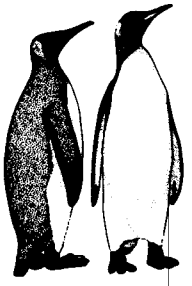

UNITED STATES AMLR ANTARCTIC MARINE LIVING RESOURCES PROGRAM

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AMLR 1994/95 FIELD SEASON REPORT

Objectives, Accomplishments and Tentative Conclusions

Edited by
Jane Rosenberg

July 1995

ADMINISTRATIVE REPORT LJ-95-13

Southwest Fisheries Science Center
Antarctic Ecosystem Research Group

The U.S. Antarctic Marine Living Resources (AMLR) program provides information neededto 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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Southwest Fisheries Science Center
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La Jolla, CA 92038

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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; and (2) the distribution of krill is affected by both physical and biological aspects of their habitat. In order to refine these hypotheses, a study area was designated in the vicinity of Elephant Island (Figure 1). A seasonal field camp was established at Seal Island, off the northwest coast of Elephant Island, where reproductive success and feeding ecology of breeding seals and penguins are monitored. A complementary series of shipboard observations were initiated to describe both within and between season variations in the distributions of nekton, zooplankton, phytoplankton, and water types in the study area. The Seal Island and shipboard studies are conducted during each austral summer. In addition, research on the ecology of Adelie penguins is conducted at Palmer Station during each austral spring and summer.

SUMMARY OF 1995 RESULTS

Seven shipboard surveys were conducted in the vicinity of Elephant Island between mid-January and early March, 1995. Two major water types were identified: Drake Passage and Bransfield Strait. A prevailing southwest to northeast water flow was seen across the study area, with intensified flow in several areas. The richest phytoplankton regions were found to the south, southwest, and east of Elephant Island, and also north of the island's shelf-break; the lowest concentrations were found in the northwest portion of the study area. In late January, relatively dispersed layers of large adult krill were found west and northwest of Elephant Island, and dense aggregations of juvenile krill were seen in the Bransfield Strait. One month later, dense discrete krill swarms were common throughout the eastern portion of the study area, while diffuse layers were more often seen in the offshore waters north of Elephant Island. In late January and also in mid-February, high krill densities were found in the shoal waters just north of Elephant Island and in deeper water near sub-surface seamounts. Mean krill abundance in net samples from the Elephant Island area during both legs was about 1/3 that observed during the previous three field seasons. Mature forms of krill (probably at least 4-5 years of age) totally dominated the catches. These results indicate relatively poor krill recruitment since the 1990/91 year class. This period of poor krill recruitment has been linked to below normal winter sea ice coverage/duration in the Antarctic Peninsula area over the past three years. Poor recruitment during low ice years is believed to result from poor feeding conditions for adult krill during the winter period and subsequent delayed reproduction until late summer. In addition, late spawned larvae apparently have low survival rates. The 1994 winter was marked by greater than normal sea ice conditions, and it was thus expected that adult krill would spawn early. These predictions were supported by observations of relatively large proportions of gravid females in January and predominantly gravid and spent females in February. Spawning success was indicated by the appearance of early stage krill larvae in January and widespread occurrence of these larvae in February. Salp mean abundance was over two orders of magnitude less than in 1993 and 1994, and one order less than in 1992, again probably resulting from the presence of above normal sea ice during the 1994 winter. On Seal Island, Antarctic fur seal pup production and growth rates were lower in comparison to previous seasons. However, the mean weight of both male and female pups were similar to previous years, indicating that female seals were able to adequately obtain prey for their offspring. The number of chinstrap penguins attempting to breed this season was the lowest in all past seasons except 1990/91. However, of those eggs that hatched, their success was the second

highest recorded in all past seasons, suggesting an ample food supply offshore. The number of macaroni penguins attempting to breed was the lowest recorded in all past seasons. At Palmer Station, the number of breeding pairs of Adelie penguins at 54 censused colonies decreased by 9.3% relative to last season, while chick production was essentially unchanged.

Epibenthic surveys were conducted in March in the bays, fjords, and anchorages of South Georgia. These surveys revealed 96 distinct morphological/coloration types of fauna, which probably represented a minimum of 110 species. Frequently recorded animal types included various species of sponges, soft corals, bryozoans, sea anemones, polychaetes, isopods, starfish, brittlestars, sea urchins, ascidians, and fish.

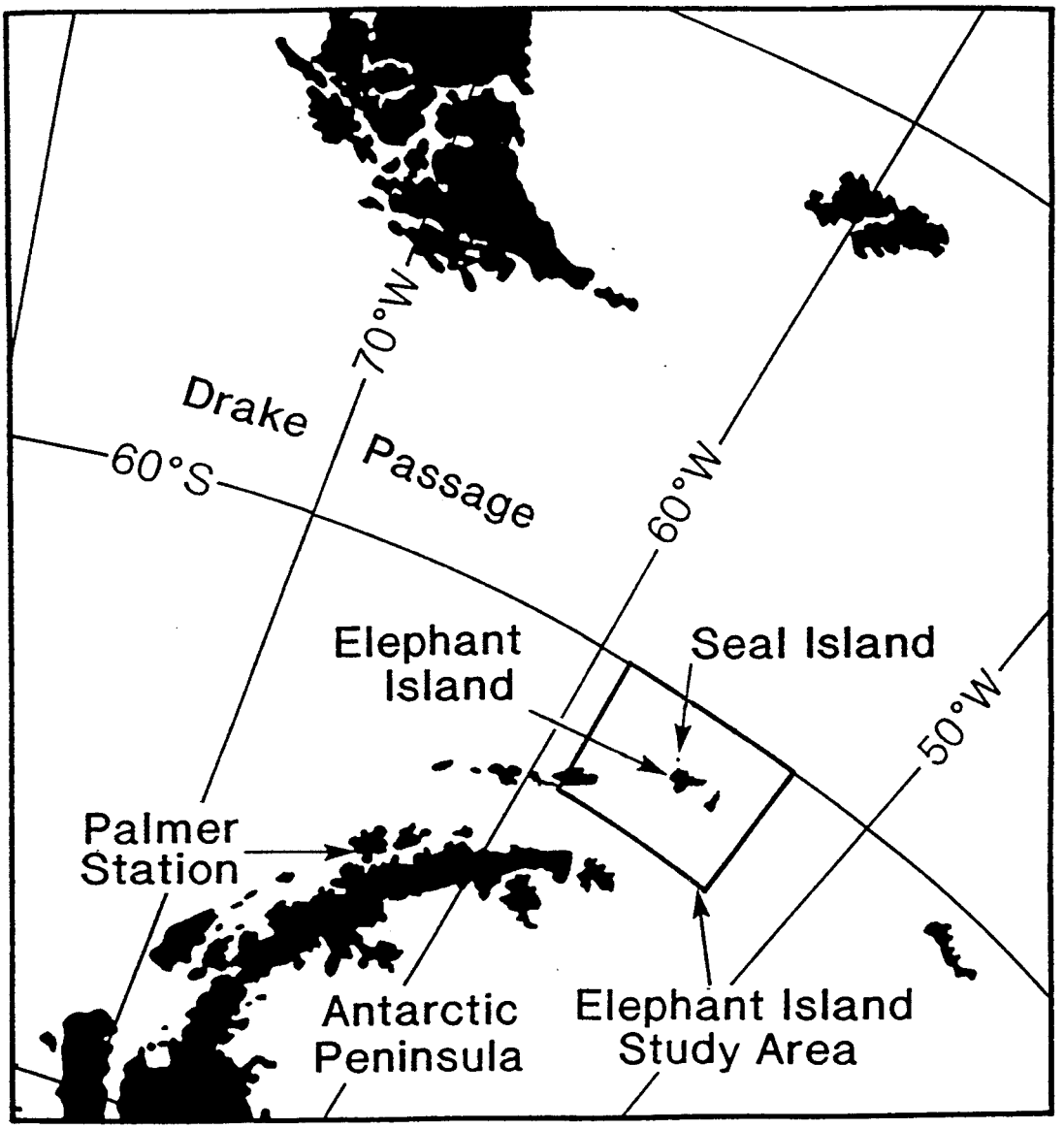

Figure 1. Locations of the U.S. AMLR field research program: Elephant Island Study Area, Seal Island, and Palmer Station.

OBJECTIVES

Shipboard Research:

1. Map meso-scale (10's to 100's of kilometers) features of water mass structure, phytoplankton biomass and productivity, and zooplankton constituents (including krill) in the vicinity of Elephant, Clarence, and the eastern end of King George Islands.

2. Estimate the abundance of krill in the area around Elephant Island.

3. Map micro-scale (1 to 10's of kilometers) features of the distribution, density, and abundance of krill immediately north of Elephant Island, within the foraging range of krill predators breeding on Seal Island.

4. Conduct acoustic and net sampling surveys in Admiralty Bay, King George Island to describe krill abundance and distribution.

5. Deploy acoustic sono-buoys to passively collect whale vocalizations. Deploy drogued buoys to measure flow rate and circulation patterns of surface waters in the study area.

6. Collect continuous measurements of ship's position and heading, water depth, sea surface temperature, salinity, turbidity, fluorescence, air temperature, barometric pressure, relative humidity, wind speed and direction, and solar irradiance.

7. Conduct marine bird and mammal observations in the AMLR study area during Legs I and II.

8. Conduct a census of fur seal pups at selected sites on the Seal Island archipelago, and calibrate an automatic direction finding (ADF) system located on the island.

9. Provide logistical support to the Seal Island field camp.

10. Conduct surveys with a remotely operated vehicle (ROV) to estimate density, abundance, and distribution of crabs, in conjunction with Seabeam surveys to characterize their habitat, around South Georgia on Leg III.

11. Conduct faunal surveys with the ROV of epibenthic organisms living in various bays, anchorages, and fjords (BAFs) around South Georgia; to be conducted as a contingency to objective 10.

Land-based Research:

<u>Seal Island</u>

1. Monitor Antarctic fur seal pup growth rates and adult female foraging according to CCAMLR Ecosystem Monitoring Program (CEMP) protocols.

2. Conduct cooperative research on fur seal foraging patterns and prey availability with scientists from the Japanese R/V *Kaiyo Maru*.

3. Conduct directed research on fur seal pup production, female foraging behavior, diet, abundance, survival, and recruitment.

4. Determine offshore foraging areas of fur seals, using an ADF system.

5. Monitor the abundance of all other pinniped species on the island, and resight tagged female fur seals to assess female survival, reproductive rates, and tag loss.

6. Monitor the breeding success, fledgling size, reproductive chronology, foraging behavior, diet, abundance, survival, and recruitment of chinstrap and macaroni penguins according to CEMP protocols.

7. Conduct directed research on seasonal and diel patterns in the diving behavior of chinstrap penguins to assess changes in foraging patterns and effort as physical and biological components change through the breeding season.

8. Collect data on locations of offshore foraging areas of chinstrap penguins using an automated data collection computer and directional antennas on top of the island.

9. Conduct a cooperative study with scientists on board *Kaiyo Maru* examining interactions between chinstrap penguins and their prey by tracking birds on foraging trips while simultaneously conducting oceanographic sampling.

10. Describe and report marine debris sighted on beaches or on animals.

<u>Palmer Station</u>

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 duration of Adelie penguin foraging trips.

6. Band a representative sample (1000 chicks) of the Adelie penguin chick population for demographic studies.

7. Determine adult Adelie penguin breeding chronology.

DESCRIPTION OF OPERATIONS

Shipboard Research:

Itinerary

Southbound Transit:	Depart Seattle, WA	10 December 1994
	Arrive San Diego, CA	14 December
	Depart San Diego	17 December
	Arrive Valparaíso, Chile	31 December
	Depart Valparaíso	3 January
	Arrive Punta Arenas, Chile	8 January
Leg I:	Depart Punta Arenas	11 January
	Resupply Seal Island	14 January
	Acoustic Transducer Calibration	15 January
	Survey AB1	15-16 January
	Survey A	16-29 January
	Survey B	29 January-01 February
	Call at Seal Island	01 February
	Pleuragramma net tows	02 February
	Arrive Punta Arenas	05 February
Leg II:	Depart Punta Arenas	08 February
	Resupply Seal Island	11 February
	Survey C	11-15 February
	Survey D	15-27 February
	Acoustic Transducer Calibration	26 February
	Survey AB2	26-27 February
	Call at Seal Island	28 February
	Survey E	28 February-01 March
	Arrive Punta Arenas	04 March
Leg III:	Depart Punta Arenas	09 March
	Arrive South Georgia	12 March
	Offshore ROV transects	13-14 March
	BAFs Surveys	15-25 March
	Call at Grytviken	26 March
	BAFs Surveys/Seabeam survey	27 March-04 April
	Arrive Punta Arenas	07 April
Northbound Transit:	Depart Punta Arenas	11 April
	Arrive Valparaíso	17 April
	Depart Valparaíso	20 April
	Arrive San Diego	04 May
	Depart San Diego	08 May
	Arrive Seattle	16 May

Leg I.

1. *Surveyor* took her departure from Punta Arenas, Chile via the eastern end of the Strait of Magellan. Land fall was made at Seal Island, and all provisions and supplies were brought ashore to the AMLR field camp. During the resupply, a census of fur seal breeding sites on several islets in the Seal Island archipelago was conducted.

2. Two acoustic transducers were calibrated at Martel Inlet, Admiralty Bay, King George Island. The transducers, operating at 120 kilohertz (kHz) 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 both transducers.

3. An acoustic/net survey (Survey AB1) of krill was conducted in Admiralty Bay, King George Island in collaboration with studies of foraging behavior and reproductive performance of Adelie penguins in the area (Figure 2).

4. A large-area survey of 91 Conductivity-Temperature-Depth (CTD)/rosette and net sampling stations, separated by acoustic transects, was conducted in the vicinity of Elephant, Clarence, and the eastern end of King George Islands (Survey A, Stations A01-A91, Figure 3). Acoustic transects were conducted at 10 knots, using hull-mounted 120kHz and 200kHz down-looking transducers. Operations at each station included: (a) measurement of temperature, salinity, oxygen, light, transmissometer, and fluorescence profiles; (b) collection of discrete water samples at standard depths for analysis of chlorophyll-a content, particulate absorption spectra, particulate organic carbon and nitrogen concentrations, primary production, ATP content, size fractionation, floristics, and inorganic nutrient content; and (c) deployment of an Isaacs-Kidd Midwater Trawl (IKMT) to obtain samples of zooplankton and nekton. At Station A74, the IKMT tow was aborted due to technical difficulties.

5. A small-area acoustic survey was conducted north of Elephant Island (Survey B, Figure 4). The survey was conducted at a ship's speed of approximately 8 knots over a 4-day period. Acoustic data were collected using the hull-mounted 120kHz and 200kHz down-looking transducers. The survey was complemented with directed sampling using the IKMT during hours of darkness.

6. Fur seal pups were counted on a small islet at the far end of the Seal Island archipelago.

7. An ADF system was calibrated by personnel on Seal Island. A floating sled, equipped with a radio transmitter, was towed behind *Surveyor* and signals were recorded by the system.

8. A series of eight net sampling stations were conducted in the southeast corner of the study area to obtain specimens of Antarctic silverfish (*Pleuragramma antarcticum*).

9. Continuous underway measurements of ship's position and heading, water depth, sea surface temperature, salinity, turbidity, fluorescence, air temperature, barometric pressure, relative humidity, wind speed and direction, and solar irradiance were recorded.

10. Observations of the distribution and abundance of marine birds and mammals were conducted.

Leg II.

1. *Surveyor* departed Punta Arenas, Chile via the Beagle Channel and arrived at Seal Island. Fresh provisions and mail were transferred to the field camp, and trash materials were retrograded.

2. A small-area acoustic survey was conducted north of Elephant Island (Survey C, Figure 4). The survey was conducted at a ship's speed of approximately 8 knots over a 4-day period. As on Leg I, acoustic data were collected using the hull-mounted 120kHz and 200kHz down-looking transducers. The survey was complemented with directed sampling using the IKMT during hours of darkness.

3. A large-area survey, similar to Survey A, was conducted around Elephant, Clarence, and the eastern end of King George Islands (Survey D, Stations D01-D91, Figure 3). Acoustic transects were again conducted at 10 knots, using the hull-mounted 120kHz and 200kHz down-looking transducers. Due to adverse weather conditions, a CTD/rosette cast and net tow were not conducted at Station D15; a net tow was also not conducted at Station D42.

4. A second acoustic/net survey (Survey AB2) of krill, similar to that conducted at the beginning of Leg I, was conducted in Admiralty Bay (Figure 2).

5. The hull-mounted 120kHz and 200kHz down-looking transducers were again calibrated in Martel Inlet, Admiralty Bay, King George Island, using similar methods to the first calibration.

6. An acoustic survey (Survey E) was conducted along the shelf-break north and west of Elephant Island; two IKMT tows were conducted during the survey to confirm the size and maturity stage of the krill.

7. Continuous underway measurements, similar to those collected during Leg I, were recorded.

8. Observations of the distribution and abundance of marine birds and mammals were conducted.

Leg III.

1. Five ROV transects were conducted at three sample stations offshore of South Georgia (Figure 5). The ship's Seabeam system was used to make bathymetric maps of these stations.

2. Fifty-two ROV transects were conducted at thirteen sample stations in the BAFs along the northern and eastern coasts of South Georgia (Figure 5).

3. Dredge samples were collected at eleven stations occupied during the BAFs Survey to provide positive species identification of the animals observed with the ROV.

4. Using the Seabeam system, a bathymetric map of an offshore area in which crabs were commercially harvested in 1992 was constructed.

