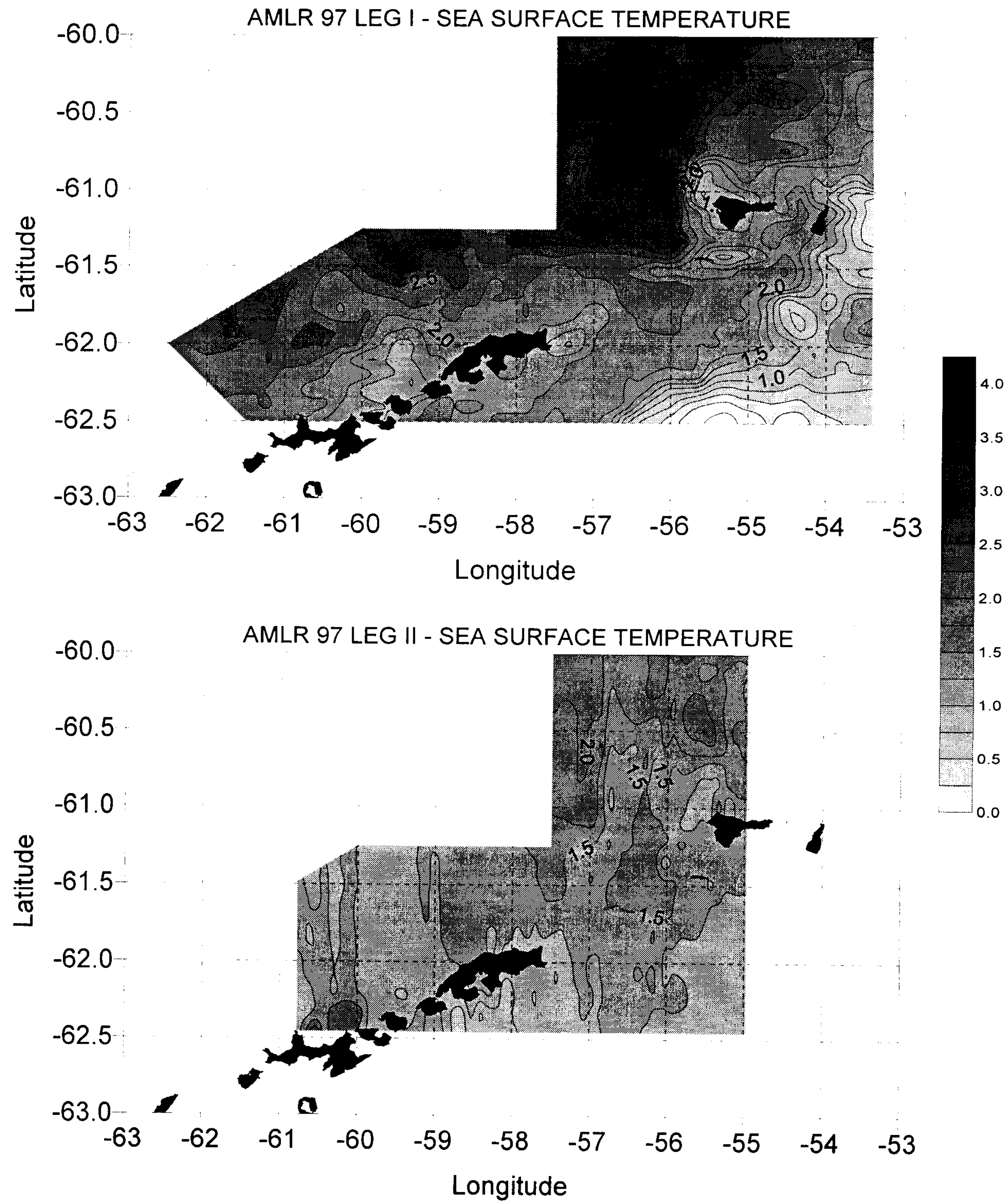


Figure 1.5a Horizontal maps of near surface oceanographic conditions (temperature) in the AMLR study area during Legs I and II. Data are from the continuously recorded underway environmental system.

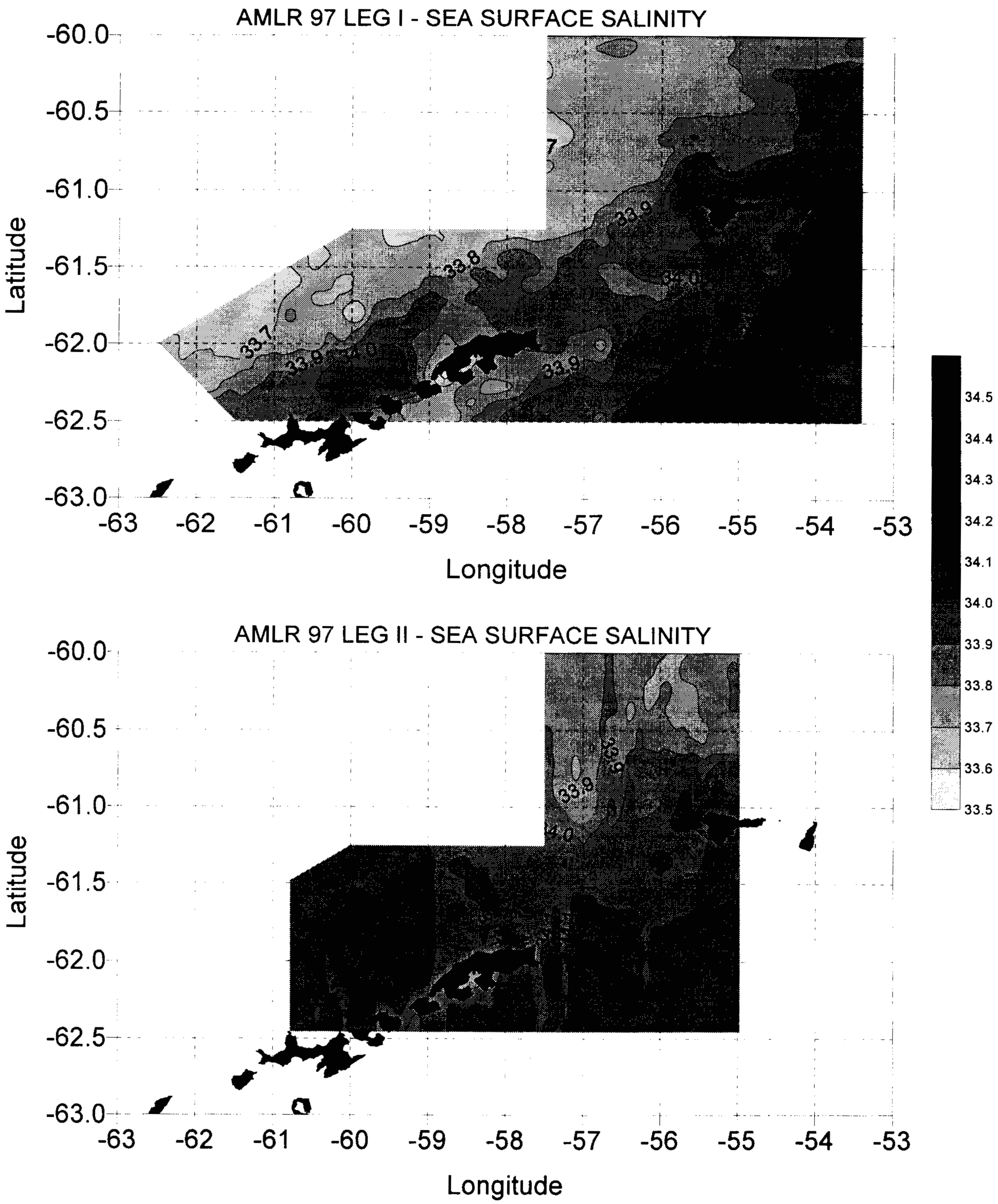


Figure 1.5b Horizontal maps of near surface oceanographic conditions (salinity) in the AMLR study area during Legs I and II. Data are from the continuously recorded underway environmental system.

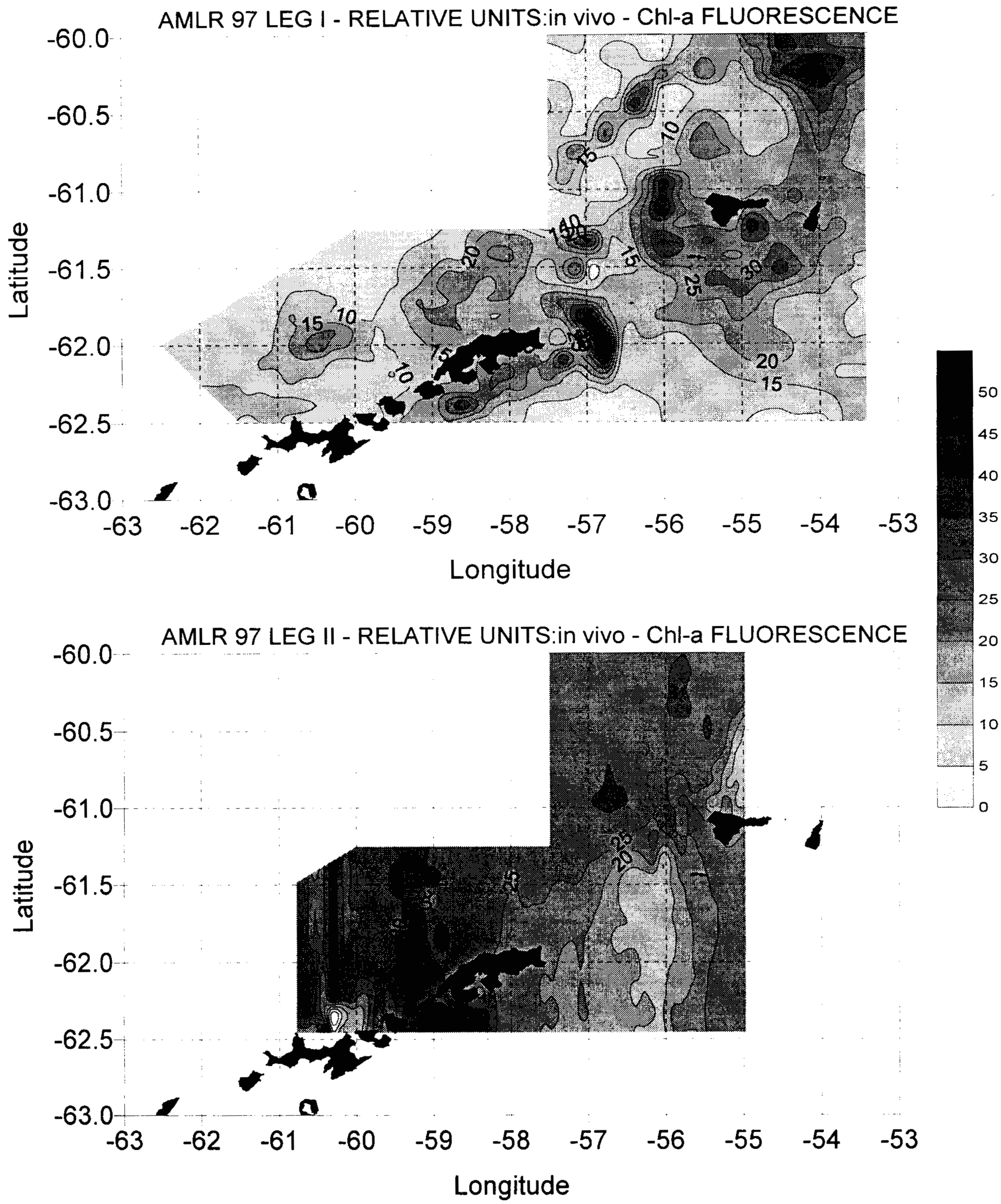


Figure 1.5c Horizontal maps of near surface oceanographic conditions (chlorophyll-a fluorescence) in the AMLR study area during Legs I and II. Data are from the continuously recorded underway environmental system.

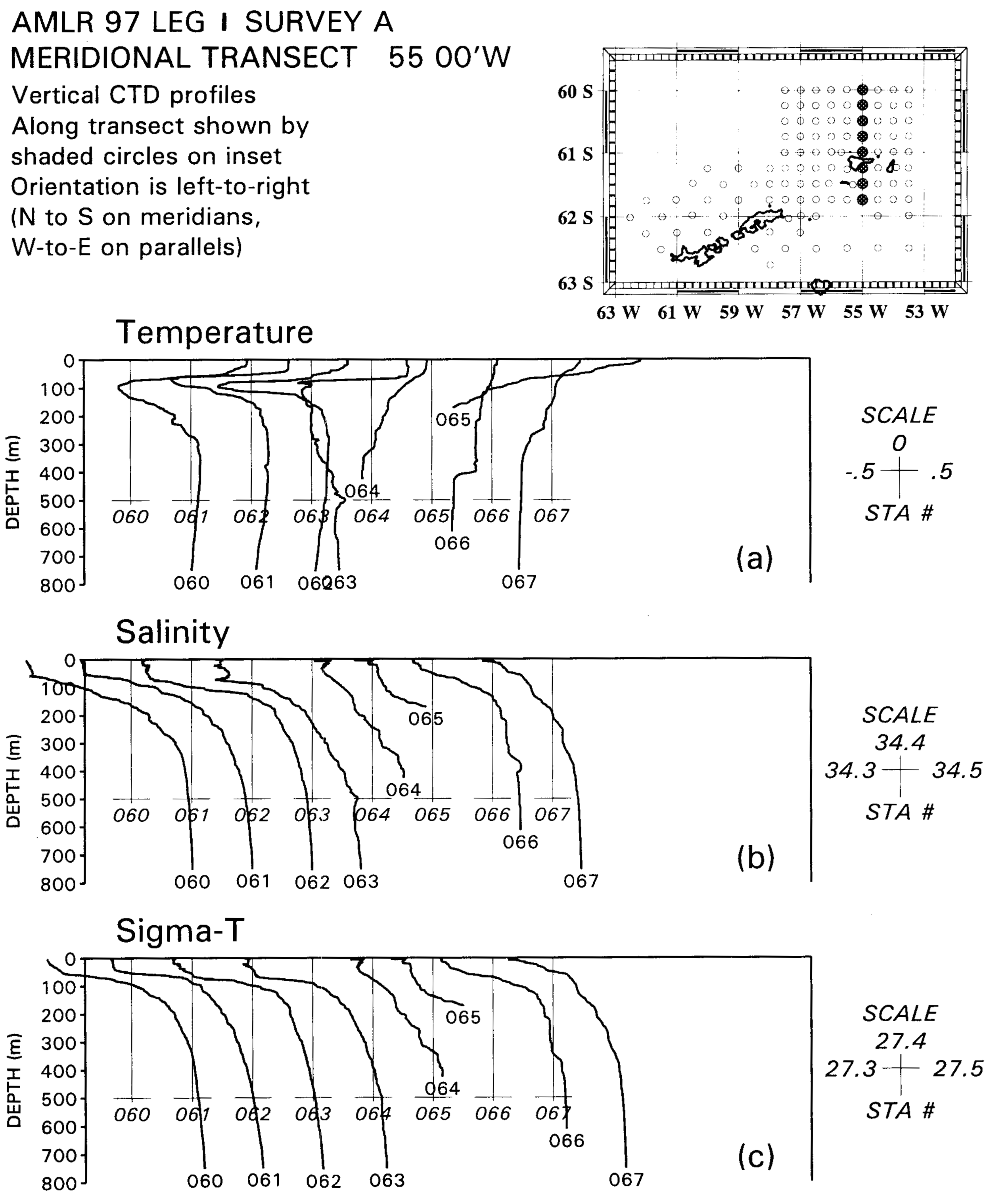


Figure 1.6 Vertical profiles of oceanographic parameters along the 55°W meridian in the AMLR study area during Survey A. (a) Temperature; (b) Salinity; (c) Sigma-T.

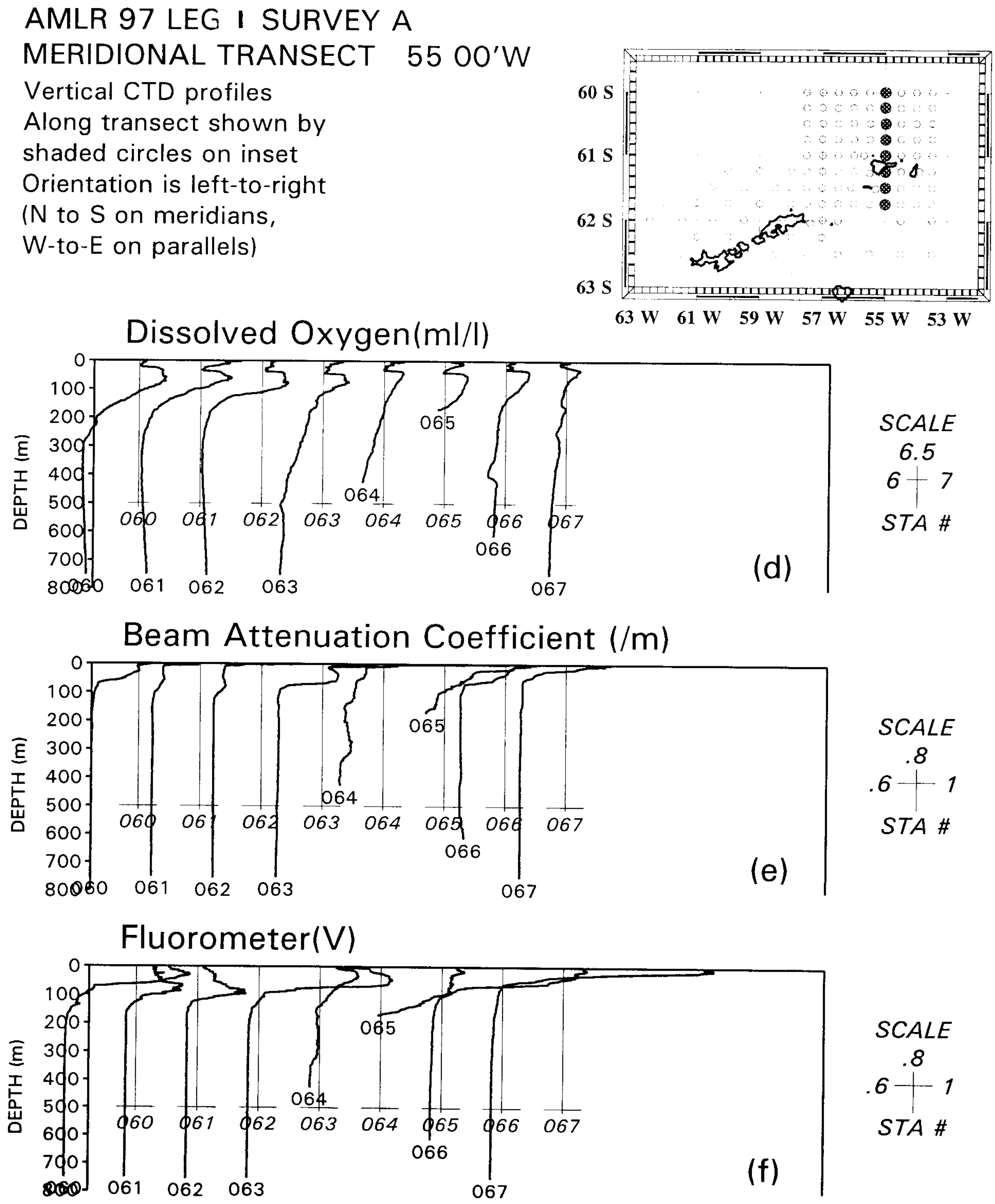


Figure 1.6 (cont.) (d) Dissolved Oxygen; (e) Beam Attenuation Coefficient; (f) Fluorometer.

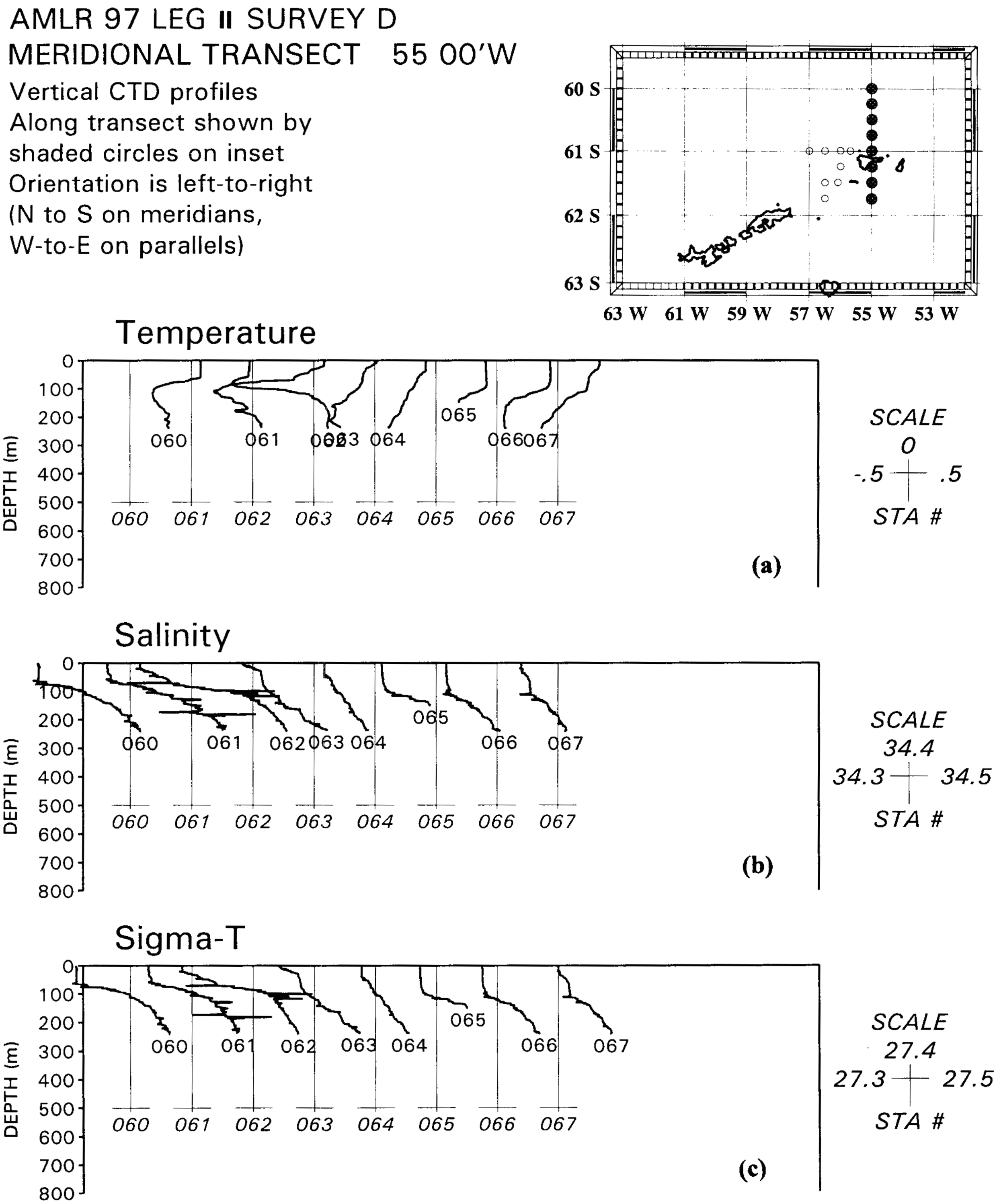
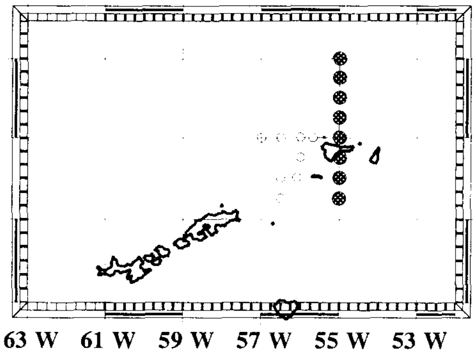


Figure 1.7 Vertical profiles of oceanographic parameters along the 55°W meridian in the AMLR study area during Survey D. (a) Temperature; (b) Salinity; (c) Sigma-T.

AMLR 97 LEG II SURVEY D
MERIDIONAL TRANSECT 55 00'W

Vertical CTD profiles
Along transect shown by
shaded circles on inset
Orientation is left-to-right
(N to S on meridians,
W-to-E on parallels)



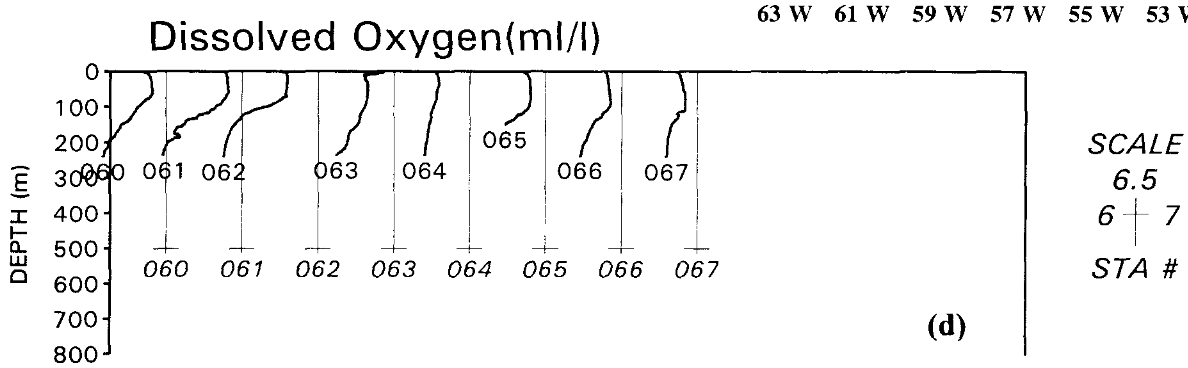


Figure 1.7 (cont.) (d) Dissolved Oxygen.

2. Phytoplankton; submitted by Osmund Holm-Hansen (Leg I), Christopher D. Hewes (Leg I), Gaston Gonzalez-Rodas (Legs I and II), Jenny Maturana A. (Legs I and II), Lorena Rios (Leg I), and Martin Hernandez (Leg II).

2.1 Objectives: The overall objective of this research project was to assess the distribution and concentration of food reservoirs available to the herbivorous zooplankton populations throughout the AMLR study area during the austral summer. Specific objectives of our work were: (1) to determine the distribution and biomass of phytoplankton in the upper water column (surface to 750m), with emphasis on the upper 100m; (2) to determine the rate of primary production throughout the euphotic zone; (3) to evaluate the photoadaptational state of the phytoplankton at various depths in the euphotic zone; (4) to estimate the concentrations of total particulate organic carbon and nitrogen in the upper 75m of the water column; (5) to determine the species composition of the phytoplankton, in addition to cell size and biomass expressed in cellular organic carbon; (6) to examine the importance of physical, chemical, and optical characteristics in the upper water column as controlling factors for the distribution and photosynthetic activity of phytoplankton; and (7) to relate the profiles of oxygen and alkalinity throughout the euphotic zone to metabolic activity of both the autotrophic and heterotrophic assemblages of organisms.

2.2 Methods and Accomplishments: The major types of data acquired during our studies are listed below, together with an explanation of the methodology employed.

(A) Sampling Strategy:

The protocol relied on the following ways to obtain water samples for analyses or to acquire data from various sensors: (1) Water samples were obtained from 10-liter Niskin bottles (with teflon covered springs) at eleven standard depths (5, 10, 15, 20, 30, 40, 50, 75, 100, 200, and 750m or within 10m of the bottom at the shallow stations) from every upcast of the CTD/carousel unit. Leg I occupied 106 stations. There were no similar CTD/carousel casts during Leg II. During Leg II, however, a Sea-bird Seacat CTD unit (model SBE-16) with pH and oxygen sensors (but with no attached water-sampling bottles) was deployed to a maximum depth of 250m. This CTD unit had internal recording of data, so that the use of conducting cable was not required. Water samples from the Niskin bottles (or buckets) were used for measurements described below. (2) Water from the ship's clean water intake line (approximately 4m depth) was used to monitor phytoplankton concentrations continuously during the entire cruise and also to obtain samples for extraction of chlorophyll-a (chl-a) at many of the CTD/carousel stations. The sensors used for acquiring data included instruments to record solar irradiance (both incident and *in situ*), fluorometers to record *in vivo* chl-a fluorescence, transmissometers to determine the attenuation of collimated light (by both scattering and absorption), and electrodes to measure pH (Leg II only) and oxygen.

(B) Measurements and Data Acquired:

(1) Chlorophyll-a concentrations: Chl-a concentrations in the water samples (ten depths from 5 to

200m) from the Niskin bottles at every CTD/carousel station were determined by measurement of chl-a fluorescence after extraction in absolute methanol. Sample volumes of 100 milliliters (ml) were filtered through glass fiber filters (Whatmann GF/F, 25mm) at reduced pressure (maximal differential pressure of 1/3rd atmosphere). The filters with the particulate material were placed in 10ml of absolute methanol in 15ml polyethylene centrifuge tubes (with leak-proof screw-caps), and the photosynthetic pigments were allowed to extract at 4°C for at least 12 hours. The samples were then shaken, centrifuged, and the clear supernatant poured into cuvettes (13 x 100mm) for measurement of chl-a fluorescence before and after addition of two drops of 1.0 N HCl. Fluorescence was measured in two Turner Designs Fluorometers (models 10-005R and 750) for all samples during Leg I; during Leg II only the latter instrument was used. Both fluorometers had been calibrated using spectrophotometrically determined chl-a concentrations. Stability of the fluorometers was verified daily by use of sealed coproporphyrin standards which fluoresce in the same spectral region as chl-a.

(2) Primary production: Rates of primary production were measured at each CTD/carousel station occupied around 0700 each day during the survey grid. Water samples from eight depths (from 5 to 75m) were poured into 50ml polycarbonate screw-cap tubes and inoculated with 5 microcuries (μCi) of ^{14}C-labeled sodium bicarbonate. Duplicate tubes were used for each depth, in addition to one tube from 5m and one from 75m which were kept in the dark and were used to estimate the rate of dark-fixation of CO_2. These tubes were attached to a Plexiglas frame with sections of neutral density screening to simulate the irradiance at the depths from which the phytoplankton had been sampled. The frame with the tubes was placed in a wooden incubator with pumped surface seawater (which just covered the tubes) for temperature control. The incubator was in a relatively shade-free area on the ship's upper deck. The irradiance incident upon the samples ranged from 95% of incident radiation for the 5m sample to 0.5% for the sample from 75m. At the end of the incubation period (8-10 hours), the samples were filtered through GF/F glass fiber filters (25mm). The filters were placed in 7ml glass scintillation vials and any inorganic ^{14}C was eliminated by fuming with HCl fumes for at least 10 hours. The filters and vials were dried at 35°C and then sealed and stored until analysis. Fixed radioactivity in the samples was determined by conventional liquid scintillation techniques.

(3) Solar Radiation measurements: Measurements of solar irradiance included: (a) continuous recording (every minute) of PAR using a 2-pi sensor (model #QSR-240, Biospherical Instruments, Inc.), which was mounted in a shade-free location close to the primary production incubators; (b) attenuation of PAR in the water column using a light sensor with a cosine response (model #QCP-200L, Biospherical Instruments, Inc.) mounted on the carousel; and (c) attenuation of PAR by the neutral density screens used in the productivity experiments using a 4-pi light sensor (model #QSL-100, Biospherical Instruments, Inc.).

(4) Inorganic nutrients: Water samples for measurement of nitrite, nitrate, phosphate, and silicic acid were taken from 5m depth at every station during Leg I (Survey A), in addition to detailed profiles of these nutrients at some of the productivity stations and also at Stations A60-A64.

Water samples (about 35ml) were poured into acid-cleaned 50ml polyethylene screw-cap bottles and maintained at -20°C until time of analysis using an autoanalyzer at the Universidad Católica de Valparaiso, Chile.

(5) Dissolved oxygen: Concentrations of dissolved oxygen were determined in water samples obtained from various depths from the Niskin bottles on the carousel. These oxygen determinations were made using a micro-Winkler titration unit and were used primarily to check the calibration of the oxygen sensor mounted on the CTD/carousel unit.

(6) Photoadaptational state of the phytoplankton: Simultaneous with the primary production measurements, water samples from high-light conditions (5m) and from low-light conditions (between 50 to 100m) were treated in a similar fashion except that replicate water samples from each of the above depths were exposed to the eight different irradiances (95 to 0.5% of incident solar radiation). The resulting photosynthesis vs irradiance data will be analyzed together with the physical and optical characteristics of the upper water column to determine the degree of adaptation of the phytoplankton to variable conditions of irradiance.

(7) Phytoplankton cell size and species composition: The following methods were used to obtain information on the floristic characteristics of the phytoplankton. (a) The phytoplankton in the nanoplankton size category [<20 micrometers (μm)] in water samples from 5m depth at every CTD/carousel station during Leg I were separated from the microplankton (>20μm) by filtration through Nytex mesh with an effective pore size of 20μm. The proportion of phytoplankton biomass in the two size categories was estimated by measurement of chl-a concentrations as described above. (b) A water sample (100ml) from 5m depth at every CTD/carousel station was preserved with borate-buffered formalin. These preserved samples will be returned to our home laboratories for floristic examination by inverted microscope techniques which will provide information on species composition, cell size and numbers, and cell volumes. (c) Nuclepore filters (1.0 and 5.0μm pore size) were used to determine the percentage of chl-a in cells that were <5.0μm and <1.0 μm in size. The filtrate from these fractionations was put through a GF/F filter, which supposedly retains all phytoplankton, including the picoplankton. In separate tests with natural phytoplankton assemblages, GF/F filters were found to retain as much chl-a as the Millipore GS filters (0.22μm). Glass fiber filters (GF/F) were thus used in our fractionation studies because of their much faster rate of filtration.

(8) Biomass and organic carbon concentrations: Two methods were used to estimate phytoplankton biomass expressed as cellular organic carbon. (a) The data obtained from the microscopic observations (see above) will be used to calculate cellular organic carbon by standard equations relating cell volumes to cellular organic carbon. (b) Data on beam coefficients (cp, as obtained with the transmissometer on the CTD/carousel unit and also the one on the pumped sea water line) will be used to estimate particulate organic carbon by use of an algorithm that was developed from data previously obtained in the AMLR program.

(9) Alkalinity and pH: These measurements were done only during Leg II. A pH electrode was installed in the continuous-flow system, so that the pH of surface waters was recorded continuously. Profiles of pH, oxygen, temperature, and salinity were obtained from 0 to 250m at Stations D29, D36, D37, D39, D48, D49, D50, D55 and D60-D67. At these stations a bucket also was used to obtain a surface water sample for measurement of pH (with an electrode), oxygen by the Winkler titration method, and alkalinity by titration.

2.3 Results and Tentative Conclusions:

(A) The distribution of chl-a varied greatly throughout the large-area survey grid as shown by the concentrations of chl-a at 5m depth (Figure 2.1). The lowest chl-a concentrations were found in the northwest portions of the grid, including the outermost new stations north of Livingston Island. These areas correspond to Water Zone I waters as described by the physical oceanographic data (see Section 1, Physical oceanography). Relatively low concentrations were also found in Weddell Sea waters (Water Zone V). The richest phytoplankton regions were found close to the continental shelf-break running in a northeasterly direction to the north of the South Shetland Islands and Elephant Island (Water Zones II and III) and also in Bransfield Strait waters (Water Zone IV). The mean chl-a concentration at 5m depth for all stations during Leg I was 1.18 milligrams chl-a per cubic meter (mg m^{-3}).

(B) The contour map showing the concentrations of integrated chl-a in the upper 100m of the water column (Figure 2.2) shows a fairly similar pattern to that seen in Figure 2.1. The most obvious difference is that the stations in Water Zone I appear to have slightly more integrated chl-a than would be expected from the 5m values. This reflects the fact that stations in Water Zone I usually have a deep sub-surface chl-a maximum between 50 to 100m in depth. The mean value for integrated chl-a in the upper 100m of the water column for all stations during Leg I was 53.8 milligrams of chl-a per square meter (mg m^{-2}).

(C) The dramatic differences in distribution and concentration of chl-a in Water Zone I waters as compared to other regions in the AMLR survey grid are shown for two representative stations in Figure 2.3. At Station A143 in Water Zone I, surface chl-a concentrations were very low, and there was a pronounced sub-surface maximum at depths between 50 to 100m (Figure 2.3A and 2.3B). This distribution of biomass is also evidenced by the transmissometer data, which showed a minimum of transmission at the deep chl-a maximum. In contrast, Station A144 in Water Zone II showed high chl-a biomass in surface waters, and rapidly decreasing concentrations below 20-30m (Figures 2.3C and 2.3D). The transmissometer data also show that minimal transmission of light occurred in the upper 20m. This difference between Water Zone I waters and all other stations in the AMLR survey grid has been consistent throughout the eight years of the AMLR program.

(D) The consistency in this difference between Water Zone I waters and the other water zones in the AMLR survey grid is illustrated by the data in Figure 2.4. Due to the low surface concentrations of chl-a and the deep chl-a maximum, the ratio of the surface chlorophyll to that at depth in Water Zone I will be very low as compared to stations with a chl-a maximum in surface waters. The areas where this ratio is low are restricted to Drake Passage waters (Water Zone I) and Weddell Sea Waters in the southeastern portion of the grid (Water Zone V). Stations in Water Zone V do not show a deep chl-a maximum; however, due to the relatively low stability of the water column, the concentrations of phytoplankton are deeply distributed but without any pronounced sub-surface maximum.

(E) As the *in situ* fluorometer and the transmissometer mounted on the CTD/carousel unit provide continuous data on the profile of chl-a and the attenuation of light due to absorption and/or scattering, respectively, it was of interest to test how well data from these instruments correlated with the extracted chl-a values. The data show that there is a highly significant correlation between *in vivo* fluorescence and extracted chl-a values (Figure 2.5A), between percent light transmission and extracted chl-a values (Figure 2.5B), and also between percent light transmission and *in vivo* fluorescence (Figure 2.5C). The data from both these profiling instruments thus complement the data obtained by extraction and measurement of chl-a, and they can provide the fine structure associated with the distribution of phytoplankton throughout the water column.

2.4 Disposition of the Samples and Data: The nutrient samples will be processed at the Universidad Católica de Valparaiso (Chile). All other samples (for radiocarbon measurement and floristic determination) will be returned to SIO for processing. All data obtained during the cruise have been stored on 1 GByte Jaz disks. After compilation of the final data sets, a copy of all data will be deposited with the AERG in La Jolla, CA. Copies of any of our data sets are available to all other AMLR investigators upon request.

2.5 Problems and Suggestions: It would be useful if the ship acquired one or two additional transformers for use in the laboratories with our instruments requiring 115 volts. Comparison of the down and upcasts of the CTD/carousel unit shows that quality of the data on the upcast is often compromised as a result of the physical arrangement of the various instruments and sensors on the carousel. This makes it difficult for us to compare the continuous data acquired on the downcast with the data acquired at the depth at which the Niskin bottles are closed on the upcast. It would enhance the quality and utility of the data used by our program if this mismatch in the down and upcasts could be minimized with a different physical arrangement of the sensors on the carousel unit.

2.6 Acknowledgments: We want to express our gratitude and appreciation to the entire complement of the R/V *Yuzhmorgeologiya* for their generous and valuable help during the entire cruise. They not only aided immeasurably in our ability to obtain the desired oceanographic data, but they also made the cruise most enjoyable and rewarding in many ways. We also thank all other AMLR personnel for help and support which was essential to the success of our program, especially to the physical oceanographic group who meshed some of our instruments and sensors with their data acquisition systems. Special thanks are also due Jeff Hill for solving many instrument problems so efficiently.