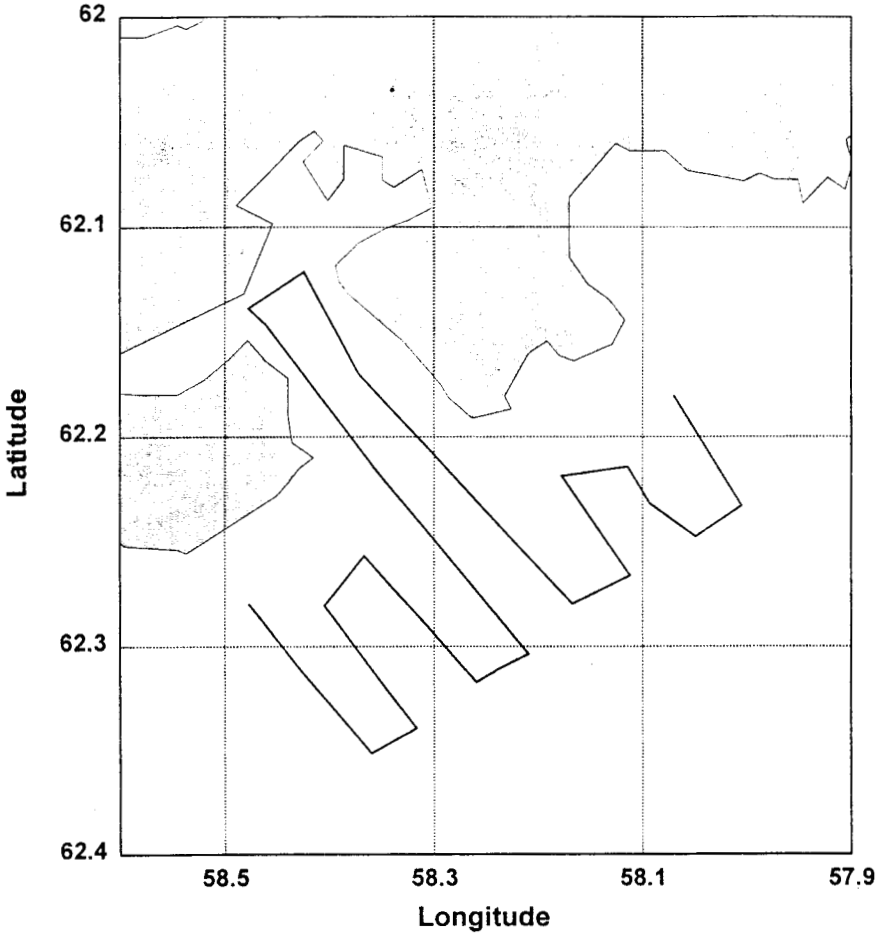

Figure 2. The Admiralty Bay surveys (Surveys AB1 and AB2)

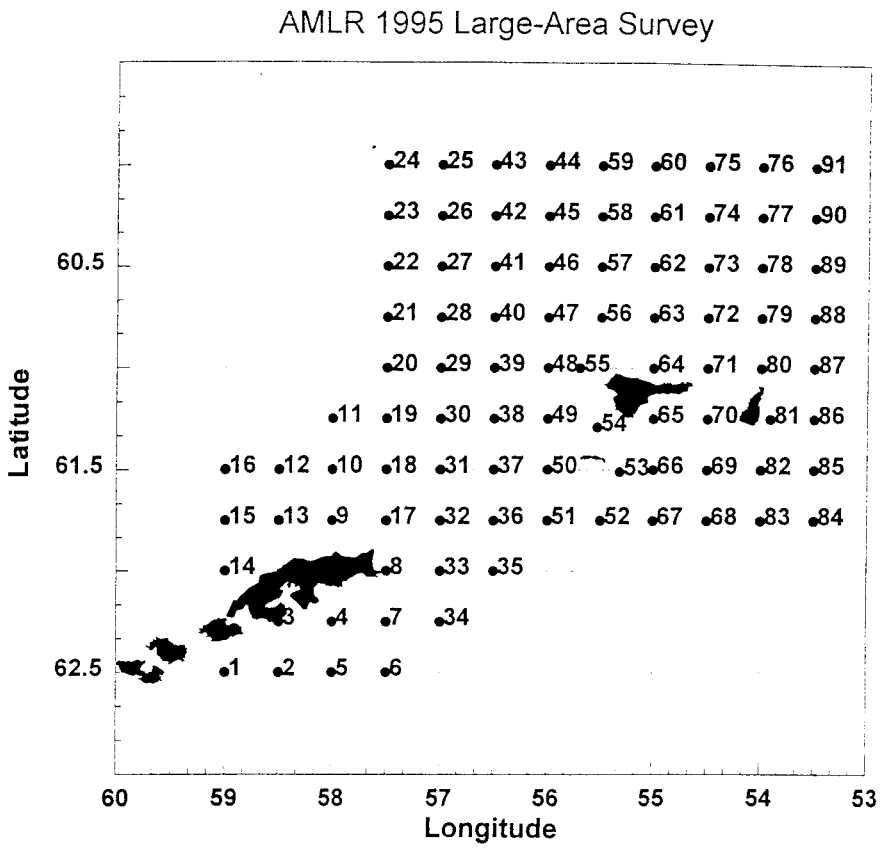

Figure 3. The large-area surveys for AMLR 95 (Surveys A and D).

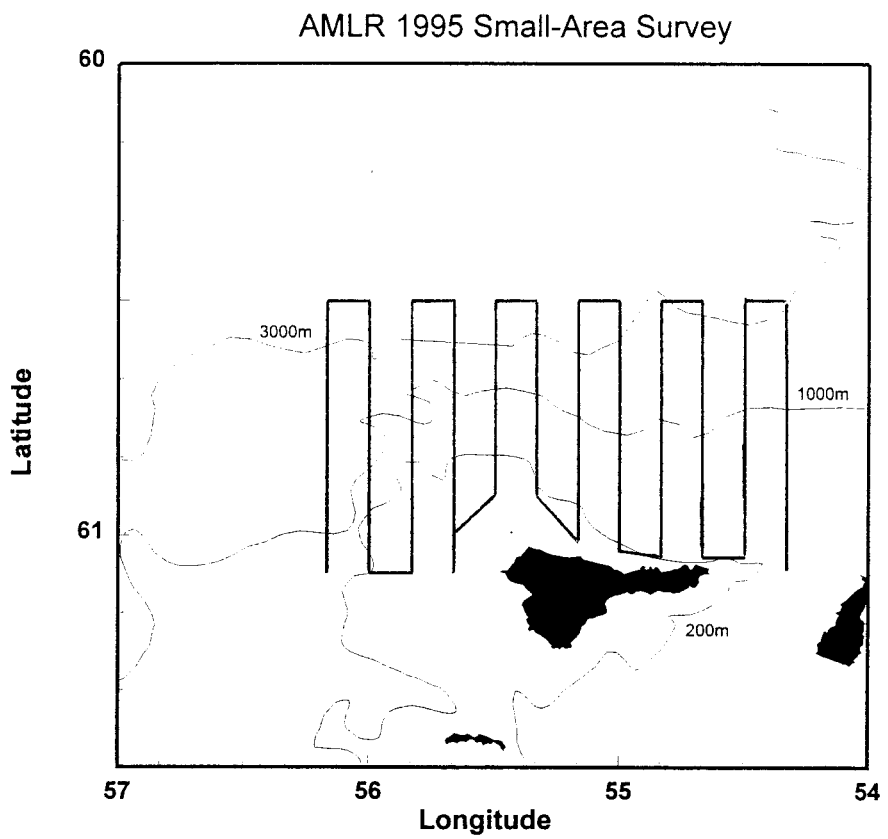

Figure 4. The small-area surveys for AMLR 95 (Surveys B and C).

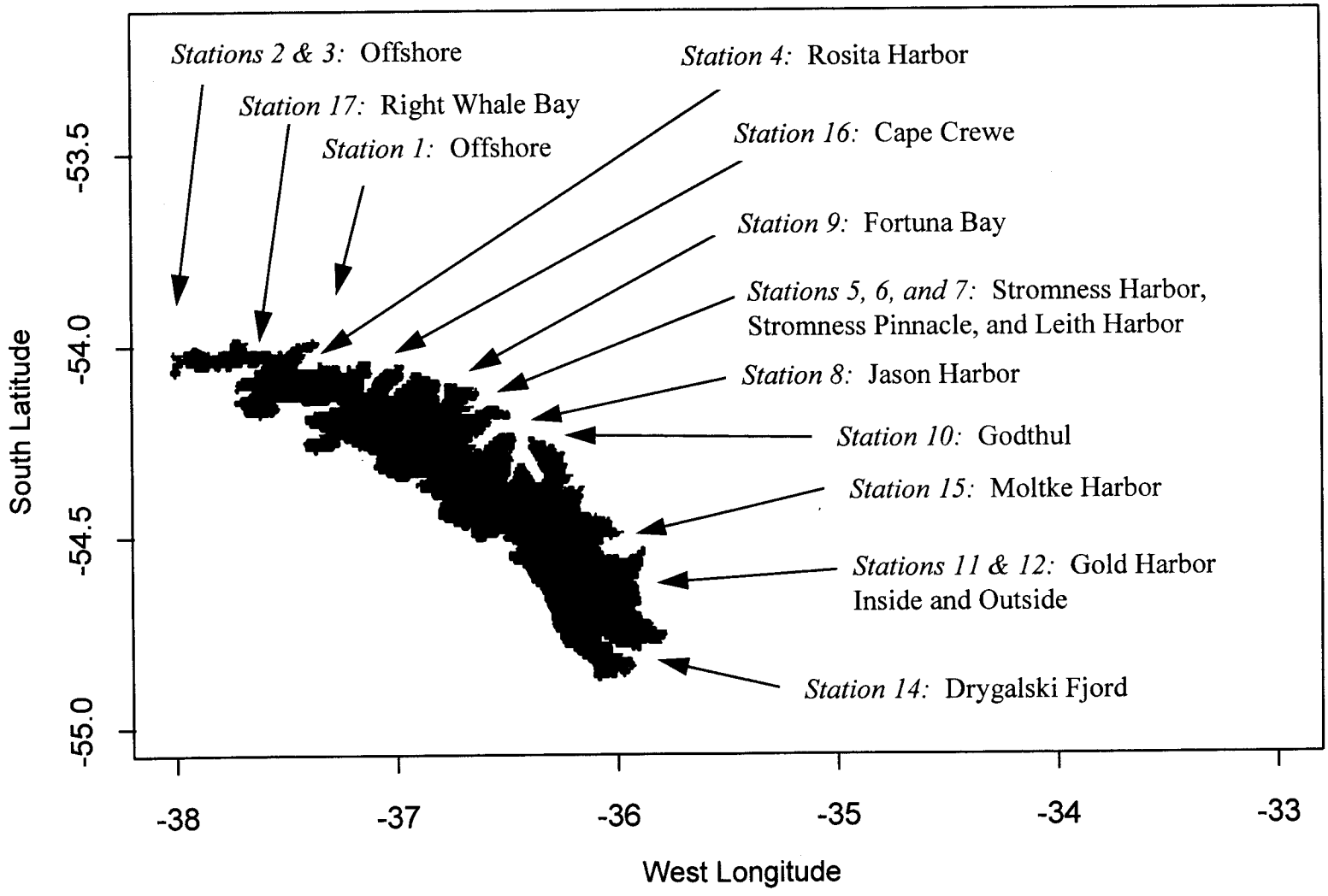

Figure 5. Station locations for AMLR 95 Leg III.

Land-based Research:

Seal Island

1. A six-person field team (J. Bengtson, M. Cameron, L. Hiruki, R. Holt, J. Jansen, and W. Meyer) arrived at Seal Island on 30 November 1994. The team reactivated the field camp.

2. Radio transmitters were attached to 40 perinatal female fur seals in early December to measure durations of foraging trips. Eighteen of these animals were also fitted with time-depth recorders (TDRs) to document dive characteristics and other foraging parameters.

3. Three team members (Bengtson, Cameron, and Meyer) embarked the Japanese R/V *Kaiyo Maru* on 16 December for a 10-day predator/prey tracking study. Ten female fur seals were instrumented with satellite-linked transmitters in conjunction with the study. On 25 December, Meyer returned to Seal Island; Bengtson and Cameron remained aboard *Kaiyo Maru* for its return trip to South America.

4. Fur seal pups were weighed at two-week intervals from late December through February. Pups (both alive and dead) were counted daily at the island's two main breeding colonies (North Cove and North Annex) as well as a smaller colony (Big Booté). Censuses of fur seal breeding colonies on Large Leap Island, Saddle Rock, and Transmitter Island were also conducted.

5. All classes of fur seals at North Cove and North Annex were censused daily during the month of December; all seals at Beaker Bay beach were censused at weekly intervals throughout the season. Daily observations of tagged female fur seals were made to assess survival, reproductive rates, and tag loss. Also, 30 new adult females seals were tagged this season.

6. Fur seal scat samples were collected opportunistically from female fur seals for subsequent analysis of prey remains at National Marine Mammal Laboratory (NMML).

7. An ADF system was used to estimate the direction and distance of radio-tagged fur seals and penguins foraging within approximately 10 nautical miles (n.mi.) of Seal Island.

8. Weekly counts of other pinnipeds (Southern elephant seals, Weddell seals, and leopard seals) were conducted. Leopard seals were also opportunistically photographed and identified.

9. *Surveyor* called at the island on 14 January to offload fresh supplies and also to disembark two new field team members (P. Boveng and W. Cobb). Three team members (Boveng, Hiruki, Jansen) embarked *Kaiyo Maru* on 19 January for the second 10-day predator/prey tracking study.

10. Penguin censuses, breeding success, and breeding chronology studies were begun in early December. Breeding success of chinstrap penguins was estimated by determining the number of chicks raised to the creche stage at designated nests in two study plots on the island. Macaroni penguin nests were also monitored.

11. Thirty-eight adult chinstrap penguins were equipped with radio transmitters to monitor duration of foraging trips. Twenty-seven transmitters were also deployed on other chinstrap penguins in conjunction with the *Kaiyo Maru* predator tracking studies; twenty-one of these animals were also fitted with TDRs. Also, 34 chinstrap penguins were instrumented with TDRs to provide information on diving behavior.

12. The number of breeding pairs in all penguin colonies was counted after the completion of egg laying.

13. Five diet samples were lavaged from breeding chinstrap penguins at the end of December and January in conjunction with the *Kaiyo Maru* predator/prey study.

14. Following the initiation of chinstrap penguin fledging in mid-February, the following measurements were made on 343 fledglings: weight, culmen length and depth, and wing chord length.

15. Prior to the end of Leg I, *Surveyor* called at Seal Island on 1 February to embark W. Meyer and P. Boveng for return to the United States. At the beginning of Leg II on 11 February, the ship visited again to deliver fresh supplies to the team.

16. Daily radio communications were maintained with Palmer Station until *Surveyor* arrived in the study area in mid-January. Radio contacts were also made with biologists and other personnel at Copacabana camp (King George Island), Cuperville Island, and M/V *Explorer*.

17. The field camp was closed on 28 February, and *Surveyor* recovered the field team for return to the United States.

<u>Palmer Station</u>

1. Field work at Palmer Station was initiated on 18 October 1994 and terminated on 24 March 1995.

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 (29 November to 2 December).

4. The proportion of 1 and 2 Adelie penguin chick broods was assessed at 49 sample colonies between 9 and 12 January. Chick production was determined by censusing Adelie chicks on 22 and 23 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 4 and 23 February.

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

7. Adult Adelie penguins were captured and lavaged for diet composition studies.

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

SCIENTIFIC PERSONNEL

Cruise Leader:

Roger P. Hewitt, Southwest Fisheries Science Center (Legs I and II)
George Watters, Southwest Fisheries Science Center (Leg III)

Physical Oceanography:

Anthony F. Amos, University of Texas at Austin (Leg II)
Charles Rowe, University of Texas at Austin (Legs I and II)
Andrea Wickham, University of Texas at Austin (Leg I)

Phytoplankton:

Osmund Holm-Hansen, Scripps Institution of Oceanography (Leg II)
Sergio Figueroa, Universidad de Valparaíso (Legs I and II)
Walter Helbling, Scripps Institution of Oceanography (Leg I)
Martín Montes, Universidad Nacional de la Patagonia (Legs I and II)
Lorena Linacre Rojas, Universidad Católica de Valparaíso (Leg II)
Claudia Valenzuela, Universidad Católica de Valparaíso (Legs I, II, and III)
Virginia E. Villafañe, Scripps Institution of Oceanography (Leg I)

Krill and Zooplankton Sampling:

Valerie Loeb, Moss Landing Marine Laboratories (Legs I and II)
Michael Force (Southbound Transit, Legs I and II)
Debbie Nebenzahl, Moss Landing Marine Laboratories (Legs I and II)
Dawn Outram, Moss Landing Marine Laboratories (Legs I and II)
Charles F. Phleger, San Diego State University (Leg I)
Aaron Setran, U.S. Environmental Protection Agency (Legs II and III)
Gary Shigenaka, NOAA Hazardous Materials Division (Leg I)
Cesar Alarcon Zapata, Universidad de Magallanes (Leg I)

Bioacoustic Survey:

David Demer, Southwest Fisheries Science Center (Leg I)
Mark Prowse, Sea Fisheries Research Institute (Leg II)
Jane Rosenberg, Southwest Fisheries Science Center (Legs I, II, and III)
Scott Rumsey, Scripps Institution of Oceanography (Leg I)
Stephanie Sexton, Southwest Fisheries Science Center (Leg II)

Crab/Epifaunal Survey:

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Julian Gutt, Alfred Wegener Research Institute (Leg III)
Jan-Otto Pettersson, Kristineberg Marine Science Station (Leg III)

Seal Island Field Team:

John Bengtson, National Marine Mammal Laboratory
Peter Boveng, National Marine Mammal Laboratory
Mike Cameron, National Marine Mammal Laboratory
William T. Cobb, Southwest Fisheries Science Center
Lisa Hiruki, National Marine Mammal Laboratory
Rennie Holt, Southwest Fisheries Science Center
John Jansen, National Marine Mammal Laboratory
William Meyer, National Marine Mammal Laboratory

Palmer Station:

William R. Fraser, Montana State University
Donna L. Patterson, Montana State University
Eric J. Holm, Montana State University
Karen M. Carney, Montana State University

DETAILED REPORTS

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

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 95 is the sixth field season for the collaboration of physical measurements with biological studies.

1.2 Accomplishments:

CTD/Rosette Stations: Ninety-five CTD/rosette casts were made on Leg I, and 94 casts were made on Leg II. The majority of the casts occurred at the 91 stations of the large-area surveys, designated Survey A (Stations A01-A91) on Leg I and Survey D (Stations D01-D91) on Leg II. Station D15 was skipped due to bad weather conditions. In addition, eight deep CTD/rosette stations (four on each leg) were conducted to contrast the mid-depth waters of the Drake Passage and the Bransfield Strait and for nutrient sampling. Some 1,732 water samples were collected from the rosette bottles. Water from these were analyzed for micronutrient concentration, phytoplankton, and chlorophyll by the phytoplankton group; for salinity by *Surveyor's* Survey Technicians; and for dissolved oxygen by the phytoplankton team. All samples were analyzed for salinity 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 measurements of these samples and the CTD salinity was about 0.008, confirming the high accuracy of the CTD.