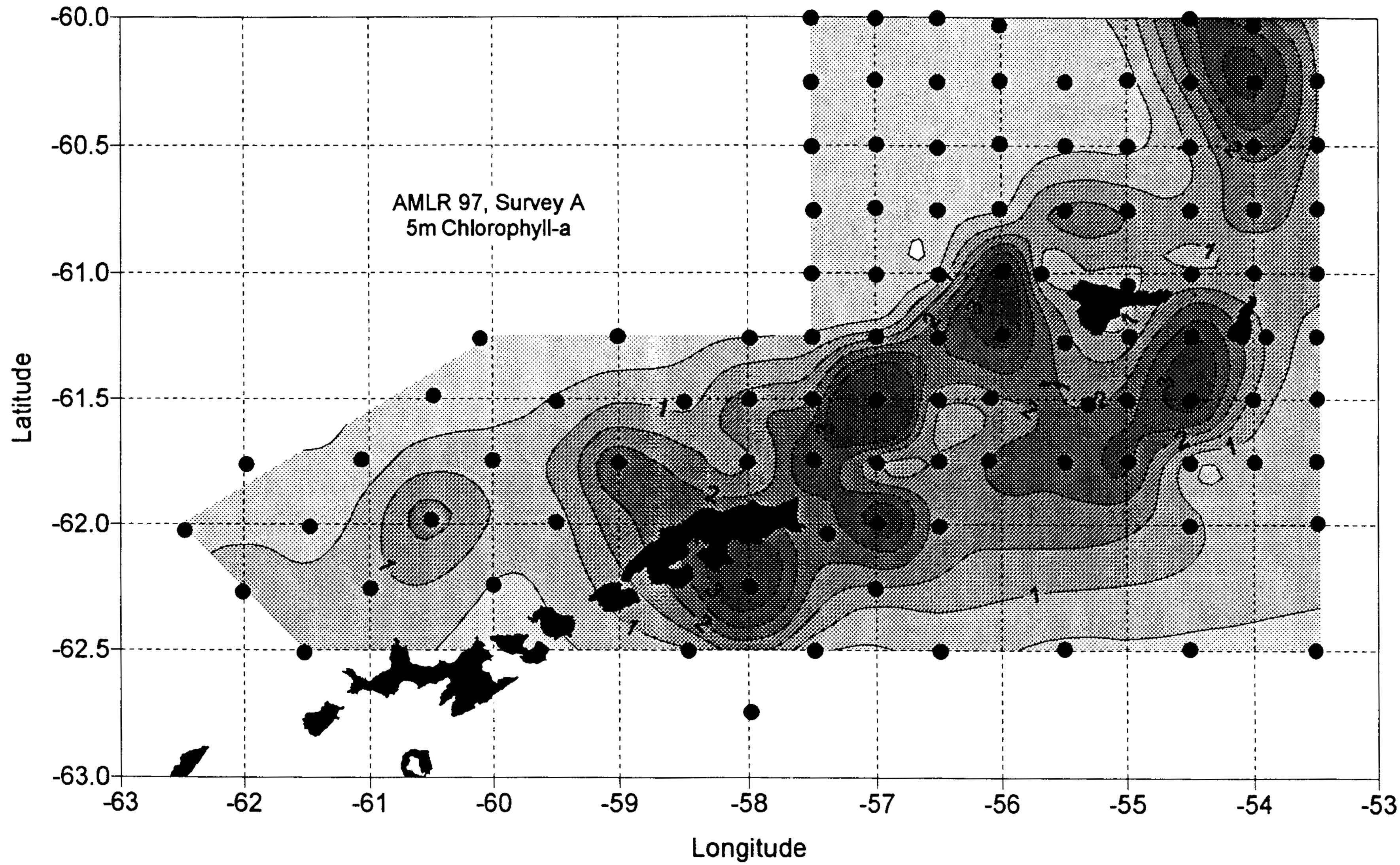


Figure 2.1 Concentration of chl-a (mg m^{-3}) at 5m depth throughout the large-area survey grid during Leg I (Survey A). The darkest areas (>3.0 mg m^{-3}) include stations where the concentrations were between 3.0 to 7.2 mg m^{-3}.

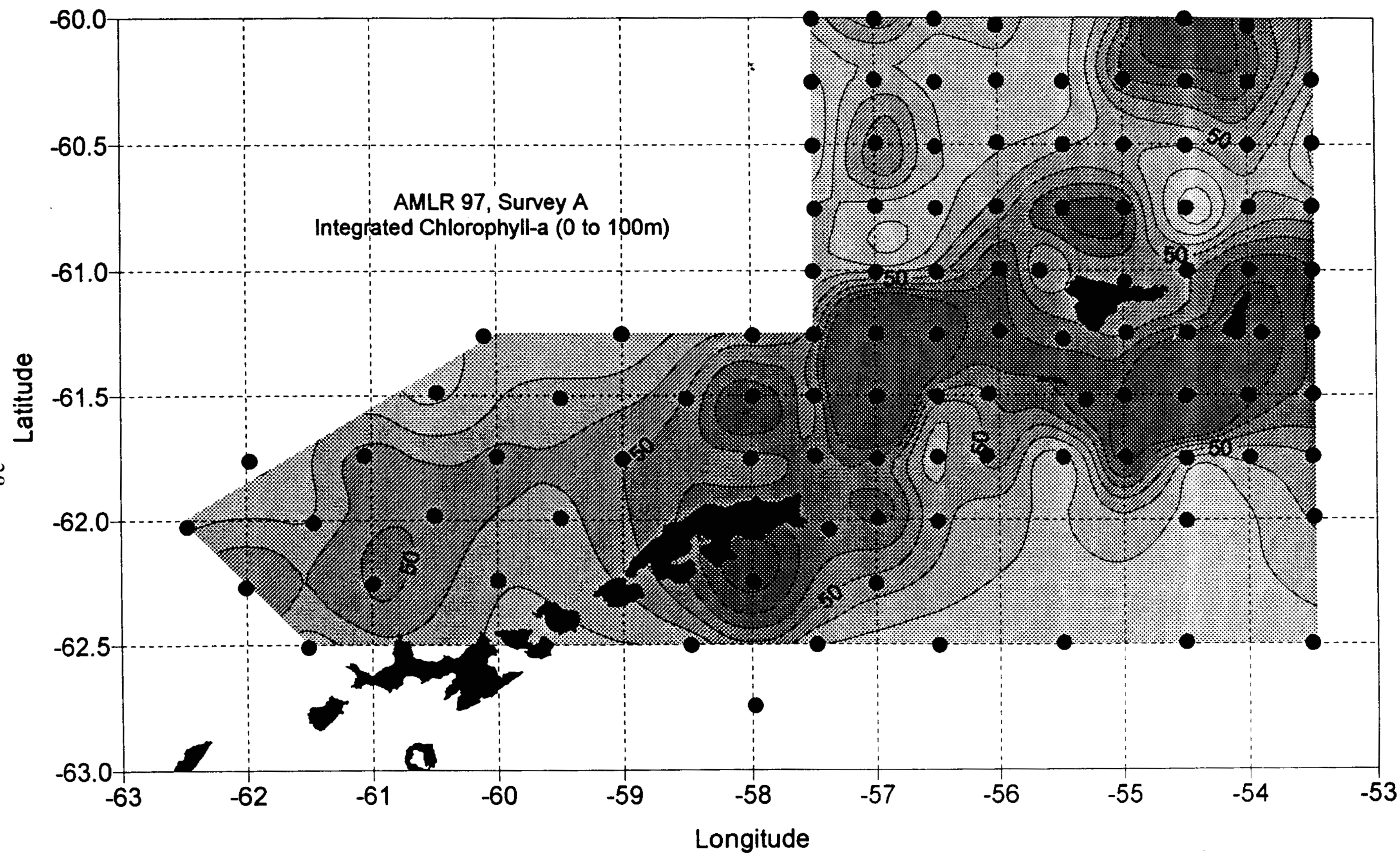


Figure 2.2 Concentration of integrated chl-a (mg m^{-2}, 0 to 100m) throughout the large-area survey grid during Leg I (Survey A). The darkest areas (>80 mg m^{-2}) include stations where the concentrations were between 80 to 176 mg m^{-2}.

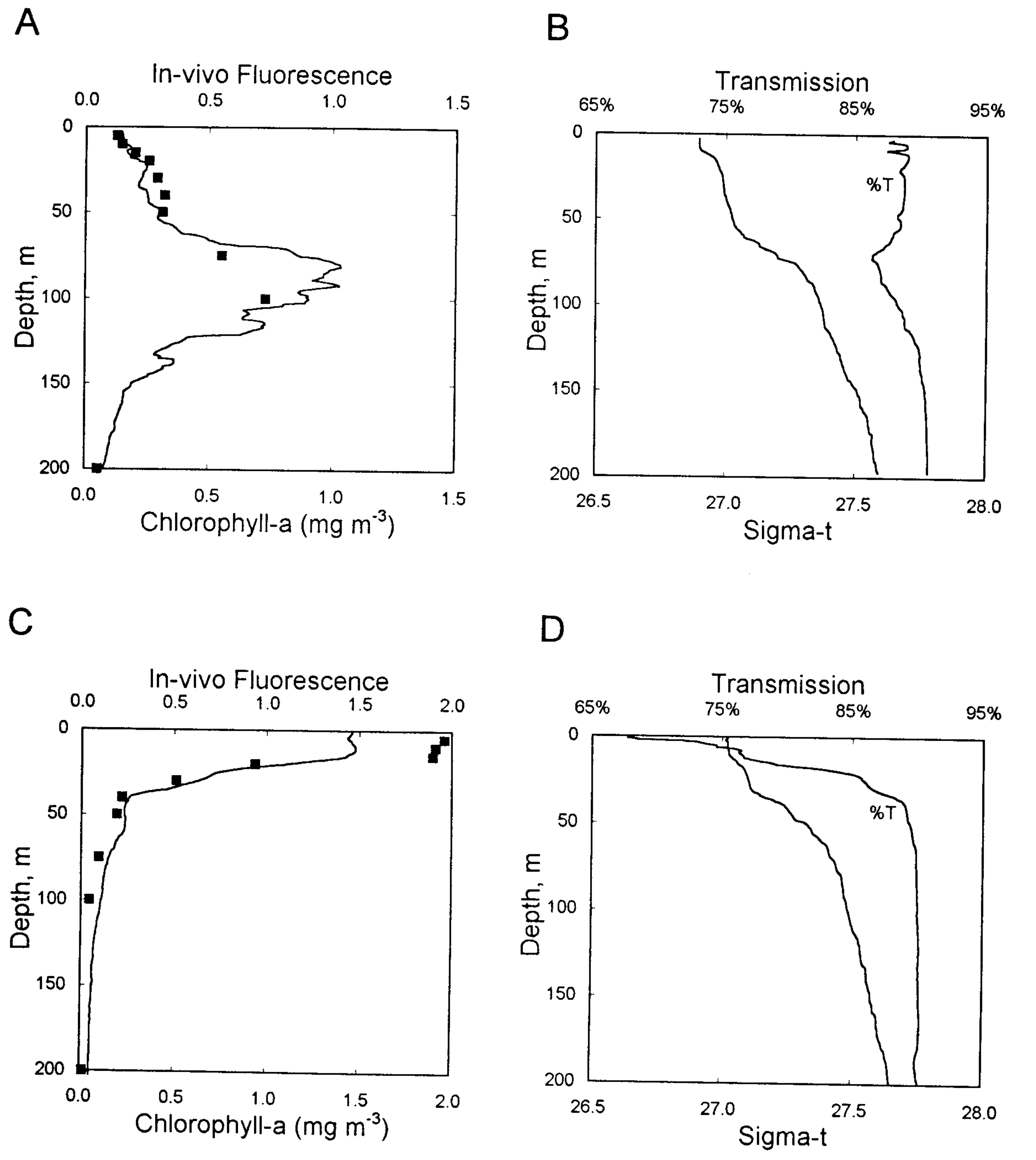


Figure 2.3 Contrasting depth distribution of phytoplankton at two contiguous stations during Leg I, showing profiles of *in situ* chl-a fluorescence (solid line), extracted chl-a values (filled squares), percent light transmission, and water density. (A) and (B), Station A143 located in Water Zone I. (C) and (D), Station A144 located in Water Zone II.

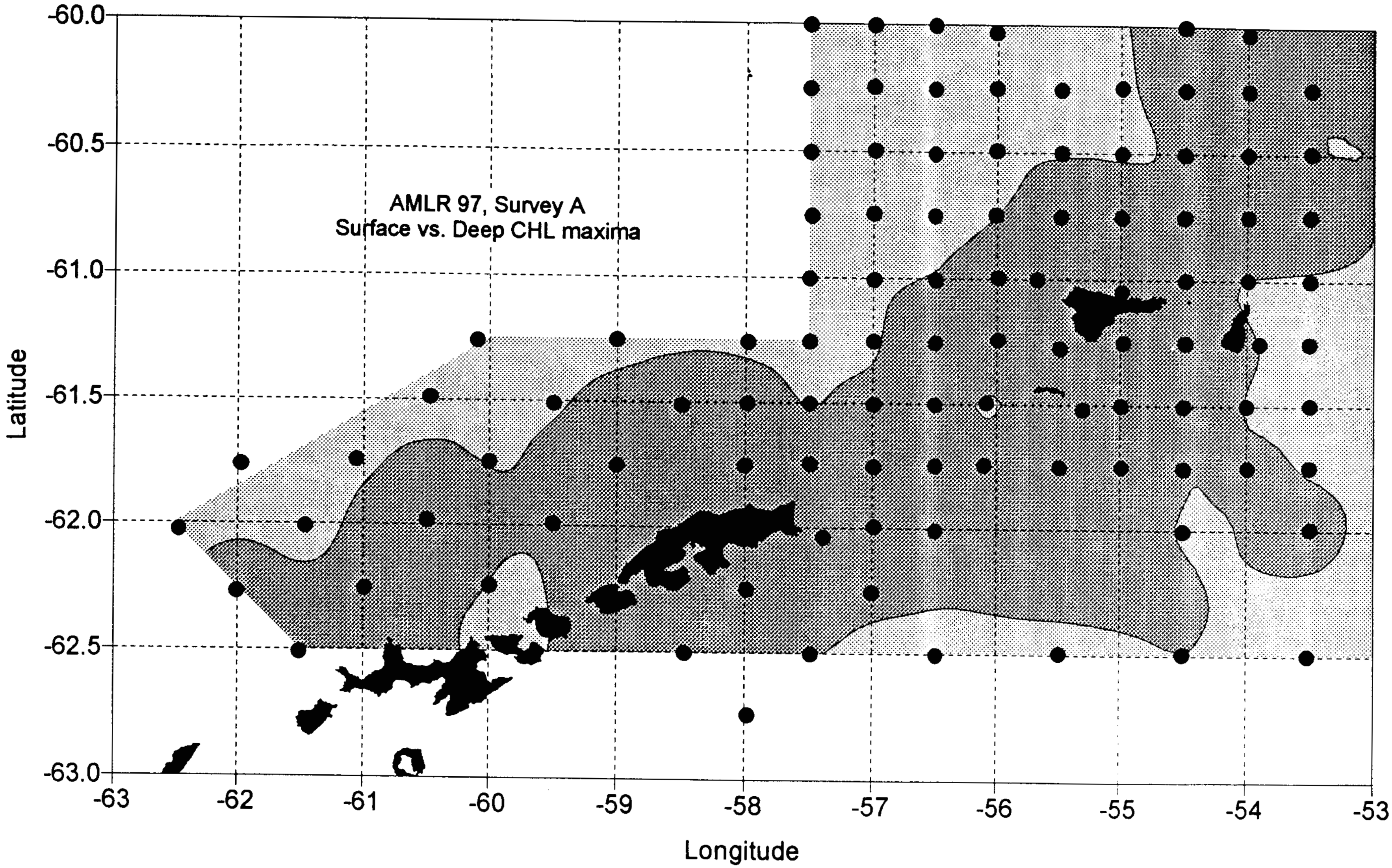


Figure 2.4 Map of the large-area survey grid, showing regions where the ratio of integrated chl-a (5 to 30m) to integrated chl-a (50 to 100m) exceeds the value of 1.0 (dark area) and where the ratio is less than 1.0 (light areas).

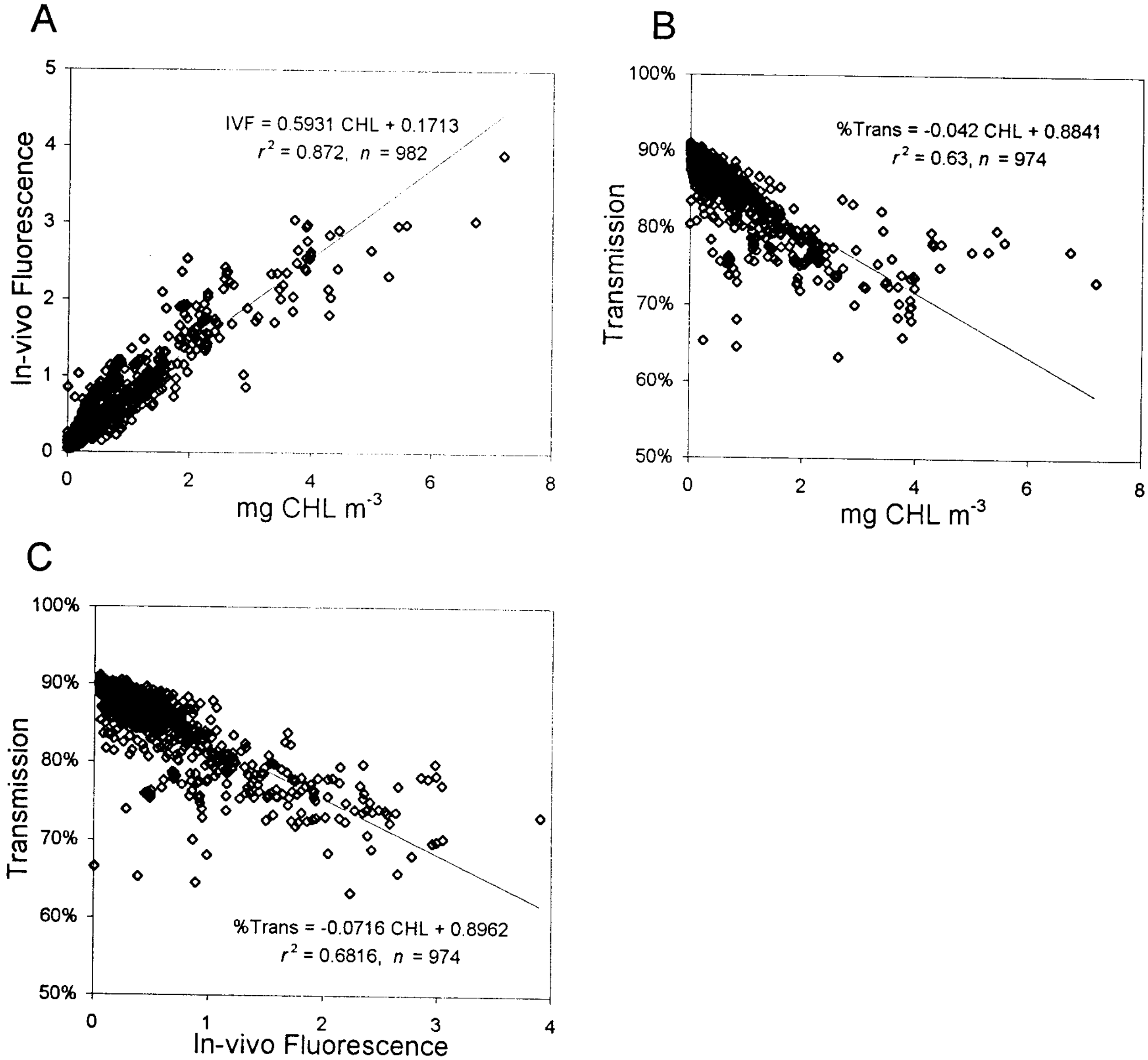


Figure 2.5 Linear regressions showing the relationships between the signal outputs from the sensors mounted on the CTD/carousel unit. All data were obtained at the depths (5 to 200m) and simultaneously with the closing of the Niskin bottles during the upcast. (A) Relationship between *in situ* fluorescence and extracted chl-a concentrations (p<0.001, n = 982). (B) Relationship between light transmission from the transmissometer and extracted chl-a concentrations (p<0.001, n = 974). (C) Relationship between light transmission from the transmissometer and *in situ* fluorescence (p<0.001, n = 974).

3. Bioacoustic survey; submitted by Roger Hewitt (Leg I), Vanesa Lopez (Leg I), Don Hyug Kang (Leg I), David Demer (Leg II), Jacqueline Popp (Leg II), and Nathalie Jaquet (Leg II).

3.1 Objectives: The primary objectives of the bioacoustic sampling program were to map the meso-scale (10's of kilometers) dispersion of krill (*Euphausia superba*) in the vicinity of the South Shetland Islands; to estimate their biomass; and to determine their association with predator foraging patterns, water mass boundaries, spatial patterns of primary productivity, and bathymetry. Additionally, in conjunction with the pilot trawl survey, multiple-frequency acoustic methods were employed in an effort to map the locations and densities of benthic and epibenthic fish.

3.2 Methods and Accomplishments: Acoustic data were collected using a multi-frequency echo sounder (Simrad EK500) configured with downlooking 38, 120, and 200kHz transducers mounted in the hull of the ship. Pulses were transmitted every two seconds at 1 kilowatt (kW) for 1.0 milliseconds (ms) duration at 38kHz, 1.0ms at 120kHz, and 0.6ms at 200kHz. Geographic positions were logged every 60 seconds. Ethernet communications were maintained between the EK500, a UNIX workstation, and a Windows-95 workstation. The UNIX workstation was used for system control; logging of volume backscattering strength (S_v) and target strength (TS) data; data post-processing including interpretation of echograms (e.g. visual delineation of biological scattering from noise); and calculating integrated volume backscattering strength (s_A). Processed data were passed to the Windows-95 PC for gridding and contouring of integrated volume backscattering strength. System calibrations were conducted before and after the surveys with a 38.1mm tungsten-carbide standard sphere while the ship was at anchor in Ezcurra Inlet, King George Island.

For the purposes of generating distribution maps of biological scatterers, bottom return, surface turbulence, and system noise were eliminated from the echograms. Preliminarily, the remaining volume backscatter was integrated over depth (from 15-500m for the 38kHz data, 15-225m for the 120kHz data, and 15-175m for the 200kHz data) and averaged over 0.1 n.mi. (185m) distance intervals. A 30x15 cell grid was imposed on the survey area; adjustments were made for the scaling discrepancy between longitude and latitude; and integrated volume backscattering values were interpolated at grid nodes using Kriging methods and assuming a linear variogram model.

For the purpose of roughly estimating krill biomass density, all volume backscattering at 120kHz was assumed to be from krill. Integrated volume backscattering strength per unit sea surface area (s_A) was converted to estimates of krill biomass density (ρ) by applying a factor equal to the quotient of the weight of an individual krill and its backscattering cross-sectional area, summed over the sampled length frequency distribution from Survey A (Hewitt and Demer, 1993). The relationship of krill wet weight as a function of standard length (l) was taken from Siegel (1986) for krill caught in March. The relationship of backscattering cross-sectional area as a function of l was derived from the definition of krill TS as proposed by Greene et al. (1991) at 120kHz. Substituting these relationships into the expression for density (ρ):

$$\rho = 0.249 \sum_{i=1}^{n} f_i (l_i)^{-0.16} s_A \qquad (g/m^2)$$

(Hewitt and Demer, 1993), where s_A is expressed in units of $m^2(n.mi.)^{-2}$ and f_i = the relative frequency of krill of standard length l_i such that

$$\sum_{i=1}^{n} f_i = 1$$

where i refers to the ith length class and n is the number of length classes.

Consistent with prior AMLR surveys, krill density was estimated as the mean ρ from transects conducted in the Elephant Island area portion of the survey. This area is outlined on Figure 3.1a and is similar to areas used for estimating krill density during previous surveys.

Large-Area Surveys: Survey A (27 January - 10 February, Figure 3.1) and Survey D (17 - 24 March, Figure 3.3) were conducted to map the meso-scale dispersion of krill in the vicinity of the South Shetland Islands, and to estimate the biomass of krill in a 12,600 n.mi.^{2} area centered on Elephant Island. Survey A consisted of approximately 2000 n.mi. of transects conducted between 106 stations. Station work included a CTD cast and an IKMT plankton tow. Mean krill density was calculated from nine north-south transects with 15 n.mi. spacing between lines. Due to time constraints resulting from the ship's engine failure, Survey D was a greatly abbreviated version of the planned survey and consisted of approximately 800 n.mi. of irregular trackline and 16 CTD/IKMT stations. Krill density was not estimated from these data.

Transects: Additional acoustic transects were conducted while transiting in and out of Admiralty Bay (see Introduction Section, Figure 2). Transects were also conducted while crossing the Drake Passage at the beginning of both legs, during transits for island operations, and during the pilot bottom trawl survey (Figure 3.3). The transect line at 55° W longitude was examined more closely than the others due to its value as the focus for an international data integration effort (Surveys A and D, Figures 3.4 and 3.5, respectively).

3.3 Tentative Conclusions:

Large-Area Surveys: A discontinuous band of high s_A was mapped on the north side of the South Shetland Islands (Figure 3.1). This band tended to be north of the frontal zone running parallel to the archipelago, widening and spreading onto the shelf in the vicinity of Elephant Island. Other areas of high s_A were mapped on the shelf near Livingston Island and in deeper water in Bransfield Strait. IKMT samples indicated that the krill north of the South Shetland Islands were adults in advanced maturity stages, while the krill caught on the island shelf and in the Bransfield Strait were a mixture of 1-year old juvenile and adult krill.

A44 - A100 Cross-section: Figure 3.2 is a compressed echogram describing a cross-section of s_A from Station A44 through A100 (bold transect line in Figure 3.1a). A notable feature is the krill layer between 25 and 100m depth extending from half-way between A44 and A45 to A47; a large aggregation of surface feeding fin whales was observed in this area (see Section 9, Cetaceans in the AMLR study area). Also notable is the ca. 100m thick layer of krill rising toward the surface as sunset approached and abruptly ending at 200m water depth. The echogram also suggests a downward migration of krill prior to sunrise on the south side of the South Shetland shelf and scattered krill swarms across Bransfield Strait and onto the Antarctic Peninsula shelf.

Transect at 55° West Longitude: Figures 3.4 and 3.5 depict the acoustic cross-section (S_v versus depth) of a transect at 55°W longitude and between 60° and 61.75°S latitude. During Survey A backscattering strengths were highest in the Drake Passage water, indicative of near-surface krill swarms in the transition zone, and relatively low in the Bransfield Strait water to the south of Elephant Island (Figure 3.4). In sharp contrast, the same transect during Survey D showed appreciable scattering only to the north of Elephant Island and deeper than 125m (Figure 3.5).

Preliminary Density Estimates: Krill density estimates for the Elephant Island area are compared from the austral summers of 1992 through 1997, excluding 1993 (Table 3.1). The data quality from 1993 is considered suspect due to equipment malfunction, calibration uncertainties, and high salp densities. Judging from one preliminary estimate, krill density in 1997 was higher than the previous five years.

3.4 Disposition of Data: Integrated volume backscattering data will be made available to other investigators in MS-DOS or UNIX (Sun-OS) format ASCII files. The analyzed echo-integration data, averaged over 0.1 n.mi. intervals, consumes approximately 10 Mbyte. The data are available from Roger Hewitt, Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037; phone/fax - (619) 546-5602/546-5608; internet: rhewitt@ucsd.edu.

3.5 References:

Greene, C.H., T.K. Stanton, P.H. Wiebe, and S. McClatchie. 1991. *Nature*, 349: 110.
Hewitt, R.P. and D.A. Demer. 1993. *Mar. Ecol. Prog. Ser.* 99:29-39.
Siegel, V.1986. Arch. FischWiss. 37:51-72.

Table 3.1 Mean krill biomass density for surveys conducted during 1992 through 1997.
** Previously reported biomass density values for 1993 are omitted due to problems with equipment performance and possible misinterpretation of backscatter from salps.

Year and Survey	Mean Krill Biomass Density (g/m²)
1992 Survey A (Jan-Feb) Survey D (Feb-Mar)	61.20 29.63
1993 Survey A (January) Survey E (Feb-Mar)	** **
1994 Survey A (Jan-Feb) Survey D (Feb-Mar)	9.63 7.74
1995 Survey A (January) Survey D (February)	27.84 35.52
1996 Survey A (January) Survey D (Feb-Mar)	80.82 70.10
1997 Survey A (Jan-Feb)	100.47

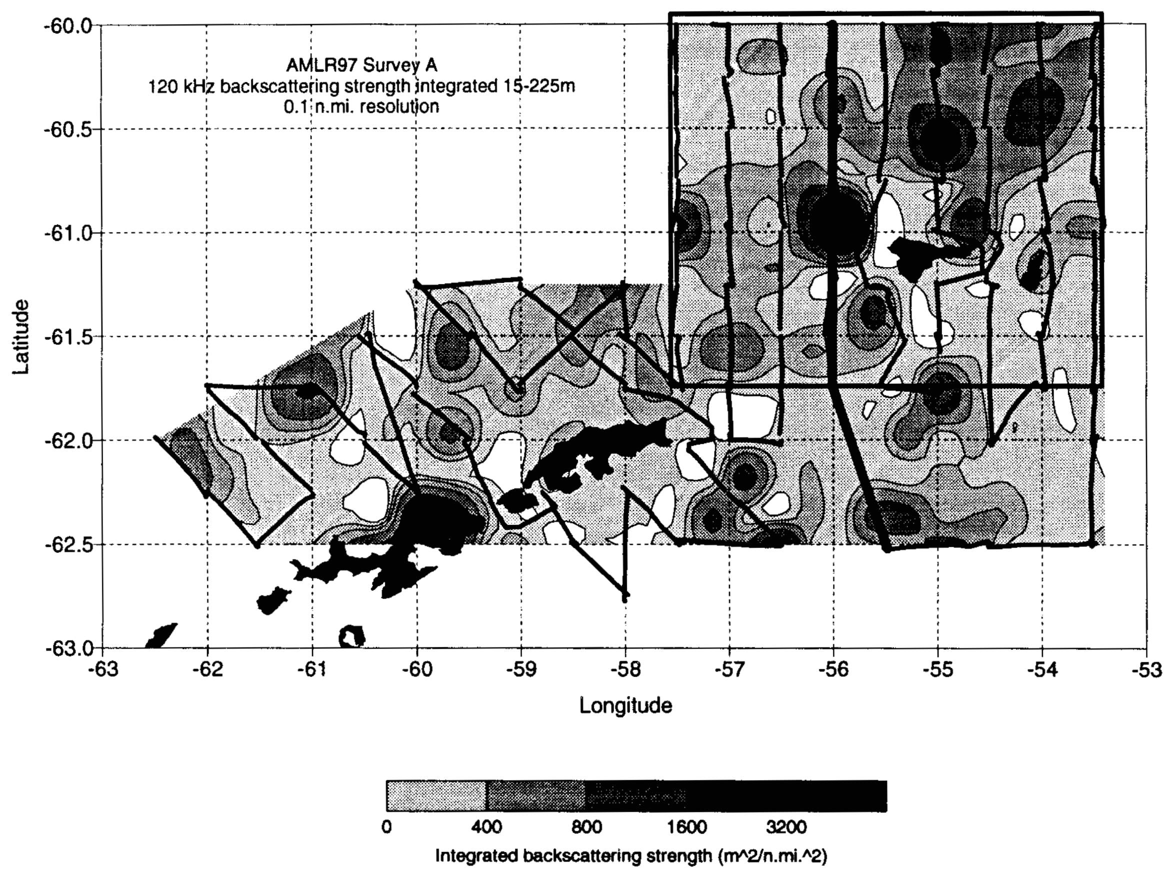
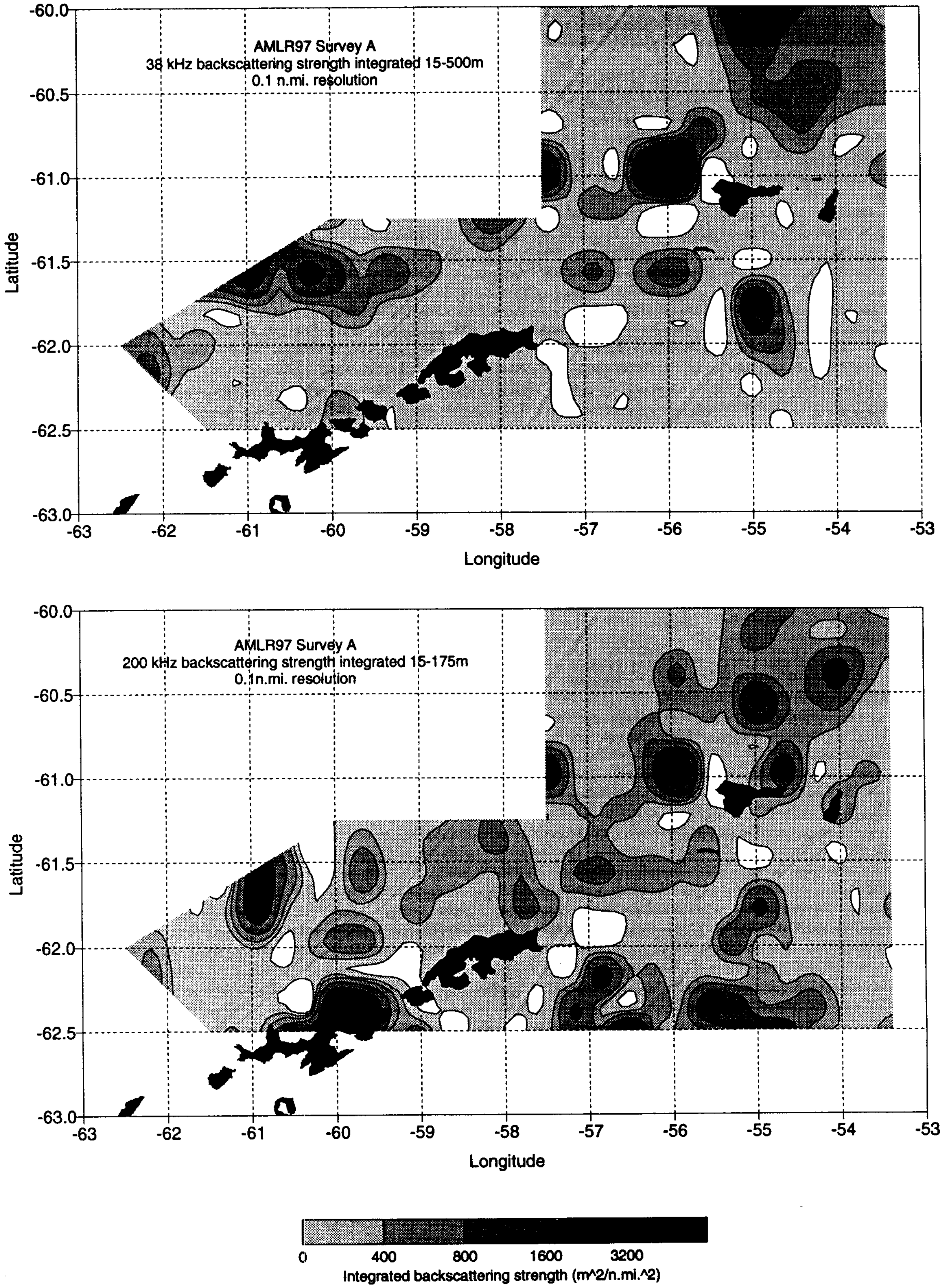


Figure 3.1a Integrated volume backscattering at 120kHz. Transect lines are indicated (-). The bold transect (circa -56° longitude) indicates the position of the acoustic cross-section described in Figure 3.2. The box around Elephant Island indicates the area for which average krill biomass density was estimated.



Figures 3.1b and 3.1c Integrated volume backscattering strength at 38kHz and 200kHz.

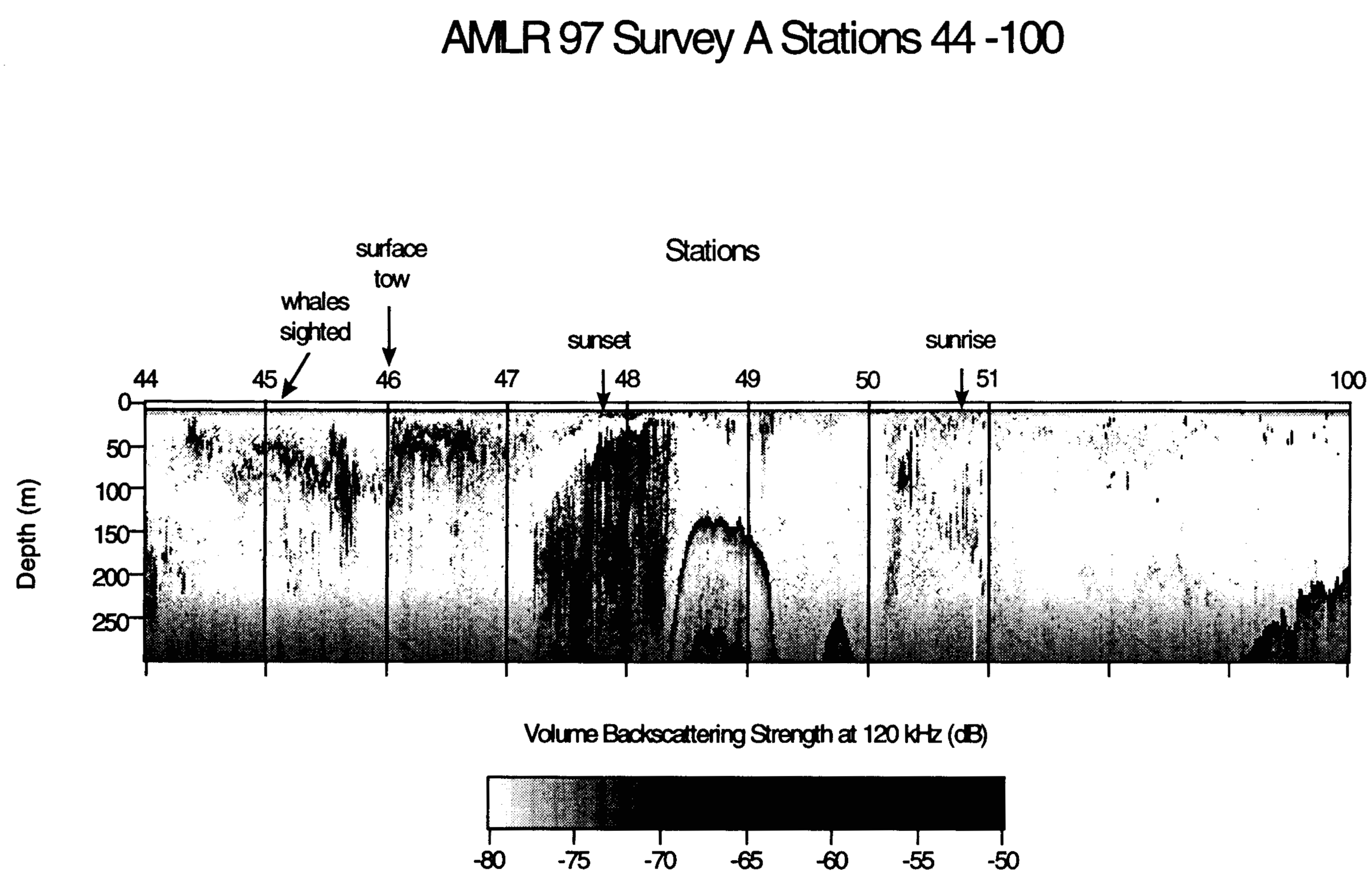


Figure 3.2 Acoustic cross-section from Stations A44 to A100.

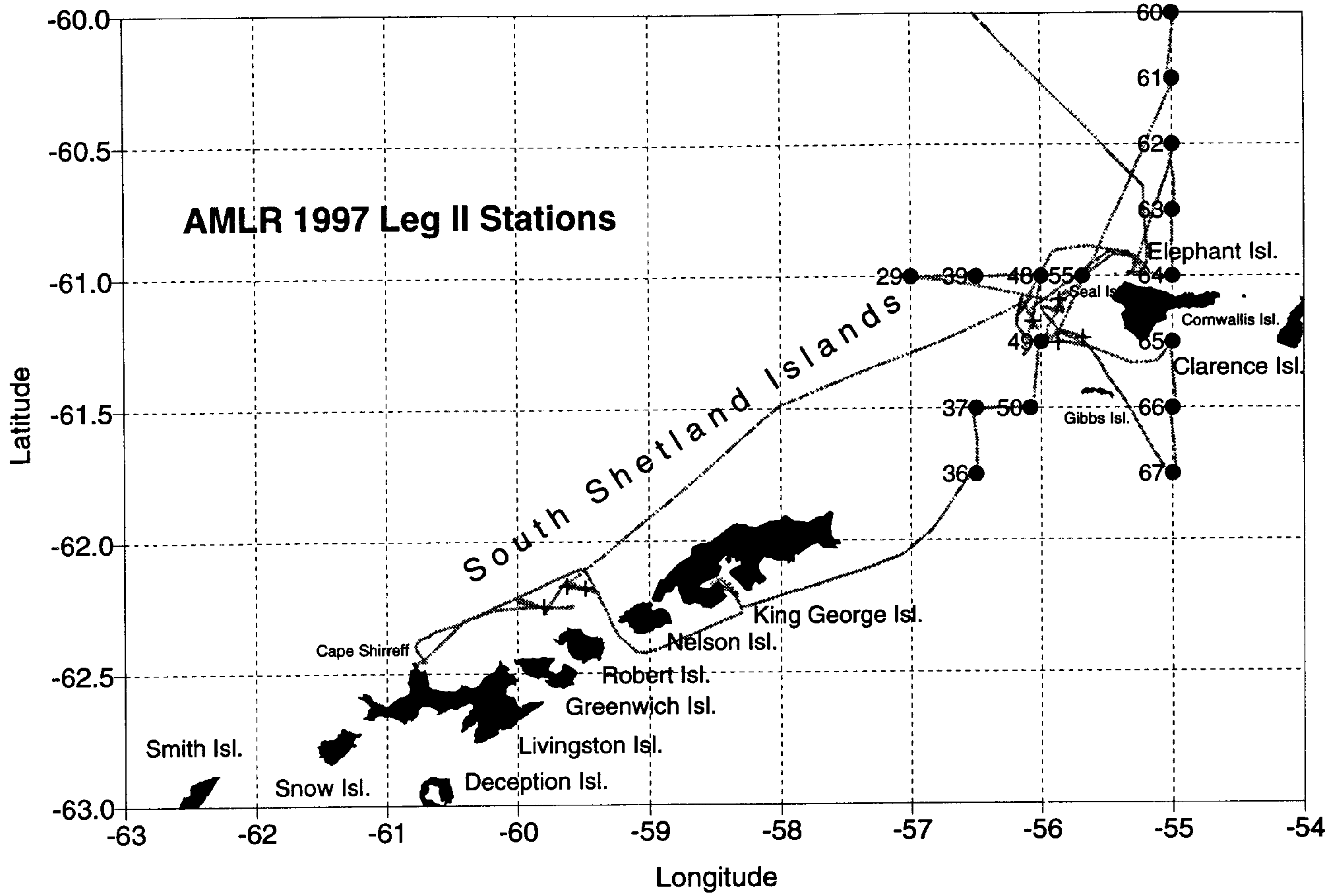


Figure 3.3 Acoustic trackline (-), Survey D stations (●), and bottom trawl stations (+).