Underway Environmental Observations: Twenty-six and 25 days of continuously acquired weather, sea temperature, salinity, water clarity, chlorophyll, and solar radiation data were collected during Leg I and Leg II, respectively. Augmented with ship's navigational information these data provided complete coverage of surface environmental conditions encountered in the AMLR study area.

1.3 Methods:

CTD/Rosette: Water profiles were collected with a Sea-Bird model SBE-9 PLUS CTD/rosette. CTD profiles were limited to 750 meter (m) depth (or to within a few meters of the ocean floor when the depth was 750m, or less). A Benthos 12kHz pinger was attached to the rosette frame. Difficulties arose with this pinger, and it was replaced on Leg I with the ship's DataSonics pinger. A Sea-Bird dissolved oxygen sensor, Seatech 25-centimeter (cm) beam transmissometer, Biospherical Instruments Photosynthetically Available Radiation (PAR) sensor, and a Seatech *in situ* fluorometer (interfaced with the CTD/rosette 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. Data were collected at 24 scans/sec on the downtrace and 6 scans/sec on the up. All rosette 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 by 1-meter averages for analysis. A sorted printout of the rosette bottle tripping sequence was produced so that sampling strategies could be adjusted immediately after the CTD/rosette unit was retrieved.

This season a method was devised to produce a log sheet unique to each CTD/rosette station. Just before a station was started, the CTD operator entered the station number into the CTD computer. Data from the underway equipment were sent to the CTD computer, copied into the log sheet, recorded on a disk file, and printed. 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.

Underway Data: Data from various environmental sensors were collected, multiplexed, and combined with the Global Positioning System (GPS) navigational information. A Data World computer equipped with a GTEK multiple serial port card was used to acquire, display, and store the data at one-minute intervals throughout Leg I and II of the cruise. *Surveyor's* Electronic Technicians installed several RS-232 interfaces, allowing ASCII data to be sent from the ship's various systems to the Data World computer. Ship's position data were obtained using a Trimble NavPac II GPS system. Ship's course was acquired from the gyro compass; relative wind speed, direction, and air temperature from the R.M. Young weather system; and sea temperature and salinity from the Sea-Bird SBE-21 Thermosalinograph. Vertical depth data came from the center beam of the Seabeam system. Using a Weathermeasure signal conditioning unit, barometric pressure, air temperature, and relative humidity data were sent to a Hewlett-Packard 3421A data acquisition unit, where they were multiplexed and sent to the Data World computer via an IEEE-488GPIB interface.

A single optical sensor (Biospherical Instruments PAR sensor) was mounted on the flying bridge to sense solar radiation relatively unobstructed by *Surveyor's* superstructure and masts. These data were fed directly to the HP multiplexer. Finally, a plumbed sea-water flow-through system provided bubble-free water for a Seatech 25cm transmissometer and a Turner Designs Fluorometer to monitor sea surface water clarity and chlorophyll fluorescence. The inputs were also fed to the HP 3421A. Throughout the cruise, a Hewlett-Packard 7475A plotter was used to provide real-time graphical representation of environmental conditions.

1.4 Results and Tentative Conclusions:

Oceanography: As in past years, we have classified and grouped stations with similar vertical temperature/salinity (T/S) characteristics. We have identified five water types, designated I through V. It should be noted that these are based on the T/S curves from the surface to 750m (or to the bottom in water shallower than 750m). For example, water type I has the following characteristics: warm, low salinity surface water; a strong sub-surface 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). We have defined the oceanic water of the Drake Passage as water type I. The Bransfield Strait and south of Elephant Island have been designated water type IV. Water type IV has the following characteristics: bottom waters around -1°C and sub-surface extrema that are far less prominent, although a slight "crook" in the curve is characteristic. In between, there are transition zones where adjacent water types mix.

The composite T/S scatter diagram for all stations of Surveys A and D are shown in Figure 1.1a and 1.1b. T/S data are presented in Figures 1.2a-1.2e for Survey A and in Figures 1.2f-1.2j for Survey D. Each diagram shows the group T/S relationship in gray for the water type with a depth-averaged curve in solid black. The map inserts show the location and station numbers belonging to each water type. In this way, the locations of the five water types in the AMLR study area can be envisioned. Although considerable care has been taken to classify each station by water type, these data are still preliminary as some stations are transitional. This particularly applies to water type II, which is characterized by the evidence of isopycnal mixing of the CDW with shelf water. Stations 11 and 19 had winter water in Leg I but largely lost this characteristic by Leg II (Figures 1.2b and 1.2g). These stations could have been grouped with water type I on the first leg but show the CDW mixing on both legs. Differences between Leg I and Leg II can be seen in the T/S curves. For illustration, refer to Figures 1.2a and 1.2f, water type I. Seasonal warming was seen this year in the surface water (<3°C on Leg I and up to 3.5°C on Leg II) and in the erosion of the winter water. The core was deeper and warmer on Leg II at -0.7°C than it was on Leg I at below -1°C. In contrast to previous years, Leg II did not show a separation in the T/S curve for water type I stations (Figure 1.2f). This indicates a higher salinity of the winter water temperature minimum and less penetration of water type I close to Elephant and Clarence Islands. In Figure 1.3a and 1.3b, each T/S curve has been plotted on a map of stations in the AMLR study area. From these "worm diagrams", the two major water divisions can clearly be seen for both legs. A dotted line is shown to delineate the border of water type I from the other types.

The dynamic topography of the region is shown in Figures 1.4a and 1.4b. 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 SW to NE flow across the entire AMLR study area. Like previous years, this flow was intensified in three zones: north of Elephant Island, roughly following the topographic trend of the shelf-break; in a narrow band paralleling the northern boundary of the Bransfield Strait south of King George Island; and a more northerly trend between Elephant and Clarence Islands. Another intensification was seen north of King George Island.

Similar to previous years, a dynamic topographic high occurred in the north of the AMLR study area near 57°W longitude. As in 1994, the high shifted to the east during Leg II. The existence of this eddy and another southwest of Clarence Island, as revealed by the geostrophic current streamlines calculated from the CTD data, was confirmed by the drift track of three barometer drifters deployed during Leg I. Figure 1.5 shows the tracks of the three drifters deployed along the north-south line of Stations A25-A34. In all cases, the

drifters followed a course which mirrored the eddies, doubling back on their otherwise northeasterly drift. We have recorded similar eddies on most previous AMLR cruises, indicating that they are quasi-permanent features of the circulation. A similar pattern was revealed when the surface was referenced to 200m, so it is assumed that these patterns are reasonably representative of the mean flow in the upper water column.

The surface (10m) temperature, salinity, density, and dissolved oxygen fields for Survey A are contoured in Figures 1.6a-1.6d. The surface (10m) temperature, salinity, and density fields for Survey D are contoured in Figures 1.6e-1.6g. This year the 2°C contour penetrated more to the south compared to AMLR 94, while surface water less than 0°C was not found in the AMLR study area. Surface water of 2°C was found in the Bransfield Strait on Leg II for the first time on an AMLR cruise. An extensive area of surface water >3°C occupied the northwestern Drake Passage area of the large-area survey grid. Consequently, 1995 was a "hot" year. Surface salinity distribution was similar to that of 1994. Surface density contours show the density front that separates the Drake Passage waters from those of the Bransfield Strait.

This year the chlorophyll values were at bloom levels throughout much of the AMLR study area, especially during Leg II (see "Phytoplankton" report). Preliminary analysis of the physical oceanographic data did not show any compelling difference from previous years that might account for the high phytoplankton concentrations. It is possible that the warmer surface waters and calmer conditions for part of the cruise may have been favorable for phytoplankton growth. The sub-surface temperature minimum of the winter water often coincided with a chlorophyll and oxygen maximum, but some stations in the Drake Passage did not follow this rule. Generally, the remnant of last winter's deep homogeneous surface layer retains its high oxygen content, while warming surface waters lose oxygen. The dissolved oxygen sensor gave consistent and reasonable values for the major part of AMLR 95. Unfortunately, it failed towards the end of Leg II, and the absolute values were not consistently comparable to results obtained from new dissolved oxygen analysis equipment. Before the failure on Leg II, the uptrace values from the dissolved oxygen sensor compared closely with the independent oxygen analyses. Vertical CTD profiles along the 57°W meridional line (Stations A25-A34) are shown in Figures 1.7a-1.7f.

Underway Data: Underway data were recorded at 1-minute intervals covering 9,050 n.mi. of cruise track with almost no data loss. One significant feature was the constancy of the winds on both legs (approximately 65% westerly winds). On Leg II, the mean winds were about normal (16 knots), and the maximum (47 knots) was higher than on Leg I. There were relatively few storm during AMLR 95. Air temperatures were below freezing for only a few hours during Leg II, and the overall air temperature was warmer than in 1994.

1.5 Disposition of Data: The CTD/rosette and underway data have been stored on 44 Mbyte and 150 Mbyte Bernoulli disks. The raw data will be taken to the University of Texas Marine Science Institute in Port Aransas, Texas for backup. Final analysis will be under the direction of Anthony F. Amos. Copies of the CTD/rosette 1-meter averages and modified 1-minute underway data have been distributed on diskettes to the phytoplankton and acoustics

groups. Copies of the printed log sheets and plot were provided daily to the phytoplankton group and bird/mammal observers. Special logs listing time, position and weather conditions for each scientific event were provided to cruise participants.

1.6 Acknowledgements: Special mention goes to the Electronic Technicians; the survey department for setting up the CTD/rosette for each station, collecting water samples, and processing salinity samples; the winch operators for their expert handling of the CTD/rosette under assorted sea conditions; and the Ship's Officers for keeping station and on-deck coordination of operations. We note with sadness that this will be the last time *Surveyor* will be used for AMLR. As the years have gone by, we have learned how to use the ship to do the AMLR surveys and our work goes more smoothly with each passing year. We will be sorry to see the "Old Girl" go.

1.7 Problems and Suggestions: During Leg I, frequent reterminations of the CTD sea cable were necessary due to kinking. However, the problem was alleviated on Leg II with the addition of extra weight on the rosette frame and a chain link from the sea cable mechanical termination to the CTD/rosette bail. We did not have to re-terminate during Leg II and were able to lower the CTD/rosette unit at a proper rate of 60m/minute.

Seabeam depth data could not be continuously collected due to interference to the acoustic system by the Seabeam system. This is unfortunate because more complete depth data across the front north of Elephant Island might reveal whether the front is topographically linked.

At a few stations, the bottom bottle of the rosette sampler inexplicably collected a surface sample. The communications between CTD/rosette control unit and main deck, winch, and bridge were greatly improved this year.

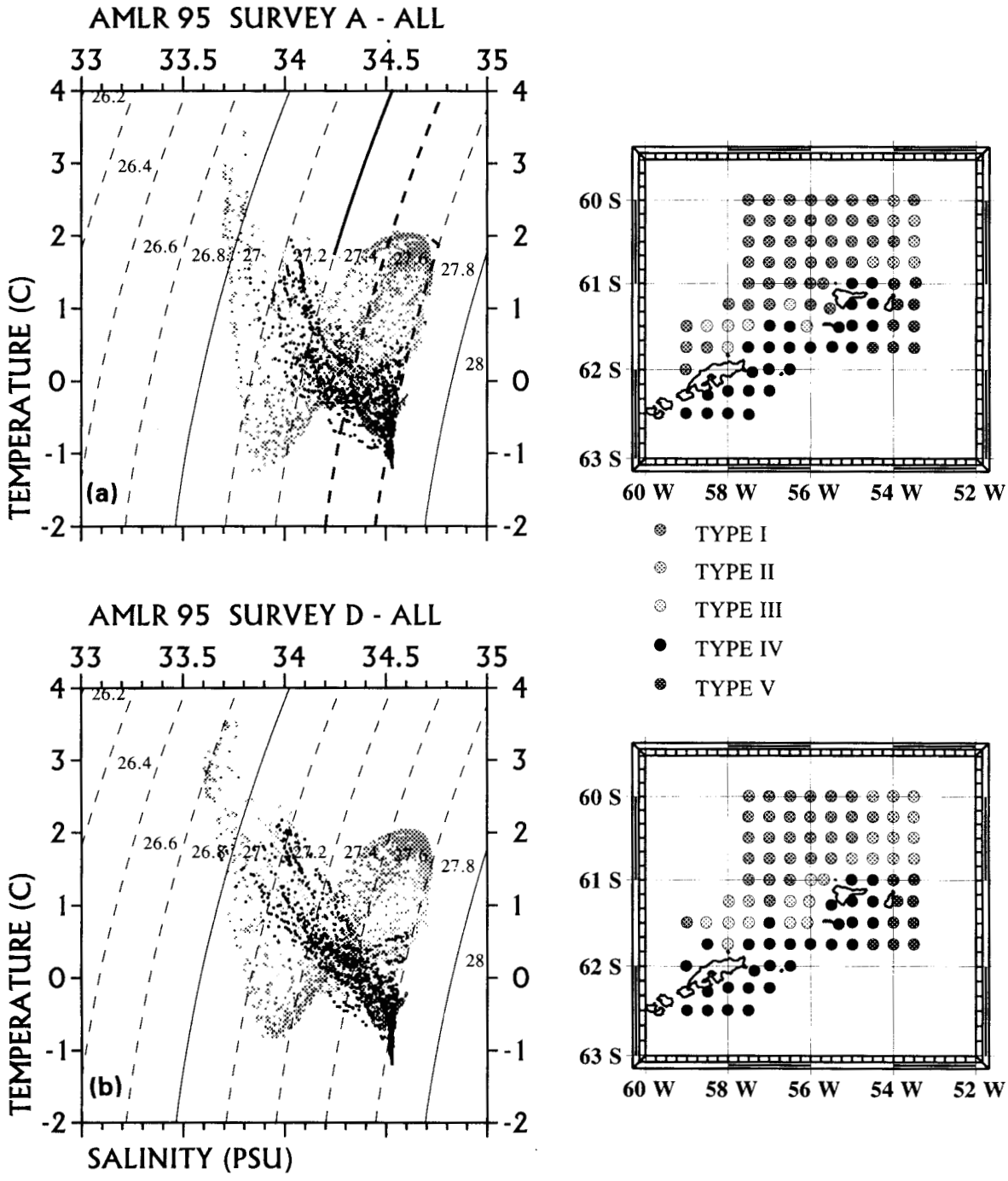


Figure 1.1 Composite Temperature/Salinity diagram for all stations from the large-area surveys. (a) Survey A, Leg I; (b) Survey D, Leg II. Symbols on inset maps show station locations shaded by water types.

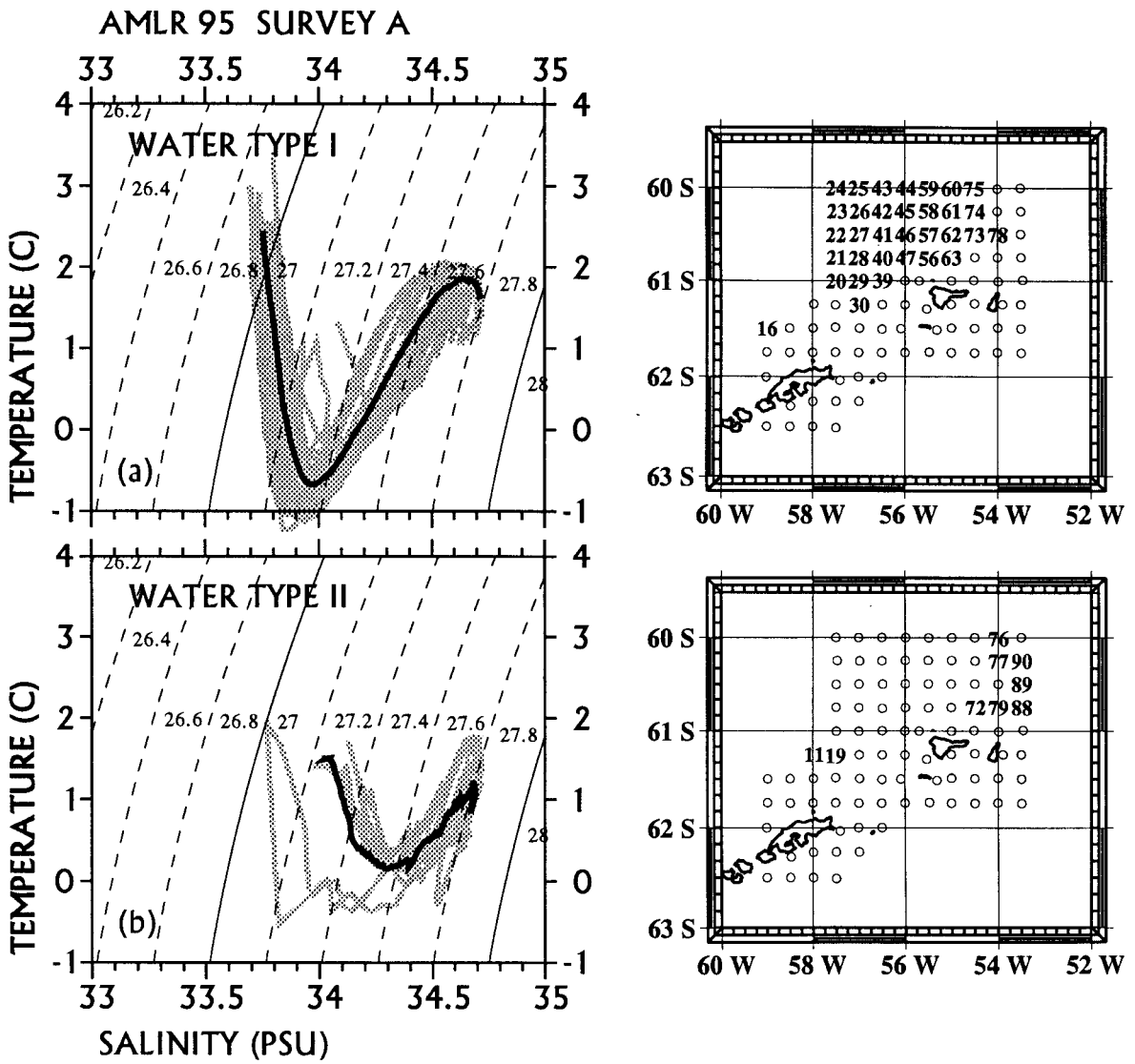


Figure 1.2 Temperature/Salinity curves for various water types in the AMLR study area. The gray area is the T/S envelope of all stations identified as having the water type characteristics. The heavy black curve is the mean T/S curve for each water type. Inset maps show the location and numbers of stations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

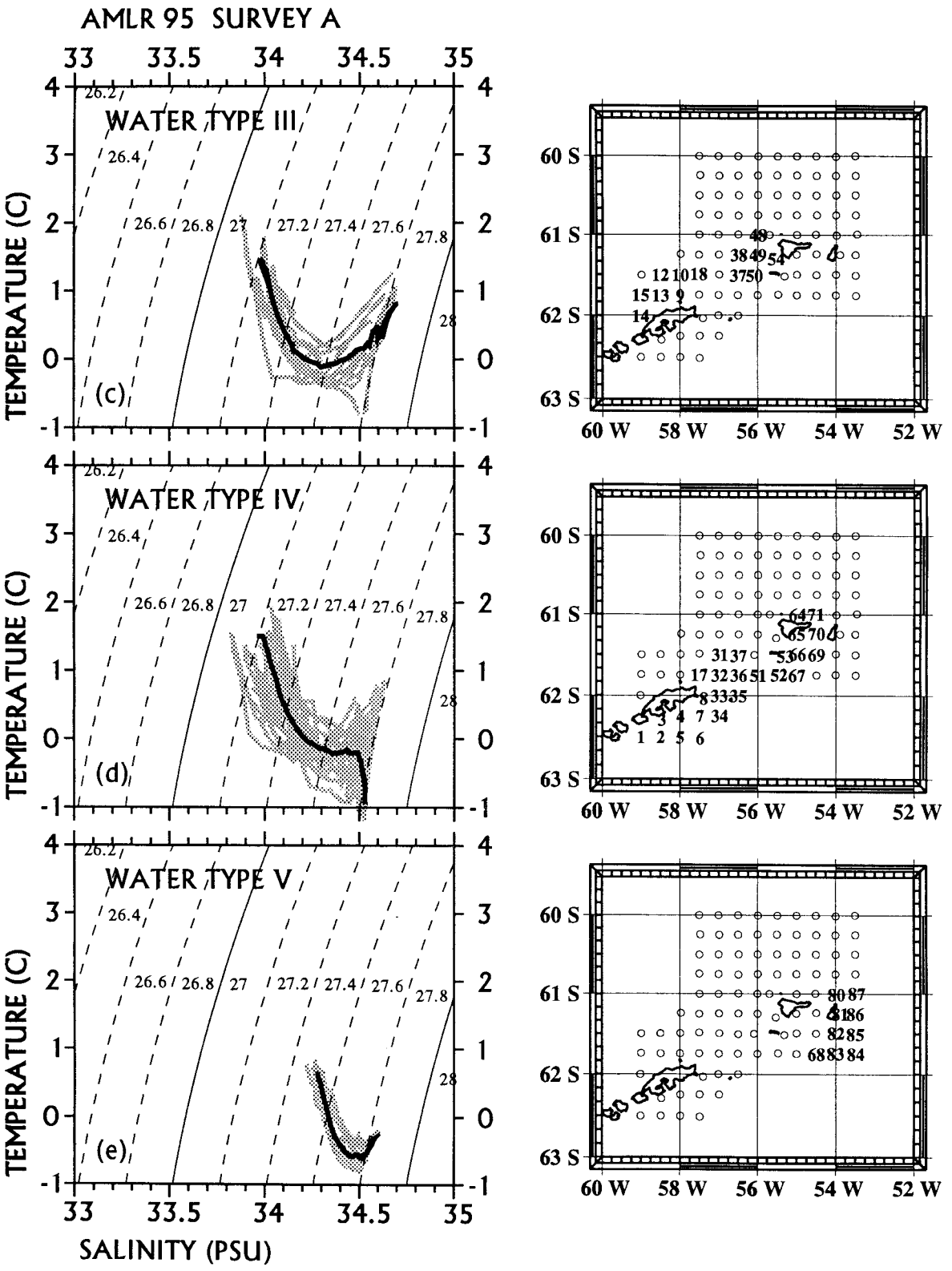


Figure 1.2 (cont.) (c) Survey A, water type III; (d) Survey A, water type IV; (e) Survey A, water type V.

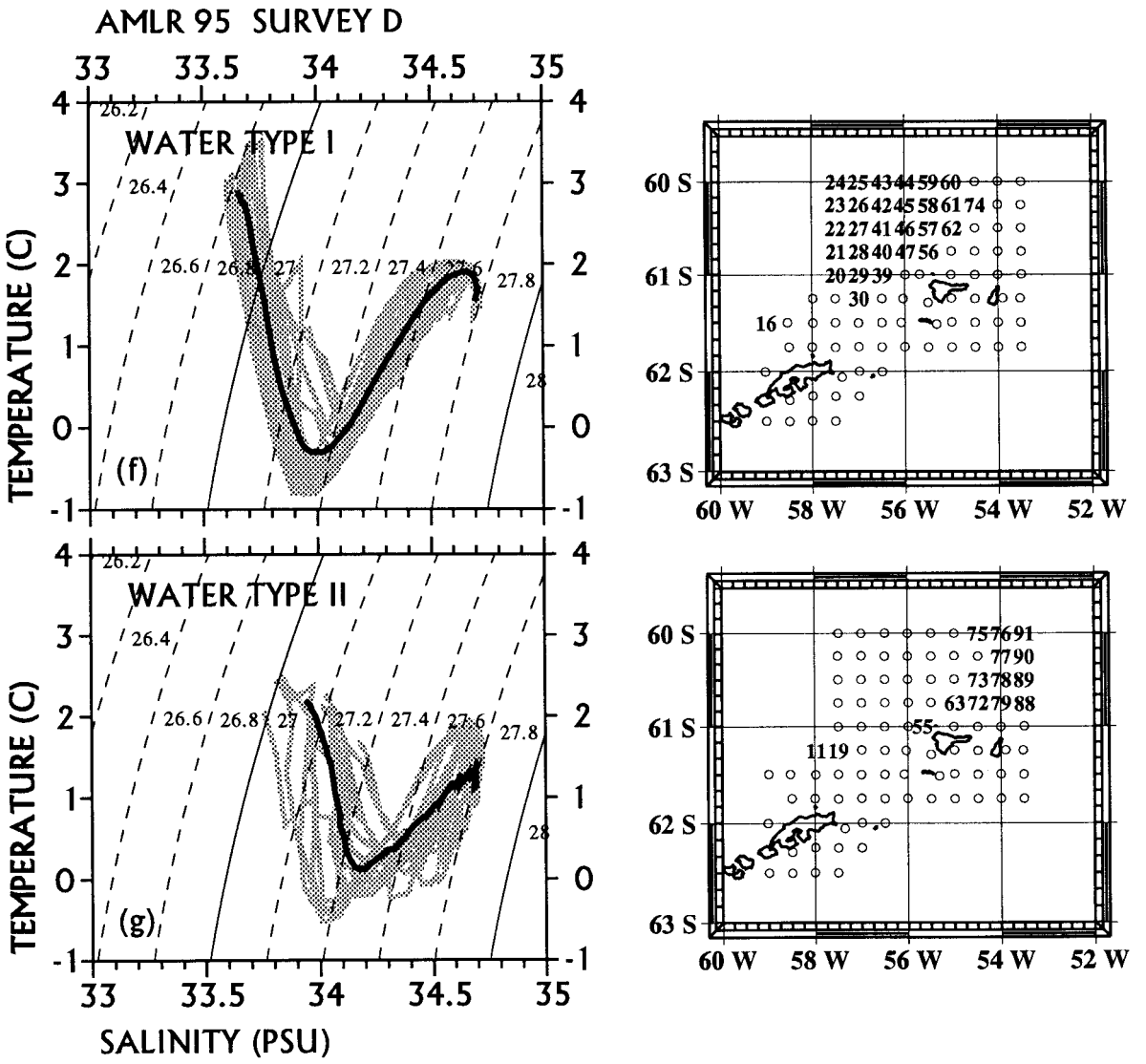


Figure 1.2 (cont.) (f) Survey D, water type I; (g) Survey D, water type II.

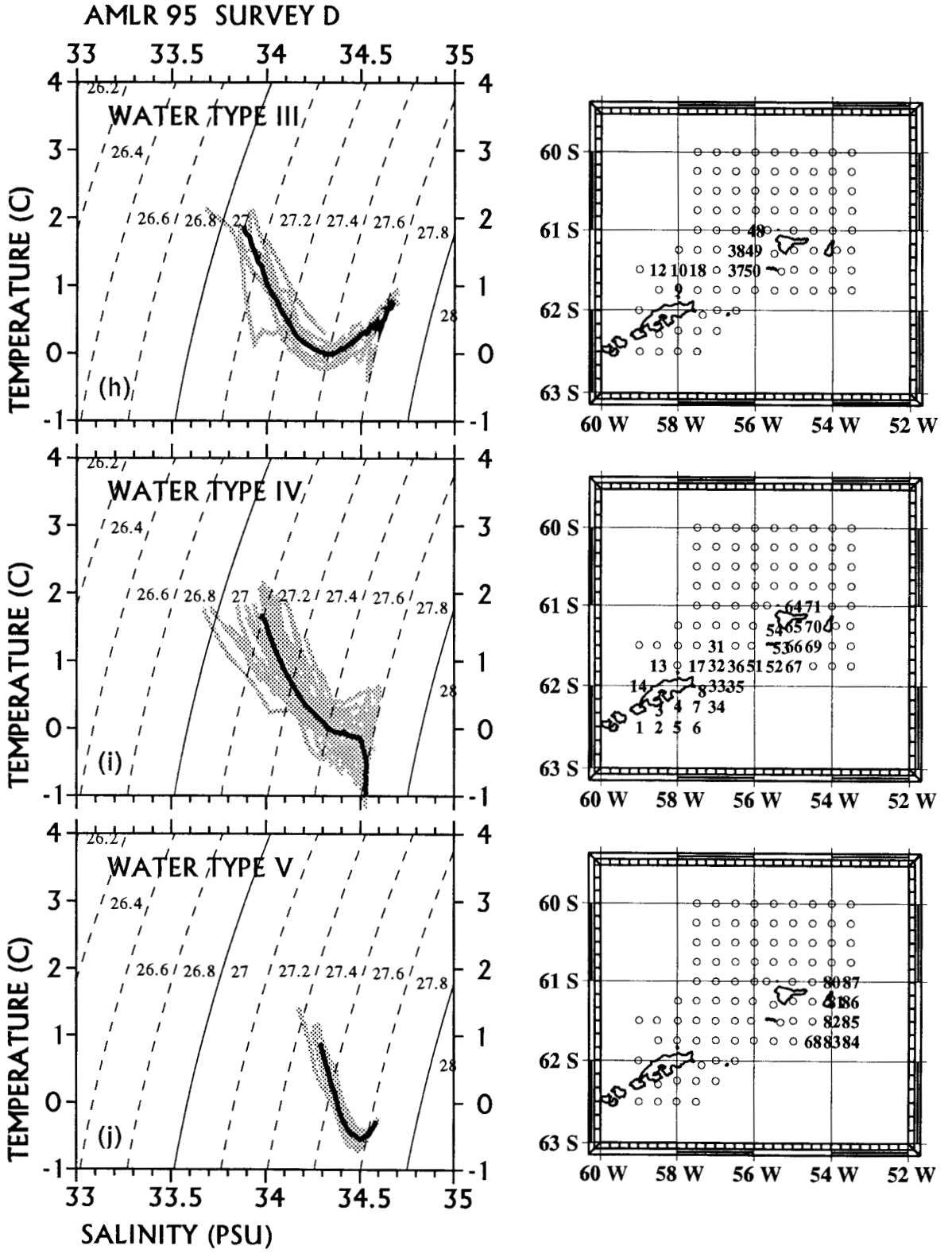


Figure 1.2 (cont.) (h) Survey D, water type III; (i) Survey D, water type IV; (j) Survey D, water type V.

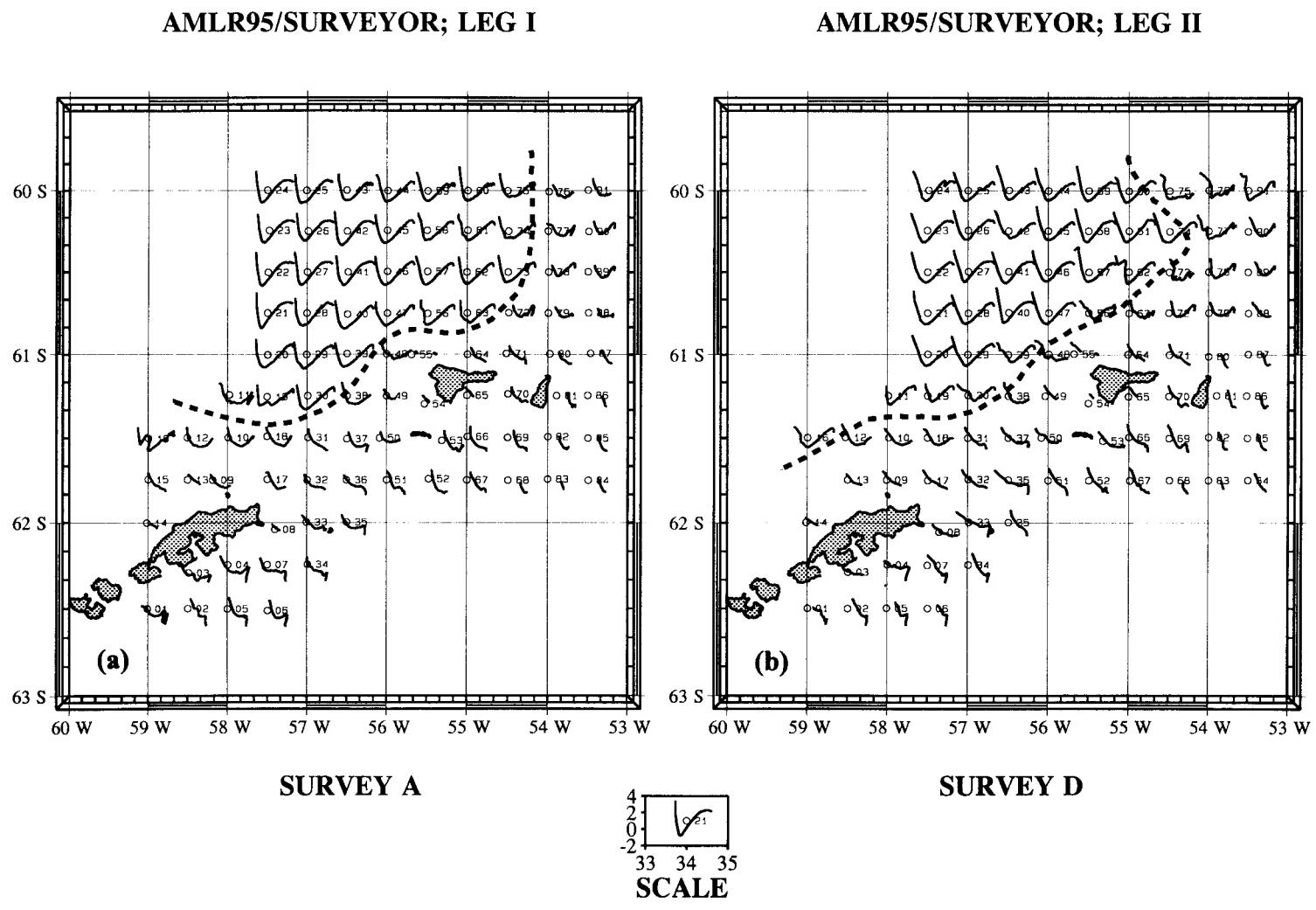


Figure 1.3 "Worm diagram" showing Temperature/Salinity curves for individual stations plotted at the station location. The circle representing station location is plotted at S=34, T=+0.5 (see scale inset). Dashed lines show divisions between water type I and the rest of the water types. (a) Survey A, Leg I; (b) Survey D, Leg II.