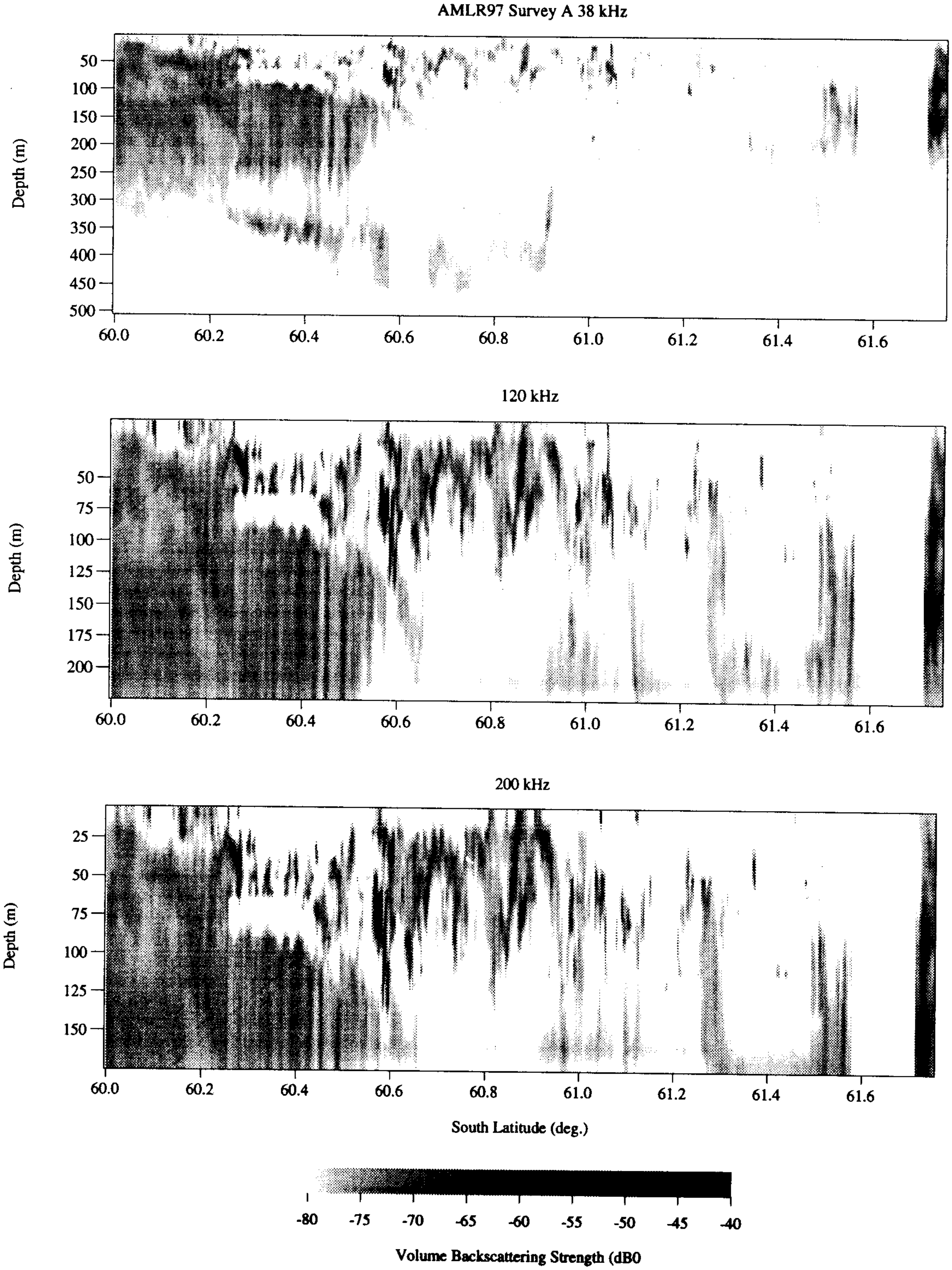


Figure 3.4 Acoustic cross-section of 55°W transect during Survey A (continuous from 8-9 February).

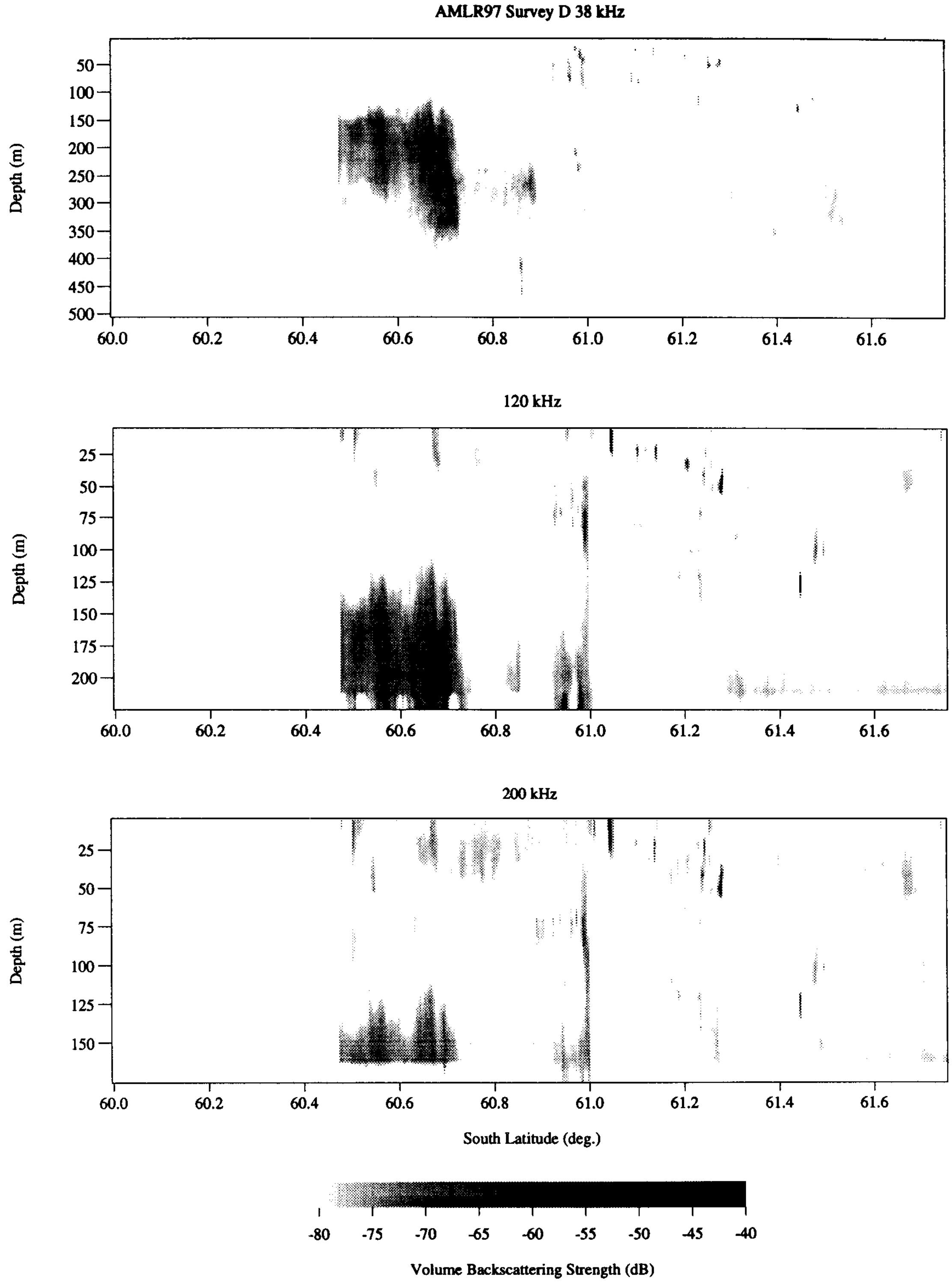


Figure 3.5 Acoustic cross-section of 55°W transect during Survey D (discontinuous from 16-24 March; see Figure 3.3).

4. Direct krill and zooplankton sampling; submitted by Valerie Loeb (Legs I and II), Dawn Outram (Leg I), Kimberly Puglise (Legs I and II), Wesley A. Armstrong (Leg I), Alistair Hobday (Leg II), Matthew M. Nelson (Leg I), Charles F. Phleger (Leg I), Jeremy Sterling (Legs I and II), George Watters (Leg II), and Ruth Yender (Leg II).

4.1 Objectives: The objective of this work was to provide information on the demographic structure of Antarctic krill (*Euphausia superba*) and the abundance and distribution of zooplankton components in the Elephant, King George, and Livingston Islands survey area. Essential demographic information for krill includes length, sex ratio, reproductive condition, and maturity stage composition. Information useful for determining the relationship between krill distribution and population structure and ambient environmental conditions was derived from net samples taken at CTD/carousel stations within the large-area survey. Information on the abundance and distribution of other zooplankton components was also obtained from the large-area survey samples. Additional attention was focused on salps (*Salpa thompsoni*) because of their inclusion in acoustical biomass assessment and potential influence on the distribution, behavior, and recruitment success of krill. Results from 1997 are compared to those from 1992-1996 AMLR surveys to assess between-year differences in krill demography and zooplankton composition and abundance.

4.2 Accomplishments:

Large-Area Survey Samples.

Krill and zooplankton were obtained from a 6-foot IKMT fitted with a 505μm mesh plankton net. Flow volumes were measured using a calibrated General Oceanics flow meter mounted on the frame in front of the net mouth opening. All tows were fished obliquely to a depth of 170m or to ca. 10m above bottom in shallower waters. Tow depths were derived from a real time depth recorder mounted on the trawl bridle and monitored in the acoustics lab. Tow speeds were ca. 2 knots. During Leg I (Survey A), samples were collected over the extended survey area (see Introduction Section, Figure 3). Due to limited time during Leg II (Survey D), samples were collected at only 16 stations within the Elephant Island area (see Introduction Section, Figure 4). However, these stations represented most of the bathymetric, hydrographic, and biogeographic regions regularly monitored in the Elephant Island area. Statistical analyses of Survey A data (see page 57) indicate that, except for species richness, results derived from these 16 stations are representative of the Elephant Island and extended large-area survey.

Shipboard Analyses.

All net samples were processed on board using fresh material. Krill demographic analyses were made using fresh or freshly frozen specimens. The other zooplankton/micronekton analyses were made within 1 hour of sample collection using unpreserved samples.

Abundance estimates of krill, salps, and other zooplankton/micronekton taxa are expressed as numbers per 1000 m^3 of water filtered; krill abundance is also expressed as numbers per m^2 sea surface to allow comparisons with other data sets. Data from Leg I are presented for the entire large-area survey and for the more restricted "Elephant Island Area" (a box around Elephant Island, see Figure 4.1) to allow comparison with previous AMLR cruises. Data from the limited station coverage within the Elephant Island area during Leg II are compared to those from the same 16 stations, as well as all 105 stations sampled during Leg I.

(1) Krill: Krill were removed and counted prior to other sample processing. All krill from samples containing <150 individuals were analyzed. For larger samples, 100-200 individuals were measured, sexed, and staged. Measurements were made of total length (mm); stages were based on the classification scheme of Makarov and Denys (1981).

(2) Salps: All salps were removed from the samples. For entire samples of ≤100 individuals, the two forms (aggregate/sexual and solitary/asexual) were enumerated and the internal body length (Foxton, 1966) was measured to the nearest millimeter. Representative subsamples of 50-110 individuals were analyzed for larger catches.

(3) Fish: All adult myctophids were removed, identified, measured to the nearest millimeter SL, and frozen.

(4) Zooplankton: After krill, salps, and adult fish were removed, the remaining zooplankton samples were analyzed; these zooplankton samples typically were <500ml in volume. All of the larger organisms (e.g., other euphausiids, amphipods, pteropods, polychaetes) were sorted from the samples, identified to species if possible, and enumerated. The smaller constituents (e.g., copepods, chaetognaths, euphausiid larvae) in representative aliquots were then enumerated using dissecting microscopes; these aliquots generally accounted for 5-20% of the total small fraction. After analysis, the zooplankton samples (minus krill, salps, and adult fish) were returned to sample jars and preserved in 10% buffered formalin for long-term storage.

4.3 Results and Preliminary Conclusions:

(I) Leg I, Survey A

(1) Krill: IKMT samples were collected at 105 stations during Survey A (Table 4.1a). These samples collected an estimated total of ca. 13560 krill; 5026 of these were measured, sexed, and staged to provide demographic information. The Elephant Island area was represented by 71 samples and ca. 7000 krill. Krill were present in 98 of the Survey A samples (93.3%) with a median abundance of 5.6 per 1000 m^3. Six of the largest catches (145.5-569.0 per 1000 m^3) occurred in Bransfield Strait, and three (115.8-483.2 per 1000 m^3) occurred in Drake Passage waters adjacent to Livingston and Elephant Islands (Figure 4.1). The relatively large catch at Station A46 was made in the vicinity of intense whale feeding activity (see Section 9, Cetaceans in the AMLR study area). Relatively modest krill catches (e.g., 1-39 per 1000 m^3) extended across much of the Elephant Island area.

Krill lengths within the large-area survey ranged from 15 to 58mm with three distinct modes at 26-27mm, 34-37mm, and 49-50mm (Figure 4.2a). These modal lengths conform to the 1+, 2+, and 3+ age groups. The 30-42mm length category was most abundant and contributed 54% of the total, reflecting successful recruitment of the 1994/95 year class. This length category is comprised of individuals which are entering the adult stage during the 1996/97 spawning season. Smaller and larger krill respectively made up 20% and 28% of the total. The 30-42mm length category contributed a similar proportion (52%) of krill in the Elephant Island area, but <30mm individuals were comparatively rare there (9% of total; Figure 4.2b).

Krill within both the large-area survey and Elephant Island area were dominated by mature stages (respectively 37.2% and 54.2%; Table 4.2). This is due to the presence of maturing 2+ females as well as older individuals. Juveniles made up 29.9% of the total across the survey area and only 15.2% within the Elephant Island area, suggesting substantially lower recruitment of the 1995/96 year class compared to the previous year. Most of the mature females exhibited ovarian development (3c stage), were gravid (3d), or spent (3e). Fully gravid and spent stages increased in frequency of occurrence as the survey progressed, indicating that peak spawning probably will occur in mid-February-early March (i.e., one to three weeks later; Harrington and Ikeda 1986). Overall, 77.4% of females were in advanced maturity stages, while 83.2% of those in the Elephant Island area were in advanced stages. This difference may in part be due to the later sampling period in the Elephant Island area. The German Elephant Island survey in December, 1996 collected a few gravid females (V. Siegel, pers. com.). The numerically dominant calyptopis stage krill larvae in our samples (ca. 5-7 weeks old) resulted from late-December/early January spawning, while the furcilia stages came from earlier (i.e., mid-December) spawning (Ross et al., 1988). Based on the proportion of female maturity stages, the 1996/97 peak spawning period appears to be slightly delayed relative to the previous two years but is far earlier than during 1992-1994 (Table 4.2).

Cluster analysis was performed on length frequency distributions of krill in samples represented by ≥20 individuals. This resulted in two groups with different length/maturity stage composition and geographical distribution patterns. Cluster 1 was primarily comprised of 30-42mm (68%) and <30mm (30%) length categories (i.e., 2+ and 1+ age classes), while Cluster 2 included primarily the >42mm (66%) and 30-42mm length categories (29%) (3+ and 2+ age classes) (Figure 4.3a). The fact that the three distinct length categories do not yield three distinct clusters results from the co-occurrence of the intermediate size 2+ age class with both younger and older krill. The maturity stage composition of the two clusters reflects these mixed size groups (Figure 4.3b). Cluster 1 was largely composed of juveniles (44%) and immature stages (45%); Cluster 2 was composed mostly of mature (76%) and immature stages (15%). The distributional pattern of the two length/maturity groups conforms to that typically observed in this area during austral summer, with the smaller/younger krill largely distributed within Bransfield Strait and the older/larger krill primarily in Drake Passage (Figure 4.4). The whales observed near Station A46 were undoubtedly feeding on large Cluster 2 krill (50-55mm) sampled there. The krill distributions are associated with water mass influences, as indicated by the sea surface salinity values (see Section 1, Physical oceanography). Cluster 1 krill generally occurred in association with salinity values ≥34.0 ppt (e.g., Bransfield Strait and Weddell Sea water), while Cluster 2 krill occurred in lower salinity (e.g., Drake Passage) water. The presence of Cluster 1 krill north of Livingston Island and of Cluster 2 krill south of King George Island is notable and suggests advective exchange in this area (Figure 4.4). Small-sized krill (15-25mm) collected in the eastern portion of Bransfield Strait (Station A93) may represent some influence from the Weddell Sea krill stock (Siegel et al. in press).

(2) Zooplankton and Micronekton: A total of 72 zooplankton and micronekton species and taxonomic categories were identified (Table 4.3). Copepods were present in all of the samples and were the most abundant category collected with a mean abundance of 582.6 per 1000 m^3. Salps (181.4 per 1000 m^3) and *Thysanoessa macrura* postlarvae (104.4 per 1000 m^3) were present in 103 of the 105 samples (97%) and respectively ranked 2 and 3 in mean abundance. Postlarval krill, with a mean abundance of 40.4 per 1000 m^3, comprised the fourth most abundant taxon. Although much less frequent (e.g., 45-75% of samples), chaetognaths (22.9 per 1000 m^3), and larval stages of *T. macrura* (17.0 per 1000 m^3) and krill (15.2 per 1000 m^3) were relatively abundant. Calyptopis stages (mostly 1 and 2) made up 93% of the krill larvae; furcilia stage 1 made up 7%. Krill larvae were primarily collected over >1000m bottom depths in Drake Passage; the maximum abundance was 96.5 per 1000 m^3 (Figure 4.5).

(a) Salps: Relatively large concentrations of salps (e.g., >100 per 1000 m^3) were distributed across the survey area (Figure 4.6). Only the southeast portion of survey area in Bransfield Strait had notably low salp abundance, possibly due to Weddell Sea water influence. Aggregate (sexual) stages comprised 80% and solitary (asexual) stages 20% of the total catch. Sizes ranged from 4-172mm (Figures 4.7a and 4.7b). The solitary stages were represented primarily by newly released embryos 4-7mm in length (49%) and old large individuals (all forms >78mm, 34%). The vast majority of the aggregate stages (98%) were <60mm in length. The aggregate forms demonstrated three distinct size modes around 7-17mm (31%), 25-35mm (23%), and 45-50mm (10%), which suggest peak budding periods by the solitary stages during spring and summer months. Cluster analyses on both the size and stage composition of salps in large-area survey samples do not yield any obvious distributional patterns.

(b) Other Taxa: Six hyperiid amphipod species were relatively frequent, occurring in ≥50% of the samples. These were, in order of decreasing frequency: *Themisto gaudichaudii, Cyllopus magellanicus, Vibilia antarctica, Primno macropa, Hyperiella dilatata,* and *C. lucasii* (Table 4.3). The pteropod *Spongiobranchaea australis* was present in 68% of samples. Although it was present in only 42% of the samples, *Euphausia frigida* was the eighth most abundant taxon.

(3) Leg I, Day-Night Catch Differences: Day, night, and twilight were represented by 72, 24, and 9 samples, respectively. Analysis of variance (ANOVA) and post hoc Tukey tests indicate significantly higher night vs. day abundance for eight taxa: salps ($P<0.0001$); *E. frigida*, *T. gaudichaudii*, and copepods ($P<0.01$); postlarval krill, *C. lucasii, C. magellanicus,* and *V. antarctica*, ($P<0.05$). Two postlarval euphausiids had significantly higher night vs. day and twilight abundance: *E. triacantha* ($P\leq0.01$) and *T. macrura* ($P\leq0.05$). The abundance differences of krill are probably primarily due to visually aided daytime net avoidance, while those of the other taxa may be related to diel vertical migration into the upper 170m. One species, the amphipod *P. macropa,* had significantly higher daytime abundance ($P<0.01$).

(4) Leg I, Interspecific Relationships: Various zooplankton/micronekton taxa demonstrate significant correlations of abundance across the large-area survey as indicated by Kendall's Tau values ≥ 0.31 ($P<0.0001$). Abundances of salps, *E. frigida*, and *E. triacantha* are all positively correlated, reflecting increased night time abundance in the upper 170m due to diel vertical migrations. Abundance of salps and *C. lucasii, C. magellanicus*, and *V. antarctica* are also positively correlated probably due to commensal relationships of these amphipods with salps (Madin and Harbison, 1977). There is also a significant positive correlation resulting from the parasitic relationship between the amphipod *H. dilatata* and pteropod *S. australis:* 15% of the *S. australis* were attached to *H. dilatata,* while 15% of *H. dilatata* had these pteropods skewered between their hind legs. Apparently, the toxicity of *S. australis* is used by *H. dilatata* as a predation detractor (McClintock and Janssen, 1990). Because of shared distributional patterns in primarily Drake Passage water, abundances of larval krill and larval *T. macrura* are significantly and positively correlated with *H. dilatata* and *S. australis*. As during 1996 (Loeb et al., 1996), the distributions of larval and postlarval *T. macrura* are diametrically opposed as indicated by a significant negative correlation.

(5) Leg I, Between Year Comparisons:

(a) Krill: Both median and mean krill abundance estimates for the Elephant Island area were about half of those observed during January 1996; they were most similar to those during January 1992 and 1993 (Table 4.4). The overall maturity stage composition, with ca. 30% of the population represented by immature krill, was most like that observed in January 1993 (Table 4.2); both 1993 and 1997 followed years with relatively strong krill recruitment. Proportionately more juveniles were collected during 1997 than 1993 (15.2 vs. 7.2%), suggesting more successful recruitment of the 1995/96 year class relative to the 1991/92 year class. Somewhat lower proportions of adult females were in advanced spawning condition during January-February 1997 than the previous two years (83% vs. 96-98%), suggesting a slightly delayed peak spawning period. However, spawning in 1996/97 is still substantially earlier than during 1992-1994. The broadly distributed krill larvae, including 7% furcilia stages, indicate that although peak spawning may be delayed, active spawning was initiated early relative to the other years.

(b) Salps: Both median and mean salp abundance during January 1997 were 8X larger than during 1996, an order of magnitude larger than during 1995, and 15-35% of the values observed during the 1993 and 1994 "salp years." In this context, 1997 may herald a transition to "salp years." The relatively large proportions of solitary stages during January-February 1997 (20%) differed from other years when aggregate stages made up $\geq 95\%$ of the individuals collected. The overall length frequency distribution was significantly different from those during January 1994-1996 (Kolmogorov-Smirnov tests, $P<0.05$ for 1994 and 1996, $P<0.01$ for 1995; Figure 4.7b). These differences were due to the large numbers of small solitary stages and broad, more evenly represented size range of aggregate stages during 1997. During 1994 and 1996, the populations were dominated ($\geq 60\%$) by aggregate forms of 20-40mm length, and small aggregate forms of

15-25mm length predominated in 1995. The apparent peaks in aggregate stage production in 1997 suggest successive release of blocks of young (i.e., three chains of aggregates) by the parent solitary stages across spring and summer months; large numbers of small solitary stages may result from early seasonal spawning by the first two pulses of aggregate chains produced in spring (e.g., those that have grown to ca. 25mm and larger; Foxton 1966) (Figure 4.7a).

Compared to other years the salp length and stage composition, along with relatively high abundance, during January-February 1997 suggests a long and successful budding period, with increasingly favorable conditions across the survey area during late spring-summer months (Figure 4.7b). This could result from an early retreat of seasonal sea-ice in spring and increasingly benign widespread conditions (e.g., warm upper water column temperatures) across subsequent months. This contrasts strongly with the previous three years. Low sea-ice extent during winter 1993 preceded the 1993/94 "salp year," while above-average winter sea-ice in 1994 and 1995 was not favorable for salp population growth in 1994/95 and 1995/96 (Loeb et al., in press). Despite differences in winter sea-ice conditions and related salp population size, the salp size frequency distributions in January 1994 and 1996 were similar. The bell shaped curves around ca. 30mm suggest a fairly long budding season with peak intensity in spring (possibly November) and declining aggregate production in summer months. The predominately small-sized salps of 1995 were most abundant in Bransfield Strait waters to the south and east of Elephant Island and possibly of local derivation with small sizes resulting from a relatively short growth period there. In contrast, the larger salps collected during 1996 were most abundant in Drake Passage water and possibly were transported into the Elephant Island area after a prolonged growth period in the West Wind Drift. The widespread occurrence and high abundance of large salps across the Elephant Island area during 1994 most likely resulted from rapid population growth and an extended growing season both locally and offshore.

(c) Overall Zooplankton/Micronekton Assemblage: Overall diversity in the survey samples (73 taxonomic categories; Table 4.3) was similar to that observed during January 1995 and 1996 surveys and presumably is characteristic of the large-area survey during this time of the year, at least during "non-salp years." Relatively high Percent Similarity Index (PSI) values of 70.5-77.2 resulting from comparisons of taxonomic composition during these years, and extremely low values of 16.7-34.4 from comparisons between these and the 1994 "salp year," suggest that this is generally typical of the January-February zooplankton/micronekton assemblage here except during extensive salp blooms. However, current sample analysis techniques must be applied to material collected during another "salp year" to determine the validity of apparent low overall diversity and abundance during 1993 and 1994.

While this appears to be a generally "typical" assemblage, there are a few notable differences in occurrence and/or abundance of various taxa which sets this apart from the previous two "non-salp years." Increased frequency of occurrence and abundance of *C. magellanicus*, *V. antarctica*, and *C. lucasii* are associated with those of salps. Increased occurrence and abundance of *P. macropa* and *H. dilatata* this year may be in part sampling artifacts due to enumeration of the individuals occurring in small fraction aliquots. However, the significant positive correlation between *S. australis*, which is notably more frequent and abundant this year, and *H. dilatata* does not support a sampling artifact for this amphipod. Abundance of larval *T. macrura* was similar to that in 1995, and both were about 20% of that in 1996, supporting the idea that *Thysanoessa* spawning in 1996 was anomalously early and/or intense. Among the larval fish, *Lepidonothen kempi* was notably more widespread and abundant than in previous years. Since the largest catches of this species were within the traditional large-area survey, this elevated abundance is not related to extended sampling to the west.

(II) Representativeness of Leg II Station Coverage Based on Leg I Data

Due to the ship's mechanical problems, sampling during Leg II was quite limited compared to other years. The potential impacts of relatively small sample size must be addressed to validate and/or accommodate for results from Survey D.

(1) Bathymetric and Hydrographic Representation: The 16 stations were located to the north, south, west, and southwest of Elephant Island (see Figure 4.10) and fairly adequately represent the bathymetric, hydrographic, and biogeographic features regularly monitored in the Elephant Island area during AMLR surveys (see Sections 1, 2, and 4, this and previous AMLR field season reports). The full bathymetric range of the Elephant Island area, from <200m shelf areas to depths >1000m in both Drake Passage and Bransfield Strait, were represented by these 16 stations. Based on past hydrographic surveys, the location of these stations should have represented at least four of the five water zones typically present in the Elephant Island area during February-March. However, Water Zone II and/or Water Zone V, characteristic of the areas east of Elephant Island, may not have been included this year. The stations also span regions of highest to lowest integrated chl-a concentrations and the distributions of krill length-maturity stage clusters typically observed in the Elephant Island area during late summer.

(2) Ecological Representation: Analyses of the species, size, and stage composition represented at the 16 stations during Survey A relative to the 71 station Elephant Island area and 105 station large-area survey support the ecological representativeness of the limited data set.

Taxonomic composition and abundance: Each data set is numerically dominated in the same way by copepods, salps, *T. macrura*, and krill, while calyptopis stage krill larvae, *E. frigida*, larval *T. macrura*, and chaetognaths comprise the four next abundant taxa (Table 4.5). Overall taxonomic composition and abundance ranks of other relatively abundant taxa are quite similar between the data sets. PSI values based on the mean abundance of all taxa are quite high, ranging from 89.3 (limited vs. Elephant Island) to 95.3 (Elephant Island vs. Survey A). There is no significant difference between the ranks of the 13 most abundant taxa in the limited data set vs. the Elephant Island and Survey A data sets (rank difference correlation coefficients 0.91 and 0.87, respectively; $P > 0.20$). Furthermore, there are no significant differences between the mean abundance values of individual taxa in the data sets presented in Table 4.5 (ANOVAs and post-hoc Tukey test P values all >0.20).

Despite the overall similarity between the composition and abundance of the dominant and common taxa, the limited 16 station sampling effort yielded roughly half as many taxa as did the extensive Survey A (Table 4.6a). The difference is obviously due to the rarer taxa which are collected with more intensive sampling effort, as demonstrated in Figure 4.8. Within the survey area, starting off with the Elephant Island area the curve reflects the following: 25 taxa (5 tows); 35 taxa (12 tows); 45 taxa (24 tows); 55 taxa (48 tows); and 61 taxa (72 tows). Subsequent sharp increases in taxa result from sampling to the west of the Elephant Island area.

Krill size frequency distribution represented by the 16 stations was quite similar to those of the larger two data sets (Figures 4.9a, 4.9b; Kolmogorov-Smirnov tests, $P>0.20$ in both cases). Overall krill maturity stage composition in the limited data set is also quite similar to the others (PSI values 84.9 vs. the Elephant Island area and 89.4 vs. Survey A).

As with krill, the salp size frequency distribution and stage composition in the 16 samples was quite similar to that represented in the Elephant Island and Survey A areas. The proportion of solitary stages in the limited sampling was slightly less than in the larger areas (15% vs. 20% and 21%, respectively) and results in high PSI values from comparison of sexual stage composition with those areas (94 and 95). Cumulative percent curves derived from salp length frequency distributions in each area were similar ($P>0.20$ in all cases).

Based on these results one may assume that, although limited, the Survey D micronekton and zooplankton data are fairly representative of the numerically dominant common taxa across the broader Elephant Island and large-area survey, and that these data may be used in meaningful comparisons with other data sets. However, caution must be applied to less common taxa and/or taxa that have distribution patterns primarily outside the scope of Survey D.

(III) Leg II, Survey D

(1) Krill: Krill were present at 11 of 16 IKMT stations (69%) in the Elephant Island area sampled during 16-23 March (Table 4.1b). A total of 1327 krill were collected; 560 were analyzed for demographic information. Largest catches (204.2 and 134.4 per 1000 m^3) and moderate sized catches (22.8-65.2 per 1000 m^3) occurred north and southwest of Elephant Island, while small or no catches generally occurred west and south of the island (Figure 4.10). Mean and median krill abundance estimates were 30.4 and 4.6 per 1000 m^3, respectively. These values are similar to those observed in the Elephant Island area during Survey A (Table 4.4).

Krill lengths ranged from 24-57mm and demonstrated three size modes centered around 29-30mm (1+ age group), 37-41mm (2+), and 49-52mm (3+) (Figure 4.11). The two smaller modes are 3mm longer than those observed during Survey A, while the larger mode is unchanged. This suggests summertime growth rates over a 45 day period of ca. 0.07mm per day for the 1+ and 2+ age classes; this summertime growth rate has also been reported for 2+ krill but is nearly half of that reported for the 1+ age group (Siegel and Kalinowski, 1994). In contrast to Survey A, large krill 44-56mm were most abundant and comprised 62.3% of the total, while intermediate 35-43mm sized krill made up 31.9%. Small krill (<35mm) made up 6.5% of the total, which was proportionally slightly less than observed in the Elephant Island area during January-February

(9%). These changes could result from seasonal migrations of the different maturity stages (Siegel, 1988).

In accordance with the size distribution, most of the krill were mature (72.3%) while immature stages made up 19.7% and juveniles 8.0% (Table 4.2). The mature females were primarily gravid (3d stage, 76.0%) and spent (3e, 19.0%), indicating a mid- to late-March spawning peak. The female maturity stage composition observed during Survey A suggested peak spawning in mid-February to early-March. Either that spawning peak was delayed or a second spawning peak was initiated one month later. In any event, the 1996/1997 spawning period was prolonged, extending from mid-December through March. Despite its duration, spawning success did not appear to be good as suggested by only modestly higher concentrations of krill larvae in mid-March compared to Survey A.

Cluster analysis performed on krill length frequency data from the eight stations represented by ≥20 individuals resulted in two clusters (Figure 4.12a and 4.12b). Acknowledging the small sample size, the occurrence of the two clusters was generally similar to that during Survey A. Cluster 1 occurred in Bransfield Strait and over the northern shelf of Elephant Island, while Cluster 2 occurred at Drake Passage stations (Figure 4.13). Cluster 1 included a broad size range but was dominated (72%) by intermediate sizes of 35-43mm (2+ age group). Smaller krill (24-34mm) made up 19% and larger krill (44-56mm) made up 9% of the total. Immature stages were most abundant (52%), and juvenile and mature stages were fairly equally represented (23% and 25%, respectively; Figure 4.12a and 4.12b). Over half of the mature individuals were spent females; these represented 95% of the mature female stages. In contrast, Cluster 2 was comprised only of krill >37mm and dominated by 44-56mm individuals (90%). Almost all of these krill were mature (97%). As with Cluster 1, over half of the mature individuals were females, but these were for the most part gravid (87%); only 7% of the Cluster 2 females were spent. These observations conform to the overall seasonal distribution patterns of krill maturity stages and onshore migration of post spawning females reported by Siegel (1988).

(2) Zooplankton and Micronekton: A total of 37 taxa were represented in the 16 Survey D station samples. This was about half the number collected in 105 samples from the Survey A area (Table 4.6a) but similar to the number of taxa collected at the same 16 stations during Leg I (Table 4.6b). Mean and median species richness at those stations were similar (13.5-14.5 taxa per tow) during both surveys. The same eight numerically dominant taxa from Survey A again dominated the samples. Copepods (mean 1267.8 per 1000 m^3), salps (1243.8 per 1000 m^3), and post-larval *T. macrura* (181.3 per 1000 m^3) were the most abundant, followed by *E. frigida* (44.8 1000 per m^3) and postlarval krill (30.4 per 1000 m^3). Among these taxa, significantly higher mean abundances of salps (Z test, $P<0.001$) and *E. frigida* ($P<0.05$) indicate substantial population growth during late summer. Krill larvae ranked 6 in mean abundance (25.0 per 1000 m^3). Only calyptopis stages were collected; these were most frequent and abundant west of Elephant Island (Figure 4.14). Although mean larval krill abundance was elevated over Survey A, this increase is not statistically significant suggesting relatively poor spawning success and/or egg and larval survival during January-February. If the absence of furcilia larvae is not an artifact due to their distributional pattern, it may be another indication of poor larval survival.

Chaetognaths (18.2 per 1000 m^3) and larval *T. macrura* (10.8 per 1000 m^3) ranked 7 and 8 in abundance. The lower larval *T. macrura* abundance relative to Survey A is due to their primary distribution in Drake Passage waters outside the scope of Survey D (Loeb et al., 1996).

(a) Salps: Salps were present at all 16 station with concentrations ranging from 280-4350 per 1000 m^3. Four of the five largest catches (>2000 per 1000 m^3) occurred in Drake Passage water north of Elephant Island (Table 4.1b; Figure 4.15). Aggregate stages were most abundant and contributed 92% of the total individuals; proportionately fewer solitary stages were collected than during Survey A (8% vs. 20%). Most (66%) of the aggregate stages were 8-16mm in length and resulted from relatively recent chain release by solitary stages. As during Survey A, the larger aggregate stages demonstrated a polymodal distribution (Figure 4.16a). Within the 17-82mm aggregate size range, abundance peaks occurred around 26-38mm (26%), 45-55mm (26%), and 69-74mm (9%). These size modes and increased proportions of individuals >60mm relative to Survey A (Figure 4.16b) suggest a net length increase of ca. 20mm over a 45 day period; this corresponds to a growth rate of ca. 14mm per month (0.4mm per day) during summer. This is twice the estimated solitary stage growth rate during winter (6-8mm per month; Foxton, 1966). The solitary stages were primarily represented by newly released embryos 4-10mm in length (29%) and old large (74-145mm) individuals (51%). Cluster analysis of salp size distribution and stage composition at each station did not yield any meaningful patterns.

(b) Other Taxa: The hyperiid amphipods *C. magellanicus*, *C. lucasii*, *T. gaudichaudii*, and *V. antarctica* were all frequent (81.3-93.8% of samples) and moderately abundant (2.4-8.1 per 1000 m^3) at the 16 stations. Significantly increased mean abundance of *V. antarctica* ($P<0.05$) and *C. lucasii* ($P<0.01$) relative to Survey A are directly associated with increased salp population size. Significantly decreased mean abundance of *H. dilitata* ($P<0.001$) and *T. carpenteri* are most likely artifacts due to the limited sampling, while that of *P. macropa* may be due to the low numbers of daytime samples collected during Survey D.

(3) Leg II, Day-night Catch Differences and Interspecific Relationships: None of the taxa which exhibited significant day-night catch differences during Leg I demonstrated significant abundance differences between the 5 day and 11 night samples collected during Leg II (ANOVAs and post-hoc Tukey test P values all >0.05). Additionally, only the abundances of salps and *V. antarctica* were significantly correlated (Kendall's $T = 0.45$, $P = 0.02$). The paucity of significant statistical results relative to Leg I is attributed to the limited Leg II sampling effort.

(4) Leg II, Between Year Comparisons:

(a) Krill: As during Survey A, mean krill abundance during Survey D was most similar to that observed in 1992 and 1993 (Table 4.4). The seasonally decreased proportion of juvenile stages is typical of other years and results from migration out of the survey area in mid to late summer (Table 4.2). Two peak spawning periods during January-March were also indicated in 1996, while only one spawning peak was apparent during 1992-1995. Despite the early initiation of spawning and multiple spawning peaks, the relatively low larval krill abundance and absence of furcilia so late in the season suggest that spawning effort was weak (e.g., small batch size) and/or egg and larval survival was poor (Tables 4.6 and 4.7). These conditions could result from competition with, and egg and larval predation by, the rapidly increasing salp populations over the summer period.

(b) Salps: Mean and median salp abundance values were second only to those during February-March 1993 and, like 1993, resulted from massive population growth during summer. These two years contrast with the others which demonstrated declines in median salp abundance with the advancing season (Table 4.4). The overall salp length frequency distribution and stage composition during March 1997 differed from those of previous years (Figure 4.17). Both 1995 and 1997 were characterized by large proportions of small individuals during late summer, but in 1995 these were the newly spawned overwintering solitary stages. Late-season production of aggregate stages occurred in both 1996 and 1997, but the bell shaped length frequency distribution around ca. 25-50mm in 1996 was more like that in 1994. These differences reflect large interannual variations in conditions influencing the initiation, duration, and continuity of both aggregate and solitary stage production across the Antarctic Peninsula region.

(c) Other taxa: The high postlarval *T. macrura* abundance during 1997 Survey D relative to previous years may in part be a sampling artifact resulting from limited sampling (Table 4.5). However, this large value draws attention to the fact that mean and median *T. macrura* abundance during January-March has been steadily increasing since 1992 (Table 4.4). Mean copepod abundance during Survey D was similar to that in 1996 and both were about half the values observed in 1994 and 1995. Relatively abundant hyperiid amphipod species *C. magellanicus, C. lucasii,* and *V. antarctica* during 1997, like those in 1994, are related to abundant salps.

(IV) AMLR 97 Cruise Summary: Mean krill abundance during 1997 was similar to that observed during the 1992-1994 period (Table 4.4). The marked decrease relative to 1996 values was due to lower recruitment success of the 1995/96 year class relative to that of 1994/95. Exceedingly good recruitment success of the 1994/95 year class was associated with above average sea-ice conditions during winter 1994 (regional sea-ice index 4.86) and 1995 (5.00) and reflects early seasonal spawning activity and overwintering survival associated with such sea-ice conditions. Winter 1996 was characterized by average sea-ice conditions (regional sea ice index = 4.02 vs. the 1978-96 average of 4.04). Lower recruitment success of the 1995/96 year class supports the hypothesis that winter sea-ice extent affects larval survival and recruitment even when krill spawning is relatively early (Siegel and Loeb, 1995; Loeb et al. in press).

Salp biomass concentrations in the Elephant Island area during 1997 were the largest observed since 1993 and 1994 (Tables 4.4 and 4.8). The ratios of salp to krill biomass based on median values were 2.4 and 10.1, respectively, during Surveys A and D. Salp:krill carbon biomass ratio values >1.0 are here defined as representing "salp years." Although this is a salp year, its impact on krill is most likely not as dramatic as during 1994 when, because of predominantly larger aggregate stages, the biomass ratios were an order of magnitude larger. However, the relatively low concentrations of krill larvae and absence of advanced stages suggest that the impact of rapidly increasing salp population densities during spring and summer greatly affected krill reproductive success despite early initiation of seasonal spawning. Competition by salps for phytoplankton food resources may have reduced spawning effort (e.g., reduced batch size in multiple spawning efforts or delayed peak spawning for ca. 6 weeks), while predation by salps on krill eggs and larvae may have greatly reduced their numbers. Based on Survey D observations, poor recruitment success is predicted for the 1996/97 krill year class. The strong possibility of another winter with average or below average sea-ice extent during 1997 strengthens the likelihood of recruitment failure.

4.4 Disposition of Data and Samples: All of the krill, salp, other zooplankton, and fish data have been digitized and are available upon request from Valerie Loeb. These data have been submitted to Roger Hewitt and David Demer (Southwest Fisheries Science Center). Frozen krill, salps, other zooplankton, and myctophid specimens were provided to Charles Phleger for use in lipid analyses. Additional krill material was provided to Stephen Nicol (Australian Antarctic Division) and Giaccomo Bernardi (University of California at Santa Cruz) for genetic studies and Vanesa Lopez (University of California at Santa Cruz) for krill mandible studies.

4.5 Problems and Suggestions: The analysis of limited sampling efforts in the Elephant Island area during Survey D provides useful information for developing reduced effort in this area as the AMLR program shifts its interest to the Livingston Island area. AMLR must continue to survey the Elephant Island area as part of the large-area surveys each cruise to maintain this unique historical data base; however, it is obvious that this survey effort need not be so intensive for the krill and zooplankton studies. An appropriate sampling effort for these studies would probably be 45 stations occupying five stations per line rather than the current eight. This number would ensure collection of less common taxa and permit statistically useful analyses within and between the resulting data sets with a 38% reduction in sampling effort.

4.6 References:

Foxton, P. 1966. The distribution and life history of *Salpa thompsoni* Foxton with observations on a related species, *Salpa gerlachei* Foxton. Discovery Rept. 34: 1-116.

Harrington, S.A. and T. Ikeda. 1986. Laboratory observations on spawning, brood size and egg hatchability of the Antarctic krill *Euphausia superba* from Prydz Bay, Antarctica. *Marine Biology* 92: 231-235.

Loeb, V., V. Siegel, O. Holm-Hansen, R. Hewitt, W. Fraser, W. Trivelpiece, and S. Trivelpiece. In press. Effects of sea-ice extent and krill or salp dominance on the Antarctic food web. *Nature.*

Loeb et al. 1996. AMLR 1995/96 Field Season Report. Objectives, Accomplishments and Tentative Conclusions. NOAA/NMFS Administrative Report LJ-96-15.

Madin, L.P. and G.R. Harbison. 1977. The associations of Amphipoda Hydperiidea with gelatinous zooplankton - I. Associations with Salpidae. *Deep-Sea Res.* 24: 449-463.

Makarov. R.R. and C.J.I. Denys. 1981. Stages of sexual maturity of *Euphausia superba.* BIOMASS Handbook 11.

McClintock, J.B. and J. Janssen. 1990. Pteropod abduction as a chemical defense in a pelagic Antarctic amphipod. *Nature*. 346: 462-464.

Ross, R.M., L.B. Quetin, and E. Kirsch. 1988. Effect of temperature on developmental times and survival of early larval stages of *Euphausia superba* Dana. *Journal of Experimental Marine Biology and Ecology*. 121: 55-71.

Siegel, V. 1988. A concept of seasonal variation of krill (*Euphausia superba*) distribution and abundance west of the Antarctic Peninsula. Pp. 219-230 In D. Sahrhage (ed.) Antarctic Ocean and Resources Variability. Springer-Verlag, Berlin.

Siegel, V. and J. Kalinowski. 1994. Krill demography and small-scale processes: a review. Pp. 145-163 In S.Z. El-Sayed (ed.) Southern Ocean ecology: the BIOMASS perspective. Cambridge Univ. Press, Cambridge.

Siegel, V. and V. Loeb. 1995. Recruitment of Antarctic krill *Euphausia superba* and possible causes for its variability. *Mar. Ecol. Progr. Ser.* 123: 45-56.

Siegel, V., W. de la Mare, and V. Loeb. In press. Long-term monitoring of krill recruitment and abundance indices in the Elephant Island area (Antarctic Peninsula). CCAMLR Science.

Table 4.1 AMLR 1997 Large-area survey IKMT station information.

A. SURVEY A

STATION #	DATE	START TIME	END TIME	DIEL	TOW DEPTH (m)	BOTTOM DEPTH (m)	VOLUME (m3)	KRILL ABUNDANCE TOTAL	KRILL ABUNDANCE #/m2	KRILL ABUNDANCE #/1000m3	SALP ABUNDANCE TOTAL	SALP ABUNDANCE #/1000m3
A169	26/01/97	2224	2249	T	168	4658	3637.9	0	0.00	0.00	381	104.73
A170	27/01/97	0156	0220	N	169	1800	2860.5	9	0.53	3.15	1200	419.51
A171	27/01/97	0507	0523	D	115	135	2431.7	3	0.14	1.23	13	5.35
A160	27/01/97	0817	0838	D	169	208	2990.6	7	0.40	2.34	22	7.36
A159	27/01/97	1133	1206	D	170	2200	4944.5	1	0.03	0.20	36	7.28
A158	27/01/97	1501	1531	D	170	4050	4612.7	0	0.00	0.00	1	0.22
A143	27/01/97	1919	1938	D	170	3400	2390.1	24	1.71	10.04	45	18.83
A144	27/01/97	2238	2304	T	170	1600	3795.4	35	1.57	9.22	329	86.68
A145	28/01/97	0152	0206	N	75	91	2108.5	671	23.87	318.23	22	10.43
A128	28/01/97	0758	0833	D	170	4000	6176.8	0	0.00	0.00	126	20.40
A129	28/01/97	1141	1212	D	170	1600	4938.2	270	9.29	54.68	182	36.86
A130	28/01/97	1457	1527	D	173	188	3760.9	1	0.05	0.27	3	0.80
A02	29/01/97	0120	0146	N	169	1650	4192.5	10	0.40	2.39	1444	344.43
A131	29/01/97	0450	0523	T	167	797	5154.1	2	0.06	0.39	1739	337.40
A04	29/01/97	0911	0940	D	170	1600	4261.7	25	1.00	5.87	67	15.72
A06	29/01/97	1246	1311	D	170	1500	3295.3	301	15.53	91.34	476	144.45
A108	29/01/97	1626	1654	D	170	353	4133.7	735	30.23	177.81	256	61.93
A34	29/01/97	1939	2007	D	170	1500	3551.5	1110	53.13	312.54	237	66.73
A08	29/01/97	2218	2229	D	75	91	1589.8	4	0.19	2.52	4	2.52
A09	30/01/97	0243	0308	N	170	264	3666.2	236	10.94	64.37	38	10.37
A12	30/01/97	0606	0634	D	170	950	3873.2	52	2.28	13.43	94	24.27
A107	30/01/97	0929	0951	D	170	3600	2921.0	25	1.45	8.56	27	9.24
A113	30/01/97	1324	1352	D	170	5100	3814.6	7	0.31	1.84	2	0.52
A115	30/01/97	1655	1726	D	170	3160	4440.1	6	0.23	1.35	27	6.08
A15	30/01/97	2010	2034	D	170	327	3409.6	96	4.79	28.16	81	23.76
A11	31/01/97	0111	0145	N	171	2300	6353.6	296	7.97	46.59	387	60.91
A10	31/01/97	0414	0446	T	168	900	4530.9	48	1.78	10.59	184	40.61
A17	31/01/97	0735	0758	D	168	350	3136.4	49	2.62	15.62	197	62.81
A18	31/01/97	1016	1043	D	170	620	3752.8	32	1.45	8.53	363	96.73
A19	31/01/97	1304	1336	D	170	2600	5350.0	19	0.60	3.55	88	16.45
A20	31/01/97	1554	1624	D	170	4000	4538.8	12	0.45	2.64	657	144.75
A21	31/01/97	1857	1928	D	170	4700	5206.8	15	0.49	2.88	828	159.02
A22	31/01/97	2149	2211	T	168	3700	3129.8	0	0.00	0.00	2109	673.84
A23	01/02/97	0031	0050	N	169	2100	2504.2	1	0.07	0.40	1904	760.33
A24	01/02/97	0309	0327	N	171	3900	1934.3	11	0.97	5.69	1543	797.71
A25	01/02/97	0608	0633	D	169	3600	3555.0	49	2.33	13.78	156	43.88
A26	01/02/97	0916	0943	D	170	4000	4121.3	11	0.45	2.67	326	79.10
A27	01/02/97	1208	1236	D	170	1500	3878.1	23	1.01	5.93	22	5.67
A28	01/02/97	1449	1515	D	170	3600	3494.2	8	0.39	2.29	106	30.34
A29	01/02/97	1745	1815	D	170	3000	4547.6	5	0.19	1.10	581	127.76
A30	01/02/97	2058	2128	D	170	1700	4858.7	7	0.24	1.44	438	90.15
A31	01/02/97	2343	0010	N	170	473	3802.0	158	7.06	41.56	1464	385.06
A32	02/02/97	0232	0257	N	172	407	3420.1	7	0.35	2.05	268	78.36
A33	02/02/97	0525	0548	D	169	650	2714.5	11	0.68	4.05	73	26.89
A35	02/02/97	0840	0905	D	170	1700	3464.4	7	0.34	2.02	733	211.58
A36	02/02/97	1108	1132	D	170	520	3019.3	2	0.11	0.66	49	16.23
A37	02/02/97	1344	1414	D	170	500	4359.0	134	5.23	30.74	36	8.26
A38	02/02/97	1610	1635	D	170	373	3455.9	137	6.74	39.64	18	5.21
A39	02/02/97	1846	1911	D	170	2100	3145.5	10	0.54	3.18	185	58.81
A40	02/02/97	2122	2148	T	169	2500	3263.5	68	3.52	20.84	2729	836.21
A41	02/02/97	2357	0024	N	172	3900	3876.9	10	0.44	2.58	4255	1097.54
A42	03/02/97	0246	0319	N	170	3700	5227.5	69	2.24	13.20	2306	441.13
A43	03/02/97	0545	0610	D	168	3700	3844.5	3	0.13	0.78	306	79.59
A44	03/02/97	0831	0852	D	174	3600	2879.0	1	0.06	0.35	595	206.67
A45	03/02/97	1134	1147	D	170	3800	3595.6	21	0.99	5.84	26	7.23
A46	03/02/97	1425	1455	D	170	3700	4692.0	143	5.18	30.48	157	33.46
A47	03/02/97	1911	1938	D	170	2800	4318.5	1	0.04	0.23	158	36.59
A48	03/02/97	2200	2222	T	170	410	2860.5	37	2.20	12.93	259	90.54

Table 4.1 AMLR 1997 Large-area survey IKMT station information.

A. SURVEY A

STATION #	DATE	START TIME	END TIME	DIEL	TOW DEPTH (m)	BOTTOM DEPTH (m)	VOLUME (m3)	KRILL ABUNDANCE TOTAL	KRILL ABUNDANCE #/m2	KRILL ABUNDANCE #/1000m3	SALP ABUNDANCE TOTAL	SALP ABUNDANCE #/1000m3
A49	04/02/97	0031	0101	N	155	161	4706.1	2274	74.90	483.20	410	87.12
A50	04/02/97	0301	0326	N	171	366	3240.0	157	8.29	48.46	605	186.73
A51	04/02/97	0547	0614	D	170	765	3858.7	1	0.04	0.26	272	70.49
A100	04/02/97	1107	1127	D	170	227	2641.9	1	0.06	0.38	0	0.00
A97	04/02/97	1502	1525	D	170	289	2710.2	1542	96.72	568.96	2	0.74
A93	04/02/97	1912	1932	D	170	1240	2370.7	345	24.74	145.53	0	0.00
A92	04/02/97	2325	2345	N	170	1400	2806.9	684	41.43	243.68	685	244.04
A84	05/02/97	0208	0228	N	167	530	2634.3	61	3.87	23.16	1432	543.61
A85	05/02/97	0503	0524	D	170	701	2856.2	2	0.12	0.70	810	283.60
A86	05/02/97	0800	0823	D	170	1000	3132.1	7	0.38	2.23	834	266.28
A87	05/02/97	1052	1119	D	170	1900	4309.8	10	0.39	2.32	369	85.62
A88	05/02/97	1329	1355	D	175	552	3554.7	21	1.03	5.91	233	65.55
A89	05/02/97	1621	1648	D	170	2450	3406.6	7	0.35	2.05	132	38.75
A90	05/02/97	1907	1929	D	170	2400	2708.7	20	1.26	7.38	854	315.28
A91	05/02/97	2156	2217	N	170	3300	2846.2	1	0.06	0.35	1214	426.53
A76	06/02/97	0038	0100	N	174	3000	2674.5	264	17.18	98.71	874	326.79
A77	06/02/97	0322	0343	D	168	4200	2805.6	257	15.39	91.60	178	63.44
A78	06/02/97	0612	0630	D	169	3000	2985.4	3	0.17	1.00	200	66.99
A79	06/02/97	0907	0931	D	170	1800	3407.3	91	4.54	26.71	183	53.71
A80	06/02/97	1204	1227	D	170	1100	2882.5	8	0.47	2.78	440	152.65
A81	06/02/97	1458	1524	D	170	1200	3365.2	1	0.05	0.30	478	142.04
A82	06/02/97	1757	1820	D	170	740	3044.0	0	0.00	0.00	1257	412.94
A83	06/02/97	2044	2103	D	169	347	2164.4	0	0.00	0.00	1851	855.20
A98	06/02/97	2352	0014	N	172	561	2917.8	1	0.06	0.34	2371	812.59
A68	07/02/97	0238	0257	N	173	678	2340.4	1101	81.39	470.44	146	62.38
A69	07/02/97	0521	0540	T	170	1500	2615.4	169	10.99	64.62	39	14.91
A70	07/02/97	0827	0848	D	170	945	2914.7	0	0.00	0.00	2	0.69
A71	07/02/97	1117	1137	D	170	600	2427.4	28	1.96	11.54	261	107.52
A72	07/02/97	1406	1431	D	170	2700	3441.8	212	10.47	61.60	256	74.38
A73	07/02/97	1713	1736	D	170	3100	3114.6	60	3.27	19.26	47	15.09
A75	07/02/97	2307	2331	N	172	3200	3491.1	100	4.93	28.64	810	232.02
A60	08/02/97	0210	0233	N	173	3600	3293.2	70	3.68	21.26	574	174.30
A61	08/02/97	0520	0545	D	170	3300	3242.5	11	0.58	3.39	185	57.05
A62	08/02/97	0836	0855	D	170	3200	2481.2	3	0.21	1.21	23	9.27
A63	08/02/97	1138	1156	D	173	3200	2265.1	13	0.99	5.74	92	40.62
A64	08/02/97	1408	1433	D	170	370	3616.3	5	0.24	1.38	546	150.98
A65	08/02/97	1812	1829	D	142	168	2189.6	89	5.77	40.65	77	35.17
A66	08/02/97	2059	2120	T	169	620	3025.2	2	0.11	0.66	341	112.72
A67	09/02/97	0000	0022	N	168	2100	3317.2	222	11.24	66.92	3822	1152.17
A52	09/02/97	0301	0327	N	169	2100	3996.9	9	0.38	2.25	826	206.66
A53	09/02/97	0544	0610	D	171	464	3361.5	1	0.05	0.30	440	130.89
A54	09/02/97	0817	0826	D	50	66	1070.2	6	0.37	5.61	34	31.77
A55	09/02/97	1110	1120	D	52	68	1308.0	10	0.40	7.65	8	6.12
A56	09/02/97	1403	1428	D	170	3000	3230.9	374	19.68	115.76	98	30.33
A57	09/02/97	1657	1718	D	170	3600	3152.0	30	1.62	9.52	0	0.00
A58	09/02/97	1949	2011	D	170	3500	2784.0	1	0.06	0.36	778	279.46
A59	09/02/97	2229	2251	N	171	3600	2563.4	249	16.61	97.14	5143	2006.31
SURVEY A AREA					NO.		105	13558			60590	
					MEAN				6.49	40.35		181.02
					STD				15.82	97.84		298.58
					MEDIAN				0.60	5.61		66.73
ELEPHANT ISLAND AREA					NO.		71	6993			49303	
					MEAN				4.92	29.64		223.15
					STD				13.24	80.48		336.41
					MEDIAN				0.58	5.61		87.12

Table 4.1 AMLR 1997 Large-area survey IKMT station information.

B. SURVEY D

STATION #	DATE	START TIME	END TIME	DIEL	TOW DEPTH (m)	BOTTOM DEPTH (m)	VOLUME (m3)	KRILL ABUNDANCE TOTAL	KRILL ABUNDANCE #/m2	KRILL ABUNDANCE #/1000m3	SALP ABUNDANCE TOTAL	SALP ABUNDANCE #/1000m3
D62	16/03/97	2212	2234	N	168	3300	2483.6	162	10.96	65.23	7013	2823.77
D63	17/03/97	0140	0202	N	168	3200	3051.4	623	34.30	204.17	6596	2161.64
D64	17/03/97	0413	0430	N	170	280	2567.9	78	5.16	30.37	755	294.01
D55	17/03/97	1302	1310	D	45	64	1059.9	0	0.00	0.00	398	375.49
D49	17/03/97	1540	1601	D	140	160	3332.6	0	0.00	0.00	1378	413.50
D50	17/02/97	1821	1845	D	170	326	2953.7	0	0.00	0.00	707	239.36
D37	17/03/97	2043	2104	N	170	520	2626.0	60	3.88	22.85	3267	1244.11
D36	17/03/97	2315	2336	N	171	540	2365.1	318	22.99	134.45	1260	532.74
D48	22/03/97	0239	0340	N	178	560	3442.2	35	1.81	10.17	1753	509.27
D39	22/03/97	0536	0602	T	171	2200	2823.9	2	0.12	0.71	1918	679.20
D29	22/03/97	0840	0903	D	169	2782	3674.6	0	0.00	0.00	1405	382.36
D65	22/03/97	2011	2032	N	153	171	3246.2	4	0.19	1.23	1234	380.14
D66	22/03/97	2308	2326	N	169	640	2559.4	4	0.26	1.56	706	275.84
D67	23/03/97	0210	0226	N	170	2070	2620.3	0	0.00	0.00	6713	2561.95
D61	23/03/97	2320	2339	N	166	6290	2531.7	20	1.31	7.90	6850	2705.71
D60	24/03/97	0143	0203	N	169	3600	2758.3	21	1.29	7.61	11994	4348.27
					NO.		16	1327			53947	
SURVEY D AREA					MEAN				5.14	30.39		1245.46
(ELEPHANT ISLAND AREA)					STD				9.52	56.41		1224.60
					MEDIAN				0.78	4.59		521.01

Table 4.2 Maturity stage composition of krill collected in the large-area survey and Elephant Island area during 1997 compared to the Elephant Island area during 1992-1996. Advanced maturity stages are proportions of mature females that are 3c-3e in January-February and 3d-3e in February-March. Note that the early to mid-March 1997 Survey D sampling period affects comparability of advanced female maturity stages with other, earlier sampling periods.

	E. superba January-February						
Area	1997 Survey A	1997 Elephant I.	1996 Elephant I.	1995 Elephant I.	1994 Elephant I.	1993 Elephant I.	1992 Elephant I.
	%	%	%	%	%	%	%
Juveniles	29.9	15.2	55.0	4.6	4.0	7.2	37.1
Immature stages	32.9	30.6	18.3	4.0	18.8	30.7	19.1
Mature stages	37.2	54.2	26.7	91.4	77.2	62.2	43.9
Females:							
F2	7.0	6.3	1.1	0.1	2.3	7.8	0.8
F3a	3.2	3.5	0.0	0.2	18.0	11.7	0.6
F3b	0.9	0.6	0.2	1.2	19.3	14.3	12.3
F3c	5.3	6.9	1.9	15.3	20.1	5.1	9.2
F3d	3.6	6.1	0.7	17.7	2.3	1.2	0.4
F3e	5.0	7.4	11.6	3.7	0.0	0.0	0.0
Advanced Stages	77.4	83.2	98.3	96.3	37.5	19.5	42.7
Males:							
M2a	16.8	14.6	14.6	0.9	0.3	6.8	8.7
M2b	8.3	8.2	2.1	1.5	9.4	11.9	7.3
M2c	0.9	1.5	0.5	1.5	6.8	4.2	2.3
M3a	1.0	1.5	1.4	4.4	4.3	3.7	2.8
M3b	18.2	28.1	10.9	48.9	13.2	26.2	18.7
Male:Female ratio	1.8:1	1.8:1	1.9:1	1.5:1	0.5:1	1.3:1	1.7:1
No. measured	5026	3209	4296	2294	2078	4283	2472

	February-March						
Area	1997 Survey D	1997 Elephant I.	1996 Elephant I.	1995 Elephant I.	1994 Elephant I.	1993 Elephant I.	1992 Elephant I.
	%	%	%	%	%	%	%
Juveniles	8.0	8.0	20.8	1.1	3.7	3.5	33.6
Immature stages	19.7	19.7	9.9	2.5	6.2	51.4	27.1
Mature stages	72.3	72.3	69.3	96.4	90.1	45.1	39.2
Females:							
F2	1.1	1.1	0.6	0.3	0.7	21.8	0.8
F3a	0.1	0.1	0.0	0.0	3.5	12.4	10.3
F3b	0.0	0.0	0.0	0.0	7.8	6.2	10.2
F3c	1.8	1.8	5.0	2.0	4.3	3.7	4.3
F3d	29.1	29.1	10.9	21.8	4.6	1.1	1.2
F3e	7.3	7.3	4.9	20.4	0.9	1.2	<0.01
Advanced Stages	95.0	95.0	76.0	95.5	26.1	9.3	4.6
Males:							
M2a	8.6	8.6	6.5	0.7	0.2	6.9	4.3
M2b	8.8	8.8	1.2	0.4	1.2	19.1	19.8
M2c	1.2	1.2	1.6	1.1	4.2	3.6	2.2
M3a	3.7	3.7	5.3	4.4	24.1	2.1	2.5
M3b	30.3	30.3	43.2	47.8	44.7	18.4	10.7
Male:Female ratio	1.3:1	1.3:1	2.7:1	1.2:1	3.4:1	1.1:1	1.5:1
No. measured	560	560	2984	1271	1155	3669	3646

Table 4.3 Zooplankton and nekton taxa present in the large-area survey samples during January-February 1997 compared to January 1994, 1995, and 1996. F is the frequency of occurrence (%) in tows. n.a. indicates taxon was not enumerated.

Taxon	Survey A January-February 1997 F(%) (105 tows)	Survey A January-February 1997 Mean #/1000m3	Survey A January 1996 F(%) (91 tows)	Survey A January 1996 Mean #/1000m3	Survey A January 1995 F(%) (90 tows)	Survey A January 1995 Mean #/1000m3	Survey A January 1994 F(%) (91 tows)	Survey A January 1994 Mean #/1000m3
Copepods	100.0	582.6	100.0	794.4	98.9	652.7	30.0	41.3
Salpa thompsoni	97.1	181.4	64.8	20.4	66.7	16.0	100.0	818.3
Thysanoessa macrura	97.1	104.4	98.9	106.9	91.1	96.4	90.0	79.7
Euphausia superba	93.3	40.4	96.7	112.5	87.8	14.5	77.5	27.1
Themisto gaudichaudii	92.4	3.6	92.3	4.9	76.7	4.9	83.8	10.6
Cyllopus magellanicus	76.2	3.8	41.8	1.6	24.4	0.2	82.5	6.3
Chaetognaths	74.3	22.9	68.1	12.5	98.9	79.7	n.a	n.a
Vibilia antarctica	70.5	2.5	48.4	0.5	22.2	0.2	98.8	11.8
Spongiobranchaea australis	67.6	2.2	47.3	1.8	64.4	0.5	11.3	0.1
Primno macropa	63.8	4.3	20.9	0.1	20.0	0.1	6.3	0.5
Hyperiella dilatata	56.2	2.2	41.8	0.6	54.4	0.3	18.7	0.3
Euphausia superba (larvae)	55.2	15.2	22.0	2.7	22.2	135.8	n.a	n.a
Tomopteris carpenteri	54.3	1.9	60.4	0.9	84.4	4.2	37.5	2.5
Cyllopus lucasii	49.5	0.4	11.0	0.1	22.2	0.5	16.3	0.7
Limacina helicina	47.6	2.9	74.7	33.7	43.3	1.9	6.3	0.3
Thysanoessa macrura (larvae)	44.8	17.0	90.1	308.5	36.7	15.9	n.a	n.a
Euphausia frigida	41.9	14.8	30.8	1.9	50.0	9.8	17.5	3.8
Ostracods	41.0	5.5	53.8	4.9	56.7	9.7	n.a	n.a
Radiolaria	41.0	1.8	12.1	0.1	----	----	n.a	n.a
Electrona spp. (larvae)	37.1	1.4	27.5	0.7	61.1	2.5	2.5	0.0
Lepidonotothen kempi (larvae)	32.4	0.6	30.8	0.3	20.0	0.1	6.3	0.3
Sagitta gazellae	31.4	0.3	23.1	0.3	48.9	3.4	20.0	0.4
Lepidonotothen larseni (larvae)	27.6	1.8	22.0	0.2	40.0	1.1	6.3	0.7
Clione limacina	21.9	0.3	56.0	2.1	41.1	0.5	13.8	0.3
Eukrohnia hamata	21.9	0.2	20.9	0.1	10.0	0.1	21.3	0.2
Hydromedusae	20.0	0.1	4.4	0.0	6.7	0.1	----	----
Dimophyes arctica	19.0	0.3	15.4	0.1	25.6	0.8	7.5	0.0
Euphausia triacantha	18.1	1.4	15.4	0.5	33.3	1.5	7.5	1.2
Ctenophores	16.2	0.1	----	----	6.7	0.0	----	----
Beroe cucumis	15.2	0.1	7.7	0.0	12.2	0.0	15.0	0.1
Electrona carlsbergi	10.5	0.1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Sipunculids	10.5	0.1	7.7	0.0	24.4	0.1	----	----
Diphyes antarctica	9.5	0.2	17.6	0.1	58.9	1.0	20.0	0.3
Acanthephyra pelagica	9.5	0.1	----	----	22.2	0.1	----	----
Electrona antarctica	9.5	0.0	13.2	0.0	13.3	0.1	2.5	0.0
Hyperiella macronyx	8.6	0.1	5.5	0.0	23.3	0.1	----	----
Orchomene rossi	8.6	0.0	----	----	5.6	0.0	----	----
Notolepis coatsi (larvae)	6.7	0.0	8.8	0.0	27.8	0.1	----	----
Rhynchonereella bongraini	4.8	0.1	2.2	0.0	3.3	0.1	----	----
Scina spp.	4.8	0.1	----	----	----	----	----	----
Cumaceans	3.8	0.4	1.1	0.0	----	----	----	----
Vogtia serrata	3.8	0.1	----	----	----	----	----	----
Gymnoscopelus opisthopteris	3.8	0.0	2.2	0.0	7.8	0.0	----	----
Bylgides pelagica	2.9	0.1	----	----	5.6	0.0	----	----
Fish Eggs	2.9	0.1	1.1	0.0	4.4	0.0	----	----
Atolla wyvillei	2.9	0.0	1.1	0.0	7.8	0.0	----	----
Orchomene plebs	2.9	0.0	1.1	0.0	4.4	0.0	1.3	0.0
Pleuragramma antarcticum (larvae)	2.9	0.0	1.1	0.0	2.2	0.0	----	----
Clio pyramidata	2.9	0.0	6.6	0.1	72.2	5.3	40.0	5.4
Calycopsis borchgrevinki	2.9	0.0	2.2	0.0	1.1	0.0	1.3	0.0
Epimeriella macronyx	1.9	1.4	1.1	0.0	8.9	0.0	----	----
Hyperia antarctica	1.9	0.0	----	----	0.0	0.0	----	----

Table 4.3 cont.

Taxon	Survey A January-February 1997 F(%) (105 tows)	Mean #/1000m3	Survey A January 1996 F(%) (91 tows)	Mean #/1000m3	Survey A January 1995 F(%) (90 tows)	Mean #/1000m3	Survey A January 1994 F(%) (91 tows)	Mean #/1000m3
Cyphocaris richardi	1.9	0.0	—	—	4.4	0.0	—	—
Krefftichthys anderssoni (larvae)	1.9	0.0	—	—	—	—	—	—
Gymnoscopelus nicholsi	1.9	0.0	1.1	0.0	1.1	0.0	—	—
Maupasia coeca	1.9	0.0	1.1	0.0	—	—	—	—
Cyllopus Sp.	1.0	0.0	—	—	—	—	—	—
Bathylagus sp.	1.0	0.0	2.2	0.0	8.9	0.0	—	—
Pelagobia longicirrata	1.0	0.0	1.1	0.0	—	—	—	—
Hyperia macrocephala	1.0	0.0	—	—	3.3	0.0	1.3	0.0
Hyperoche medusarum	1.0	0.0	3.3	0.0	18.9	0.0	—	—
Scyphomedusae	1.0	0.0	13.2	0.1	—	—	1.3	0.0
Travisiopsis coniceps	1.0	0.0	—	—	—	—	—	—
Polychaetes	1.0	0.0	1.1	0.0	—	—	—	—
Krefftichthys anderssoni	1.0	0.0	—	—	—	—	—	—
Vanadis antarctica	1.0	0.0	4.4	0.0	15.6	0.1	2.5	0.0
Thyphloscolex muelleri	1.0	0.0	4.4	0.0	—	—	—	—
Artededraco skottsbergi (larvae)	1.0	0.0	—	—	—	—	—	—
Notolepis annulata (larvae)	1.0	0.0	—	—	13.3	0.0	—	—
Oediceroides calmani	1.0	0.0	—	—	—	—	—	—
Artededraco sp. B (larvae)	1.0	0.0	—	—	—	—	—	—
Chionodraco rastrospinosus (larvae)	1.0	0.0	—	—	—	—	—	—
Botrynema brucei	—	—	—	—	1.1	0.0	—	—
Gymnodraco acuticeps (larvae)	—	—	—	—	1.1	0.0	—	—
Cephalopods	—	—	—	—	2.2	0.0	—	—
Euphysora gigantea	—	—	—	—	2.2	0.0	—	—
Artededraco mirus (larvae)	—	—	—	—	1.1	0.0	—	—
Travisiopsis levinseni	—	—	—	—	1.1	0.0	—	—
Eusirus microps	—	—	—	—	4.4	0.0	—	—
Gosea brachyura	—	—	—	—	3.3	0.0	—	—
Gobionotothen gibberifrons	—	—	—	—	1.1	0.0	—	—
Euphausia crystallorphorias	—	—	—	—	4.4	0.0	—	—
Pegantha martagon	—	—	—	—	1.1	0.0	—	—
Notothenia coriiceps	—	—	—	—	1.1	0.0	1.3	0.0
Decapod larvae	—	—	2.2	0.2	—	—	—	—
Lepidonotothen nudifrons (larvae)	—	—	2.2	0.0	8.9	0.1	1.3	0.2
Hyperiella antarctica	—	—	2.2	0.0	2.2	0.0	—	—
Euphausia spp. larvae	—	—	1.1	0.0	—	—	—	—
Larval fish	—	—	1.1	0.0	—	—	—	—
Tomopteris septentrionalis	—	—	1.1	0.0	—	—	—	—
Beroe forskalii	—	—	1.1	0.0	—	—	—	—
Arctapodema ampla	—	—	1.1	0.0	—	—	—	—
Phalacrophorus pictus	—	—	1.1	0.0	—	—	—	—
Eusirus perdentatus	—	—	1.1	0.0	22.2	0.1	—	—
Periphylla periphylla	—	—	1.1	0.0	1.1	0.0	—	—
Chorismus antarcticus	—	—	1.1	0.0	—	—	—	—
Eusirus antarcticus	—	—	1.1	0.0	—	—	—	—
Cryodraco antarctica (larvae)	—	—	1.1	0.0	—	—	—	—
Harpagifer antarcticus (larvae)	—	—	1.1	0.0	—	—	—	—
Gammarids	—	—	1.1	0.0	—	—	—	—
Total	72		69		70		33	

Table 4.4 Abundance of krill and dominant zooplankton species collected in the Elephant Island area during (A) January-February and (B) March 1997 compared to similar sampling periods in 1992-1996. Zooplankton data are not available for February-March 1992.

A.	January-February Elephant Island Area																	
	Euphausia superba						*Thysanoessa macrura*						*Salpa thompsoni*					
	1997	1996	1995	1994	1993	1992	1997	1996	1995	1994	1993	1992	1997	1996	1995	1994	1993	1992
No. Tows	71	72	71	63	70	63	71	72	71	63	70	63	71	72	71	63	70	63
Abundance: No./1000 m3																		
Median	5.6	11.4	3.6	3.1	8.2	5.7	52.8	52.3	36.1	25.4	27.5	22.5	87.1	10.5	1.6	582.3	245.8	14.0
Mean	29.6	82.1	9.5	34.5	28.8	23.7	101.0	103.4	104.1	74.6	48.6	48.1	223.2	25.5	20.2	931.9	1213.4	94.3
Std. Dev.	80.5	245.1	20.6	94.2	64.4	78.0	127.2	118.1	231.9	144.3	60.1	57.0	336.4	36.3	46.5	950.2	2536.7	192.3
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.5	6.9	0.0
Maximum	483.2	1500.6	146.1	495.9	438.9	594.1	616.2	500.1	239.9	901.6	307.1	233.7	2006.3	161.6	239.9	4781.7	16078.8	1231.1

B.	February-March Elephant Island Area																	
	Euphausia superba						*Thysanoessa macrura* (*includes larval stages)						*Salpa thompsoni*					
	1997	1996	1995	1994	1993	1992	1997	1996	1995	1994*	1993*	1992	1997	1996	1995	1994	1993	1992
No. Tows	16	72	71	70	67	67	16	72	71	70	67		16	72	71	70	67	
Abundance: No./1000 m3																		
Median	4.6	4.1	1.2	0.4	3.0	7.1	122.6	53.6	22.2	23.8	22.1	n.a.	521.0	5.6	0.7	242.6	605.9	n.a.
Mean	30.4	133.2	5.2	17.1	35.0	38.0	181.3	116.1	79.7	77.1	128.9	n.a.	1245.5	33.2	20.6	495.1	1585.9	n.a.
Std. Dev.	56.4	867.7	12.0	63.5	89.7	77.4	168.0	147.4	138.5	132.6	235.1	n.a.	1224.6	85.7	66.5	579.4	2725.5	n.a.
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	12.0	0.0	0.0	0.0	0.0	n.a.	239.4	0.0	0.0	5.3	2.2	n.a.
Maximum	204.2	7385.4	90.0	371.1	542.0	389.9	538.9	679.4	664.9	815.9	1141.5	n.a.	4348.3	659.4	391.9	2377.5	16662.5	n.a.

Table 4.5 Composition and abundance of dominant zooplankton taxa represented by limited station coverage compared to the Elephant Island area and to the large-area survey (Survey A), January-February 1997. The limited sampling represents the same 16 stations sampled during Survey D. Only the top 21 taxa represented in each category are considered.

	Limited Sampling 16 Stations			Elephant Island Area 71 Stations			Large Survey Area A 105 Stations		
Taxon	Rank	Mean	Std	Rank	Mean	Std	Rank	Mean	Std
Copepods	1	739.0	935.9	1	656.4	799.1	1	584.9	692.5
Salpa thompsoni	2	144.6	266.4	2	223.2	336.5	2	181.1	298.6
Thysanoessa macrura	3	119.2	172.2	3	98.8	126.0	3	105.1	123.1
Euphausia superba	4	45.6	114.7	4	29.6	80.5	4	40.3	97.8
E. superba (calyptopis larvae)	5	15.4	27.1	7	17.9	25.3	8	14.2	22.9
Euphausia frigida	6	13.1	24.7	8	9.6	21.4	7	14.8	39.2
Thysanoessa macrura (larvae)	7	12.3	23.0	5	21.5	38.4	6	17.0	34.5
Chaetognaths	8	9.2	12.4	6	19.8	25.9	5	23.7	38.6
Themisto gaudichaudii	9	3.7	3.7	11	3.6	3.6	12	3.7	4.5
Cyllopus magellanicus	10	3.2	6.1	9	5.0	8.4	11	3.8	7.2
Ostracods	11	2.9	5.9	13	3.1	7.7	9	5.4	16.4
Primno macropa	12	2.2	2.9	10	4.8	5.4	10	4.3	5.5
Spongiobranchaea australis	13	1.6	2.2	15	2.5	4.1	16	2.2	3.9
Cumaceans	14	1.3	5.1		0.3	2.5		0.4	3.1
Hyperiella dilatata	15	1.1	2.3	14	2.8	5.7	16	2.2	4.9
Vibilia antarctica	16	0.9	1.6	12	3.3	7.1	14	2.5	6.0
Radiolaria	17	0.8	2.1	19	1.5	2.9	19	1.8	4.0
Limacina helicina	18.5	0.7	1.8	16	2.2	6.5	13	2.9	6.9
Euphausia triacantha	18.5	0.7	2.2	20	1.4	3.9	21	1.4	4.2
Electrona spp. (larvae)	20.5	0.6	1.1	21	1.1	2.8	21	1.4	3.8
Lepidonotothen larseni (larvae)	20.5	0.6	1.5		0.3	1.1	19	1.8	12.8
Tomopteris carpenteri		0.5	1.5	17	1.9	4.6	17	1.9	4.3
E. superba (furcilia larvae)	----	----	----	18	1.6	6.3		1.2	5.3

Table 4.6a Macrozooplankton and nekton collected in large-area Surveys A and D, 1997. Abundance is numbers per 1000 m^3. F (%) is percent frequency of occurrence in tows. Taxa totals do not include the two larval stages of *Euphausia superba*.

	Survey A January-February 105 Stations				Survey D March 16 Stations			
Taxon	F(%)	Mean	Std	Median	F(%)	Mean	Std	Median
Copepods	100.0	582.6	693.9	402.3	100.0	1267.8	1755.6	659.8
Salpa thompsoni	97.1	181.4	298.5	65.5	100.0	1245.5	1224.6	521.0
Thysanoessa macrura	97.1	104.4	123.2	54.8	100.0	181.3	168.0	122.6
Cyllopus magellanicus	76.2	3.8	7.3	1.1	93.8	3.3	3.1	2.5
Cyllopus lucasii	49.5	0.4	0.7	0.0	93.8	2.4	1.8	2.5
Themisto gaudichaudii	92.4	3.6	4.5	2.1	87.5	2.9	2.6	2.2
Vibilia antarctica	70.5	2.5	6.0	0.6	81.3	8.1	9.9	2.5
Chaetognaths	74.3	22.9	38.3	6.6	75.0	18.2	24.0	5.5
Euphausia frigida	41.9	14.8	39.2	0.0	68.8	44.8	54.2	21.0
Euphausia superba	93.3	40.4	98.3	4.1	68.8	30.4	56.4	4.6
Ostracods	41.0	5.5	16.4	0.0	56.3	4.8	6.7	1.7
Thysanoessa macrura (larvae)	44.8	17.0	34.5	0.0	50.0	10.8	24.9	1.0
Spongiobranchaea australis	67.6	2.2	3.9	0.6	43.8	2.8	8.6	0.0
Euphausia triacantha	18.1	1.4	4.2	0.0	43.8	0.9	1.4	0.0
Euphausia superba (total larvae)	55.2	15.2	24.3	1.4	37.5	25.0	81.4	0.0
(E superba calyptopis larvae)	53.3	14.2	22.9	1.1	37.5	25.0	81.4	0.0
Tomopteris carpenteri	54.3	1.9	4.3	0.3	31.3	0.5	1.0	0.0
Electrona antarctica	9.5	0.0	0.2	0.0	31.3	0.2	0.4	0.0
Hyperiella dilatata	56.2	2.2	4.9	0.3	25.0	0.2	0.6	0.0
Primno macropa	63.8	4.3	5.5	2.3	18.8	0.5	1.3	0.0
Radiolaria	41.0	1.8	4.0	0.0	12.5	0.7	2.3	0.0
Hyperoche medusarum	1.0	0.0	0.1	0.0	12.5	0.3	1.1	0.0
Hydromedusae	20.0	0.1	0.4	0.0	12.5	0.2	0.6	0.0
Sagitta gazellae	31.4	0.3	0.9	0.0	12.5	0.1	0.5	0.0
Electrona spp. (larvae)	37.1	1.4	3.8	0.0	12.5	0.1	0.3	0.0
Dimophyes arctica	19.0	0.3	0.7	0.0	12.5	0.1	0.3	0.0
Gymnoscopelus nicholsi	1.9	0.0	0.0	0.0	12.5	0.1	0.3	0.0
Schyphomedusae	1.0	0.0	0.1	0.0	12.5	0.0	0.1	0.0
Clione limacina	21.9	0.3	1.2	0.0	12.5	0.0	0.1	0.0
Bathylagus sp. (larvae)	1.0	0.0	0.1	0.0	6.3	0.0	0.1	0.0
Scina spp.	4.8	0.1	0.7	0.0	6.3	0.5	1.9	0.0
Diphyes antarctica	9.5	0.2	0.8	0.0	6.3	0.3	1.1	0.0
Lepidonotothen kempi (larvae)	32.4	0.6	2.0	0.0	6.3	0.2	0.6	0.0
Hyperiella macronyx	8.6	0.1	0.2	0.0	6.3	0.0	0.1	0.0
Ctenophora	16.2	0.1	0.2	0.0	6.3	0.0	0.1	0.0
Sipunculids	10.5	0.1	0.2	0.0	6.3	0.0	0.1	0.0
Bathylagus sp.	1.0	0.0	0.1	0.0	6.3	0.0	0.1	0.0
Calycopsis borchgrevinki	2.9	0.0	0.1	0.0	6.3	0.0	0.1	0.0
Notolepis annulata (larvae)	1.0	0.0	0.0	0.0	6.3	0.0	0.1	0.0
Limacina helicina	47.6	2.9	6.9	0.0	—	—	—	—
Lepidonotothen larseni (larvae)	27.6	1.8	12.8	0.0	—	—	—	—
Eukrohnia hamata	21.9	0.2	0.6	0.0	—	—	—	—
Beroe cucumis	15.2	0.1	0.2	0.0	—	—	—	—
(Euphausia superba furcilia larvae)	12.4	1.2	5.3	0.0	—	—	—	—
Electrona carlsbergi	10.5	0.1	0.5	0.0	—	—	—	—

Table 4.6a cont.