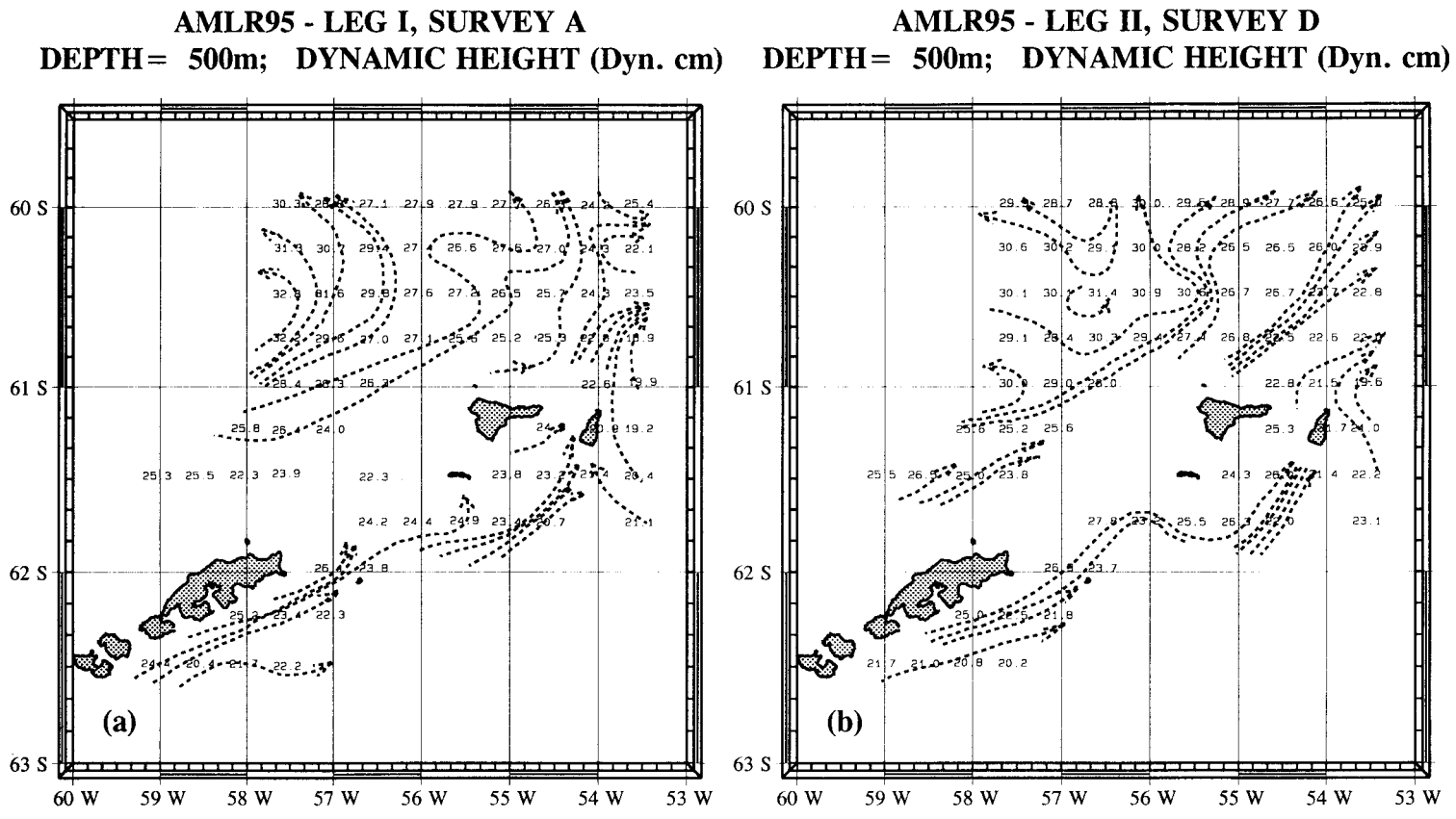
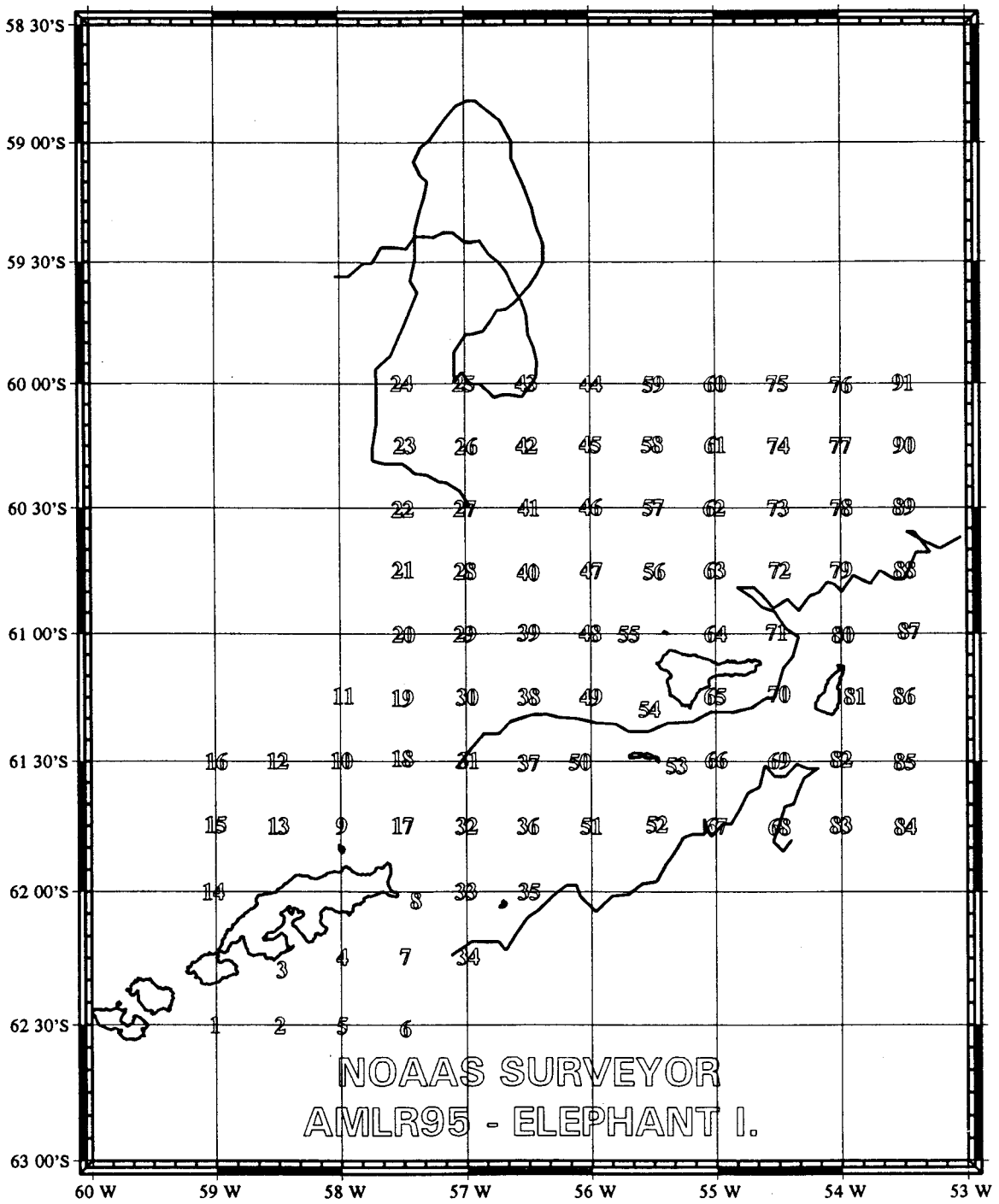


Figure 1.4 Dynamic topography of the AMLR study area. Dynamic height with respect to 500dbar at the surface (dyn. cm.). (a) Survey A, Leg I; (b) Survey D, Leg II.



DRIFTER A27: Dist from starting point 120.8k m; Total dist drifted 595.1km; Mean speed 22.9cm/sec

DRIFTER A31: Dist from starting point 234.4k m; Total dist drifted 371.5km; Mean speed 14.3cm/sec

DRIFTER A34: Dist from starting point 148.6km; Total dist drifted 277.5km; Mean speed 10.7cm/sec

Figure 1.5 Tracks of three barometer drifters deployed during Leg I.

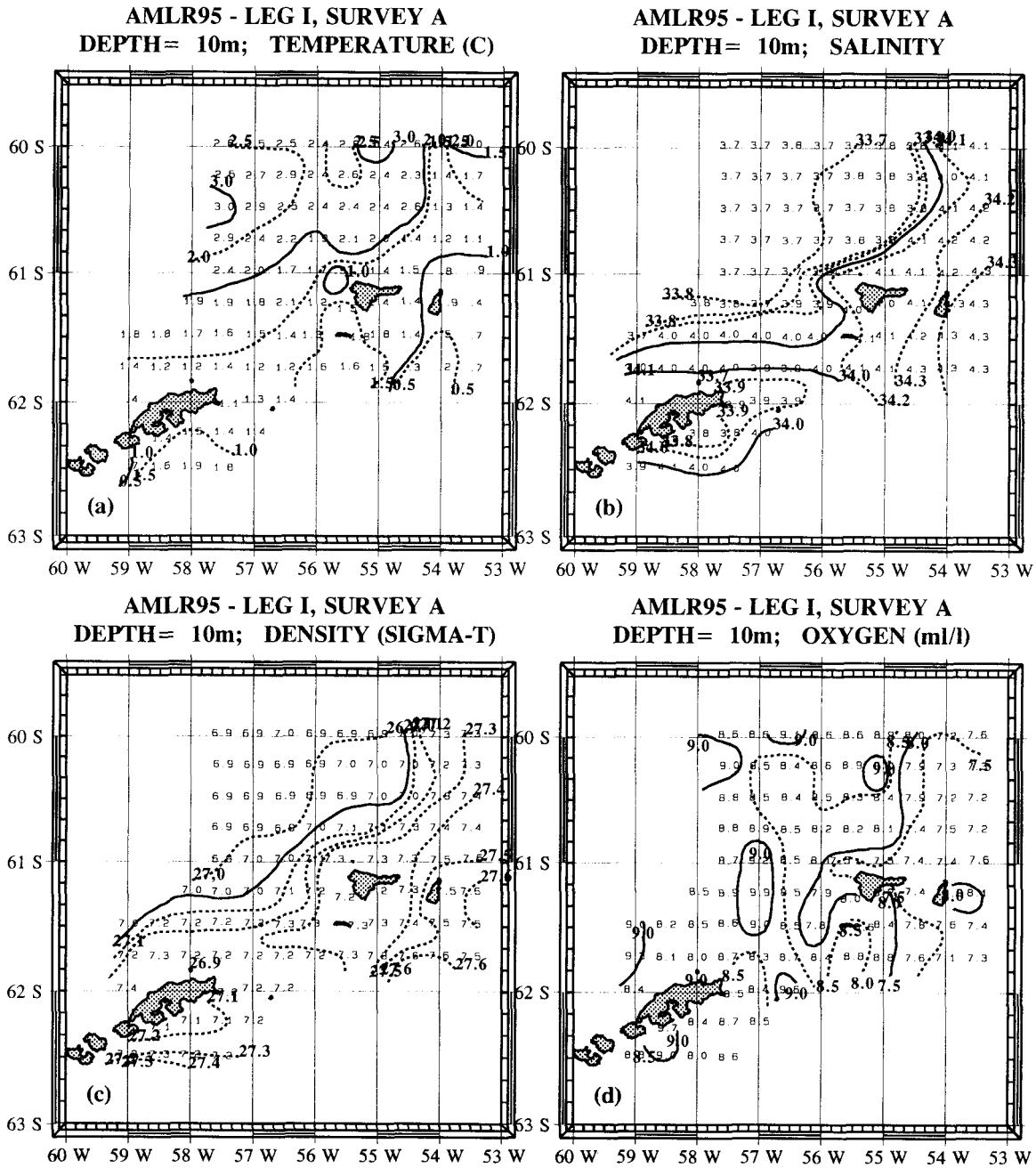


Figure 1.6 Horizontal maps of near surface oceanographic conditions in the AMLR study area during Survey A. (a) Temperature, contour interval 0.5°C; (b) Salinity, contour interval 0.1; (c) Density (Sigma-T), contour interval 0.1; (d) Dissolved oxygen, contour interval 0.5ml/liter.

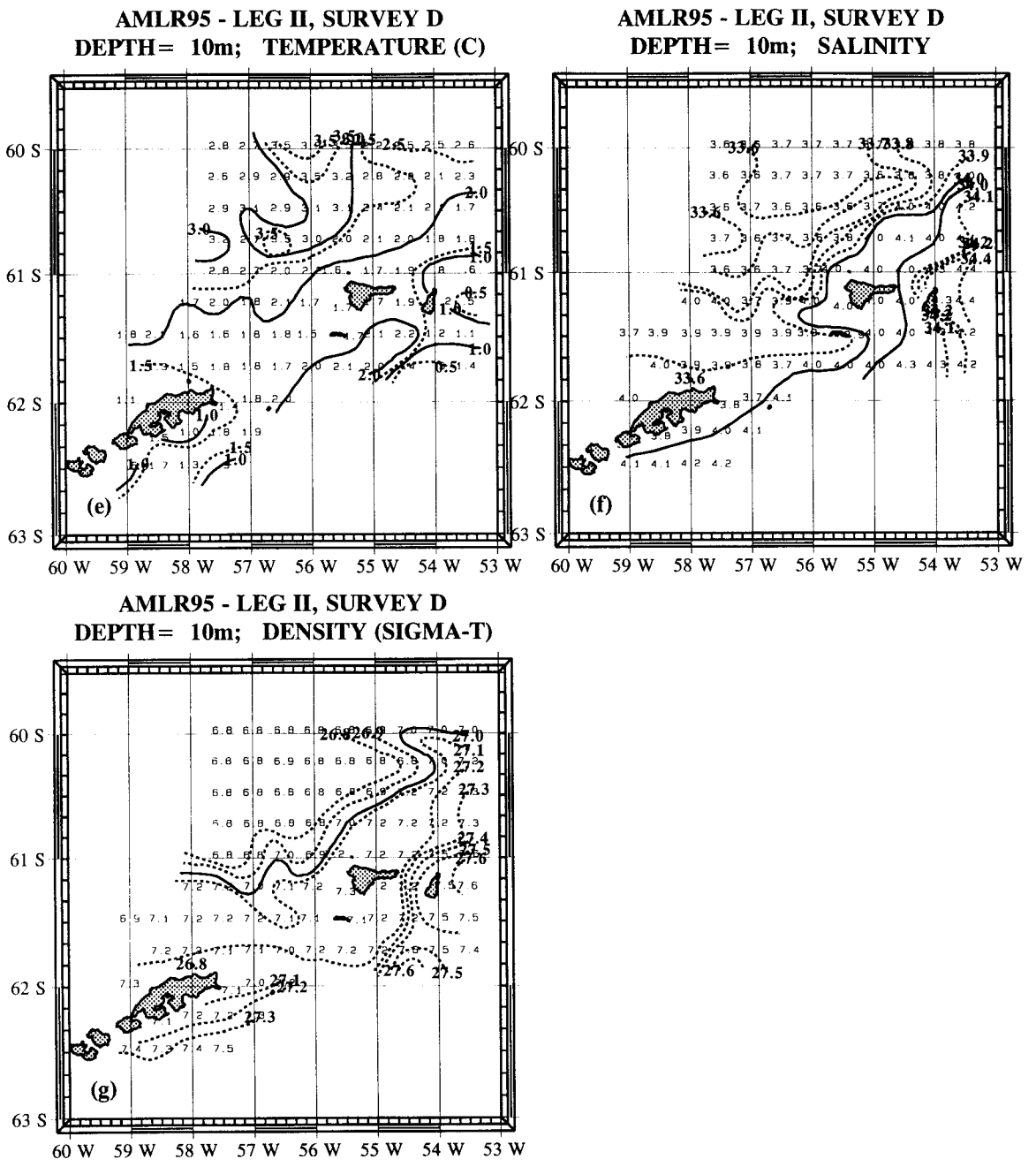


Figure 1.6 (cont.) Horizontal maps of near surface oceanographic conditions in the AMLR study area during Survey D. (e) Temperature, contour interval 0.5°C; (f) Salinity, contour interval 0.1; (g) Density (Sigma-T), contour interval 0.1.

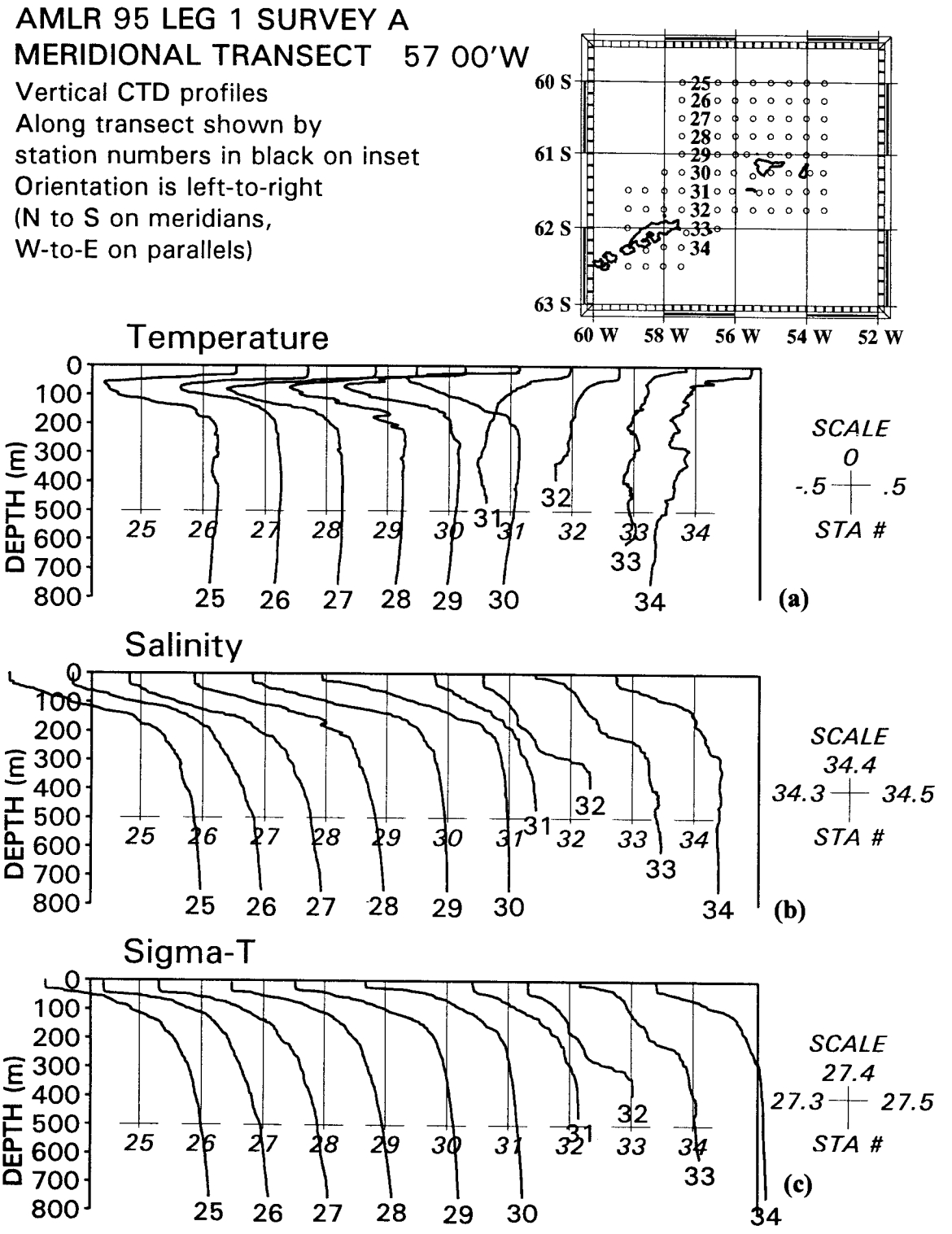


Figure 1.7 Vertical profiles of oceanographic parameters along selected meridians and parallels in the AMLR study area during Survey A. (a) Temperature; (b) Salinity; (c) Density (Sigma-T)