	Survey A January-February				Survey D March			
Taxon	F(%)	Mean	Std	Median	F(%)	Mean	Std	Median
Acanthephyra pelagica	9.5	0.1	0.2	0.0	—	—	—	—
Orchomene rossi	8.6	0.0	0.2	0.0	—	—	—	—
Notolepis coatsi (larvae)	6.7	0.0	0.1	0.0	—	—	—	—
Rhynchonereella bongraini	4.8	0.1	0.7	0.0	—	—	—	—
Cumaceans	3.8	0.4	3.1	0.0	—	—	—	—
Vogtia serrata	3.8	0.1	0.4	0.0	—	—	—	—
Gymnoscopelus opisthopteris	3.8	0.0	0.1	0.0	—	—	—	—
Bylgides pelagica	2.9	0.1	0.9	0.0	—	—	—	—
Fish eggs	2.9	0.1	0.4	0.0	—	—	—	—
Atolla wyvillei	2.9	0.0	0.2	0.0	—	—	—	—
Orchomene plebs	2.9	0.0	0.1	0.0	—	—	—	—
Pleuragramma antarcticum (larvae)	2.9	0.0	0.1	0.0	—	—	—	—
Clio pyramidata	2.9	0.0	0.1	0.0	—	—	—	—
Epimeriella macronyx	1.9	1.4	10.5	0.0	—	—	—	—
Hyperia antarctica	1.9	0.0	0.1	0.0	—	—	—	—
Krefftichthys anderssoni (larvae)	1.9	0.0	0.0	0.0	—	—	—	—
Maupasia coeca	1.9	0.0	0.0	0.0	—	—	—	—
Cyllopus Sp.	1.0	0.0	0.4	0.0	—	—	—	—
Pelagobia longicirrata	1.0	0.0	0.1	0.0	—	—	—	—
Hyperia macrocephala	1.0	0.0	0.1	0.0	—	—	—	—
Travisiopsis coniceps	1.0	0.0	0.0	0.0	—	—	—	—
Polychaetes	1.0	0.0	0.0	0.0	—	—	—	—
Krefftichthys anderssoni	1.0	0.0	0.0	0.0	—	—	—	—
Vanadis antarctica	1.0	0.0	0.0	0.0	—	—	—	—
Thyphloscolex muelleri	1.0	0.0	0.0	0.0	—	—	—	—
Artedidraco skottsbergi (larvae)	1.0	0.0	0.0	0.0	—	—	—	—
Oediceroides calmani	1.0	0.0	0.0	0.0	—	—	—	—
Artedidraco Sp. B (larvae)	1.0	0.0	0.0	0.0	—	—	—	—
Chionodraco rastrospinosus (larvae)	1.0	0.0	0.0	0.0	—	—	—	—
Total Abundance		1019.8	898.5	727.0		2876.6	2235.5	2004.8
Total Taxa	72	16.4	4.4	17.0	37	13.8	2.7	13.5

Table 4.6b. Macrozooplankton and nekton collected at 16 Elephant Island stations during Surveys A and D, 1997. Abundance is numbers per 1000 m3. F(%) is percent frequency of occurrence in tows.

	Survey A January-February 16 Stations				Survey D March 16 Stations			
Taxon	F(%)	Mean	Std	Median	F(%)	Mean	Std	Median
Copepods	100.0	739.0	935.9	441.6	100.0	1267.8	1755.6	659.8
Salpa thompsoni	100.0	144.6	266.4	73.0	100.0	1243.8	1225.8	521.0
Thysanoessa macrura	100.0	119.2	172.2	33.7	100.0	181.3	168.0	122.6
Cyllopus magellanicus	87.5	3.2	6.1	1.3	93.8	3.3	3.1	2.5
Cyllopus lucasii	50.0	0.4	0.8	0.2	93.8	2.4	1.8	2.5
Themisto gaudichaudii	100.0	3.7	3.7	2.4	87.5	2.9	2.6	2.2
Vibilia antarctica	68.8	0.9	1.6	0.5	81.3	8.1	9.9	2.5
Chaetognaths	62.5	9.2	12.4	2.8	75.0	18.2	24.0	5.5
Euphausia frigida	37.5	13.1	24.7	0.0	68.8	44.8	54.2	21.0
Euphausia superba	100.0	45.6	114.7	6.7	68.8	30.4	56.4	4.5
Ostracods	37.5	2.9	5.9	0.0	56.3	4.8	6.7	1.7
Thysanoessa macrura (larvae)	37.5	12.3	23.0	0.0	50.0	10.8	24.9	1.0
Spongiobranchaea australis	62.5	1.6	2.2	0.6	43.8	2.8	8.6	0.0
Euphausia triacantha	25.0	0.7	2.2	0.0	43.8	0.9	1.4	0.0
E. superba (larvae)	56.3	15.4	27.1	0.8	37.5	25.0	81.4	0.0
Tomopteris carpenteri	25.0	0.5	1.5	0.0	31.3	0.5	1.0	0.0
Electrona antarctica	6.3	0.0	0.1	0.0	31.3	0.2	0.4	0.0
Hyperiella dilatata	43.8	1.1	2.3	0.0	25.0	0.2	0.6	0.0
Primno macropa	50.0	2.2	2.9	0.2	18.8	0.5	1.3	0.0
Radiolaria	25.0	0.8	2.1	0.0	12.5	0.7	2.3	0.0
Hyperoche medusarum	0.0	0.0	0.0	0.0	12.5	0.3	1.1	0.0
Hydromedusae	25.0	0.1	0.3	0.0	12.5	0.2	0.6	0.0
Sagitta gazellae	18.8	0.2	0.5	0.0	12.5	0.1	0.5	0.0
Electrona spp. (larvae)	37.5	0.6	1.1	0.0	12.5	0.1	0.3	0.0
Dimophyes arctica	12.5	0.1	0.2	0.0	12.5	0.1	0.3	0.0
Gymnoscopelus nicholsi	0.0	0.0	0.0	0.0	12.5	0.1	0.3	0.0
Scyphomedusae	0.0	0.0	0.0	0.0	12.5	0.0	0.1	0.0
Clione limacina	18.8	0.0	0.1	0.0	12.5	0.0	0.1	0.0
Scina spp.	0.0	0.0	0.0	0.0	6.3	0.5	1.9	0.0
Diphyes antarctica	0.0	0.0	0.0	0.0	6.3	0.3	1.1	0.0
Lepidonotothen kempi (larvae)	12.5	0.1	0.4	0.0	6.3	0.2	0.6	0.0
Hyperiella macronyx	0.0	0.0	0.0	0.0	6.3	0.0	0.1	0.0
Sipunculids	0.0	0.0	0.0	0.0	6.3	0.0	0.1	0.0
Bathylagus sp. (larvae)	0.0	0.0	0.0	0.0	6.3	0.0	0.1	0.0
Ctenophora	12.5	0.1	0.2	0.0	6.3	0.0	0.1	0.0
Calycopsis borchgrevinki	6.3	0.0	0.1	0.0	6.3	0.0	0.1	0.0
Notolepis annulata (larvae)	0.0	0.0	0.0	0.0	6.3	0.0	0.1	0.0
Limacina helicina	25.0	0.7	1.8	0.0	—	—	—	—
Lepidonotothen larseni (larvae)	25.0	0.6	1.5	0.0	—	—	—	—
Cumaceans	12.5	1.3	5.1	0.0	—	—	—	—
Electrona carlsbergi	12.5	0.3	0.8	0.0	—	—	—	—
Orchomene plebs	12.5	0.1	0.2	0.0	—	—	—	—
Pleuragramma antarcticum (larvae)	6.3	0.0	0.2	0.0	—	—	—	—
Orchomene rossi	6.3	0.0	0.2	0.0	—	—	—	—
Polychaetes	6.3	0.0	0.1	0.0	—	—	—	—
Eukrohnia hamata	6.3	0.0	0.1	0.0	—	—	—	—
Gymnoscopelus opisthopteris	6.3	0.0	0.1	0.0	—	—	—	—
Notolepis coatsi (larvae)	6.3	0.0	0.1	0.0	—	—	—	—
Oediceroides calmani	6.3	0.0	0.1	0.0	—	—	—	—
Total		1136.6	1278.4	735.2		2876.6	2235.5	2004.8
Taxa	41	14.5	3.4	14.0	37	13.8	2.7	13.5

Table 4.7 Zooplankton taxa present in large-area survey samples during March 1997 compared to February-March 1994-1996. F is the frequency of occurrence (%) in tows. n.a. indicates taxon was not enumerated.

	Survey D March 1997		Survey D February-March 1996		Survey D February 1995		Survey D February-March 1994	
Taxon	F(%) (16 tows)	Mean #/1000m3	F(%) (91 tows)	Mean #/1000m3	F(%) (89 tows)	Mean #/1000m3	F(%) (89 tows)	Mean #/1000m3
Copepods	100.0	1267.8	98.9	1387.0	100.0	3189.1	89.9	3090.2
Salpa thompsoni	100.0	1243.8	62.6	28.2	59.6	16.5	98.9	523.5
Thysanoessa macrura	100.0	181.3	91.2	143.3	93.3	161.3	91.0	118.9
Cyllopus magellanicus	93.8	3.3	46.2	2.1	25.8	0.7	79.8	4.4
Cyllopus lucasii	93.8	2.4	34.1	0.2	23.6	0.5	89.9	6.1
Themisto gaudichaudii	87.5	2.9	91.2	2.5	74.2	3.6	94.4	11.8
Vibilia antarctica	81.3	8.1	48.4	1.0	23.6	0.2	85.4	6.4
Chaetognaths	75.0	18.2	93.4	64.1	100.0	296.4	n.a.	n.a.
Euphausia frigida	68.8	44.8	54.9	9.0	60.7	16.7	61.8	25.9
Euphausia superba	68.8	30.4	86.8	106.7	78.7	5.7	66.3	18.4
Ostracods	56.3	4.8	47.3	10.1	75.3	43.4	n.a.	n.a.
Thysanoessa macrura (larvae)	50.0	10.8	87.9	414.4	79.8	276.9	n.a.	n.a.
Spongiobranchaea australis	43.8	2.8	68.1	1.4	60.7	0.4	14.6	0.1
Euphausia triacantha	43.8	0.9	22.0	0.8	28.1	1.6	11.2	1.0
Euphausia superba (larvae)	37.5	25.0	62.6	13.9	93.3	3690.0	n.a.	n.a.
Tomopteris carpenteri	31.3	0.5	38.5	0.9	57.3	1.3	24.7	0.6
Electrona antarctica	31.3	0.2	20.9	0.2	15.7	0.1	13.5	0.1
Hyperiella dilatata	25.0	0.2	52.7	0.8	24.7	0.1	36.0	0.6
Primno macropa	18.8	0.5	63.7	3.5	31.5	0.4	10.1	0.1
Hyperoche medusarum	12.5	0.3	2.2	0.0	12.4	0.0	5.6	0.1
Hydromedusae	12.5	0.2	3.3	0.1	5.6	0.0	----	----
Sagitta gazellae	12.5	0.1	31.9	0.3	59.6	3.0	34.8	3.8
Electrona spp. (larvae)	12.5	0.1	38.5	0.9	62.9	5.2	11.2	0.2
Dimophyes arctica	12.5	0.1	13.2	0.1	13.5	0.3	10.1	0.0
Gymnoscopelus nicholsi	12.5	0.1	3.3	0.0	1.1	0.0	----	----
Scyphomedusae	12.5	0.0	19.8	0.1	13.5	0.1	----	----
Clione limacina	12.5	0.0	15.4	0.2	0.0	0.00	----	----
Scina spp.	6.3	0.5	2.2	0.0	1.1	0.0	----	----
Diphyes antarctica	6.3	0.3	7.7	0.1	23.6	0.4	13.5	0.1
Lepidonotothen kempi (larvae)	6.3	0.2	39.6	0.4	48.3	0.4	6.7	0.1
Hyperiella macronyx	6.3	0.0	6.6	0.1	13.5	0.0	----	----
Sipunculids	6.3	0.0	8.8	0.1	9.0	0.0	3.4	0.0
Bathylagus sp. (larvae)	6.3	0.0	1.1	0.0	14.6	0.0	----	----
Calycopsis borchgrevinki	6.3	0.0	6.6	0.0	11.2	0.0	10.1	0.1
Notolepis annulata (larvae)	6.3	0.0	5.5	0.0	3.4	0.0	----	----
Ctenophores	6.3	0.0	1.1	0.0	3.4	0.0	----	----
Limacina helicina	----	----	24.2	1.9	4.5	0.0	----	----
Eukronia hamata	----	----	19.8	0.1	33.7	0.8	3.4	0.1
Notolepis coatsi (larvae)	----	----	18.7	0.1	36.0	0.2	----	----
Lepidonothen larseni (larvae)	----	----	13.2	0.3	10.1	0.0	----	----
Beroe cucumis	----	----	11.0	0.1	4.5	0.0	2.2	0.0
Cephalopods	----	----	9.9	0.0	----	----	----	----
Orchomene rossi	----	----	5.5	0.5	6.7	0.0	----	----
Rhynchonereella bongraini	----	----	5.5	0.1	20.2	0.1	----	----
Polychaetes	----	----	3.3	0.1	2.2	0.0	----	----
Clio pyramidata	----	----	3.3	0.0	12.4	0.0	9.0	0.2
Eusirus microps	----	----	3.3	0.0	----	----	----	----
Gymnoscopelus opisthopterus	----	----	3.3	0.0	10.1	0.0	2.2	0.0
Orchomene plebs	----	----	2.2	0.0	3.4	0.0	2.2	0.1
Eusirus perdentatus	----	----	2.2	0.0	6.7	0.1	----	----
Hyperia spp.	----	----	1.1	0.1	----	----	----	----
Atolla wyvillei	----	----	1.1	0.0	----	----	----	----
Cumaceans	----	----	1.1	0.0	----	----	----	----

Table 4.7 (Contd.)

	Survey D March 1997		Survey D February-March 1996		Survey D February 1995		Survey D February-March 1994	
Taxon	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean
Hyperia macrocephala	----	----	1.1	0.0	5.6	0.0	----	----
Epimeriella macronyx	----	----	1.1	0.0	5.6	0.6	----	----
Travisiopsis coniceps	----	----	1.1	0.0	1.1	0.0	----	----
Lepidonotothen nudifrons (larvae)	----	----	1.1	0.0	3.4	0.0	----	----
Hyperiids	----	----	1.1	0.0	----	----	----	----
Harpagifer antarcticus (larvae)	----	----	1.1	0.0	----	----	----	----
Unid. larval fish	----	----	1.1	0.0	----	----	----	----
Decapod larvae	----	----	1.1	0.0	----	----	----	----
Cyphocaris richardi	----	----	1.1	0.0	3.4	0.1	----	----
Periphylla periphylla	----	----	1.1	0.0	1.1	0.0	3.4	0.0
Pleurogramma antarcticum (juv.)	----	----	1.1	0.0	2.2	0.0	----	----
Vanadis antarctica	----	----	1.1	0.0	6.7	0.0	7.9	0.1
Acanthephyra pelagica (larvae)	----	----	----	----	5.6	0.0	----	----
Byglides pelagica	----	----	----	----	2.2	0.0	----	----
Notolepis spp. (larvae)	----	----	----	----	2.2	0.0	5.6	0.0
Beroe forskalii	----	----	----	----	1.1	0.0	3.4	0.1
Lepidonothen larseni (juv)	----	----	----	----	1.1	0.0	----	----
Pagetopsis macropterus	----	----	----	----	1.1	0.0	----	----
Champsocephalus gunnari	----	----	----	----	1.1	0.0	----	----
Fish eggs	----	----	----	----	1.1	0.0	7.9	0.1

Table 4.8. Salp and krill carbon biomass (mg C m^-2) in the Elephant Island area during 1994-1997 surveys. N is number of samples. Salp:Krill ratio is based on median values. "Salp years" are characterized by salp:krill biomass ratios >1.0.

January	1994		1995		1996		1997	
Biomass (mg C m^-2)	Salps	Krill	Salps	Krill	Salps	Krill	Salps	Krill
Mean	570.6	314.1	7.8	242.3	20.2	337.3	334.5	229.0
S.D.	563.2	856.4	16.1	201.1	30.9	756.1	1115.6	522.1
Median	400.5	25.6	1.3	43.5	10.0	72.2	108.9	45.1
Maximum	3276.8	4971.1	75.3	1545.2	134.2	4721.0	9434.6	3115.5
N	63	63	57	71	72	72	71	71
Salp:Krill Ratio	15.6		0.03		0.1		2.4	

February-March	1994		1995		1996		1997	
Biomass (mg C m^-2)	Salps	Krill	Salps	Krill	Salps	Krill	Salps	Krill
Mean	483.7	425.9	13.1	59.2	50.7	1702.3	1139.7	313.1
S.D.	469.5	2351.4	47.3	149.1	146.5	12441.6	1269.8	655.2
Median	285.6	2.8	0.7	13.1	4.6	40.7	504.8	50.0
Maximum	1843.6	19313.8	325.2	1107.1	954.0	106458.5	4645.4	2638.7
N	70	70	71	71	72	72	16	16
Salp:Krill Ratio	102.0		0.1		0.1		10.1	

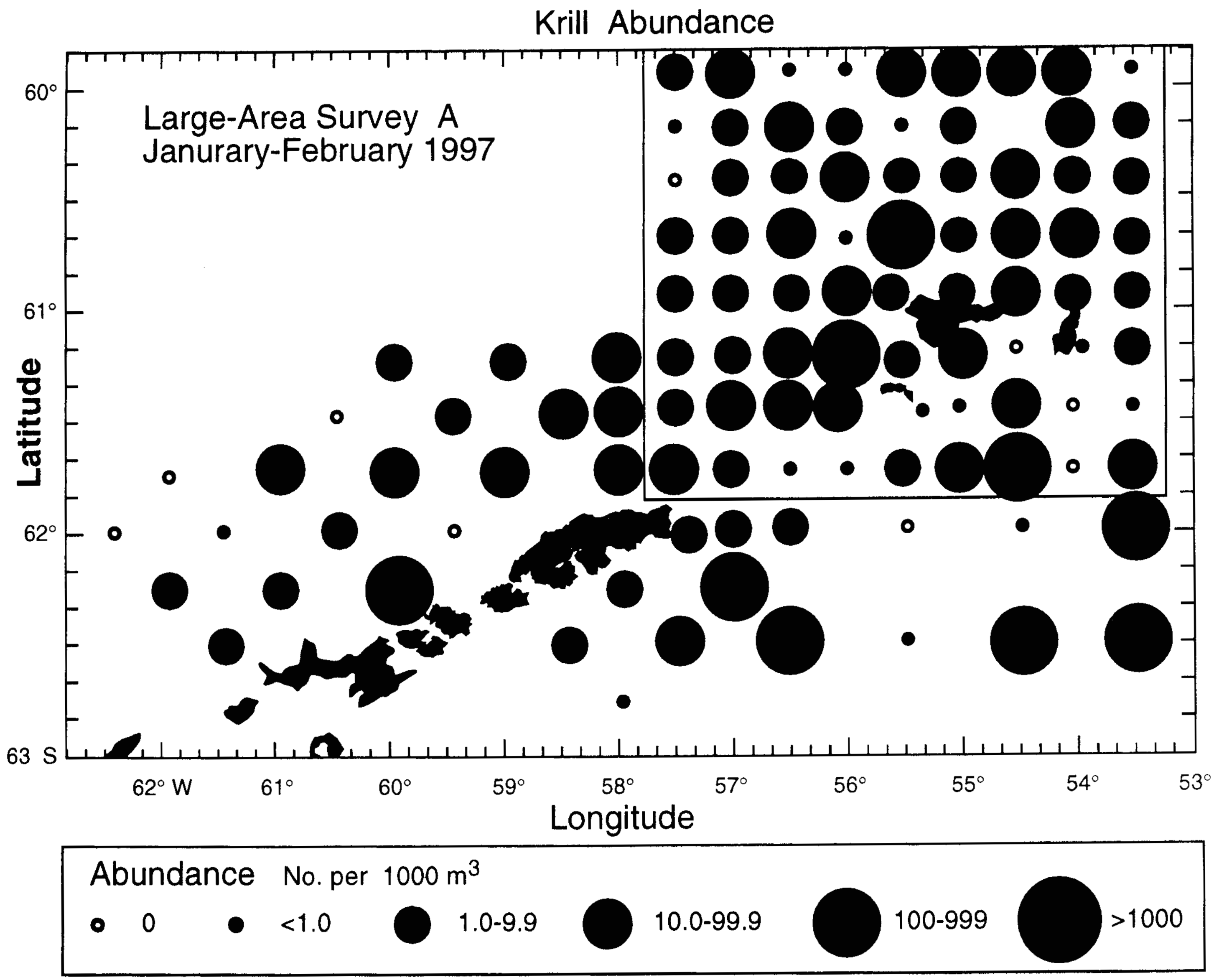
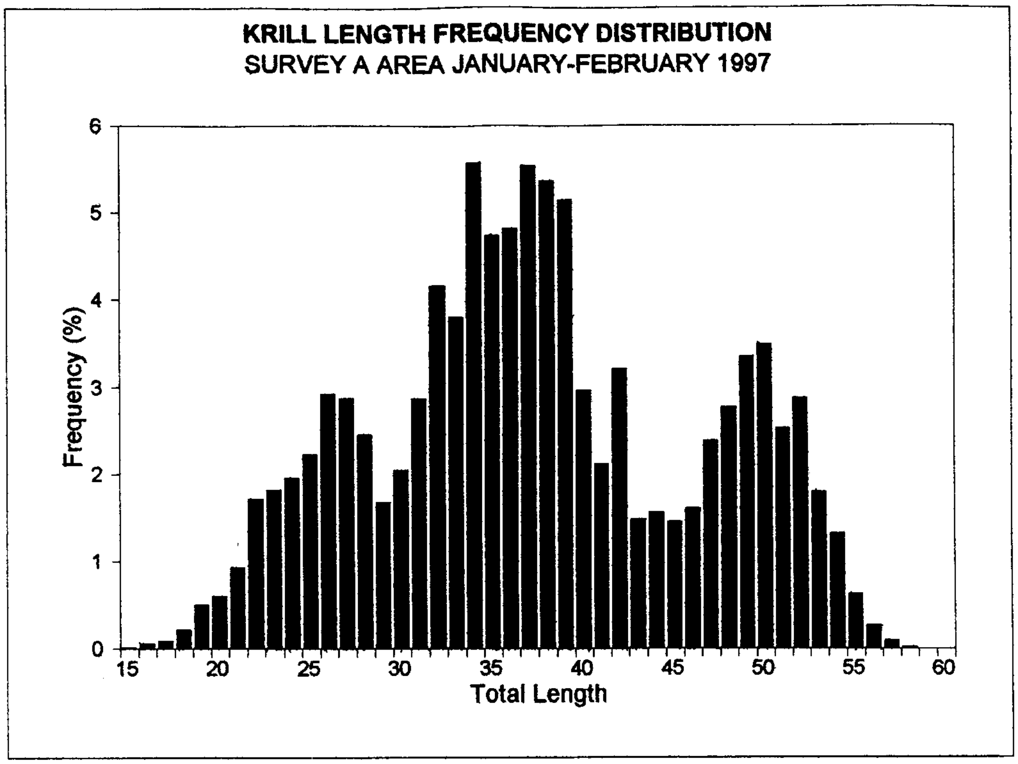


Figure 4.1 Distribution and abundance of krill in IKMT tows collected during Survey A. The outlined stations are included in the "Elephant Island area" used for between-year comparisons.



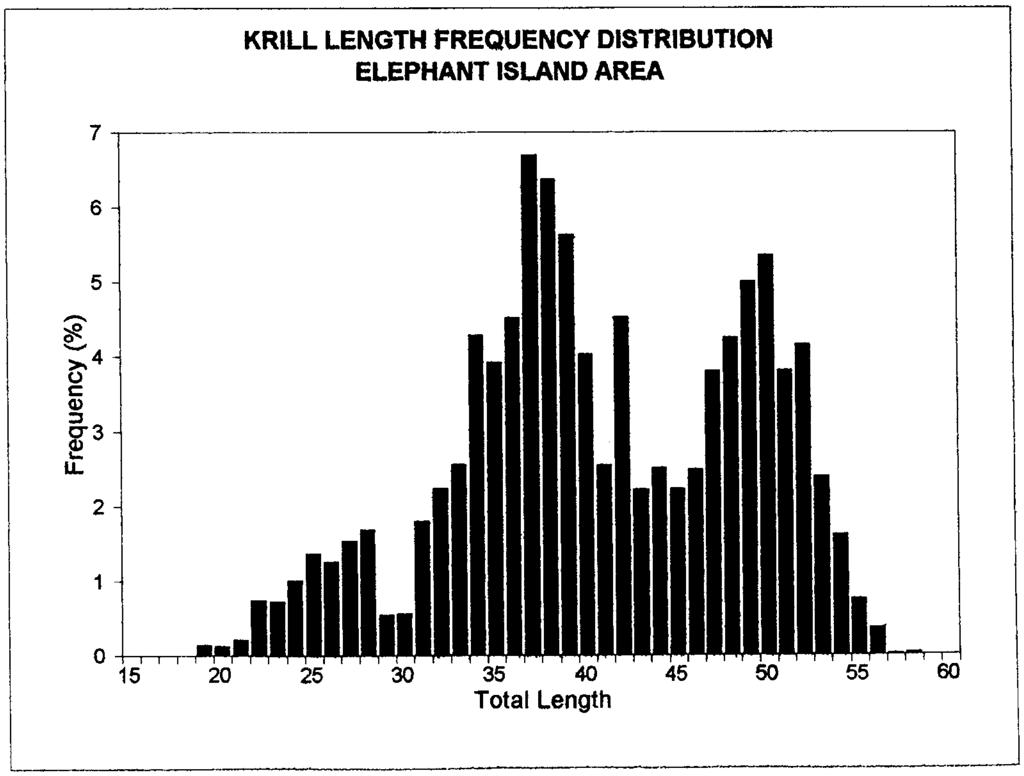
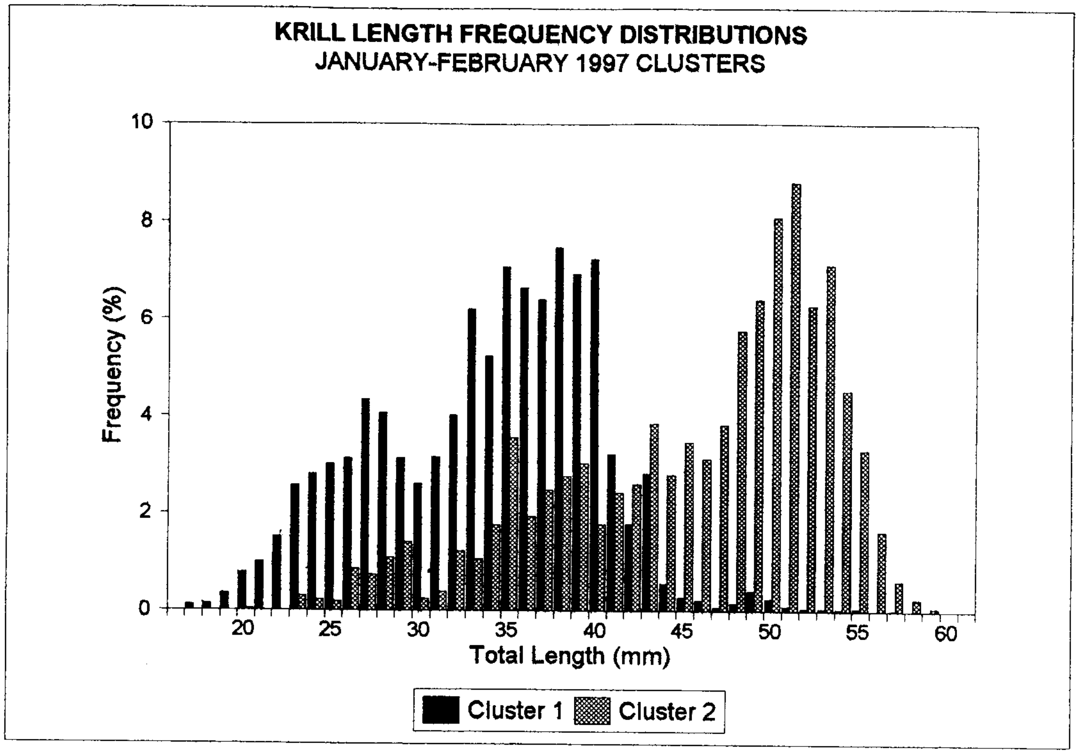


Figure 4.2 Overall length frequency distribution of krill collected (a) during Survey A and (b) in the Elephant Island area, January-February 1997.



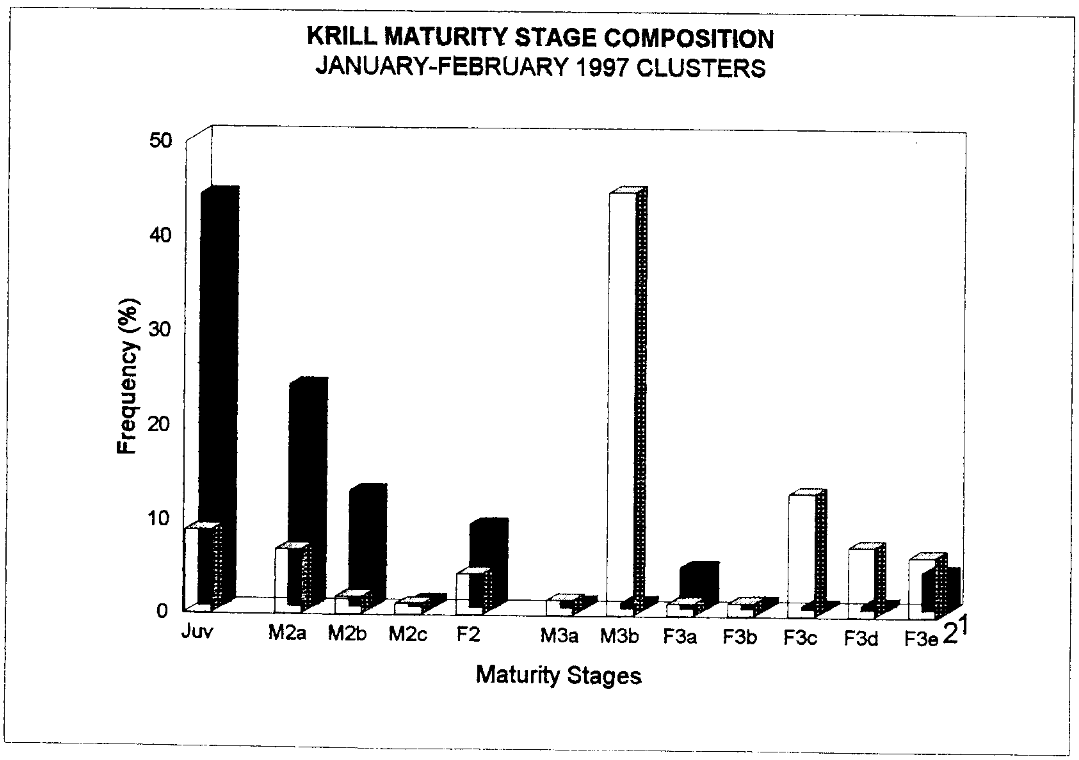


Figure 4.3 (a) Length frequency distribution and (b) maturity stage composition of krill belonging to two different length categories (Clusters 1 and 2) in the Survey A area.

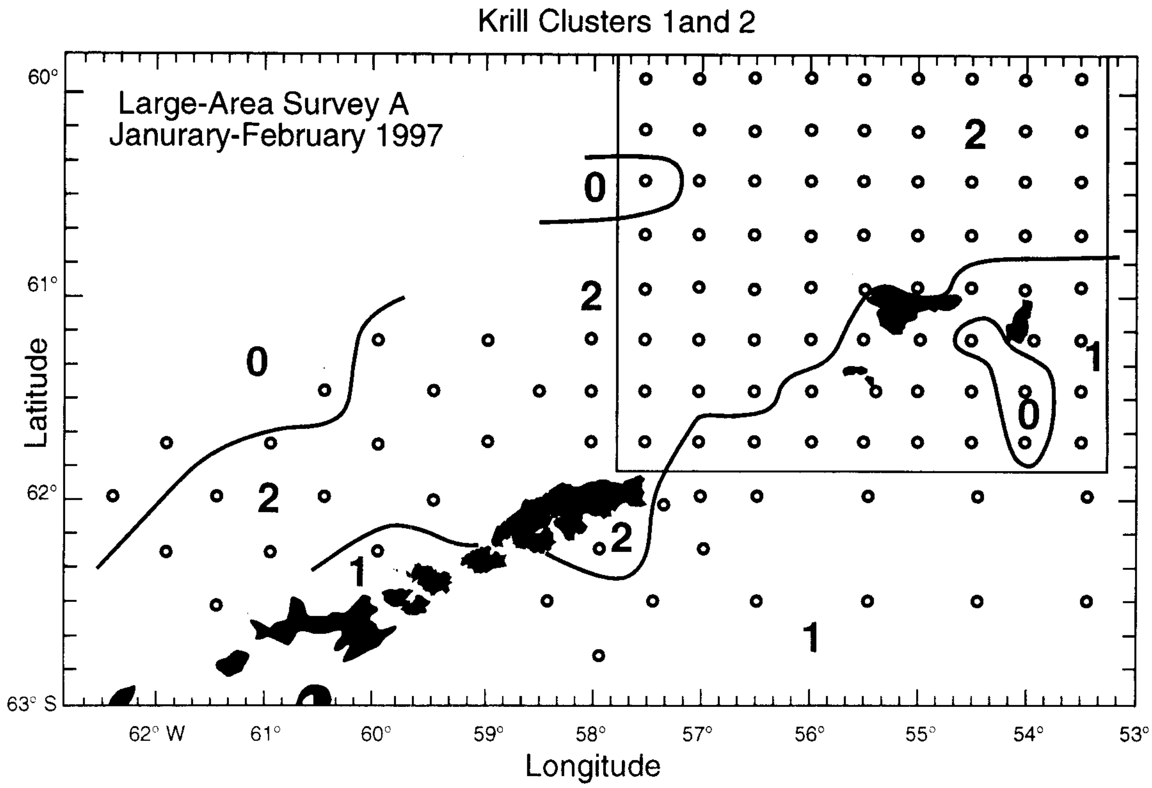


Figure 4.4 Distribution patterns of krill belonging to different length categories (Clusters 1 and 2) within the Survey A area. "0" denotes no krill caught at these locations.

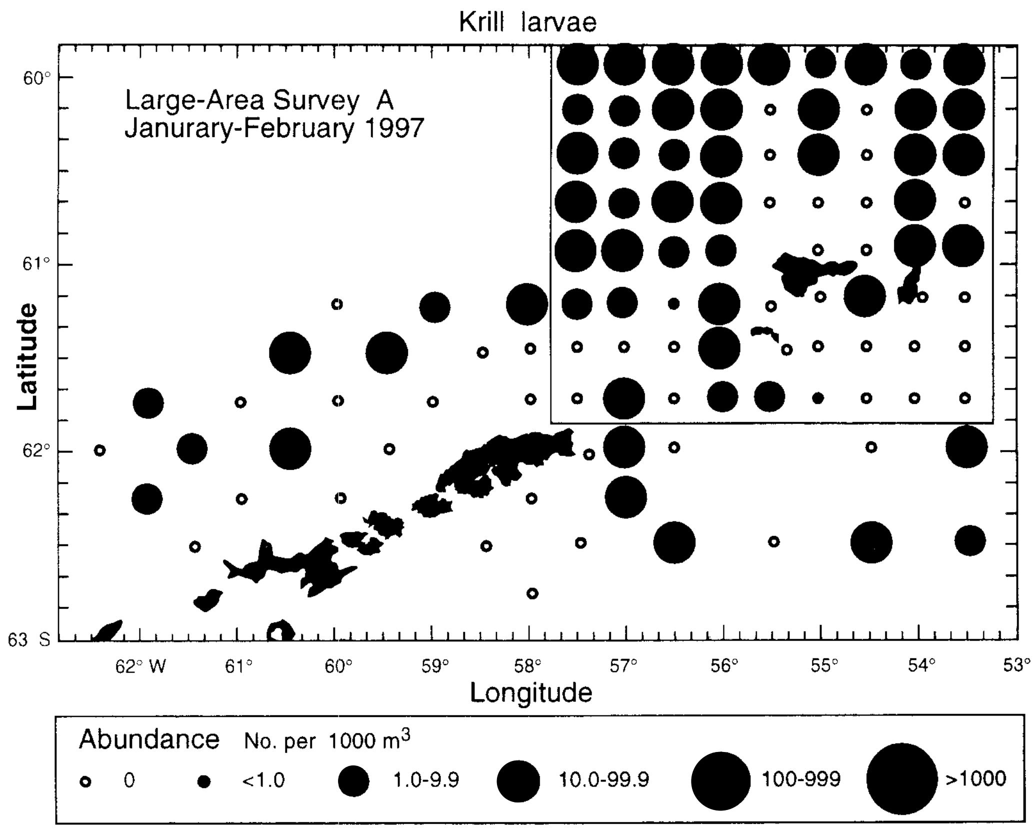


Figure 4.5 Distribution and abundance of krill larvae in the Survey A area.