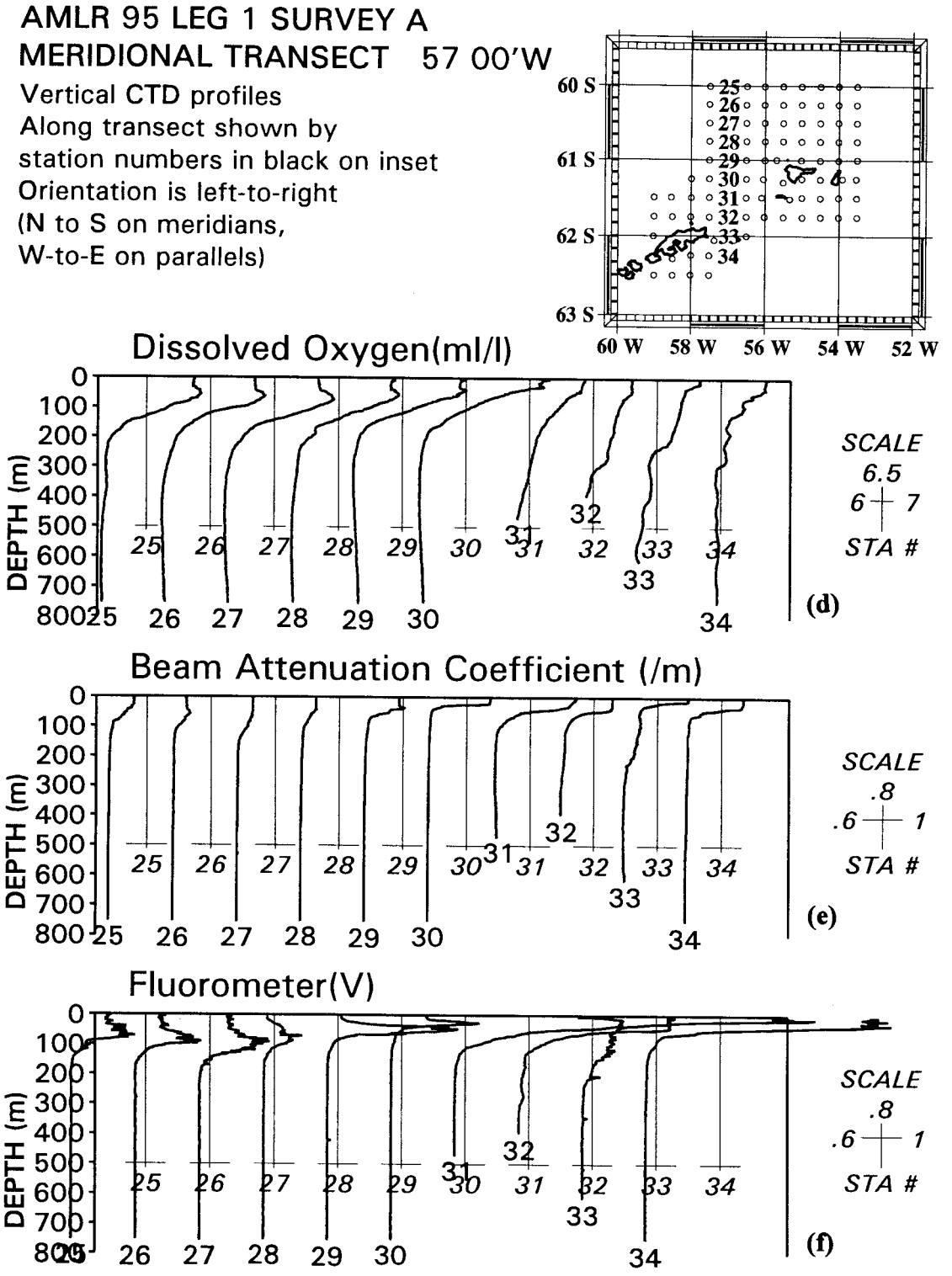


Figure 1.7 (cont.) Vertical profiles of oceanographic parameters along selected meridians and parallels in the AMLR study area during Survey A. (d) Dissolved oxygen; (e) Beam Attenuation Coefficient; (f) Fluorometer.

2. Phytoplankton; submitted by Osmund Holm-Hansen (Leg II), E. Walter Helbling (Leg I), Sergio Figueroa (Legs I and II), Martín Montes (Legs I and II), Claudia Valenzuela (Legs I and II), Lorena Linacre Rojas (Leg II), and Virginia E. Villafañe (Leg I).

2.1 Objectives: The overall objective of this research project was to assess the distribution, concentration, and rate of production of organic food reservoirs available to the herbivorous zooplankton populations throughout the AMLR study area during the austral summer. Specific objectives of our work included: (1) documentation of the distribution and biomass of phytoplankton in the upper water column (0 to 750m), with emphasis on the upper 100m; (2) determination of the concentrations of total particulate organic carbon (POC) and nitrogen (PON); (3) determination of the rate of primary production, as well as the photoadaptational state of the phytoplankton; (4) determination of the species composition of the phytoplankton, in addition to measurement of cell size; and (5) analysis of the importance of physical, chemical, and optical characteristics in the upper water column as controlling factors for the distribution and photosynthetic activity of phytoplankton.

2.2 Methods and Accomplishments: The major types of data collected are listed below, together with a brief statement regarding the methodology employed.

(A) Sampling Strategy:

The protocol relied on the following methods to obtain water samples or 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 CTD/rosette cast. The 91 CTD/rosette stations in the large-area survey grid were sampled during Leg I (Survey A, Stations A01-A91) and also during Leg II (Survey D, Stations D01-D91). In addition, eight deep casts down to 2000m were conducted at a test station and at Stations A52, A87, A91, D11, D24, D52, and D91. These water samples were used for measurements described below. (2) The ship's clean water intake line from approximately 5m depth was used to monitor phytoplankton concentrations continuously during the entire cruise and also to obtain water samples for extraction of chlorophyll-a. (3) A phytoplankton net was deployed at every odd-numbered CTD/rosette station to obtain a sample of the larger phytoplankton. (4) A variety of automatic sensors, either mounted on the ship or on the rosette, were used to obtain data as described below.

(B) Measurements and Data Acquired:

(1) Photosynthetic pigments: Chlorophyll-a (chl-a) concentrations, which are used to estimate phytoplankton biomass, were measured in all water samples at the eleven depths obtained from the CTD/rosette casts and also from the ship's flow-through system at each CTD/rosette station. Chl-a concentrations were determined on samples filtered through glass fiber filters (GF/F, 25 millimeter), extracted in absolute methanol, and the fluorescence of the extract measured in a Turner Designs fluorometer. In addition, chl-a concentrations were estimated

by *in vivo* chl-a fluorescence measurements from the ship's clean seawater intake throughout the entire cruise. *In situ* chl-a fluorescence, obtained with a pulsed fluorometer attached to the rosette, was also used to estimate phytoplankton biomass throughout the upper water column.

(2) Absorption characteristics of phytoplankton: At the 24 complete stations where primary production measurements were made (12 stations each leg; the first station occurring after 0700 each day being automatically a "complete" station), water samples from 5m and 50m depth were filtered onto glass fiber filters and extracted in absolute methanol. After centrifugation of the sample, the clear supernatant was decanted into a quartz glass cuvette and the spectral absorption characteristics [250 to 750 nanometers (nm), with resolution of 0.5nm] were determined with a Shimadzu spectrophotometer, with the data being recorded directly on to a computer. The concentrations of the various photosynthetic pigments, as well as concentrations of UV-absorbing compounds, were determined by this technique and will be used to evaluate the photoadaptational state of the phytoplankton. The optical density measurements made on these extracts were also used to validate the equation used to calculate chl-a concentrations from fluorescence measurements of extracted samples.

(3) Biomass and organic carbon concentrations: The following measurements were made to determine phytoplankton biomass in terms of organic carbon content: (a) At the complete stations, water samples from 5m depth were filtered through combusted GF/F glass fiber filters for determination of POC and PON, which will be done by gas chromatographic techniques at SIO. (b) Data on particulate beam attenuation coefficients (c_p) will be used to estimate POC by use of an algorithm that was developed from data previously obtained in the AMLR program. The c_p values were acquired from two transmissometers, one attached to the CTD/rosette unit for obtaining continuous variation of c_p with depth, and the other connected to the ship's clean intake line to provide data at 5m depth throughout the entire cruise. (c) Chl-a concentrations were used to estimate total phytoplankton organic carbon throughout the euphotic zone by applying equations developed previously from our AMLR data. (d) Approximately 100 water samples were preserved with buffered formalin for later determination of phytoplankton cell numbers, sizes and shapes, from which total cellular volumes and organic carbon can be estimated.

(4) Phytoplankton cell size and species composition: The following samples were obtained at every CTD/rosette station: (a) Samples from 5m depth were filtered through Nitex nylon mesh with 20 micrometer (μm) pore size to obtain a suspension of the nanoplankton, defined as cells having a mean cellular diameter of $<20\mu$m. Measurement of chl-a in the original water sample and in the fractionated sample provides an estimate of the relative abundances of nanoplankton ($<20\mu$m) and microplankton ($>20\mu$m) sized phytoplankton. (b) At every other station water samples from 5m depth were preserved with borate-buffered formalin (final concentration of 1%) for identification and quantification of phytoplankton species; at all complete stations samples for microscopic examination were taken at 5, 20, 50, and 100m. Inverted microscope techniques were used to determine species composition, cell numbers, and cell volumes in these preserved samples. (c) A plankton net with 15μm mesh size was deployed (horizontal tow, 5 minutes) at 46 stations during each leg to obtain a sample of the larger microplankton for floristic examination.

(5) Rate of primary production: Water samples, obtained from eight depths (from 5 to 75m) at all 24 complete CTD/rosette stations, were poured into 50 milliliter (ml) polycarbonate screw-cap tubes and inoculated with 5 microcuries (μCi) of ^{14}C-labeled bicarbonate. Duplicate tubes were used for each depth, in addition to one tube with water from 5m and one from 75m which were kept in darkness. 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 tubes were exposed to solar radiation for 6-10 hours in the incubators mounted on the helopad; flowing surface seawater was used for temperature control. The irradiance incident upon the samples varied from 95% to 0.5% of incident solar radiation. Data from these experiments will be used to calculate the rates of primary production occurring in the AMLR study area.

(6) Photoadaptational state of the phytoplankton: Simultaneous with the primary production measurements, water samples from 5 and 50m were treated in a similar fashion except that replicate water samples from each of these two depths were exposed to the eight different irradiances (95 to 0.5% of incident solar radiation). These data will be used to determine the Photosynthesis-Irradiance (P-I) characteristics of the phytoplankton at 5 and 50m, which will be indicative of the rate of mixing in the upper water column. The relative concentrations of photosynthetic pigments, as well as UV-absorbing compounds as determined in the spectrophotometer, will also be used to estimate the mean irradiance the phytoplankton have been exposed to *in situ*, which will be related to the rate of physical mixing processes in the upper water column.

(7) Inorganic nutrients: Water samples for measurement of nitrite, nitrate, phosphate and silicic acid were taken from 5m depth at every odd-numbered station in the survey grid. In addition, nutrient samples were collected at six depths (5, 20, 50, 100, 400, 750m) at all stations in two north-south lines (Stations 25-34 and 76-83), and at eleven depths (down to 2000m) at the seven stations where the CTD/rosette was deployed to 2000m. All nutrient samples were frozen (-20°C) until later analysis using an autoanalyzer at the Universidad Católica de Valparaíso, Chile.

(8) Dissolved oxygen: Concentrations of dissolved oxygen were determined in water samples from 5 and 75m (nine stations on Leg I, 20 stations on Leg II), and also from eight depths (from 5 to 2000m) at four of the deep stations. These oxygen determinations were made by the standard Winkler titration procedure and were done to calibrate the data from the oxygen sensor on the rosette system.

(9) Solar radiation measurements: The following data on incident solar radiation were collected throughout the entire cruise: (a) continuous recording (every minute) of Photosynthetic Available Radiation (PAR) using a 2-pi sensor, which was mounted in a shade-free location on the ship's superstructure; (b) attenuation of solar radiation in the water column at all daytime CTD/rosette stations with a PAR sensor (cosine response), which was mounted on the rosette.

2.3 Results and Tentative Conclusions:

(A) Phytoplankton distributions at 5m depth throughout the AMLR study area, as indicated by chl-a concentrations [milligrams chl-a per cubic meter (mg m^{-3})], are shown for Legs I and II in Figure 2.1. The patterns of phytoplankton distribution during both legs were quite similar, but there was a noticeable increase of phytoplankton biomass from Leg I to Leg II. The richest phytoplankton regions were found to the south, southwest, and east of Elephant Island, and also to the north of Elephant Island in the region of the continental shelf-break. These phytoplankton-rich areas were found mostly in waters of Bransfield Strait origin or in transitional water types involving a mixture of Bransfield Strait water with other water types. The lowest phytoplankton concentrations were found in the northwest portion of the survey grid, which encompasses approximately 20 stations. This low production region corresponded to the presence of Drake Passage waters (see "Physical oceanography" report).

(B) Phytoplankton distribution as indicated by integrated chl-a values (0-100m) throughout the large-area survey grid was quite similar to the pattern shown by chl-a concentrations in surface waters (Figure 2.2). Data in Figure 2.2 show that: (1) Integrated chl-a concentrations in the upper 100m of the water column in Drake Passage waters were very low [between 15 to 40 milligrams of chl-a per square meter (mg m^{-2})]. (2) The greatest phytoplankton concentrations were found to the south and east of Elephant Island, with values commonly exceeding 200mg m^{-2}. (3) The phytoplankton biomass in the confluence of Drake Passage and Bransfield Strait waters had intermediate values of integrated chl-a (generally between 50 to 100mg m^{-2}). (4) Integrated concentrations of chl-a also indicated a substantial increase of phytoplankton biomass from Leg I to Leg II.

(C) The mean chl-a concentrations at 5m depth throughout the study area during Legs I and II were 1.4 and 2.3mg m^{-3}, respectively, with the mean for both legs being 1.9mg m^{-3}. The unusually high standing stock of phytoplankton found during both legs this year, as well as during Leg II of 1994, can be seen when the above mean values are compared with the overall mean chl-a concentration (0.7mg m^{-3}) found in surface waters during the four AMLR field seasons from 1990 through 1993. The mean integrated values (0 to 100m) for chl-a during Legs I and II were 76 and 114mg m^{-2}, respectively, with the overall mean for the field season being 95mg m^{-2}.

(D) Vertical sections showing both *in vivo* fluorescence and chl-a concentrations in a north-south transect within the survey grid (Stations A25-A34) are shown in Figure 2.3. The distribution of chl-a in these two sections is supportive of the observations stated above, showing the presence of rich phytoplankton concentrations down to at least 50m depth in the southern portion of the survey grid. The northern stations in the transect had low phytoplankton concentrations in the upper 40m of the water column and higher concentrations between 50 to 100m. This distribution of phytoplankton in deep pelagic waters north of Elephant island may be related to a physiological limitation by iron or some other essential micro-nutrient in the upper 50m of the water column.

(E) Preliminary analysis of our chl-a data throughout the large-area survey grid shows that the concentration and distribution of phytoplankton biomass (which is directly related to the rate of primary production) with depth in the water column was strongly correlated with the different water masses found in the study area and in the profile of water column stability. Representative examples from specific stations are shown in Figures 2.4 to 2.7. Data in Figure 2.4 show the usual distributional pattern of chl-a with depth at stations influenced by Bransfield Strait waters (Station D19, for example). It is seen that there was a deep and stable (50m) upper mixed layer (UML) in which chl-a was fairly uniformly distributed. Data from the transmissometer also show that particles absorbing visible light were uniformly distributed throughout the UML, indicating that there was considerable vertical mixing occurring within the UML. Stations with this kind of physical and biological structure commonly have high integrated biomass.

A contrasting situation is seen by the data from Station D40 in Drake Passage waters (Figure 2.5). Although there was a well developed UML, chl-a concentrations were very low within the UML. Concentrations increased with depth and there was a chl-a maximum somewhere between 40 to 80m depth. Such sub-surface chl-a maxima were in general associated with the temperature minimum of the Antarctic surface winter water. This increase of phytoplankton biomass with depth is also shown by the transmissometer data and the rate of attenuation of solar radiation with depth in the water column. The light attenuation curve shows: (1) the normal curvature in the upper 10m due to spectral attenuation of the longer red wavelengths by water molecules; (2) relatively low attenuation between 10 to 40m; (3) increased attenuation between 40 to 80m; and (4) lower attenuation rates below 80m. Drake Passage waters with this pattern of physical and biological structure show the lowest phytoplankton populations and the lowest rates of primary production within the AMLR study area.

Intermediate between the two examples cited above, some stations (for example, Station D88) do not show a well defined UML, but rather a profile of progressively increasing water density with depth (Figure 2.6). At such stations, chl-a concentrations are usually highest close to the surface and decrease fairly rapidly with depth. The curves showing the attenuation of solar radiation with depth and showing the percent transmission of a collimated beam of light (transmissometer data) both are in good agreement with the *in situ* chl-a fluorescence data as well as the values of extracted chl-a. Such stations generally have intermediate values for integrated chl-a concentrations.

At some stations in the eastern portion of the survey grid which are strongly influenced by Weddell Sea water (for example, Station D68), there is very little change in water density within the upper 100m, with the result that the water column is easily mixed to considerable depths (Figure 2.7). Chl-a concentrations at these stations tend to be fairly low in surface waters but do not decrease much down to a depth of 100m or more, with the result that the integrated phytoplankton biomass may be fairly high.

(F) Data from this cruise show a dramatic increase of phytoplankton biomass from Leg I to Leg II. As the time of Leg II is approximately two months beyond the summer solstice

(December 21), it is surprising to find increased phytoplankton biomass under conditions of declining solar radiation. The most likely explanations for this finding are related either to changes in the grazing pressure exerted by the zooplankton populations or better growing conditions for phytoplankton as a result of changes in the depth and stability of the upper mixed layer of the water column. Analysis of all the data from the various scientific groups during this AMLR field season should help resolve this question as to the processes causing such dramatic seasonal changes in phytoplankton abundance and distribution.

2.4 Disposition of the Samples and Data: The nutrient samples will be processed at the Universidad Católica de Valparaíso (Chile). All other samples (for radiocarbon measurements, CHN analysis, floristic determinations) will be returned to SIO for processing. All data obtained during the cruise have been stored on duplicate 90 Mbyte Bernoulli disks. After compilation of the final datasets, a copy of all data will be deposited with the AERG office in La Jolla, CA. Copies of any of our datasets are available to all other AMLR investigators upon request to OHH.