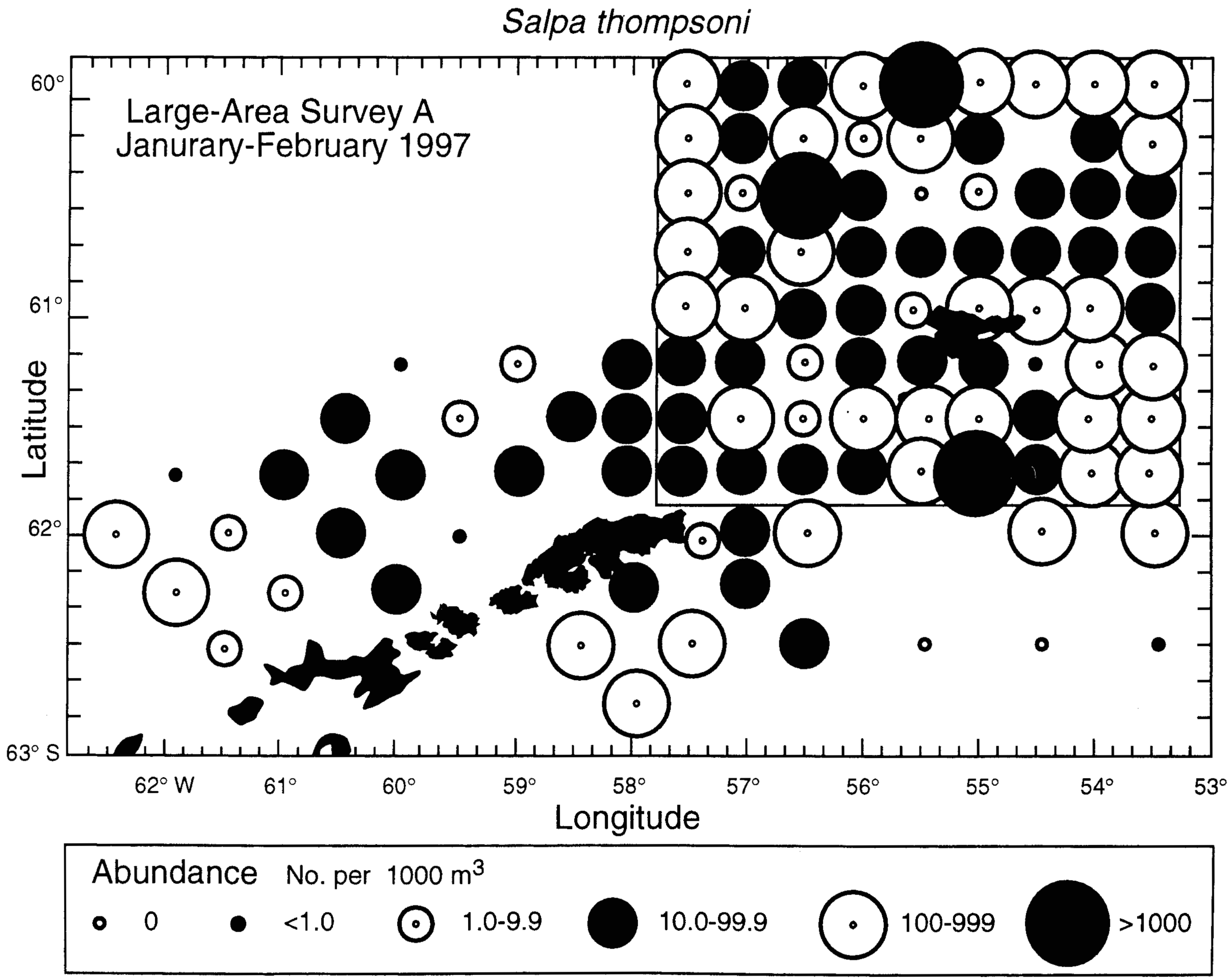
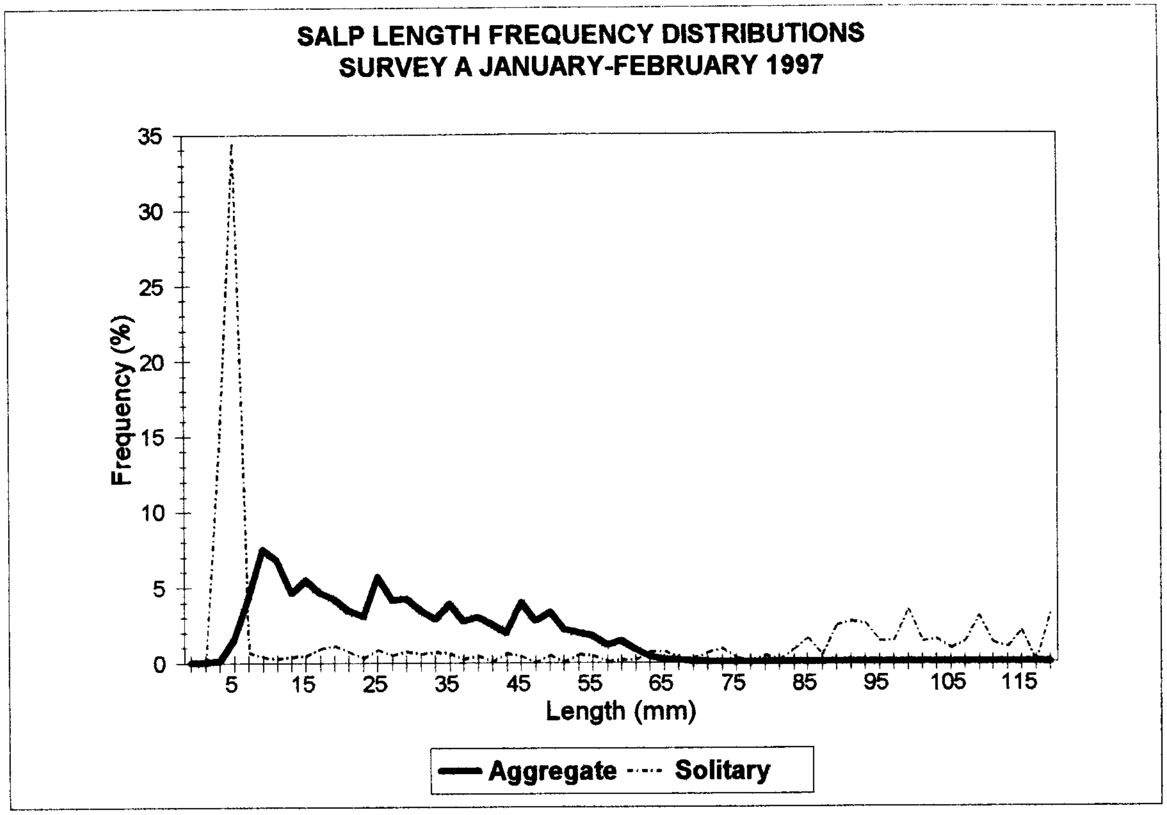


Figure 4.6 Distribution and abundance of *Salpa thompsoni* in the Survey A area.



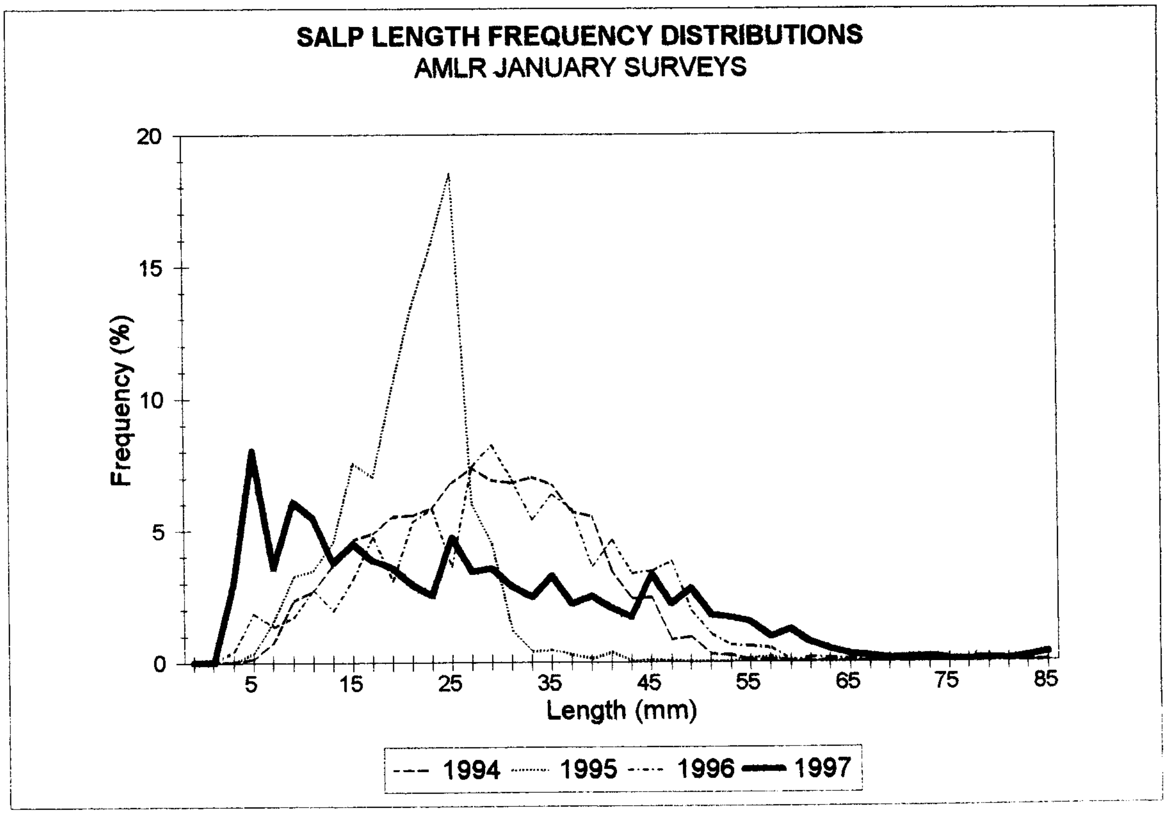


Figure 4.7 Length frequency distribution of (a) aggregate and solitary salp stages in the Survey A area, and (b) total salps during January-February 1994, 1995, 1996, and 1997.

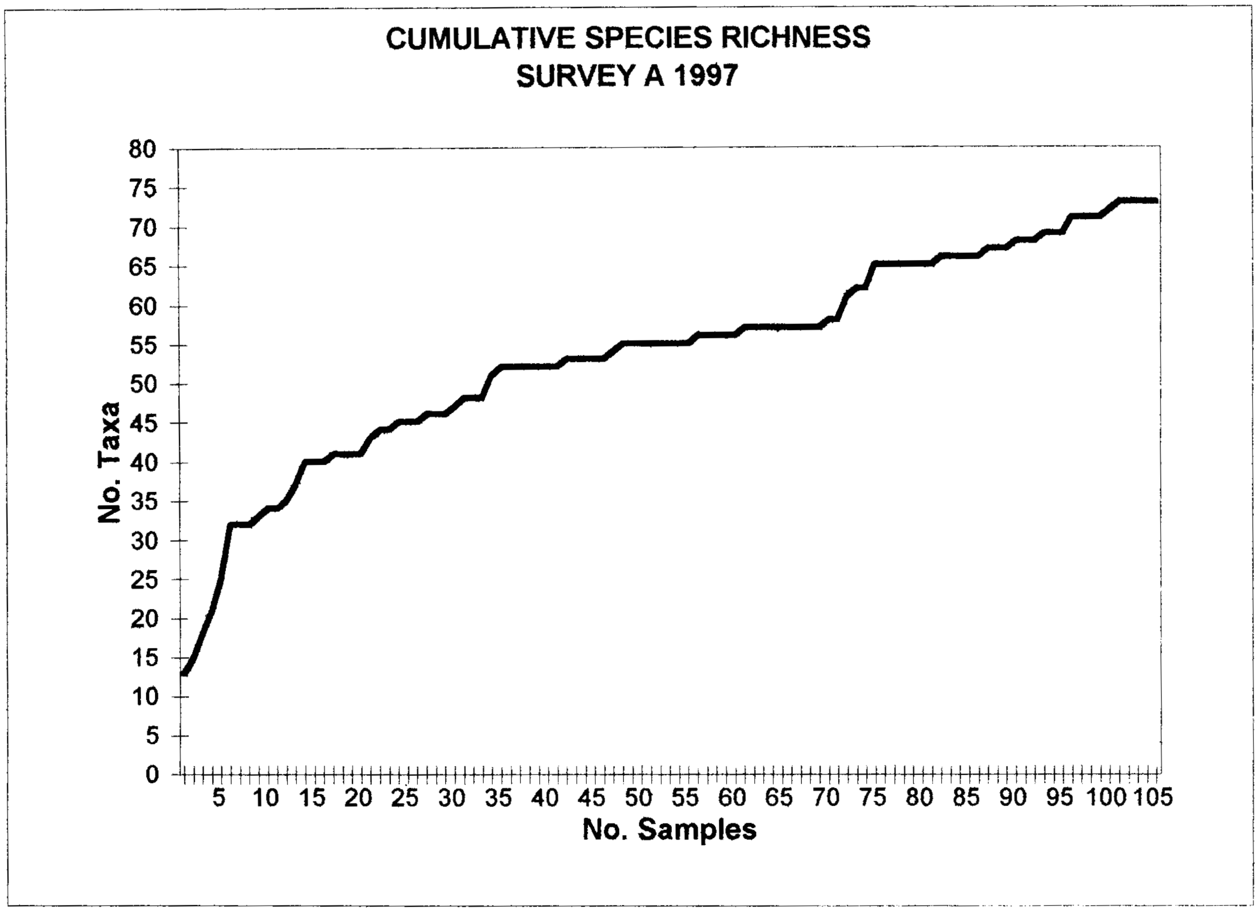
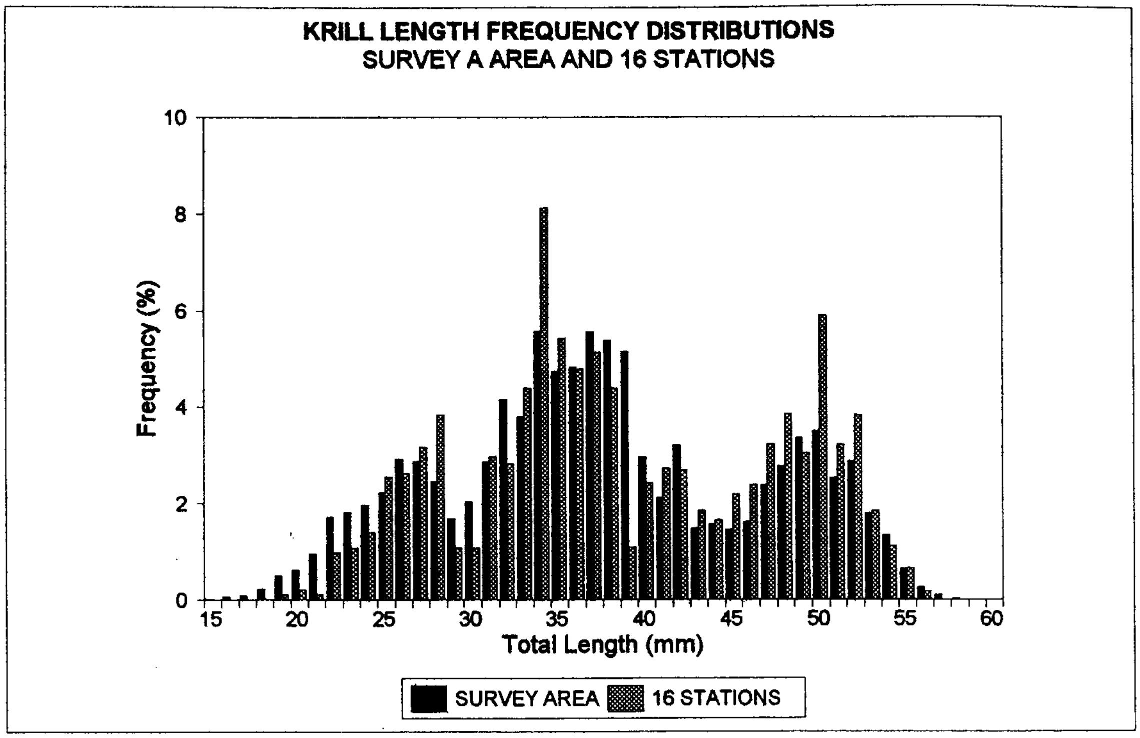


Figure 4.8 Cumulative micronekton/zooplankton species richness curve reflecting increased numbers of taxa collected with increased sampling effort. This is constructed from Survey A data, using the 16 stations sampled during Survey D, then the remaining 71 Elephant Island area stations, and finally the additional extended Survey A area stations.



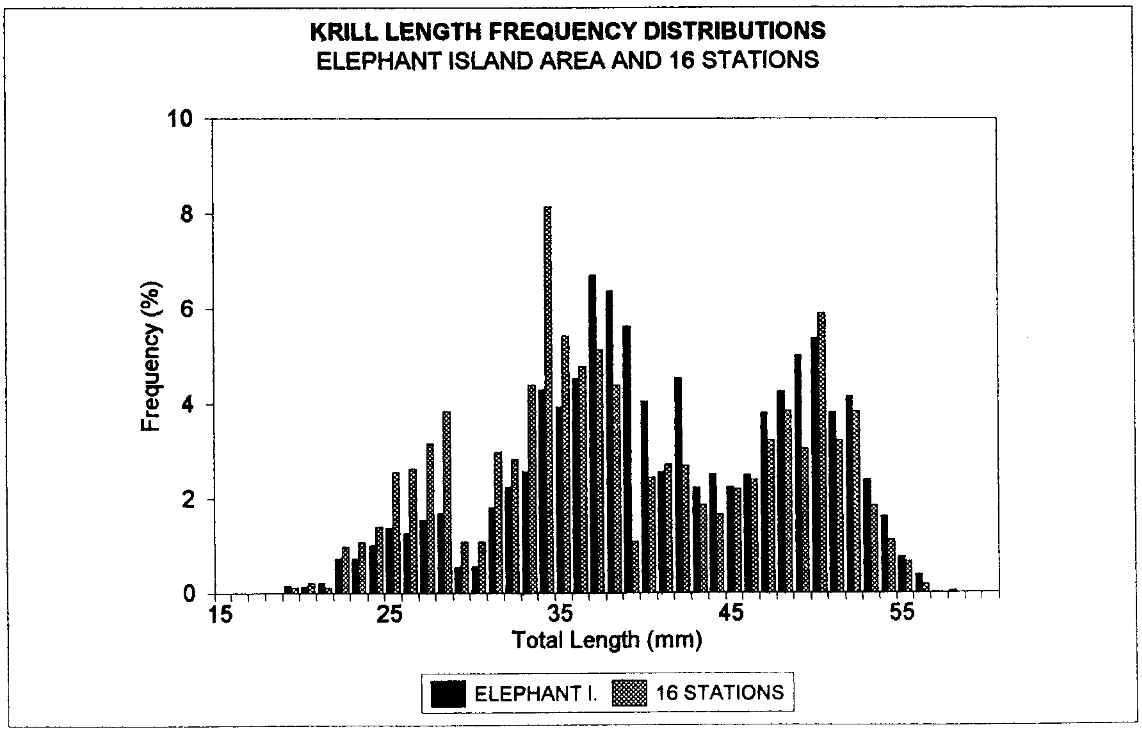


Figure 4.9 Krill length frequency distributions represented by the same 16 stations sampled during Survey D compared to (a) 105 Survey A stations and (b) 71 Elephant Island area stations sampled during Survey A.

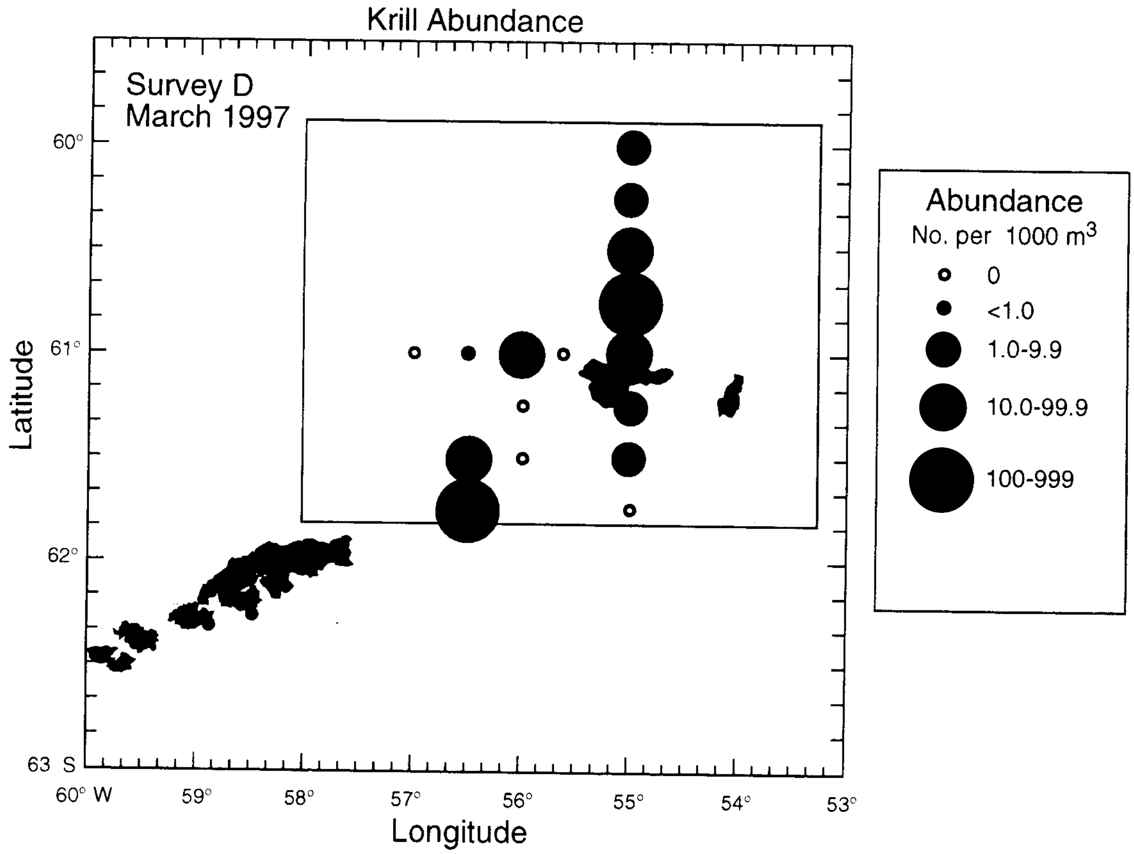


Figure 4.10 Distribution and abundance of krill in IKMT tows collected during Survey D.

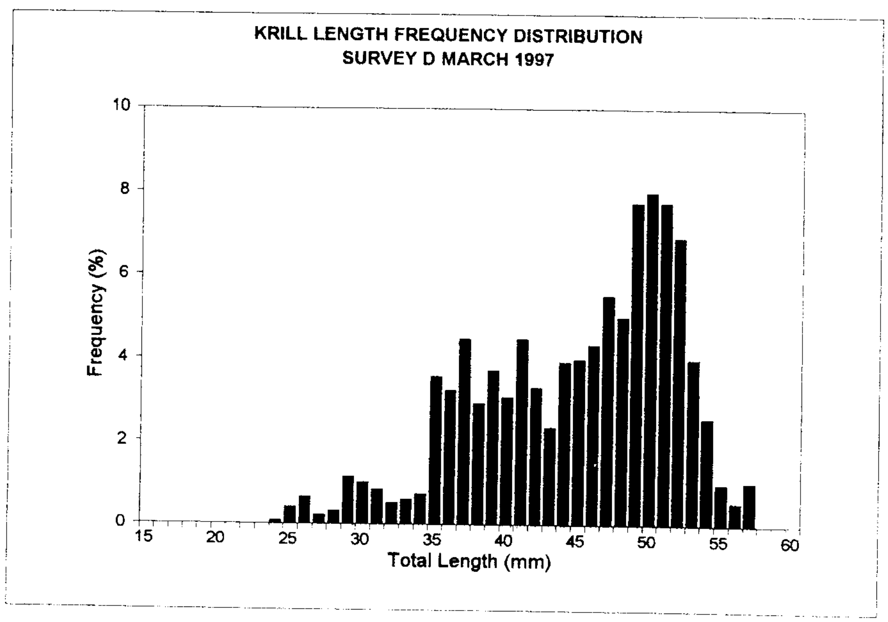
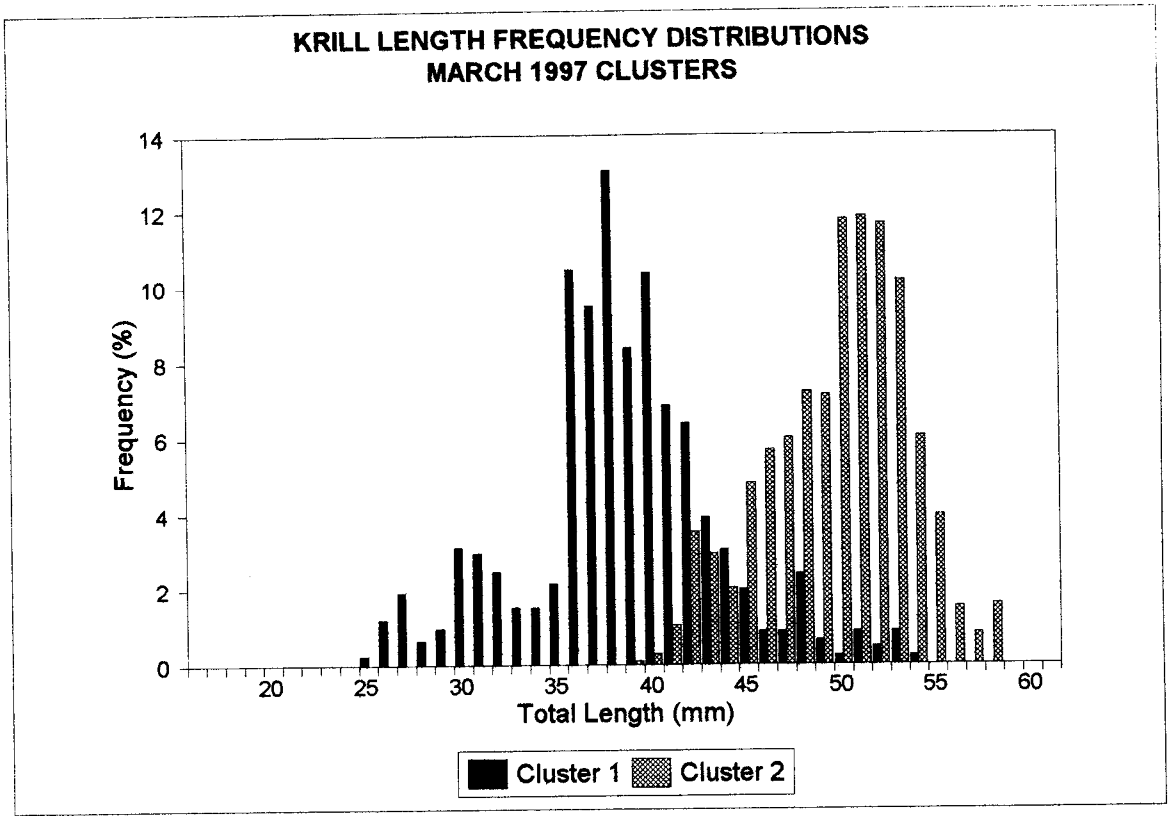


Figure 4.11 Overall length frequency distribution of krill collected during Survey D.



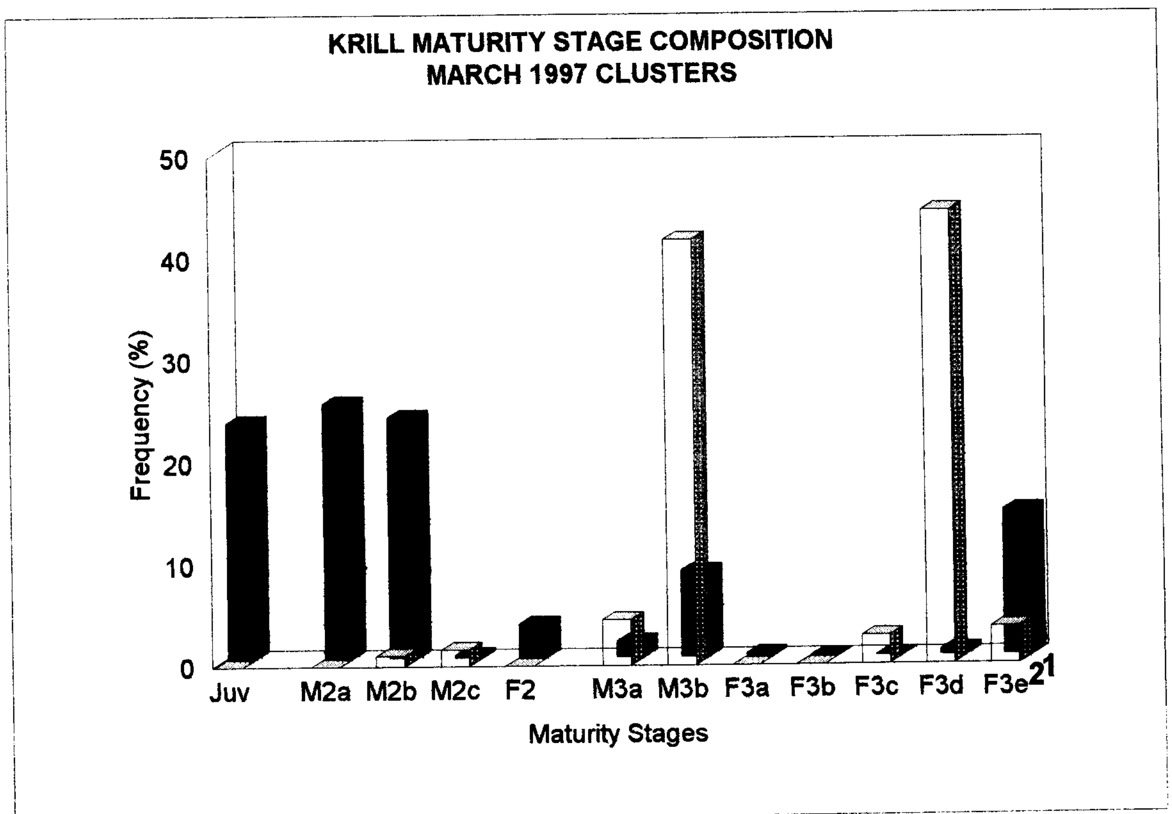


Figure 4.12 (a) Length frequency distributions and (b) maturity stage composition of krill belonging to two different length categories (Clusters 1 and 2) in the Survey D area.

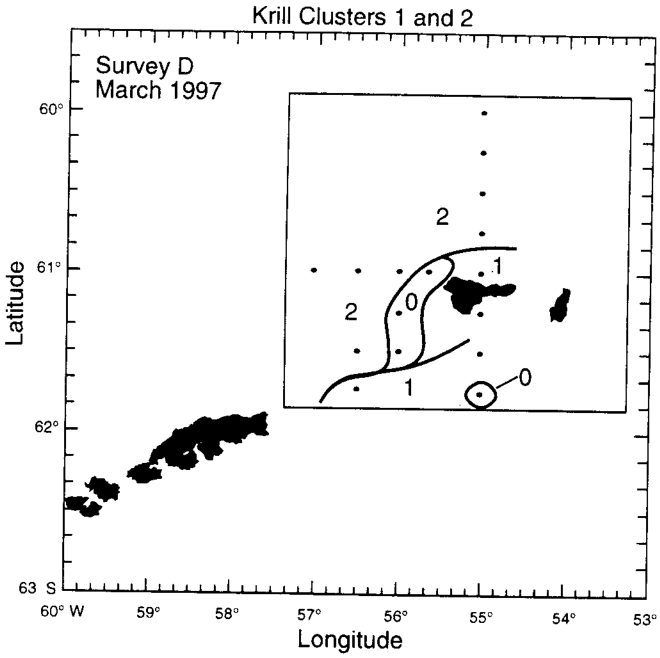


Figure 4.13 Distribution patterns of krill belonging to different length categories (Clusters 1 and 2) in the Survey D area. "0" denotes no krill caught at these locations.

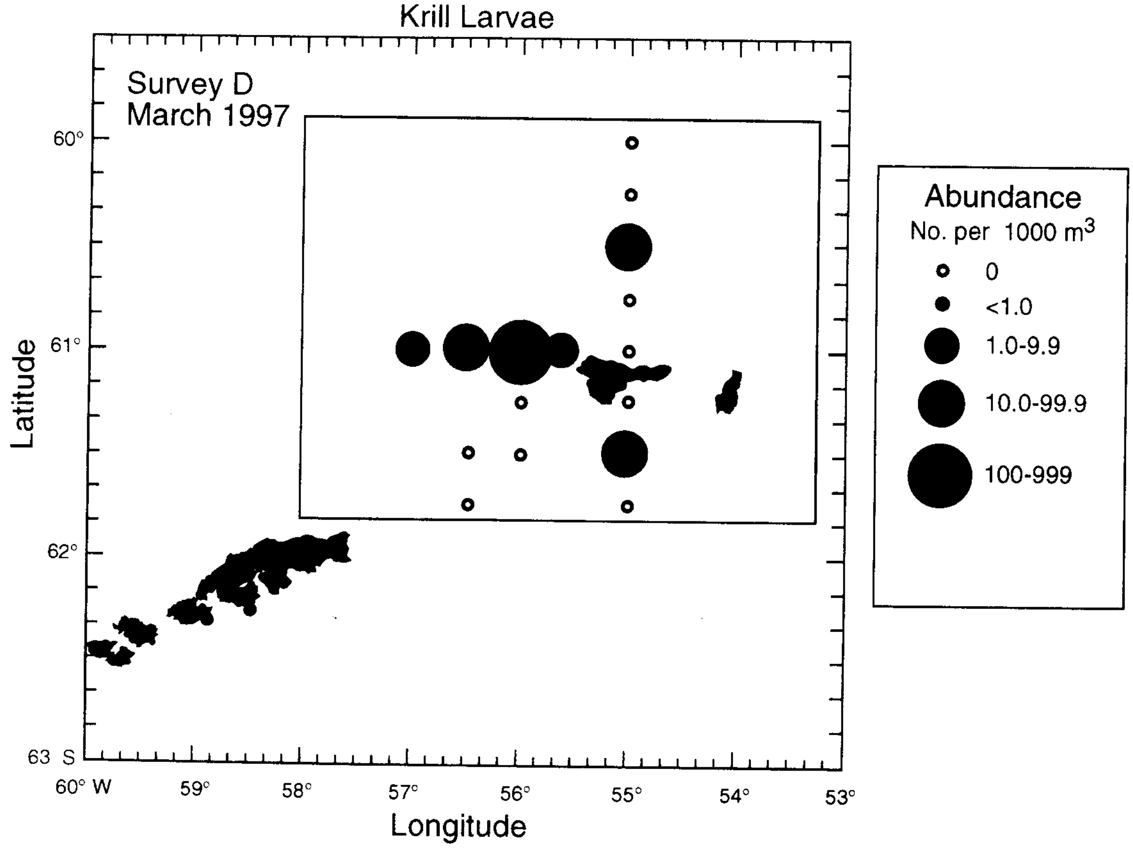


Figure 4.14 Distribution and abundance of krill larvae in the Survey D area.

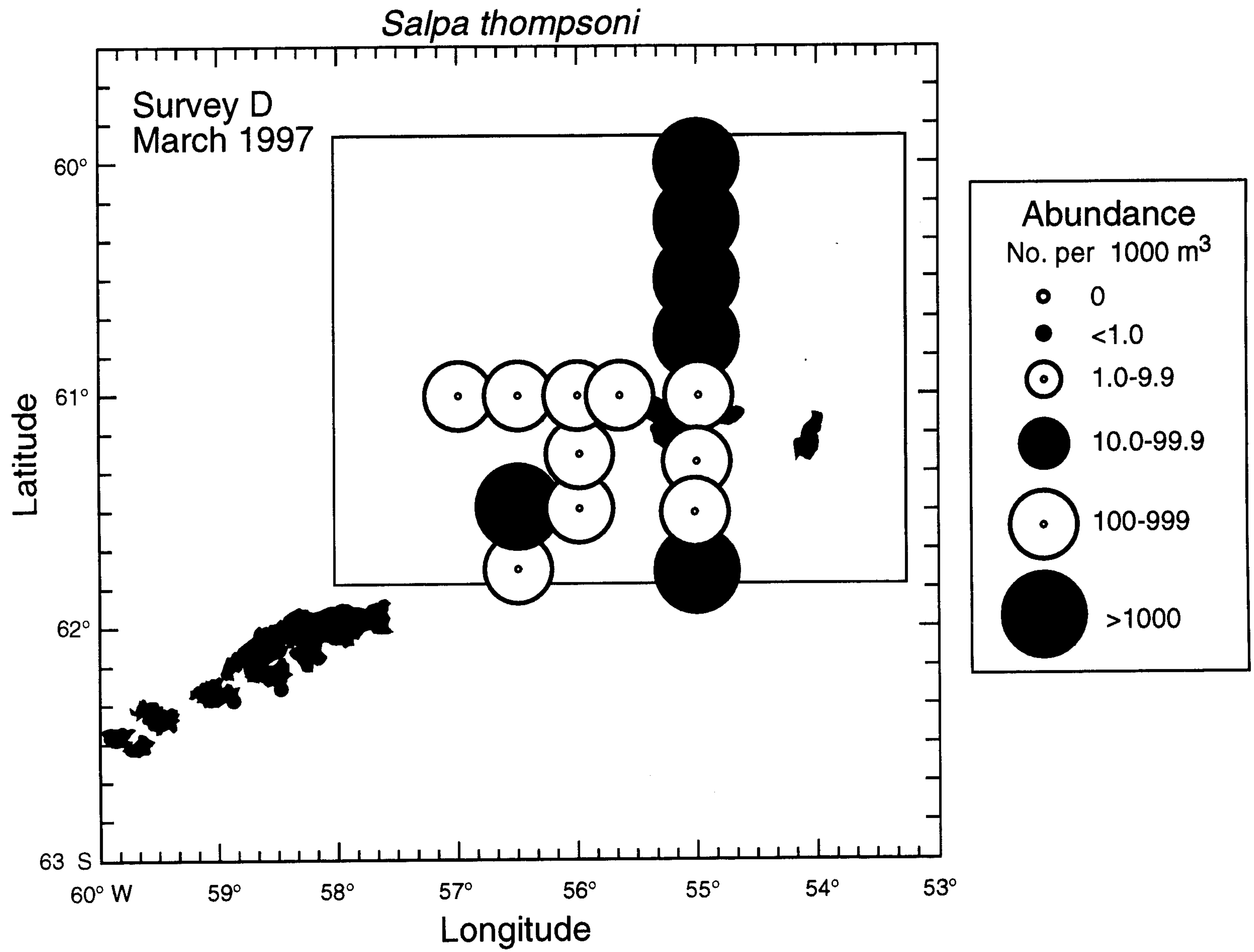
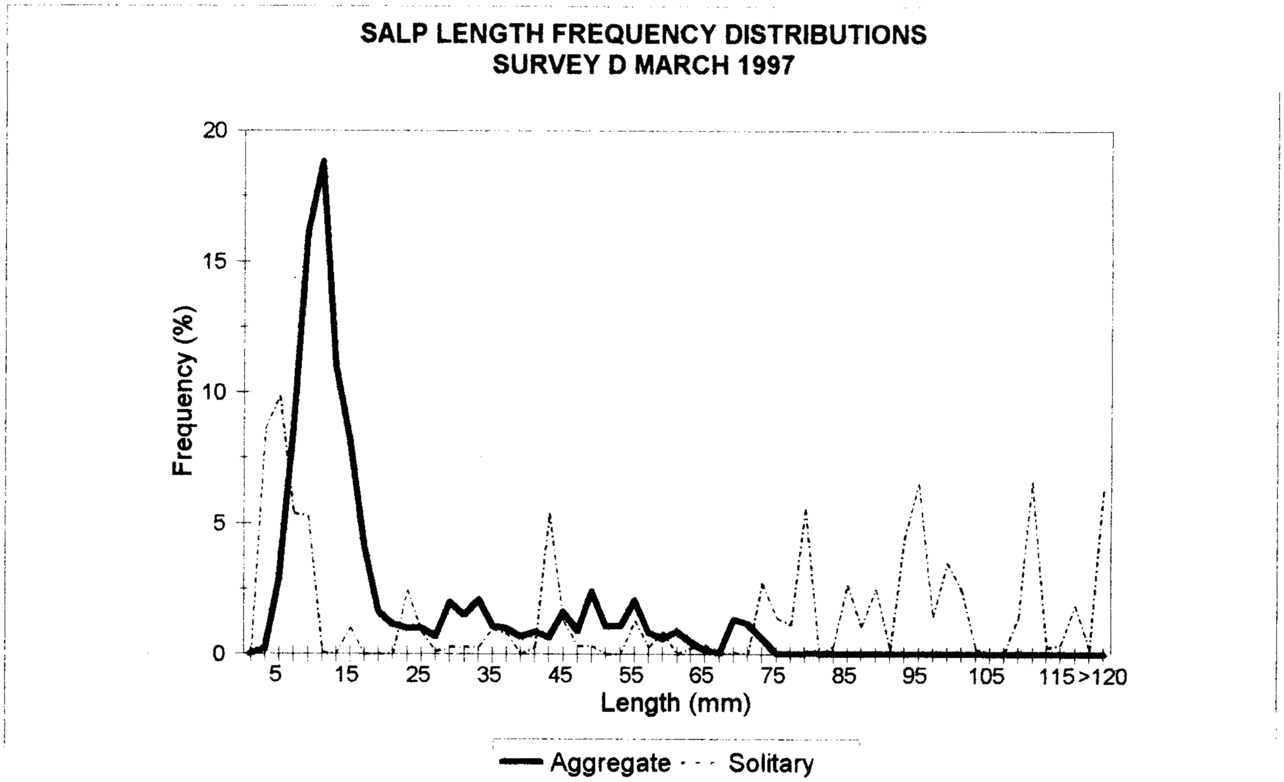


Figure 4.15 Distribution and abundance of *Salpa thompsoni* in the Survey D area.