2.5 Problems and Suggestions: All shipboard operations proceeded very well throughout both legs, without any loss of equipment. From the perspective of phytoplankton ecology, it would be desirable to have some stations or transects extending eastward toward the Weddell Sea and also two transects in the Bransfield Strait to the south of the survey grid (one across the Strait and one approximately down the middle region of the Strait). An extension of the survey grid would either require more ship time or deletion of some of the 91 stations. In regard to phytoplankton studies, it seems that we could delete a significant number of the present stations and not lose much understanding of the distribution and abundance of phytoplankton within the survey grid. This would be one way to free some time to extend the present boundaries of the study area. It is recognized, however, that this might not be a desirable option for some of the other scientific groups on board ship.

2.6 Acknowledgments: We want to express our appreciation to all officers and crew of the NOAA Ship *Surveyor* for their generous and valuable help during the entire cruise. We also thank all other AMLR personnel for help and support which was essential to the success of our program, with particular mention of the Physical Oceanography group and the Electronic Technicians who meshed some of our instruments and sensors with their data acquisition systems.

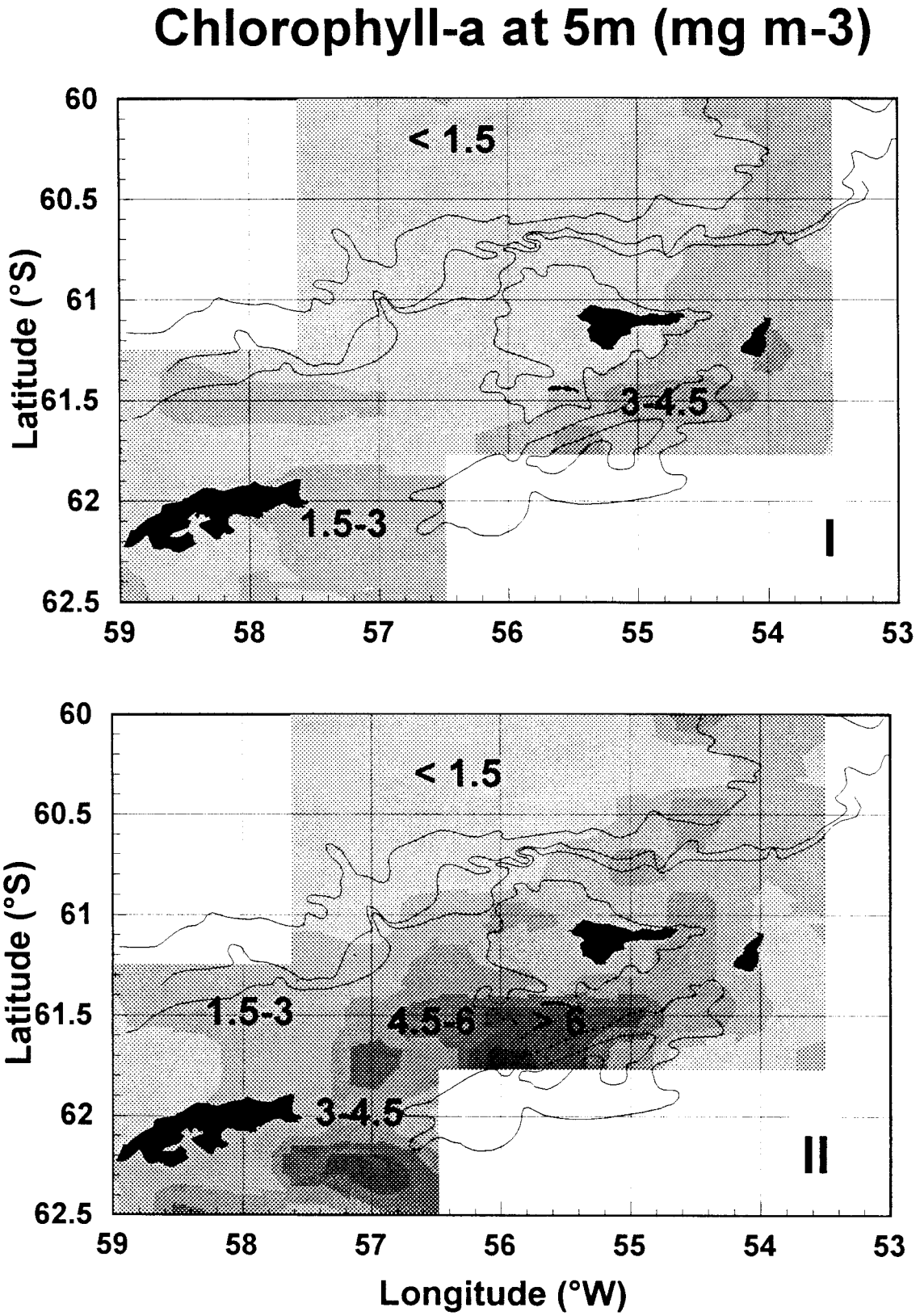


Figure 2.1 Distribution of chl-a concentrations (mg m^{-3}) at approximately 5m depth throughout the large-area survey grid. (I) Survey A, Leg I. (II) Survey D, Leg II.

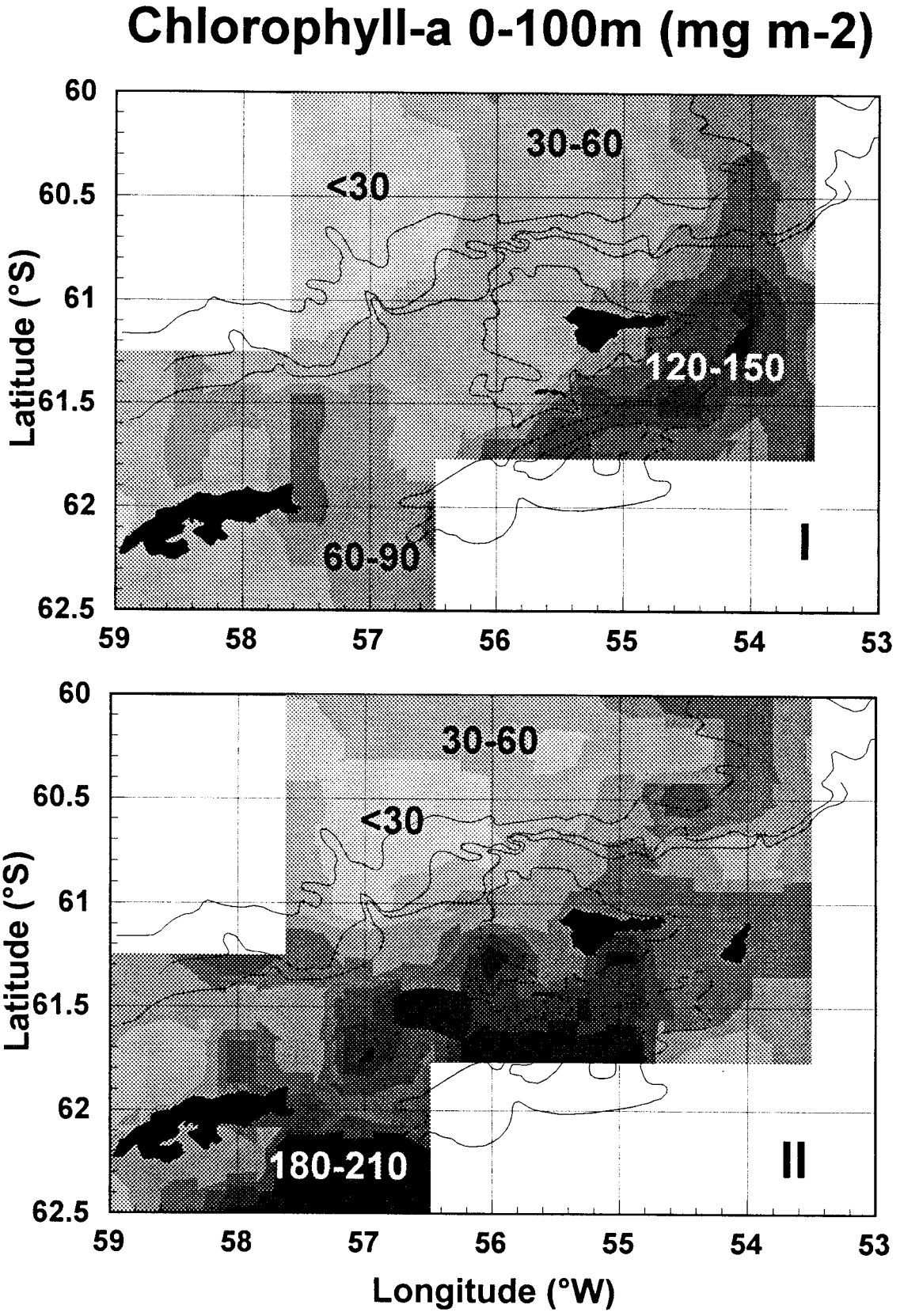


Figure 2.2 Distribution of integrated chl-a concentrations (mg m^{-2}, 0 to 100m) throughout the large-area survey grid. (I) Survey A, Leg I. (II) Survey D, Leg II.

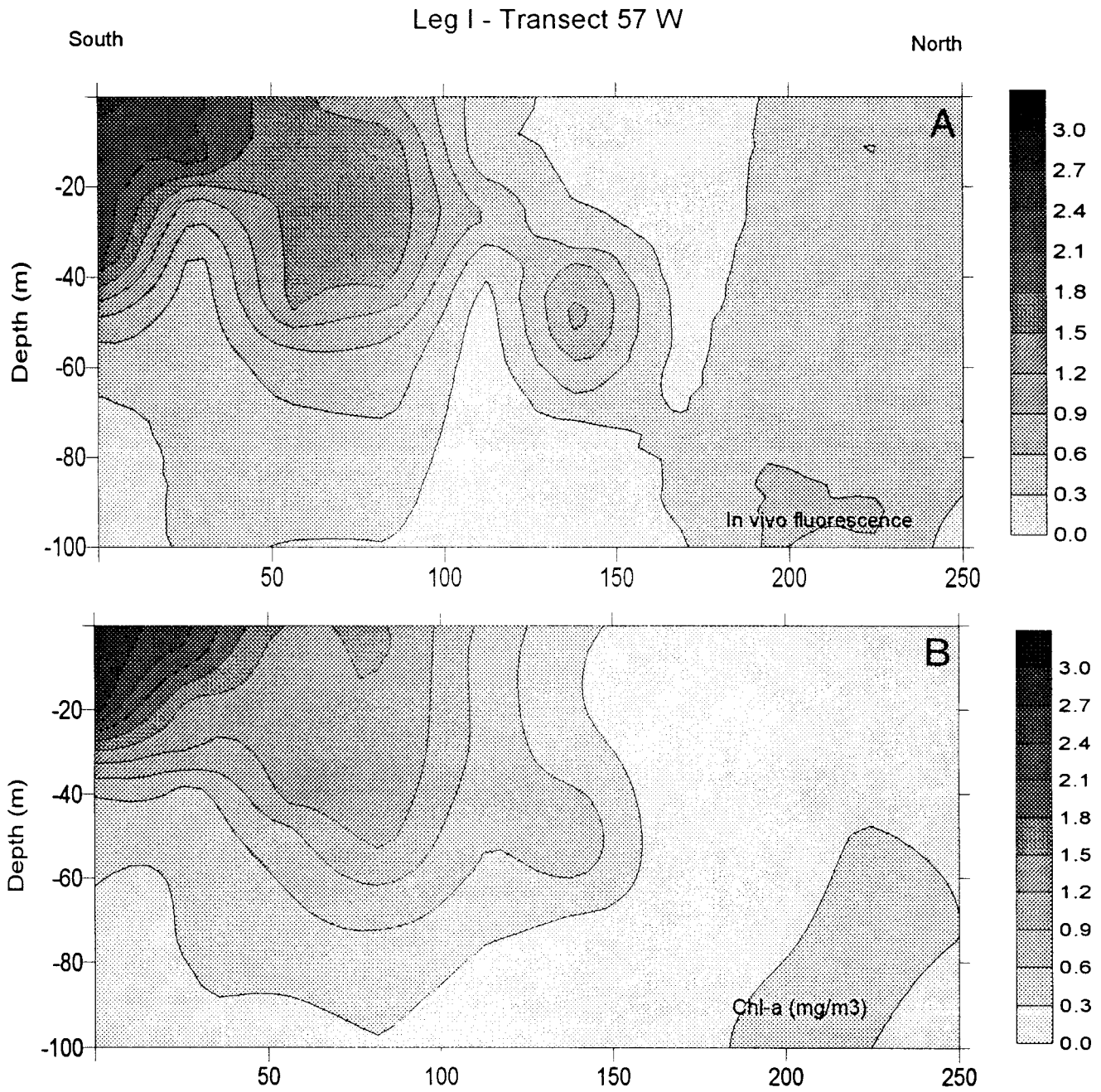


Figure 2.3 Distribution of chl-a concentrations in the upper 100m of the water column in a vertical north-south transect along 57°W (Stations A25 to A34). (A) Gradients of chl-a concentrations as indicated by the *in vivo* fluorescence of chl-a measured with a pulsed fluorometer (scale is in volts). (B) Chl-a concentrations (mg m^{-3}) determined on methanol extracts of filtered particulate material.

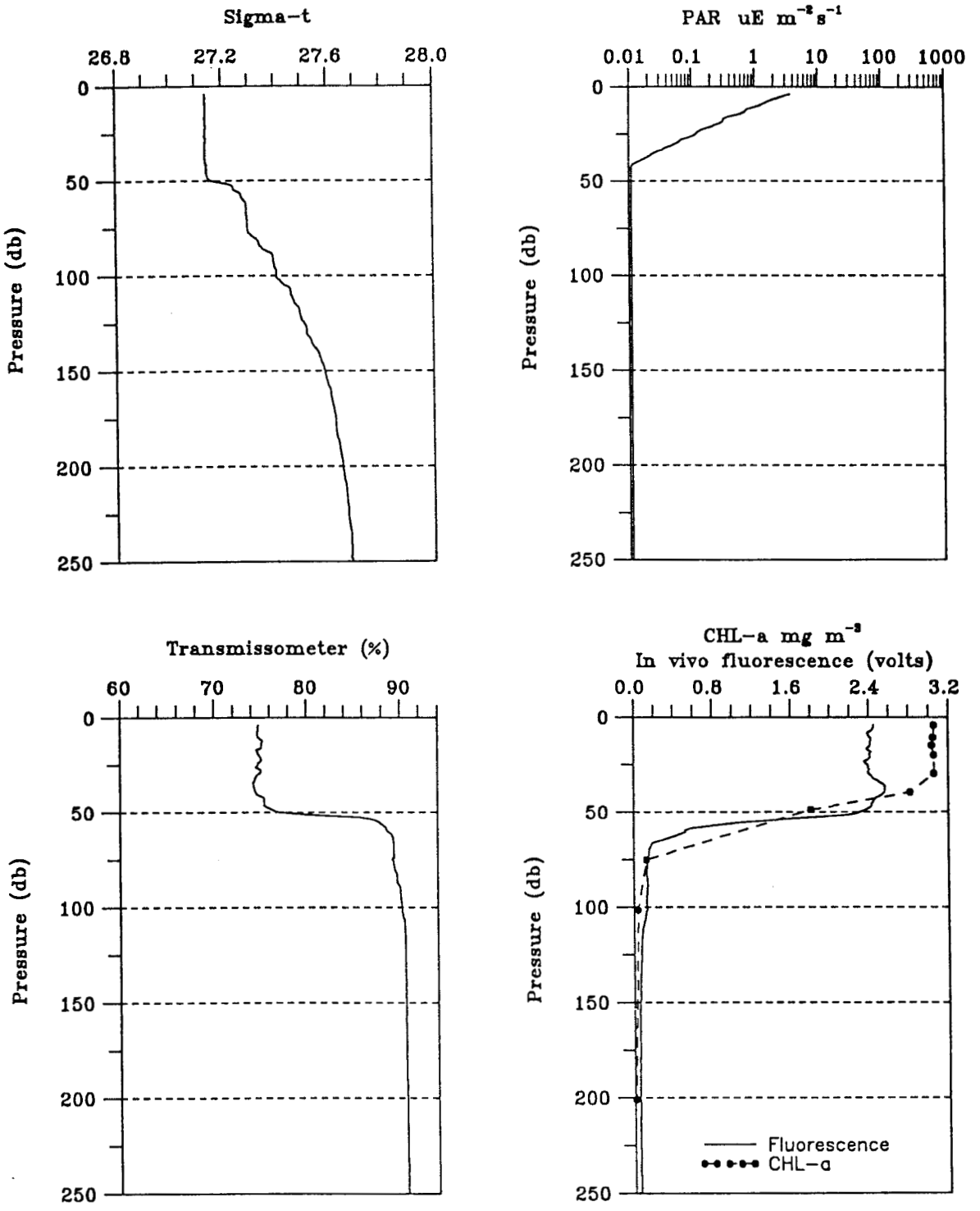


Figure 2.4 Upper water column characteristics (0 to 250m) for water density (sigma-t), attenuation of solar irrradiance, percent transmission of light, and *in vivo* fluorescence (continuous line) and extracted chl-a concentrations at Station D19 in Bransfield Strait waters. Note that solar radiation was low because the CTD/rosette cast was done at 19:00 hour.