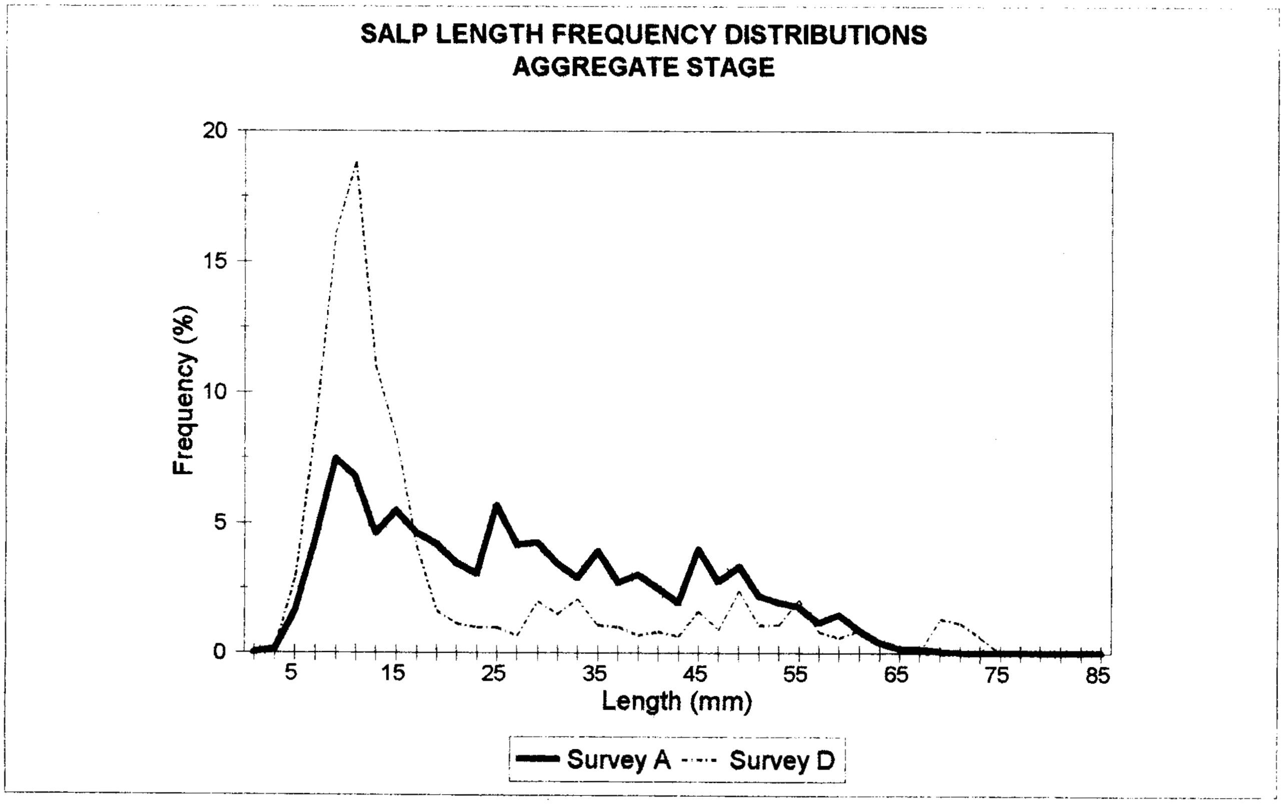


Figure 4.16 Length frequency distribution of (a) aggregate and solitary salp stages in Survey D samples and (b) aggregate stages in the Survey A and Survey D samples.

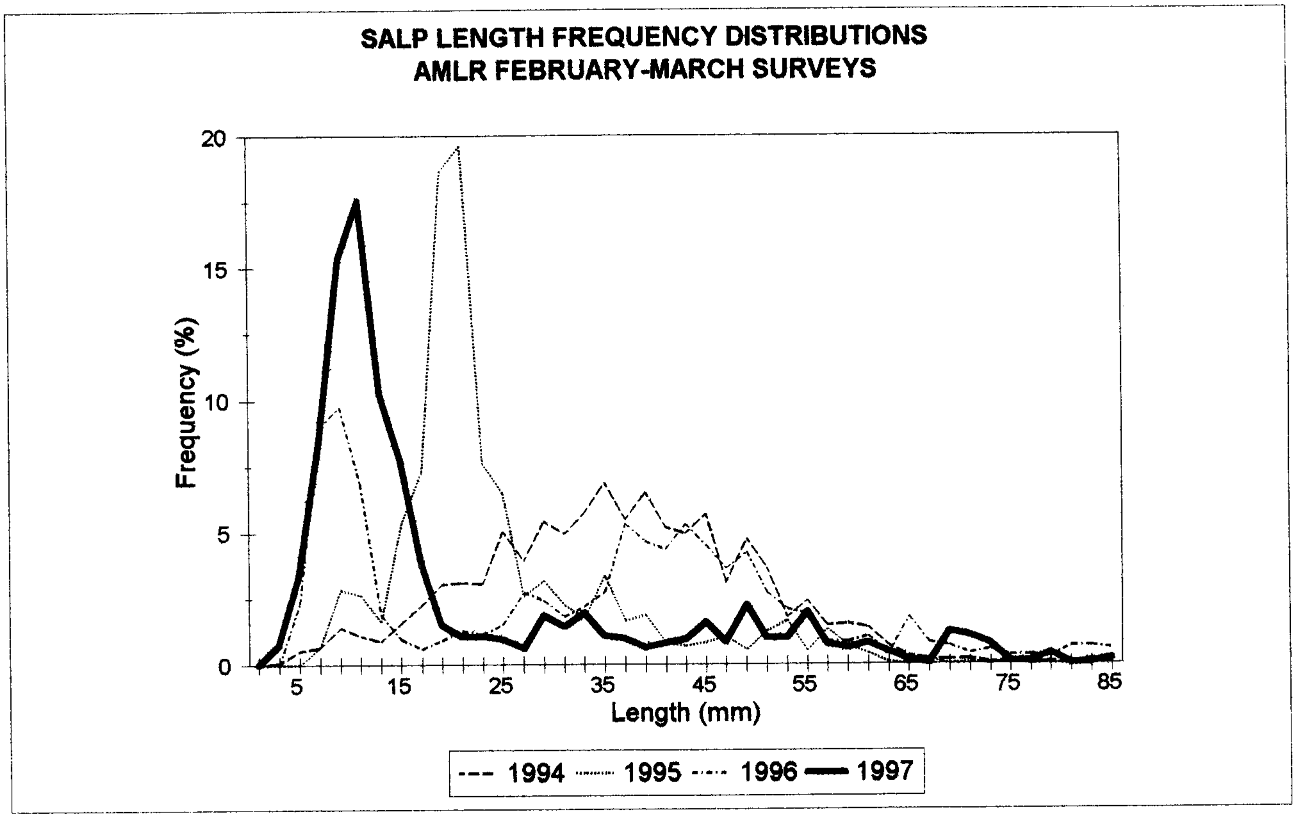


Figure 4.17 Length frequency distribution of total salps during February-March 1994, 1995, 1996, and 1997.

5. Lipids in the Antarctic zooplankton ecosystem; submitted by Charles F. Phleger (Leg I) and Matthew M. Nelson (Leg I).

5.1 Objectives: The objectives of this study were to clarify and further understand Antarctic marine zooplankton trophodynamics and seasonal variability by examining lipid classes, fatty acids, and sterols as key biochemical variables and biomarkers. Lipids are important energy reserve molecules, as well as being necessary for cell membrane structure and function, particularly the omega-3 polyunsaturated fatty acids, which are usually present in very high levels in many polar marine poikilotherms. Sterols are key biomarker compounds and can be used to diagnose recent feeding activity, as well as environmental variables. The different densities of lipids may also be important in hydroacoustics. Selected zooplankton taxa, from IKMT samples collected near Elephant and Livingston Islands, were analyzed for lipid classes, fatty acids, and sterols. These analyses were done at CSIRO, Division of Marine Science, Hobart, Tasmania, Australia, in the laboratory of Peter D. Nichols. Lipids were extracted by chloroform-methanol (Bligh-Dyer extraction) and their classes determined on an Iatroscan MK III THIO TLC-FID analyzer on silica gel chromarods. After saponification, transmethylation, and derivitization, fatty acids and sterols were analyzed on a Hewlett-Packard gas chromatograph mass spectrometer, allowing exact identification. By identifying important lipid components, including certain sterols and omega-3 fatty acids (i.e. docosopentaenoic acid), a better understanding of food web energy transfer in the krill and salp-rich Antarctic ecosystem can be obtained.

5.2 Accomplishments: Zooplankton samples from IKMT tows during Leg I were identified, sorted into phylogenetic groups, and immediately frozen for analysis (Table 5.1). We were able to collect samples around the clock by having alternate 12 hour watches. A number of species different from last year were therefore obtained, including *Euphausia frigida* and *E. triacantha*; the lantern fishes *Electrona carlsbergi* and *Krefftichthys anderssoni*; the Ctenophores *Beroe forskalii* and *Pleurobranchia pileus*; the Scyphomedusae *Atolla wyvellei*, *Stygiomedusa gigantea*, and *Diphyes antarctica* (Siphonophora); the Pteropods *Spongiobranchaea australis* and *Clio pyramidata*; and the Hyperiid Amphipods *Cyllopus lucasii*, *C. magellanicus*, *Hyperiella dilatata*, and *Vibilia antarctica*.

5.3 Results: Results of this 1997 study will be compared with those obtained from the same study area near Elephant Island in 1996. In that study, the zooplankton were characterized by low levels of wax esters (0-6.7% as % of lipid), except for the Euphausiid *Thysanoessa macrura*, with 34% wax ester. Since krill *(Euphausia superba)* lack wax ester (0.0-0.7%), adults and larvae may overwinter by feeding on benthic algae on the pack ice underside (Siegel and Loeb, 1995). The high wax ester in *T. macrura* must serve as winter energy reserves since this species does not feed benthically and is more carnivorous. Zooplankton were also characterized by high levels of omega-3 fatty acids, such as eicosopentaenoic acid, 20:5(n-3), and docosohexaenoic acid, 22:6(n-3), comprising 18-55% of the total fatty acids.

The Pteropods collected during this survey, which include *Spongiobranchaea australis*, *Clio pyramidata*, and *Clione limacina*, will allow us to confirm and extend our 1996 observation of 28% diacylglycerol ether (DAGE) in *C. limacina* from the AMLR study area (Table 5.1). The food of *C. limacina*, *Limacina helicina*, lacks DAGE. The only other reports of high levels of DAGE are from certain deep sea shark livers, Holocephalans, and Gonatid squids. A buoyancy function has been proposed since DAGE gives 23% more uplift than triacylglycerol (TAG) in 1.025 g/cc sea water. *L. helicina* has bubbles to support its test, whereas *C. limacina* lacks bubbles yet must maintain a position in the water column near *L. helicina*, its sole food source. Economically, DAGE has been reported to have anti-carcinogenic and anti-biotic activity, as well as being important in the treatment of haematopoesis and radiation sickness. The *Hyperiella dilatata* collected on this cruise carry small *Spongiobranchaea australis* on their back, which are known to secrete a toxin.

One of the most interesting discoveries was the presence of 19% docosopentaenoic acid (DPA), 22:5(n-3), in the Scyphomedusa, *Periphylla periphylla*. This unusual omega-3 fatty acid is not common in marine zooplankton, and it was not found in any other plankton species collected in the AMLR study area during 1996. *Atolla wyvellei*, *Stygiomedusa gigantea*, and *Diphyes antarctica* collected this year are to be carefully screened for DPA in the post-expedition analytical work at CSIRO (Table 5.1).

The principal sterols of all Euphausiids analyzed included 80-87% cholesterol and 5-12% desmosterol. Crustaceans are incapable of *de novo* sterol synthesis and depend on diet and dealkylation of phytosterols. Desmosterol is produced as an intermediate from phytosterol dealkylation and also comes from the marine algae *Nitzschia closterium* (100% desmosterol) and *Rhizosolenia setigera* (94% desmosterol). The sterols of *Salpa thompsoni* include brassicasterol (20%), 24-methylenecholesterol (20%), 24-nordehydrocholesterol (13%), transdehydrocholesterol (8%), cholesterol (6%), and desmosterol (5%). The main sterol in the diatom *Chaetoceros* is 24-methylenecholesterol, and brassicasterol is the main sterol in *Phaeocystis*. A benthic filter feeder Urochordate, *Distaplia cylindrica*, related to *Salpa thompsonii*, was characterized by stanols, such as cholestanol and brassicastanol. Stanols are hydrogenated sterols, which may reflect reducing activity (anoxia) in the sediments where they live (Nichols *et al.*, 1993).

Although wax esters were not an abundant component of the Antarctic zooplankton that we analyzed, their levels in the Myctophid fish, *Electrona antarctica*, from the Elephant Island area were 69-93% of total lipid. Fatty acids and fatty alcohols of the wax esters were chromatographed separately on the gas chromatograph. The fatty alcohols had very low levels of polyunsaturated fatty acids (PUFA)(0-1.5%). Fatty acids of *E. antarctica* were also relatively low in PUFA (6-27%). These spectra are characteristic of wax ester-rich fishes, such as the orange roughy, which are very poor sources of omega-3-rich fatty acids (Nichols *et al.*, 1994). The wax esters in *E. antarctica* are important long term energy reserve molecules and also have doubtless function in buoyancy in these diurnally vertically migrating fish. We collected *Electrona carlsbergi* this year (Table 5.1). According to Reinhardt and Van Vleet (1986), *E.*

carlsbergi consists mostly of TAG lipid, in contrast to *E. antarctica*. Since *E. carlbergi* populations occur mostly north of 60°S, the presence of TAG, a short term energy reserve molecule, may reflect less seasonal variability in food. *E. antarctica*, which occurs primarily south of 60°S and is rich in wax esters, may need these long term energy reserve lipids during the Antarctic winter.

5.4 Acknowledgments: We are grateful to Valerie Loeb, Dawn Outram, and Kimberly Puglise for their help with the sorting and identification of specimens. We also thank Wes Armstrong, Jeremy Sterling, and the crew of the R/V *Yuzhmorgeologiya* for their enthusiasm and hard work in sample collection.

5.5 References:

Reinhardt, S.B., and E.S. Van Vleet. 1986. Lipid composition of twenty-two species of Antarctic midwater zooplankton and fish. *Marine Biology*. 91:149-159.

Nichols, P.D., R. Leeming, M.S. Rayner, V. Latham, N.J. Ashbolt, and C. Turner. 1993. Comparison of the abundance of the fecal stanol coprostanol and fecal bacterial groups in inner-shelf waters and sediments near Sydney, Australia. *J. Chromat.* 643:189-195.

Nichols, P.D., D.S. Nichols, and M.J. Bakes. 1994. Marine oil products in Australia. *Inform.* 5(3):254-261.

Siegel, V., and V. Loeb. 1995. Recruitment of Antarctic krill *Euphausia superba* and possible causes for its variability. *Marine Ecology Progress Series.* 123:45-46.

Table 5.1 Zooplankton and micronekton samples from IKMT tows conducted during Leg I.

Taxon	Survey Station
Cnidaria	
Atolla wyvillei (Scyphomedusae)	A79
Calycopsis borchgrevinki (Hydromedusae)	A73
Diphyes antarctica (Siphonophora)	A80
Stygiomedusa gigantea (Scyphomedusae)	A36
Ctenophora	
Beroe cucumis	A145, A169
Beroe forskalii	A47
Pleurobranchia pileus	A36
Chaetognatha	
Sagitta gazellae	A34
Polychaeta	
Tomopteris carpenteri	A20, A41, A159
Pteropoda	
Clione limacina	A6, A19, A27, A28, A34, A40, A107
Clio pyramidata	A68
Spongiobranchaea australis	A107, A108, A158, A159
Euphausiacea	
Euphausia frigida	A66
Euphausia superba (adults)	A46-B, A49, A56, A72, A129
Euphausia superba (juveniles)	A49, A56, A68, A93, A97
Euphausia triacantha	A66
Thysanoessa macrura	A4, A19, A65, A70, A73
Hyperiidea	
Cyllopus lucasii	A29
Cyllopus magellanicus	A29
Hyperiella dilatata	A19
Themisto gaudichaudi	A53, A63, A89, A130
Vibilia antarctica	A88, A89, A90
Urochordata	
Salpa thompsoni	A6, A81, A128
Teleostei	
Electrona antarctica	A11, A31, A76, A92
Electrona carlsbergi	A11, A115
Gymnoscopelus nicholsi	A11, A31
Gymnoscopelus opisthopterus	A77, A170,
Krefftichthys anderssoni	A46

6. Operations and logistics at Cape Shirreff, Livingston Island, and Seal Island, Antarctica, 1997; submitted by W.T. Cobb and R.S. Holt.

6.1 Objectives: During the 1997 field season, the AMLR program established and constructed a field camp at Cape Shirreff, Livingston Island, Antarctica (62°28'07"S, 60°46'10"W) to support land-based research on seabirds and marine mammals. This camp was occupied continuously from January through March 1997. Since the 1986/87 austral summer, the AMLR program has maintained a field camp at Seal Island, Antarctica (60°59'14"S, 55°23'04"W) in support of land-based research on marine mammals and seabirds. This camp was occupied from February through March 1997. The Seal Island camp is being closed due to safety concerns about the island. The main logistics objectives of the 1997 season were:

1. To recover one person and disembark another person at the U.S. Copacabana camp in Admiralty Bay, King George Island via the R/V *Yuzhmorgeologiya*;

2. To deploy a six-person field team in mid-January from the R/V *Yuzhmorgeologiya* to Cape Shirreff to construct a research camp and to conduct opportunistic seabird monitoring;

3. To transport building materials and equipment for a new field camp to Cape Shirreff from the R/V *Yuzhmorgeologiya*;

4. To recover three field team members from Cape Shirreff in mid-February aboard the R/V *Yuzhmorgeologiya*;

5. To deploy a four-person field team to Seal Island from the R/V *Yuzhmorgeologiya* in mid-February to prepare equipment for transport to Cape Shirreff, and to conduct opportunistic seabird and marine mammal observations;

6. To recover the Seal Island field team and equipment in late February aboard the R/V *Yuzhmorgeologiya* for transport to Cape Shirreff;

7. To deploy a three-person field team with equipment recovered from Seal Island to Cape Shirreff and resupply the campsite with additional building materials and provisions from the R/V *Yuzhmorgeologiya* in late February;

8. To recover from Cape Shirreff the six-person AMLR field team, a two-person Chilean field team, and retrograde equipment and trash at the end of the field season in mid-March for transport to Chile aboard the R/V *Yuzhmorgeologiya*;

9. To recover a two-person field team and retrograde equipment and trash at the end of the season from the Copacabana camp for transport to Chile aboard the R/V *Yuzhmorgeologiya*;

10. To dismantle and retrograde two wooden blinds, three antenna towers, and the partial remains of a fiberglass pod from Seal Island;

11. To repair, maintain, and improve camp facilities at the Seal Island field camp; and

12. To maintain effective communication systems on Cape Shirreff and Seal Island and maintain daily radio contact with either Palmer station and Copacabana camp, or R/V *Yuzhmorgeologiya.*

6.2 Accomplishments: A five-person field team embarked the R/V *Yuzhmorgeologiya* in Punta Arenas, Chile, on 19 January 1997. Late arrival of shipped AMLR equipment caused a four day delay in departure. The ship proceeded directly to Admiralty Bay, King George Island to conduct acoustic calibrations and diving operations. A sixth member of the field team from the U.S. Copacabana camp in Admiralty Bay was recovered aboard the R/V *Yuzhmorgeologiya* using a MK V Zodiac. One NSF person was also disembarked to the Copacabana camp.

The R/V *Yuzhmorgeologiya* arrived at Cape Shirreff, Livingston Island on 24 January, one day delayed due to a shipboard medical emergency. Off-loading of the substantial collection of building materials from ship to shore began immediately, as did the establishment of a temporary camp ashore consisting of two Weatherhaven tents and one dome tent. A six member field team disembarked the ship on 25 January to Cape Shirreff. Off-loading operations were completed on 26 January. Good weather conditions and a protected landing resulted in efficient transport of approximately 100 Zodiac loads of materials. The assistance of the ship's crew and scientific party members both aboard ship and ashore greatly expedited loading, unloading, and transport operations. Two AMLR MK V Zodiacs with cargo racks were used for all transport of people and materials. A 4-wheel drive ATV with wagon was used to transport materials 0.25 miles from the boat landing to the camp site.

Construction of four buildings (including outhouse) at the field camp commenced on 24 January. Approximately 90% of the camp was finished before building materials were exhausted. Great care was taken to collect all waste materials created during construction. Saw dust, the most difficult waste product to control, was initially collected using wind screens and tarps. Sawing operations were moved as soon as possible into partially constructed buildings.

Three members of the field team embarked the R/V *Yuzhmorgeologiya* from Cape Shirreff on 10 February for transport to Seal Island. Six Zodiac loads of refuse were transported to the ship for disposal in Punta Arenas, Chile. All operations went quickly without incident in ideal weather conditions.

A four member field team disembarked the R/V *Yuzhmorgeologiya* to Seal Island on 11 February after a 15 hour transit from Cape Shirreff. One MK V Zodiac was kept on the island for this stay. The ship was scheduled to return on 21 February, but engine problems delayed its arrival at Seal Island until 16 March. The field team and approximately 15 Zodiac loads of equipment and food to be transported to Cape Shirreff were removed from Seal Island in foggy and windy conditions. Four swimmers in dry suits, vital to beach operations, were utilized to steady, launch and recover the Zodiacs. Operations ceased due to deteriorating weather conditions and were not continued the next day due to bad weather.

Dismantling of two remote observations blinds, three antenna towers, and a small fiberglass structure were undertaken during the extended stay at Seal Island. All traces of the structures were removed, including buried concrete supports, and packaged for retrograde to Chile. Poor weather conditions and limited time did not allow for their removal from the island.

Routine maintenance of the Seal Island camp facilities was undertaken as necessary. Obsolete and unneeded equipment was identified and readied for transport off the island. Walls in the laboratory exposed to rock falls were reinforced with 2x4's, pallets, and plywood. A second solar panel was erected and additional batteries were added to the DC power system.

On 18 March a two-person NSF team was recovered from the Copacabana camp in Admiralty Bay aboard the R/V *Yuzhmorgeologiya.* Approximately twelve Zodiac loads of retrograde equipment and trash were removed to the ship for later transfer to the NSF agent in Chile. Operations went smoothly in favorable weather conditions. Four swimmers in dry suits were used on shore to steady, launch, and recover the Zodiacs.

On 19 March the R/V *Yuzhmorgeologiya* returned to Cape Shirreff to off-load materials purchased in Chile and equipment recovered from Seal Island, while removing trash and retrograde cargo from the newly established AMLR camp and the existing Chilean camp. Approximately 20 boat loads of material were transported from ship to shore, and approximately 12 were transported from shore to ship. Operations were completed in deteriorating weather conditions. Previously on 8 March, because of uncertainties in repairs to the R/V *Yuzhmorgeologiya,* the three-person AMLR field team and two-person Chilean field team that had remained on Cape Shirreff were removed by the NSF R/V *Polar Duke.*

The R/V *Yuzhmorgeologiya* returned to Seal Island on 21 March to complete year-end closing of the camp facilities and secure remaining equipment for the winter.

Daily radio communications were maintained by Cape Shirreff and Seal Island with either the R/V *Yuzhmorgeologiya*, or Palmer station and Copacabana camp by SSB radio.

6.3 Recommendations: Support provided by the R/V *Yuzhmorgeologiya* and the AMLR scientific complement made a significant contribution to the success of the field season at Cape Shirreff and Seal Island. Use of the Chilean ATV and trailer were vital for transporting building materials. Assistance of the AMLR Electronic Technician aided in establishing radio communications at Seal Island. The continued practice of using four swimmers in dry-suits to assist with Zodiac beach operations was invaluable. Lengthy Zodiac runs at Seal Island hampered off-loading operations and made operations conducted in fog more dangerous. An anchorage less exposed to the typical westerly weather should be considered for operations at Cape Shirreff. The ship needs to do a better job of tending the boats while alongside and providing a lee from the weather.

7. Seabird and pinniped research at Seal Island, and Cape Shirreff, Livingston Island, Antarctica, 1997; submitted by W.Z. Trivelpiece, W.T. Cobb, R.S. Holt, D. Marks, J. Sterling, M. Stiehr, and T. Stiehr.

7.1 Objectives: Pinniped and seabird research was conducted by the U.S. AMLR program on Seal Island, Antarctica (60°59'14"S, 55°23'04"W) and Cape Shirreff, Livingston Island, Antarctica (62°28'07"S, 60°46'10"W) during the 1997 season. The Seal Island camp has been occupied annually since the 1986/87 austral summer. The Cape Shirreff camp is newly established this year to support land-based research on marine birds and mammals and will be part of an expanded study of the marine ecosystem of this region. Research activities at both locations were abbreviated due to safety concerns on Seal Island, and emphasis on camp construction at Cape Shirreff. The primary research objectives for the 1997 season were as follows:

1. To weigh chinstrap penguin chicks (*Pygoscelis antarctica)* at fledging on Seal Island and Cape Shirreff;

2. To record the presence of known-aged and previously-instrumented or handled seabirds and pinnipeds on Seal island;

3. To record the abundance of Antarctic fur seal pups (*Arctocephalus gazella*) on Seal Island;

4. To band 1000 chinstrap penguin chicks at Cape Shirreff for future demographic studies;

5. To reconnoiter, census, and map seabird distributions at Cape Shirreff as a requisite for designing future seabird studies to be initiated in the 1997/98 season; and

6. To observe and assist with the ongoing Chilean studies of Antarctic fur seals at Cape Shirreff in order to plan future collaboration of research on this species.

7.2 Accomplishments:

Seal Island - Seabirds.

Fledging Condition: Fledging weights of 217 chinstrap penguin chicks on Beaker Bay Beach were recorded from the initiation of fledging on 14 February until 18 February. The timing of the start of fledging was normal compared to past seasons (Table 7.1). Average (± s.d.) fledging weight was 3.22kg (± .32). This value is slightly higher than means recorded in the last seven seasons.

Resights of Banded Penguins: An average of 2000 chinstrap penguin chicks and 70 macaroni penguin chicks (*Eudyptes chrysolophus)* were banded each season at Seal Island from 1987/88 to

1993/94. Opportunistic resights of these banded birds were conducted from 11 February to 16 March. Efforts were concentrated on areas where banding had taken place in previous seasons or where birds arriving from sea congregated, and included Beaker Bay beach, Parking Lot, North Annex, Delta, Outer Rocks, and North Cove. A total of 86 resights were recorded, representing 77 individuals of which 62 were known-aged chinstrap penguins (Figure 7.1), 9 were unknown-aged chinstrap penguins (banded as adults for instrumentation or lavage studies), and 6 were known-aged macaroni penguins.

Other Seabird Resights: A banded american sheathbill (*Chionis alba*) was observed on several occasions with a single chick. A band on the left foot read "AMN," and a metallic band on the right foot was unreadable. Sheathbills have not been banded on Seal Island in the past.

Seal Island - Pinnipeds.

Seal Survey: A count of Antarctic fur seal pups in the North Cove and North Annex study areas was conducted twice on 14 February; once at midday and once in the early evening. A second count was performed because many pups were in the water during the first count; the second is believed to be the better of the two counts. These counts yielded 104 and 99 pups, respectively, for North Cove, and 84 and 92 pups, respectively, for North Annex. In past seasons, substantial declines in the North Cove fur seal pup population have been recorded during observed periods of leopard seal (*Hydrurga leptonyx*) predation. It is difficult to quantify what effect, if any, leopard seal predation had on the Seal Island pup population this season, and it is therefore impossible to predict maximum pup numbers for the island. However, the combined North Cove/North Annex pup estimate for this year (191) is the second highest since the 1993/94 season for the same period (Table 7.2). In addition, North Annex (NA) and Big Boote (BB), which are not known to be subjected to leopard seal predation and typically do not experience the same pup losses through the season, had pup populations comparable to last year (1995/96 NA: 93, BB: 25; 1996/97 NA: 92, BB: 21).

Leopard seals were not observed taking pups this year, but a single leopard seal was observed hauled out on Beaker Bay beach, and on several occasions one was seen in the water near Big Boote.

Tagged and Known-aged Seals: Fur seal pups were tagged annually between 1986/87 and 1993/94; however, tagging was discontinued when it was determined the Seal Island camp was to be closed. During this season, 16 known-aged individuals were sighted on Seal Island (Table 7.3). Of the 11 known-aged females observed this season, one was seen with a pup.

Adult fur seal females used in instrumentation studies were tagged each season from 1986/87 to 1994/95. Fifty-one of these animals were resighted this year, 17 of which were observed with pups.

Cape Shirreff - Seabirds.

The primary objective of this season at Cape Shirreff was to observe the numbers and distributions of seabird populations in order to effectively design the CCAMLR studies to begin in the 1997/98 season. This task was greatly aided by the preliminary work done by our Chilean colleagues in censusing and mapping the penguin breeding colonies and in providing us with a detailed map of the Cape Shirreff peninsula region.

Penguin Surveys: The Cape Shirreff penguin rookery consisted of 30 breeding colonies of penguins: 19 chinstrap penguin colonies, 6 gentoo penguin (*Pygoscelis papua*) colonies, and 5 mixed colonies of chinstrap and gentoo penguins. All colonies were marked with numbered wooden stakes, and their positions were plotted on the Cape Shirreff map. A census of the entire rookery, conducted on 3 February 1997, provided an estimate of 8752 chinstrap penguin chicks and 825 gentoo penguin chicks (R. Hucke-Gaete and V. Marchant, pers. comm.).

Seabird Surveys: Several seabird species breed on the Cape Shirreff peninsula, including brown skuas (*Catharacta lonnbergi*), kelp gulls (*Larus dominicanus*), cape petrels (*Daption capensis*), and blue-eyes shags (*Phalacrocorax atriceps*). Large numbers of giant petrels (*Macronectes giganteus*) also frequent the area, but no nesting sites were found. Twelve nesting territories of brown skuas were located, and a total of 16 chicks and 3 adults were captured and banded in these territories. Nearly all skua nesting sites were located atop high mesa-like hills on the peninsula, the only places not frequented by fur seals. Also of interest was the lack of south polar skuas (*Catharacta maccormicki*) and american sheathbills on the peninsula.

Demography: An initial 1000 chinstrap penguin chicks were banded on 8 February for future demographic studies. The bands were distributed among 13 of the chinstrap penguin breeding colonies ranging in size from 43 to 1862 chicks. In addition, colony 2, with an estimated 718 chicks, was designated as a long term control site where no banding or future disturbance would be allowed over the course of the CCAMLR work at this rookery.

Fledging Condition: Fledging weights of 214 chinstrap penguin chicks, including 92 banded chicks from the demography study, were recorded at Cape Shirreff by capturing birds on the peninsula beaches just prior to their departure. Approximately fifty fledglings were weighed every two days from 18 February to 26 February. The mean (±s.d.) for these birds was 3.27kg (± .31). Since this was the first year fledging weights were recorded, there is no historical index to compare average weight or commencement of fledging.

Cape Shirreff - Pinnipeds.

Fur Seal Survey: On two occasions AMLR scientists assisted Chilean colleagues in the capturing and weighing of Antarctic fur seal pups (CEMP Standard Method C.2). Collected data will be submitted to CCAMLR by the Chilean researchers. More substantial collaboration in fur seal research between the Chilean and AMLR scientists is planned in the future.

7.3 Tentative Conclusions: The Cape Shirreff field camp site appears to be an ideal location for AMLR's future predator studies. The peninsula is adjacent to a major krill fishing grounds and has large populations of chinstrap penguins and Antarctic fur seals, two key CCAMLR monitoring species. In addition, modest numbers of gentoo penguins (600-800 pairs) will allow us to follow certain aspects of this species' breeding biology as well.

Table 7.1 Summary of chinstrap fledgling information for 1989/90-1996/97 field seasons on Seal Island, Antarctica. Information from Cape Shirreff, Livingston Island, Antarctica denoted by "CS".

	1989/90	**1990/91**	**1991/92**	**1992/93**	**1993/94**	**1994/95**	**1995/96**	**1996/97**	**CS 1996/97**
Mean fledging weight (kg)	3.0	2.90	3.13	3.08	2.92	3.11	3.12	**3.22**	**3.27**
Start Fledging	5 Feb	16 Feb	19 Feb	13 Feb	12 Feb	17 Feb	16 Feb	**14 Feb**	**18 Feb**

Table 7.2 Comparison of weekly fur seal pup counts in the North Cove and North Annex study areas from the last five study seasons. Numbers in parenthesis ( ) represent dead pups at time of count and are not included in count values.

				Date				
Season	3-5 Jan	11-13 Jan	18-22 Jan	25-28 Jan	1-4 Feb	8-11 Feb	14-19 Feb	20-27 Feb
1996/97	--	--	--	--	--	--	**191**	--
1995/96	--	--	255(1)	255(1)	245(1)	--	219	231
1994/95	267	264(1)	190(2)	189(1)	186	168	159(1)	150
1993/94*	273	266	275	232	186	181	177	178
1992/93*	214	205	202	168	159	139	146	144
1991/92*	277	253	240	202	175	147	151	159

* Number of dead pups not known.

Table 7.3 Numbers of known-aged furs seals, recorded by original tagging season and sex, observed during the 1996/97 field season on Seal Island, Antarctica. Numbers of females observed with pups are given in parenthesis.

Original tagging season	Males	Females	Females with pups	Total
1986/87	0	1	(1)	1
1987/88	0	2	(0)	2
1988/89	0	0	(0)	0
1989/90	0	0	(0)	0
1990/91	1	2	(0)	3
1991/92	3	4	(0)	7
1992/93	1	2	(0)	3
1993/94	0	0	(0)	0
			Total	16

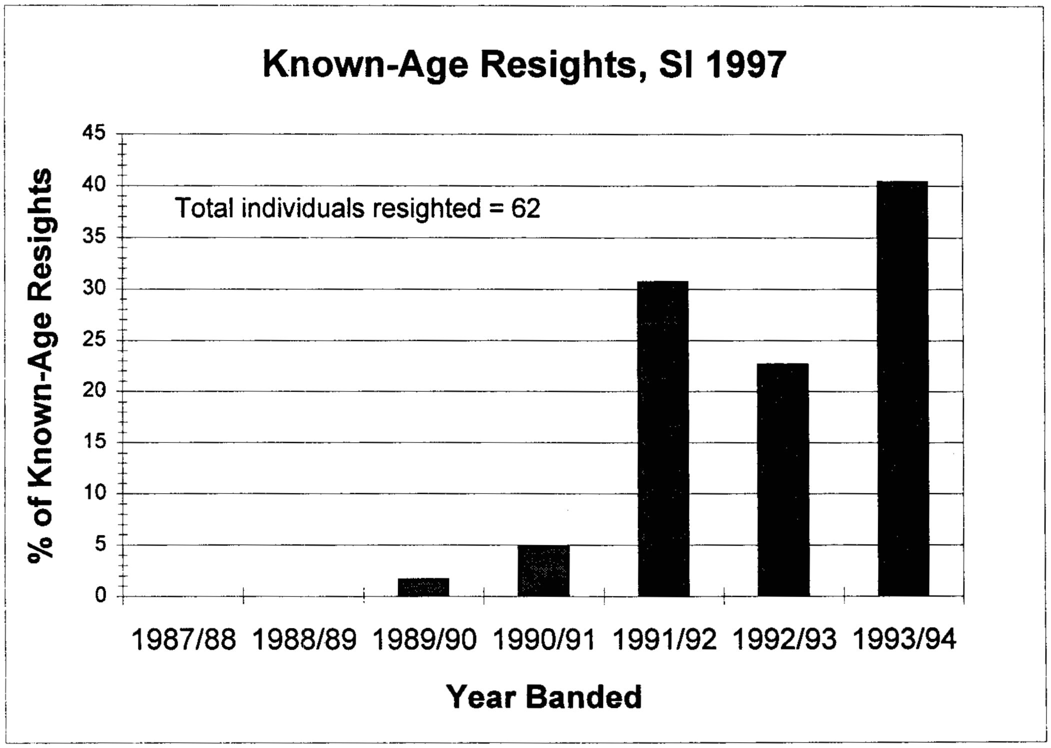


Figure 7.1 Known-aged chinstrap penguin resights represented by cohort, Seal Island, 1997. Sightings from 11 February to 16 March.

8. Collection of euphausiid specimens for genetic analysis; submitted by Wesley A. Armstrong (Leg I).

8.1 Introduction: Antarctic krill (*Euphausia superba*) is a key component of the Southern Ocean ecosystem. Currently there is not conclusive evidence to determine whether *E. superba* is a single interbreeding population or a series of locally defined stocks. It is possible *E. superba* is a single continuous interbreeding population throughout its circumpolar range. There is an apparent lack of physical barriers to gene flow in the Southern Ocean's semi-closed circulatory system. Electrophoretic analysis of polymorphic loci of *E. superba* samples from the Atlantic, Pacific, and Indian ocean sectors of the Southern Ocean indicated samples from all locations were part of a single breeding population of krill (Scheppenheim and MacDonald 1983, MacDonald et al., 1986, Fevolden and Scheppenheim 1989). Analysis of allele and phenotype distribution showed samples from all locations were part of a single breeding population of krill; spatial and temporal distributions of genetic variation detected by electrophoretic analysis from samples in all three sectors of the Southern Ocean proved to be almost homogeneous (Schneppenheim and MacDonald 1983).

Historical krill fishing data may provide indirect evidence of discontinuities in the distribution of *E. superba*. Fishing data indicate there are large areas of the Southern Ocean where krill is found in very low densities or completely absent (Makarov and Shevtsov 1972, Macintosh 1973, Lubimova et al. 1982, Lubimova 1983). Ocean circulation patterns of large and small scales may form isolated habitats for independent krill stocks (Latogurskij 1979).

8.2 Objectives: If mechanisms to prevent gene flow exist, the *E. superba* population may be separated into discrete stocks, and it would be prudent to manage them accordingly. A description of the stock structure of Antarctic krill based on genetic information will provide a rational basis for improving and defending whichever management scheme (single species or discrete stocks) is adopted by CCAMLR. Microsatellites, or tracts of tandomly repeated short nuclear DNA sequences, can be used to measure genetic distance. Results may indicate patterns of gene flow not obvious from geographic make up of the habitat (Paetkau et al., 1995).

Samples of *E. superba* and three other Antarctic euphausiid species (*Thysanoessa macrura*, *Euphausia tricantha*, and *Euphausia frigida*) were collected during the AMLR 97 field season for a pilot study to create microsatellite clones, determine DNA sequences at several sites, and design polymerase chain reaction primers for dinucleotide microsatellite nuclei.

Useful future investigations may determine species level differences between *E. superba* and other Antarctic euphausiids, determine if different geographic stocks of *E. superba* exist, and if they are distinguishable using microsatellite analysis. Further genetic analysis could determine patterns of variability of krill recruitment resulting from density dependent factors such as predator prey interactions with whales, pinnipeds, seabirds, and tunicates, and density independent factors such as ice cover affecting annual reproductive success.

8.3 Accomplishments: Euphausiid specimens for genetic analysis were collected from 14 IKMT stations conducted during Leg I. In all but one case, the minimum sample size was 25 animals. Each euphausiid sample was preserved whole in ethanol alcohol. When more than one species was collected during a station, specimens were segregated by species into separate containers. Effort was made to collect *E. superba* samples from each of the major water masses in the AMLR study area (Bellinghausen, Bransfield Straight, and Weddell/Scotia Seas). Location and species composition of genetic samples are presented in Figure 8.1.

8.4 Acknowledgments: Special thanks goes to Dawn Outram and Kim Puglise for assisting with specimen collection effort.

8.5 References:

Fevolden, S.E. 1986. Genetic variation in *Euphausia superba* Dana in the Antarctic Peninsular waters. SARSIA 71(2):169-175

Fevolden, S.E. and R. Schneppenheim. 1989. Genetic homogeneity of krill, *Euphausia superba* Dana in the Southern Ocean. *Polar Biol.* 9:533-539

Latogurskij, V.I. 1979. Recognition of independent Antarctic krill populations. Rybn. Khoz. (Mosc.) 10:12-14

Lubimova, T.G. 1983. Ecological basis of exploitation of the resources of krill. Mem. Natl. Inst. *Polar Res.*, (Spec. Issue No. 27) pp. 211-219

Lubimova, T.G., R.R.Makarov, V.V. Maslennikov, and K.V. Shust. 1982. The ecological peculiarities, stocks and role of *E. superba* in trophic structures of the Antarctic ecosystem. [Translation of report originally published in Russian. Trudy, VNIRO, Moscow. In: Selected Papers Presented to the Scientific Committee of CCAMLR, 1982-1984, Part II, pp. 391-505 (1985). Hobart, Australia: CCAMLR.]

Lubimova, T.G., A.G. Naumov, and L.L. Lagunov. 1973. Prospects of the utilization of krill and other unconventional resources of the world ocean. *J. Fish. Res. Bd. Can.*, 30:2196-2201

MacDonald, C.M., R. Williams, and M. Adams. 1986. Genetic variation and population structure of krill, *Euphausia superba* Dana from the Prydz region of Antarctic waters. *Polar Biol.* 6(4): 233-236

Mackintosh, N.A. 1973. Distribution of post-larval krill in the Antarctic. Discovery Rep. 36:95-156

Makarov, R.R. and V.V. Shevtsov. 1972. Some problems in the distribution and biology of Antarctic krill. Israel Prog. Sci. Trans. TT. 72-50077, 9 p.

Paetkau, D., W. Calvert, I. Stirling, and C. Strobeck. 1995. Microsatellite analysis of population structure in Canadian polar bears. *Mol. Ecol.* 4(3): 347-354

Schneppenheim, R. and C.M. MacDonald. 1983. Population genetics of krill (*Euphausia superba* Dana). On the Biology of krill *Euphausia superba* Polarforsch./Rep. Polar Res. 4: 239

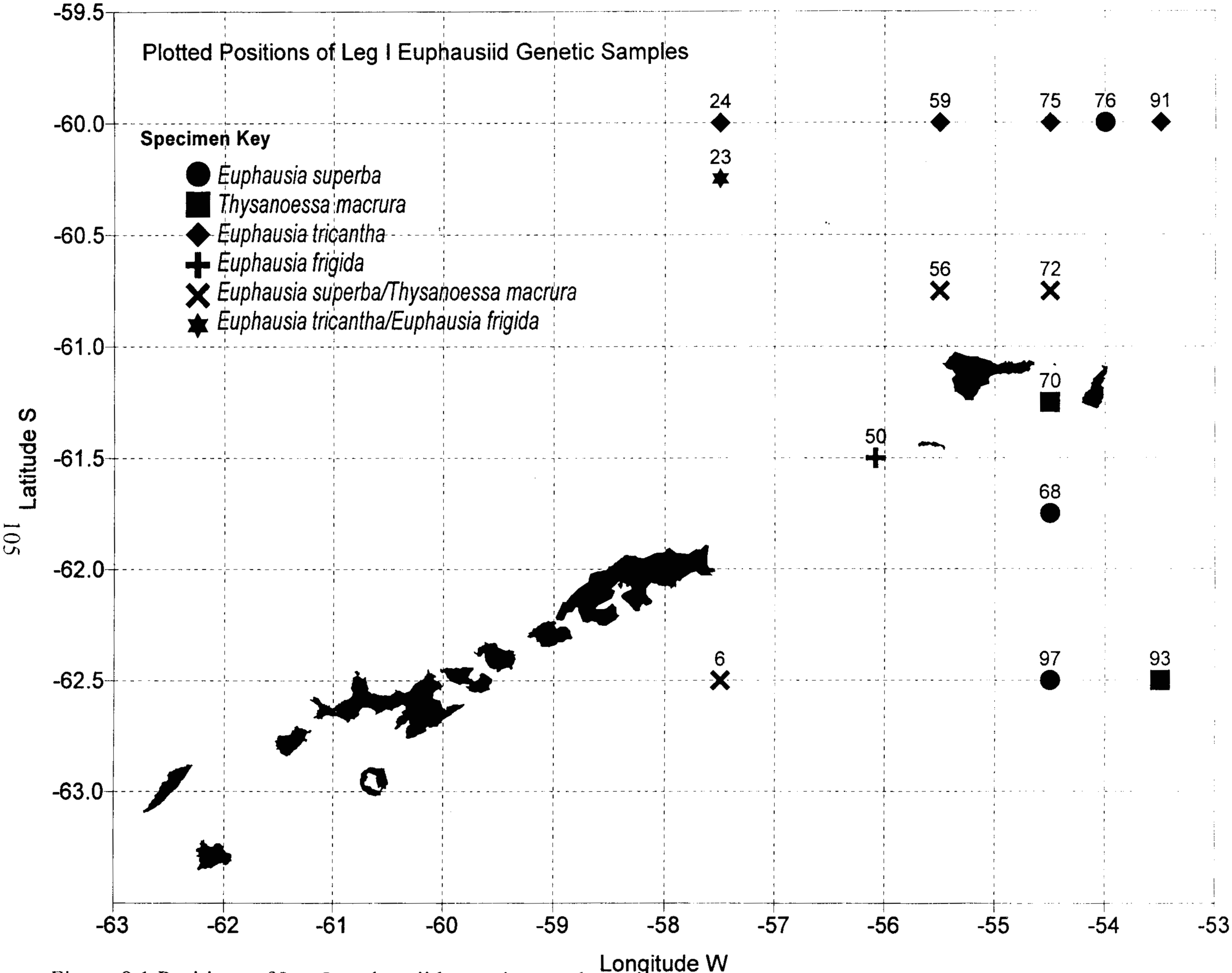


Figure 8.1 Positions of Leg I euphausiid genetic samples.

9. Cetaceans in the AMLR study area.

I. Observations of surface feeding in fin whales; submitted by Wesley A. Armstrong (Leg I) and Roger Hewitt (Leg I).

On 3 February 1997, an increase in the frequency of whale sightings was noted northwest of Elephant Island during transit from Station A45 to A46. Several groups of fin whales *(Balaenoptera physalus)* were sighted feeding and breaching. Group fidelity throughout the sighting was not strong except during active feeding bouts. Groups and subgroups often broke up and coalesced with other subgroups when active feeding activity ceased in a particular site. After bouts of active feeding subsided, surface behaviors included slow rolling and random movements suggesting whales were repositioning themselves over prey patches or searching for other prey patches.

Other krill and zooplankton predators were sighted in the area. These included chinstrap penguins *(Pygoscelis antarctica)*, cape petrels *(Daption capense)*, and Antarctic fur seals *(Arctocephalus gazella)*. A group of 6-7 hourglass dolphins *(Lagenorhynchus cruciger),* most likely a fish eater (Jefferson et. al., 1993), were observed exhibiting feeding behaviors near groups of feeding fin whales. Echograms collected during the bioacoustic survey indicated krill targets were consistently present near the surface throughout the sighting. In this report, we describe fin whale feeding behavior; compare Antarctic krill *(Euphausia superba)* collected during the standard IKMT tow (Station A46) to a second surface IKMT tow (Station A46-B); and illustrate vertical distribution of krill acoustic targets detected during the sighting.

Fin Whale Feeding Behavior: Observations of fin whale behavior were recorded while traveling to Station A46, during the station, and for approximately two hours following standard oceanographic and zooplankton sampling operations. Sighting conditions were excellent with light winds and visibility estimated at 30 kilometers (km). Large splashes and tall columnar blows were visible at distances of several kilometers. A group 15 to 20 fin whales were located approximately 1km from the port side of the ship during the standard IKMT cast. This group was distributed in "chorus line formation" (Leatherwood *et al.*, 1988) and was swimming directly toward the port beam of the ship. Whales surfaced to feed asynchronously and at times explosively with a shallow angle of approach. This aggregation of whales used lateral, vertical, and inverted variations of lunge and swallow or gulp feeding to capture euphausiid prey (Ingebrigtsen 1929, Hjort 1933, Gunther 1949, Mitchell 1974, Jurasz and Jurasz 1979, and Kawamura, 1980). On several occasions, it was possible to see euphausiids forming a surface disturbance in the area where a whale was about to surface and then moving into the air when the whale's rostrum broke the surface.

A second form of feeding behavior was noted during and just after the surface tow at Station A46-B. Several groups of fin whales performed what we interpreted to be coordinated herding and/or concentrating of surface prey. Groups of two or more whales swam rapidly in circles and formed rings that were visible at the surface. These rings persisted for several minutes and were estimated to be 75-100m in diameter. The whales blew frequently and dive intervals were generally less than 30 seconds when rings were being created. This coordinated swimming behavior may have herded, concentrated, or upwelled euphausiids distributed in patches near the surface by creating a vortex or slow spinning gyre.

Accounts of herding prey by fin whales have been reported by Dudley (1725), Mellais (1906), and Tomilin (1957). Mellais described fin whales making "one or two subsidiary circles to drive their prey together." Dudley suggested fin whales "with a short turn, cause an eddy or whirlpool by the force of which, the small fish are brought together into a cluster, so the whale with open mouth, will take in some hundred at a time." Herding and concentrating behavior has been described for at least one other species of rorqual whale. Humpback whales *(Megaptera novaengliae)* are known to herd plankton and fish prey by "releasing a discrete sequence of bubbles underwater that form a ring or closing spiral at the waters surface" (Jurasz and Jurasz 1979). There was no evidence of bubbles at the surface during the herding behavior exhibited by these groups of fin whales.

Acoustic backscattering data indicated continual low densities of krill in the upper 30m throughout the sighting as compared to deeper targets (Figure 9.1). Phalaropes (wading shore birds) are known to spin on the ocean surface to upwell planktonic prey (Obst et al., 1996). It is possible the rapid circular swimming motion by two or more whales created a mechanism to upwell and/or concentrate diffuse prey patches located near the surface during the sighting.

Whales were observed rolling onto their left side, making sharp left turns, and exposing their right sides to the surface following the closing of a ring. The white pigmented right lower lip, distended throat pleats, and the distal portion of the right pectoral flipper and fluke were visible when whales lunged laterally near the surface and sculled inside circles. Fin whales have asymmetrical head coloration. The right lower lip and mouth cavity are white, and the front 1/5 to 1/3 of the baleen is white or yellowish, but the left side of the head is evenly pigmented gray or black (Tomilin 1957, Ridgway and Harrison 1985, Leatherwood et. al. 1988, Jefferson *et al.* 1993). This asymmetrical coloration would create a counter shading effect when the whale was oriented with its light pigmented right side down and darker pigmented left side up.

All observed groups of whales exhibiting the herding and/or concentrating behavior described above were circling in counter clockwise direction and exposed the right side of the head to the surface when lateral lunge feeding. Asymmetrical coloration in fin whales has been proposed to create a counter shading effect making it difficult for prey to detect lunge feeding whales (Mitchell 1972). In this case, the orientation of laterally feeding whales did not conform to the lateral lunge feeding hypothesis presented in Tershey 1992. Actively feeding whales were consistently oriented right side up during lateral lunges. Lunge feeding with the light pigmented side up may be used to startle and/or concentrate low densities or patchy distributions of euphausiid prey. However, more observations of these behaviors need to be examined to determine if this is typical fin whale behavior when shallow patches of euphausiid prey are available in Water Zone I, the oceanic water of the Drake Passage (see Section 1, Physical oceanography).

IKMT Surface Tow (Station A46-B): After the completion of the standard IKMT tow at Station A46 (see Section 4, Direct krill and zooplankton sampling), the ship was directed toward the largest group of whales. The IKMT was deployed to a depth of 25m and towed for approximately ten minutes through a large aggregation of surface feeding fin whales.

All krill specimens captured during the surface tow were counted (n=30). Krill density was calculated and standardized (see Section 4, Direct krill and zooplankton sampling). Comparison of krill density between the standard tow and the surface tow indicated krill density was 30 percent lower during the surface tow.

Length frequency of krill measured from the surface tow (n=15) was compared to length frequency of krill measured from the standard tow (n=143). Both catches had similar length distributions and mean total length values of 51.5mm (surface tow) and 49.41mm (standard tow) (Figure 9.2). Both krill samples were composed of predominantly mature males.

Volume Backscattering Strength at 120kHz during the Fin Whale Sighting: A graphical representation of volume backscattering strength (dB) at 120kHz collected during the sighting (see Section 3, Bioacoustic survey) is presented in Figure 9.1. The figure illustrates vertical distribution and relative density of zooplankton targets in the water column. The acoustic data indicated krill and zooplankton targets were persistent in the 40km segment of trackline representing where fin whales were sighted. Krill layers were consistently located from 25-50m deep throughout the sighting. It is interesting to note lower strength targets were persistent and commonly located in the upper 25m of the water column (compared to deeper targets), particularly in the area where whales were observed herding prey.

Acknowledgments: Special thanks to Valerie Loeb for providing krill length frequency and demographic data, and Vanesa Lopez for providing graphical representation of acoustic data collected during the sighting. Andrea Wickham and Jeremy Sterling each provided detailed notes of their observations during the sighting which were invaluable for the reconstruction of the events detailed in the report.

References:

Dudley, P. 1725. An essay upon the natural history of whales, with a particular account of the ambergris found in the Sperma Ceti whale. Phil. Trans. Roy. Soc. London, Abridged, VII, pp. 78-84

Gunther, E.R. 1949. The habits of fin whales. Discovery. Reports, Vol.(25):113-142

Hjort, J. 1933. Whales and whaling. Hvalradets Skr.(7):7-29

Ingebrigtsen, A. 1929. Whales caught in the North Atlantic and other seas. *Rapp. Explor. Mer.*, LVI(27):1-26

Jefferson, T.A., S. Leatherwood, and M.A. Webber. 1993. Marine Mammals of the World. FAO Publications, Rome. 320 pp.

Jurasz, C.M. and V.P. Jurasz. 1979. Feeding mode of the humpback whale, *Megaptera novaeangliae* in Southeast Alaska. *Sci. Rpt. Whales Res. Inst.*, 31: 69-83

Kawamura, A, 1980. A Review of food of balaenopterid whales. *Sci. Rpt. Whales Res. Inst.*, 32: 155-197

Leatherwood, S. R. R. Reeves, W. F. Perrin, and W. E. Evans 1988. Whales, Dolphins, and Porpoises of the Eastern North Pacific and Adjacent Arctic Waters: A Guide to their Identification. Dover Publications, New York. 245 pp.

Mitchell, E. 1974. Trophic relationships and competition for food in Northwest Atlantic whales. *In:* Burt, M.D.B (ed.), Proc. Canadian Soc. Zoologists. Ann. Meet., 123-133

Mitchell, E. 1972. Whale pigmentation and feeding behavior. *American Zoologist*, 12: 655

Millais, J. G. 1906. The mammals of Great Britain and Ireland. Vol. III. London: Longmans Green & Co.

Obst, B.S. W. M. Hamner, P.P Hamner, E. Wolanski, M. Rubega, and B. Littlehale 1996. *Nature*, vol. 384 (6605): p. 121 .

Ridgway, S. H. and R. J. Harrison (eds). 1985. Handbook of Marine Mammals, Volume 3: The Sirenians and Baleen Whales. Academic Press, London. 362 pp.

Tomilin, A.G., 1957. Mammals of the USSR and adjacent countries. *Cetacea*, (9):717pp.

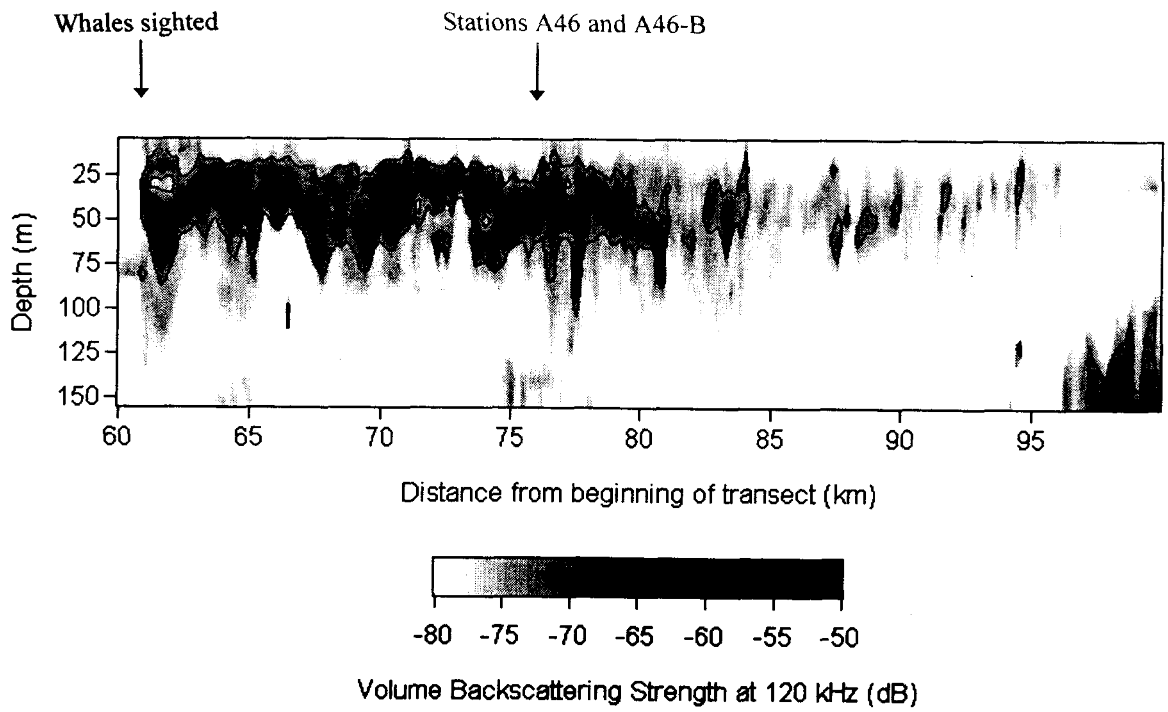
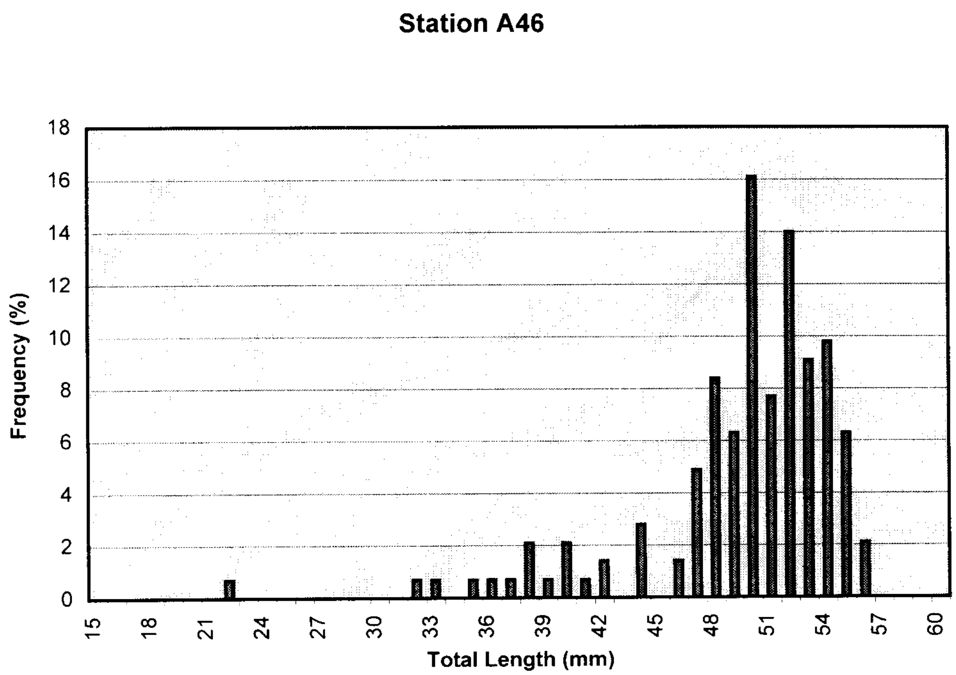


Figure 9.1 Bioacoustic survey data



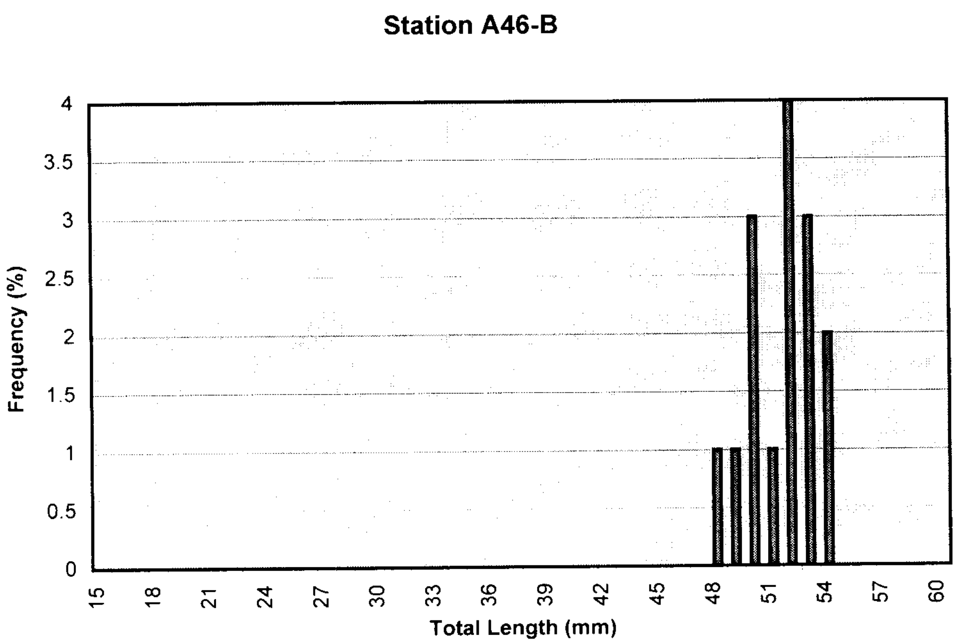


Figure 9.2 Comparison of krill length frequency between Stations A46 and A46-B

II. Observations of baleen whales; submitted by Nathalie Jaquet (Leg II).

During Leg II, one observer made observations of baleen whale distribution from the high observation deck of the R/V *Yuzhmorgeologiya*. Observations were made only when wind speed was less than or equal to Beaufort 5 and when visibility was greater than or equal to two n.mi. Four days of observation data were collected between 16 and 23 March, with approximately four to six hours of observation per day or total of 20 hours "on effort."

Baleen whales were observed and identified on only one occasion during the observation period (Sighting #1, Figure 9.3). On this occasion, two humpback whales (*Megaptera novaeangliae*) were observed south of King George Island at approximately 1 n.mi. ahead of the ship. The ship continued ahead on its transect line, passing the whales quite closely. The two whales were adults and were engaged mainly in rolling and breaching. On a second instance, one blow was seen in the distance when the ship was northwest of Elephant Island (Sighting #2, Figure 9.3). This animal was not identified.

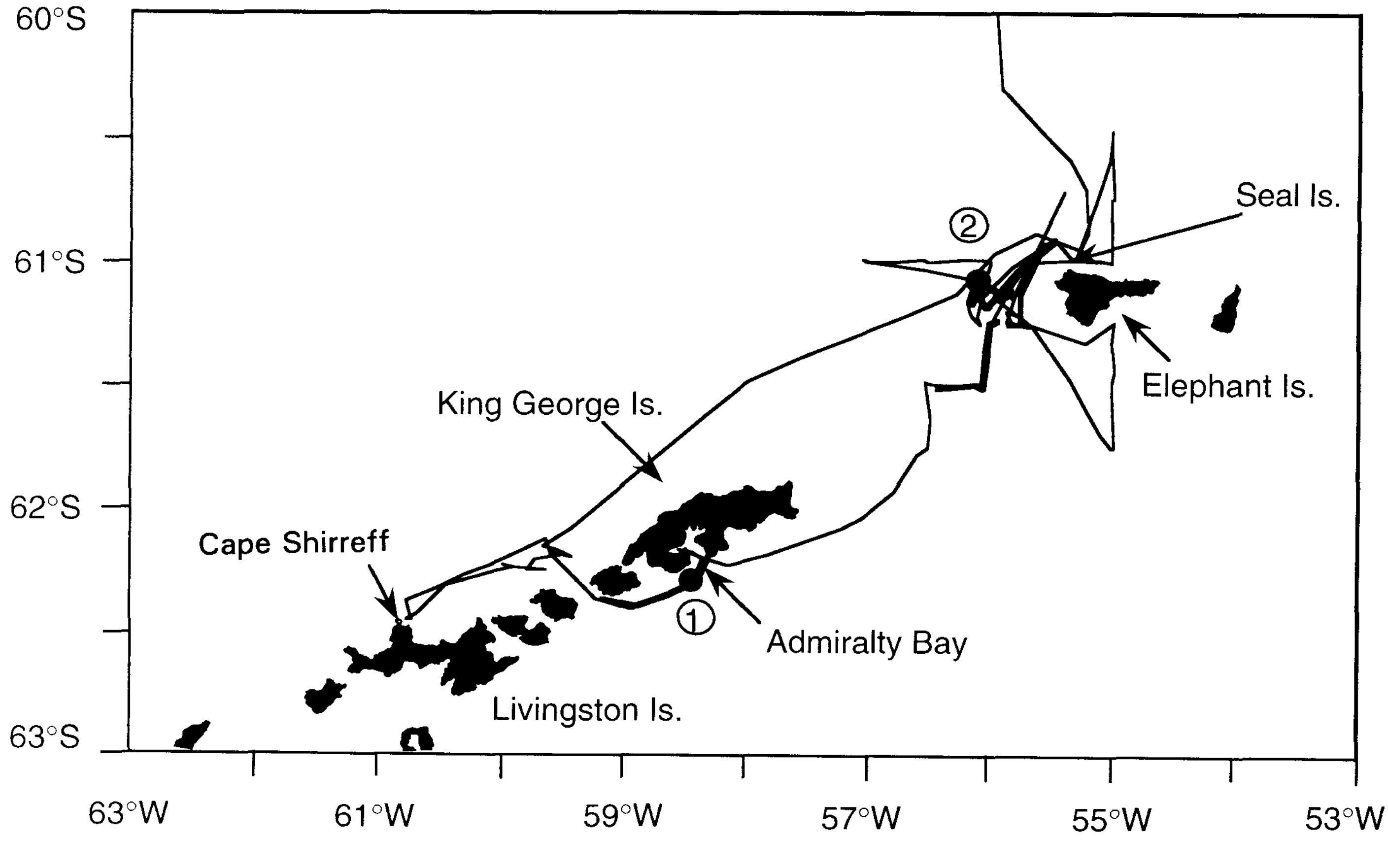


Figure 9.3 Trackline of the R/V *Yuzhmorgeologiya* within the AMLR study area during Leg II. The thick lines represent portions of the trackline where observations for whales were conducted. The large dots represent whale sightings and the numbers identify the sightings.

10. Bottom trawl feasibility survey in the vicinity of the South Shetland Islands; submitted by George Watters, Alistair Hobday, David Demer, Jacqueline Popp, Valerie Loeb, Kimberly Puglise, Jeremy Sterling, R.S. Holt, Dennis Marks, and W.T. Cobb.

10.1 Objectives: Prior to this year's field season, the AMLR program procured bottom trawl equipment to conduct surveys of finfish around the South Shetland and South Orkney Islands. These areas currently have a moratorium on the taking of finfishes. However, interest in reopening these areas to fishing has increased in recent years. The AMLR program intends to conduct future surveys to provide baseline estimates of finfish stock abundances in the event that the fisheries are reopened.

In future field seasons, the AMLR program will conduct bottom trawl surveys at stations that have been previously sampled by German and Spanish research teams. Therefore, we conducted this year's feasibility survey at some of these same sites.

Prior to the field season, modifications were made to the R/V *Yuzhmorgeologiya* to accommodate the new trawl gear. The main objective of this year's survey was to test and assess these modifications to the ship for deployment and recovery of the new trawling gear. Other objectives included training personnel to use the new trawling gear, the net-sonde, and to process the trawl catch.

10.2 Methods and Accomplishments: The surveys were conducted with a bottom trawl that had a foot-rope length of 92 feet and a head-rope length of 122.5 feet. The foot-rope was rigged with a tire-gear bosom, which was approximately 19 feet in length and 24 inches in diameter. Overall length of the trawl was about 206 feet. The belly and the wings of the net were constructed with five inch mesh; the intermediate section had four inch mesh; and the cod-end had a 40mm mesh liner. The net had a "high-rise" design, with three bridles on both the starboard and port sides of the net. The net was manufactured by Net Systems, Inc. and is called a "hardbottom snapper trawl." Vented-V doors were used and each door weighed 2250 pounds (lbs). The main warps were one inch in diameter. Diagrams of the net, the doors, and the rigging can be obtained from the AMLR program upon request.

The ship's deck configuration had four main trawling features. The ship's net reel was approximately 12 feet in diameter, 6.5 feet wide, and raised about 10 feet off the deck. The ship's stern roller was approximately 12 inches in diameter, 12 feet wide, and 16.5 feet from the water-line. The ship's aft-cargo winches, aft-gantry, and A-frame were used for deployment, retrieval, and on-deck adjustments to the gear. The ship also provided port and starboard trawl winches.

The ship was also equipped with a net-sonde, which was linked to the net via a constant-tension third wire winch. The net-sonde transducer was connected to a special panel in the net at the center line of the head-rope. The sonar images were viewed with a dedicated computer work station on the bridge. Net mensuration data (e.g. height and width of the net's mouth opening) were collected from the sonar images. The net-sonde was manufactured by Ocean Systems, Inc.

Seven bottom trawls were conducted at stations to the northwest of Robert and Nelson Islands, and to the west of Elephant Island, 20-23 March 1997 (Figure 10.1). The station locations were selected because the previous Spanish and German trawl surveys showed that these areas possess bottom characteristics which would not damage the trawl gear. Table 10.1 provides station locations and characteristics, as well as summary net mensuration data for each haul.

All trawls resulted in catches that were less than 0.5 metric tons. Four species dominated the catches: *Notothenia coriiceps*, *Gobionotothen gibberifrons*, *Chaenocephalus aceratus*, and *Champsocephalus gunnari*. Catches of these four species were counted and weighed (Table 10.2).

10.3 Tentative Conclusions: Overall the bottom trawl equipment and the set-up of the R/V *Yuzhmorgeologiya* worked well; however, considerable learning will be necessary to better accomplish the fishing of the gear, setting and hauling of the trawl, and sorting and processing of the catch.

In future surveys, it will be necessary to conduct three trawls per day to adequately survey the area of interest. Because this was the first time for bottom trawling on this vessel with new gear, less than two trawls per day were completed this year.

10.4 Disposition of Data and Specimens: Data collected during this pilot survey included catch data with species composition (see Table 10.2 for partial results), length frequencies, and net mensuration data at 5 minute intervals (see Table 10.1 for summarized results). Forms with these data are stored at the Antarctic Ecosystem Research Group, and a database has been designed to archive the data. No fish specimens were retained.

10.5 Problems and Suggestions: For future bottom trawl surveys, the R/V *Yuzhmorgeologiya* will need to supply a better echosounder on the bridge, a longer third wire for the net-sonde, and spare parts for the net-sonde. The ship will also need to ensure that a lead fisherman with the same skills and experience as this year's lead fisherman (Mr. Frank Bohannon) is present for all trawling work. Lastly, the AMLR program should obtain additional spare parts for the trawl.

10.6 Acknowledgments: Thanks go to Mr. Frank Bohannon, the deck crew of the R/V *Yuzhmorgeologiya*, and Jane Martin.

Table 10.1 Trawl locations and net mensuration data.

Station number (S or G*)	Start latitude (°S)	Start longitude (°W)	Mean bottom depth (m)	Mean tow speed (knots)	Mean mouth height (m)	Mean mouth width (m)	Haul duration (min)	Start time (GMT)
491-S	62°14.97'	59°41.45'	64.9	2.8	8.1	14.0	28	1424
546-S	62°10.91'	59°30.63'	71.4	3.2	6.9	15.3	30	1746
547-S	62°09.67'	59°34.34'	79.8	3.3	6.1	15.7	30	2130
4-G	61°09.34'	56°04.61'	189.7	4.3	5.5	18.5	30	1934
448-S	61°05.39'	55°51.33'	108.8	3.6	7.3	16.4	25	1815
10-G	61°13.21'	55°45.25'	114.4	4.2	7.2	18.2	30	1220
8-G	61°15.22'	55°46.69'	133.2	3.2	6.4	20.9	30	1905

* S or G indicates whether the station was previously occupied by a Spanish research team (S) or German research team (G).

Table 10.2 Dominant species in bottom trawl catches; left side of table provides mass (lbs) of each species caught, and right side of table provides numbers of each species caught.

Station number (S or G*)	NOC (lbs)	NOG (lbs)	SSI (lbs)	ANI (lbs)	NOC (#'s)	NOG (#'s)	SSI (#'s)	ANI (#'s)
491-S	**				2			
546-S	**		**		6		2	
547-S	**	**	**		10	1	1	
4-G		53	20	116		61	10	158
448-S		106	11	13		129	1	16
10-G		115	24	7		99	8	9
8-G	20	86	64	175	5	90	29	170

* S or G indicates whether the station was previously occupied by a Spanish research team (S) or German research team (G).
** Animals from these catches were counted, but not weighed.
NOC= *Notothenia coriiceps*, NOG=*Gobionotothen gibberifrons*, SSI=*Chaenocephalus aceratus*, and ANI=*Champsocephalus gunnari*

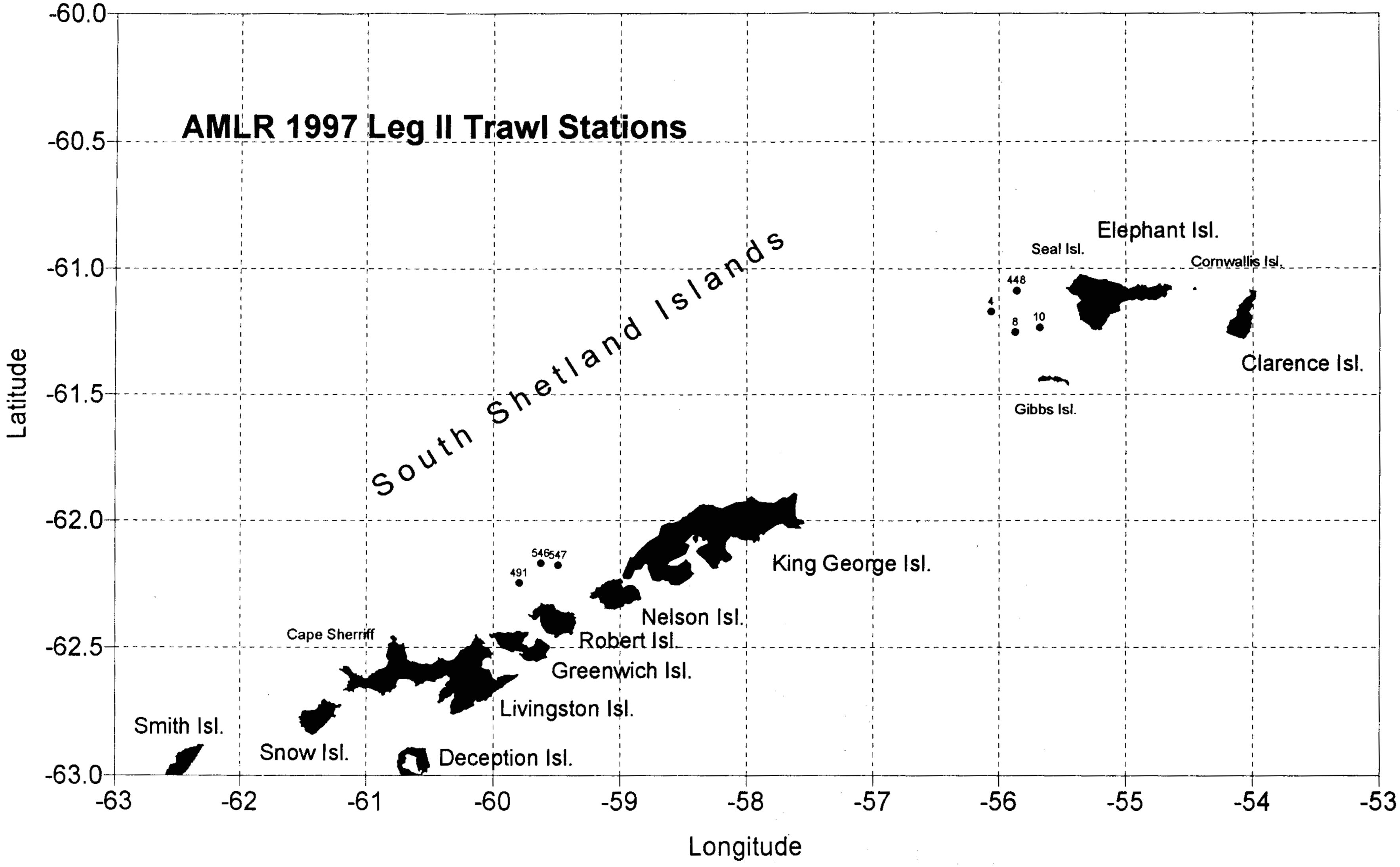


Figure 10.1 Locations of bottom trawl stations conducted during Leg II.

11. Seabird research undertaken as part of the NMFS/AMLR ecosystem monitoring program at Palmer Station, 1996/97; submitted by William R. Fraser, Donna L. Patterson, John Carlson, Peter Duley, and Eric J. Holm.

11.1 Objectives: Palmer Station is one of two sites on the Antarctic Peninsula where long-term monitoring of seabird populations is being undertaken in support of U.S. participation in the CCAMLR Ecosystem Monitoring Program (CEMP). Our objectives during 1996/97, the tenth season of field work at Palmer Station on Adelie penguins (*Pygoscelis adeliae*), were:

1. To determine Adelie penguin breeding population size,
2. To determine Adelie penguin breeding success,
3. To obtain information on Adelie penguin diet composition and meal size,
4. To determine Adelie penguin chick weights at fledging,
5. To determine adult Adelie penguin foraging trip durations,
6. To band 1000 Adelie penguin chicks for future demographic studies, and
7. To determine Adelie penguin breeding chronology.

11.2 Accomplishments: Field work at Palmer Station was initiated on 28 September 1996 and terminated on 15 April 1997. The early start date was aided by joint funding from the NSF's Office of Polar Programs. In 1990, NSF selected Palmer Station as a Long Term Ecological Research (LTER) site, and has committed long-term funding and logistics support to an ecosystem study in which Adelie penguins represent one of two key upper trophic level predators selected for research. As a result of this cooperative effort between the National Marine Fisheries Service (NMFS) and NSF, field season duration at Palmer Station now covers the entire 5-month Adelie penguin breeding season.

Breeding Biology and Demography.

Adelie penguin breeding population size was determined by censusing the number of breeding pairs at 54 sample colonies during the peak egg-laying period (14 November- 15 November 1996). These colonies contained 4445 pairs, a 18.3% decrease in population relative to the 5457 breeding pairs censused 21-23 November 1995.

Breeding success was determined by following a 100-nest sample on Humble Island from clutch initiation to creche. Adelie penguins exhibited a slightly decreased breeding success this season, creching 1.47 chicks per pair, or 0.14 chicks less than were creched per pair last season. As in past seasons, two other indices of breeding success were also determined. The proportion of one and two chick broods was assessed at 54 sample colonies on 7 and 8 January 1997. Of the 2751 broods censused, 68.1% (N=1875) contained two chicks, a slight increase from the 63.5% reported in January 1996.

Chick production was determined by censusing chicks on 25 January 1997 at 54 sample colonies when approximately 2/3 of them entered the creche stage. Production at these colonies totaled 6142 chicks, a decrease of 6.0% from January 1996 when 6532 chicks were censused.

Chick fledging weights were obtained between 2-18 February 1997 at beaches near the Humble Island rookery. Peak fledging occurred on 12 February, two days later than in February 1996. Compared to February 1996, the average fledging weight of the 364 Adelie penguin chicks sampled increased by approximately 80g (3.04 vs 2.96 kg). Data specific to the chronology of other breeding events are still under analysis and will be reported later.

As part of continued demographic studies, 1000 Adelie penguin chicks were banded on 2 February 1997 at selected AMLR colonies on Humble Island. The presence of birds banded in previous seasons was also monitored during the entire field season on Humble Island as part of these studies.

Foraging Ecology.

Diet studies were initiated on 06 January and terminated on 15 February 1997. During each of the nine sampling periods, five adult Adelie penguins were captured and lavaged (stomach pumping using a water off-loading method) as they approached their colonies to feed chicks on Torgersen Island. All birds (N=45) were subsequently released unharmed. The resulting diet samples were processed at Palmer Station. The samples taken contained a mix of prey items dominated by the presence of the euphausiid *Euphausia superba*. The number of samples containing fish and amphipods was significantly lower compared to last season. Unlike the extreme bimodal distribution of krill seen during last season, this season's samples were mainly comprised of krill (*E. superba*) in the size classes 31-35mm and 36-40mm. The predominance of krill in the 31-40mm size range is completely different than the larger individuals (46-55mm) that characterized last season's samples.

Radio receivers and automatic data loggers were deployed at the Humble Island rookery between 7 January and 20 February 1997 to monitor presence-absence data on 36 breeding Adelie penguins carrying small radio transmitters. These transmitters were glued to adult penguins feeding 10-14 day old chicks. Analysis of the data has not yet been accomplished due to the size of the databases obtained.

11.3 Tentative Conclusions: The 1996/97 season was characterized by minimal sea ice cover, but frequent and occasionally heavy snows during much of the Adelie penguin breeding season. The 18.3% decrease in breeding pairs agrees with the effects that a low ice year is expected to have on overwinter survival. An unprecedented, heavy infestation of ticks was also noted during the egg-laying period, with some preliminary evidence that it forced some birds to abandon nest sites. The decrease in breeding success of 0.14 chicks per pair may in part reflect the effects of this infestation, as some of the birds in our breeding success samples became heavily infested.

Unlike last season, when the predominant components in the diets of Adelie penguins included a mixed species assemblage of *T. macrura* and *E. superba*, this season's diets were dominated by krill. Krill size classes represented primarily intermediate lengths (31-40mm), which agrees with expectations based on a strong recruitment year in 1994. This season, in contrast to last, foraging trip durations increased by an average of 1.78 hours (10.0 hours in 1996 vs. 11.78 hours in 1997) for the same CEMP period, although we observed no delays in the onset of bloom conditions. Last season's data suggested that the timing of blooms could strongly affect within season variability in foraging trip durations. Both the foraging and phytoplankton data are still being analyzed at this writing.

11.4 Disposition of the Data: No diet samples were returned to the U.S. for analysis as all work was successfully completed at Palmer Station. All other data relevant to this season's research are currently on diskettes in our possession and will be made available to the Antarctic Ecosystem Research Group.

11.5 Problems, Suggestions and Recommendations: It is becoming more apparent that environmental variables such as snow deposition, among others, may be key determinants of at least some aspects of the annual variability inherent in some of the monitored parameters. However, at the moment, there is no formal requirement in effect by which to standardize the collection and reporting of these data. Where these effects are becoming especially clear, is in the information conveyed by measures of reproductive success based on per-pair productivity. For example, the former can vary by up to 100% within the same colony based strictly on nest location, meaning this parameter is probably not "measuring" variability in the marine foraging environment as we assume. It is our opinion that the development of standards to measure snow deposition would greatly aid our interpretive potential within and between CEMP monitoring sites.