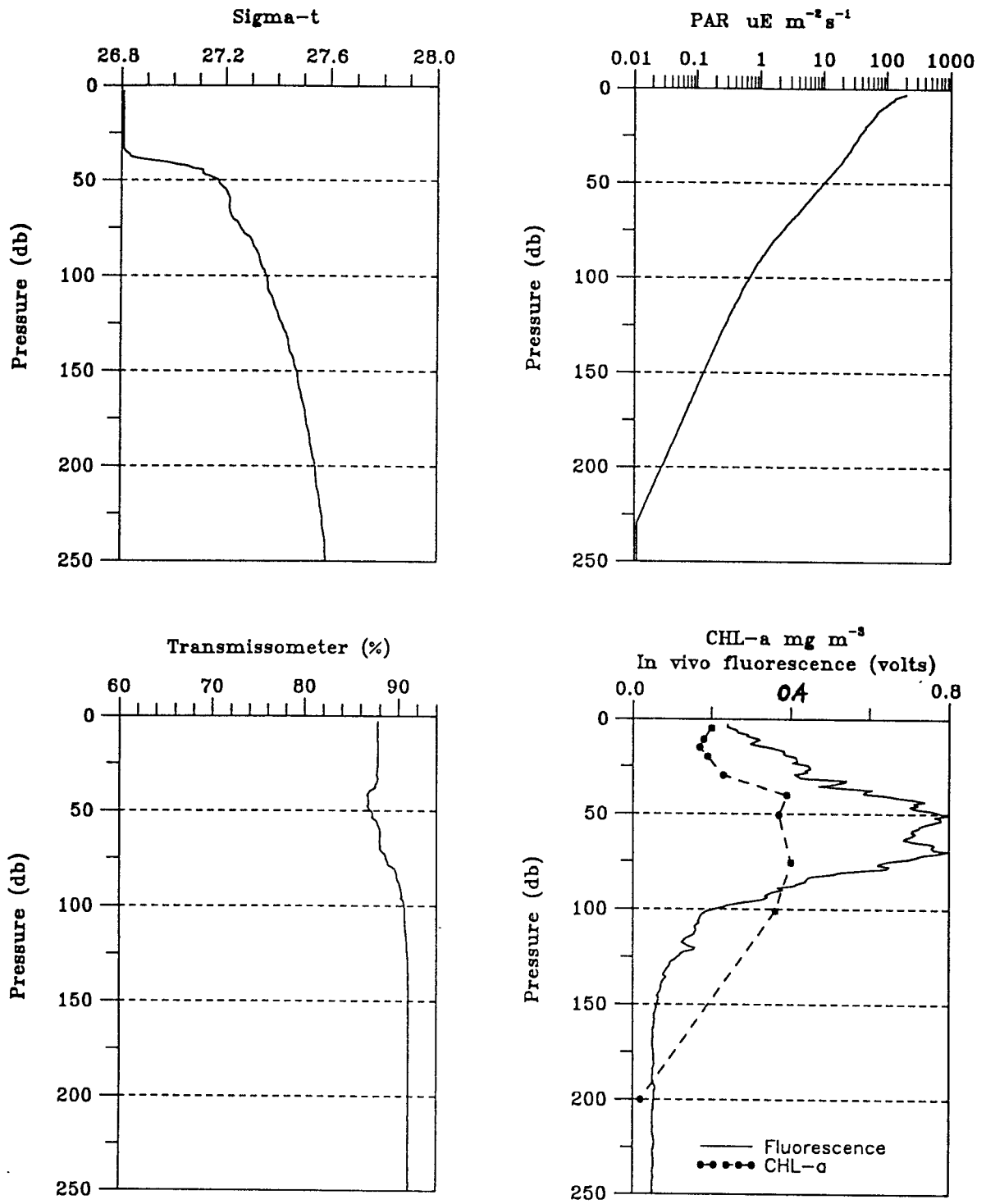


Figure 2.5 Upper water column characteristics (0 to 250m) for water density (sigma-t), attenuation of solar irradiance, percent transmission of light, and *in vivo* fluorescence (continuous line) and extracted chl-a concentrations at Station D40 in Drake Passage waters.

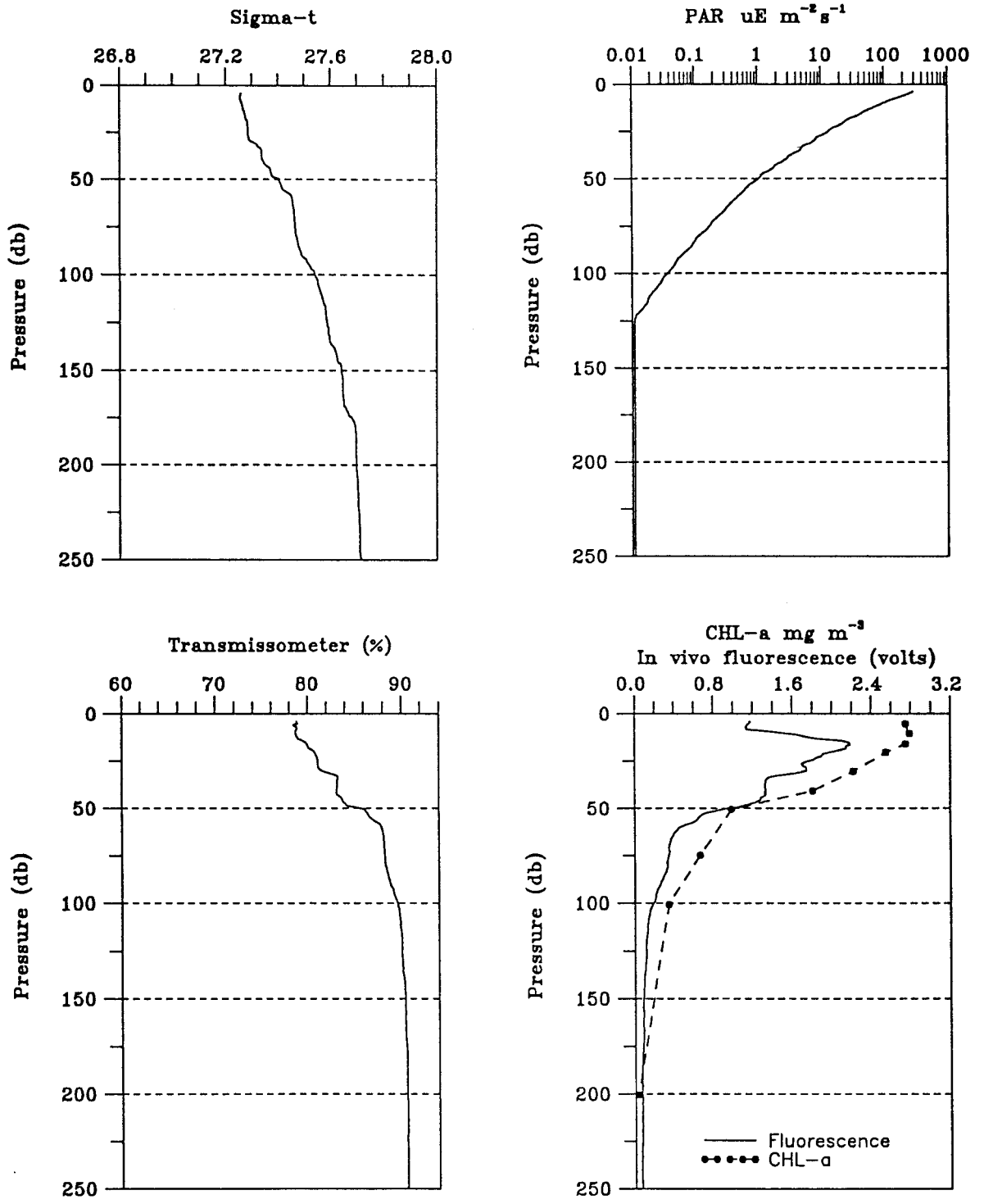


Figure 2.6 Upper water column characteristics (0 to 250m) for water density (sigma-t), attenuation of solar irradiance, percent transmission of light, and *in vivo* fluorescence (continuous line) and extracted chl-a concentrations at Station D88 in the eastern portion of the survey grid, which is influenced by waters from the Bransfield Strait and the Weddell Sea. Note that the decrease of *in vivo* fluorescence of chl-a in the upper 15m is due to photoinhibition of chl-a fluorescence from high solar irradiance and does not indicate an actual decrease in chl-a concentrations. The CTD/rosette cast was at 15:00, when incident solar irradiance was approximately 1000μEinsteins m^{-2} $second^{-1}$.

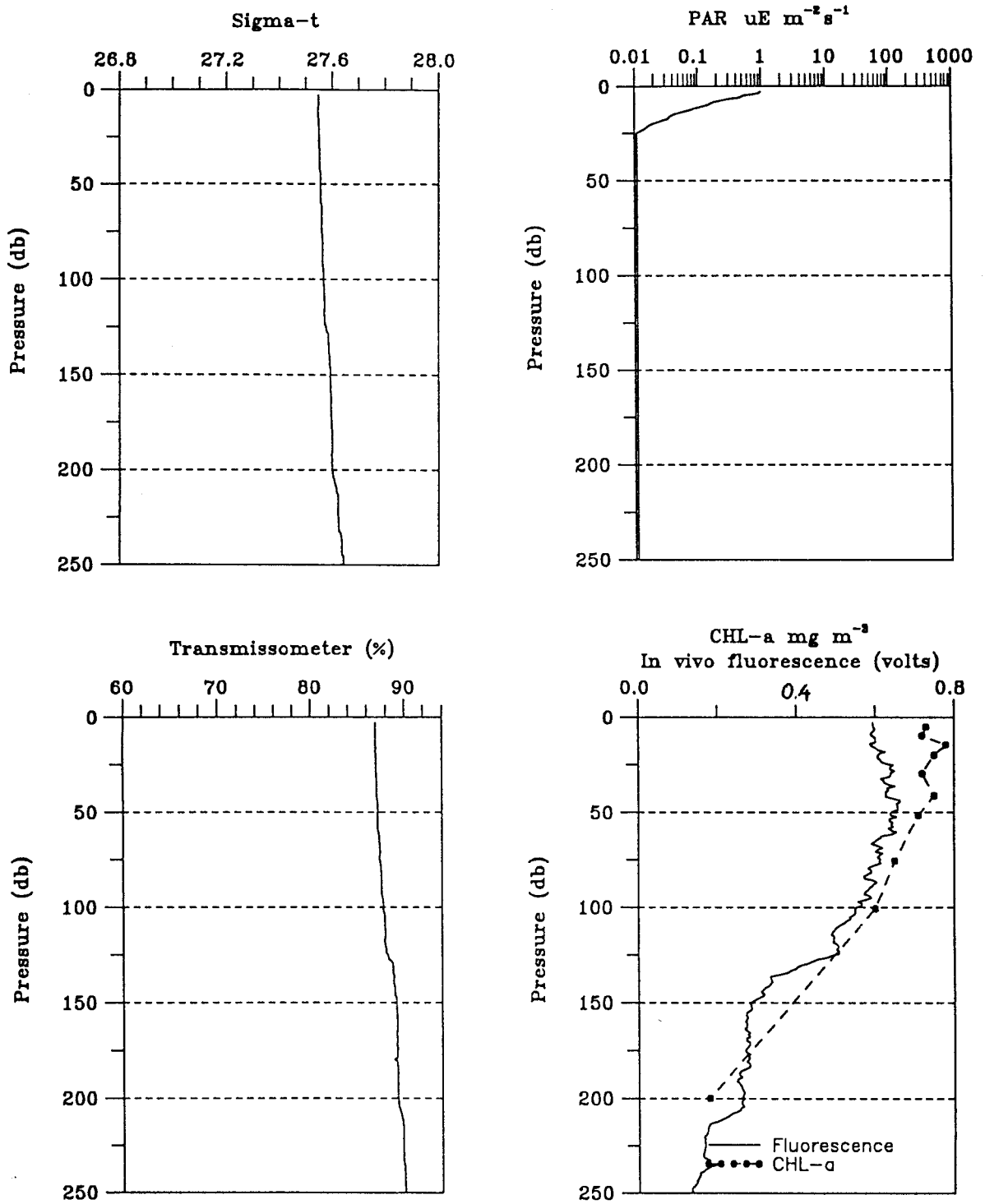


Figure 2.7 Upper water column characteristics (0 to 250m) for water density (sigma-t), attenuation of solar irradiance, percent transmission of light, and *in vivo* fluorescence (continuous line) and extracted chl-a concentrations at Station D68 in the southeastern portion of the survey grid, which is strongly influenced by Weddell Sea water.

3. Bioacoustic survey; submitted by David Demer (Leg I), Roger Hewitt (Legs I and II), Mark Prowse (Leg II), Jane Rosenberg (Leg I), Scott Rumsey (Leg I), and Stephanie Sexton (Leg II).

3.1 Objectives: The primary objectives of the bioacoustic survey were to map the meso-scale and micro-scale distributions of Antarctic krill (*Euphausia superba*) in the vicinity of Elephant Island, estimate their biomass, and determine their association with predators, bathymetry, and water masses. Secondary goals included the measurement of target strength (TS) and other scattering characteristics of macro-zooplankton and fish, and to estimate krill flux.

3.2 Methods and Accomplishments:

Equipment: An echo integration system was used to map krill distributions and to quantify their abundances. The system was comprised of a Simrad EK500 echosounder outfitted with two transceiver/transducer subsystems, two Sun SparcStations (SS 10 and SS 1+) for data logging and postprocessing, the ship's MX200 GPS receiver, and an Ethernet communication link. The 120 and 200kHz transducers were hull-mounted in a down-looking configuration at a depth of approximately 5m. Both transducers were narrow beam with 7 degrees between half-power points. Pulses were transmitted once per second at 1 kilowatt (kW) for 0.3 milliseconds (ms) (120kHz) and 0.6ms duration (200kHz). Geographic positions were logged every 60 seconds. The insonified volumes were roughly conical and sampled to a depth of 250m. The UNIX workstations were used for postprocessing, including echo-integration, TS analyses, and contour mapping. The high volume acoustic data were processed and stored on 8.0 Gbyte digital audio tapes (DAT). The Ingres database and PC files were backed-up to 650 Mbyte magneto-optical disks.

System Calibrations: The acoustic system was calibrated at the beginning (January 15) and at the end (February 26) of the field season in Martel Inlet, Admiralty Bay, King George Island. Two copper spheres, 23.0mm (TS = -40.4 dB) and 13.7mm (TS = -45.0 dB), were used to calibrate the 120 and 200kHz subsystems, respectively. The spheres were positioned beneath the ship via outriggers and monofilament line. The beam pattern was mapped for the 120kHz transducer and system gains were determined for both the 120 and 200kHz transducers. The drift in system gains for measurements of TS and volume backscattering strength (S_V) was less than 0.8 dB for both frequencies.

Admiralty Bay Surveys: Immediately following the pre-survey calibration, a collaborative 24-hour predator/prey survey (Survey AB1) was conducted in Admiralty Bay, King George Island during January 15-16. Shipboard, the distribution, abundance, and demography of krill were measured using the down-looking acoustic system and the IKMT. Concurrently, on the island, Dr. Wayne Trivelpiece studied the foraging behavior and reproductive performance of Adelie penguins using time-depth recorders and lavage techniques. An abbreviated version of this predator/prey survey (Survey AB2) was conducted February 26-27.

Large-Area Surveys: Survey A (January 16-29) and Survey D (February 15-27) were conducted to map the macro-scale distribution and abundance of krill. The surveys were roughly 15,000 n.mi.^{2} centered between Elephant and King George Islands. They were each comprised of 12 north-south transect lines, averaging approximately 105 n.mi. in length, with 15 n.mi. separating each line. Each station, also spaced 15 n.mi. apart, included a CTD/rosette cast and an IKMT. Measurements of S_V were recorded between each of the 91 stations with breaks only for CTD/rosette stations. These data were integrated from 10 to 250m in depth and averaged over 0.1 n.mi. trackline increments. The resulting data were proportional to numerical krill densities. Additionally, in-situ TS measurements of individual zooplankton were made during each IKMT. These data will be used to develop or enhance TS models for various macro-zooplankton and nekton. In turn, the models will be used to refine the proportionality constant for krill biomass estimations.

Small-Area Surveys: Two small-area surveys, Survey B (January 29-February 1) and Survey C (February 11-15), were conducted to the north of Elephant Island. The survey grids consisted of twelve north-south transect lines, each approximately 35 n.mi. long with 5 n.mi. separations. The purpose of these surveys was to better define the fine-scale distributional patterns of krill within the foraging range of krill predators (penguins and seals) residing on Seal Island. To identify the various acoustic scatterers, the surveys were both complemented with directed sampling, conducted during hours of darkness (2100-0300).

At the end of Leg II, an acoustic survey (Survey E, February 28-March 1) was conducted along the shelf-break north and west of Elephant Island. The survey design was a zigzag pattern with transects oriented across the shelf and extending from the 100m isobath to the 500m isobath. The purpose of this survey was to map the extent of near shore post-spawning aggregations of krill. Two standard IKMT tows were conducted during the survey to confirm the size and maturity stage of the krill.

Drifters: The flow rate and circulation patterns of the surface waters were monitored using three drogued buoys. The buoy location and corresponding sea surface temperatures (SST) were logged via satellite. The buoys were deployed at Stations A27 (0746Z on January 20), A31 (2153Z on January 20), and A34 (0651Z on January 21) to the west of the study area. Assuming krill are planktonic, their maximum flux (or rate of movement through the survey area) was inferred from these measurements. A second series of three drifter buoys was deployed at equally spaced intervals while crossing the Drake Passage at the end of Leg II.

3.3 Tentative Conclusions:

Admiralty Bay Surveys: The acoustic and IKMT data indicated sparsely distributed but densely aggregated swarms of juvenile krill, generally residing at depths of 60 and 110m (Figure 3.1). Krill length-frequency distributions from the IKMT tows indicated that the krill in the area were comprised of two modal size classes centered around 26 and 44mm. However, the lavage samples clearly indicated that the penguins were selectively feeding on the larger krill (see "Direct krill and zooplankton sampling" report).

Large-Area Surveys: During Survey A, acoustic scattering layers were recorded over virtually the entire survey area. A topographic map of integrated volume backscattering strength [meter squared per nautical mile squared ($m^2/n.mi.^2$)] indicated a band of moderate to high density extending from the eastern end of King George Island to the area north of Elephant Island (Figure 3.2). High levels of integrated volume backscattering strength were also mapped between land and the 200m depth contour north of Elephant Island, and in the vicinity of Clarence Island.

Three different echogram morphologies contributed to the majority of the scatter, indicated by differences in patchiness and apparent densities: (1) very dense discrete swarms were commonly found at depths from 80 to 120m; (2) one or more thin layers were frequently located just above the thermocline with densities increasing towards the south and east of Elephant Island; and (3) a disperse scattering layer was encountered between 150m and 250m over a large portion of the area north of Elephant Island.

Directed sampling and TS analyses were conducted to identify the scattering types and to delineate the integrated echo energy. Net catches confirmed dense aggregations of juvenile krill in the Bransfield Strait, to the southwest of King George Island. Relatively dispersed layers of large adult krill (40-55mm) were recorded in the areas to the west and northwest of Elephant Island. The layered assemblages appeared to be residing at the depth of a shallow thermocline (25-60m). IKMT trawls through the deep scattering layer consistently identified these scatterers to be two species of Myctophidae (*Electrona antarctica* and *Gymnoscopelus opisthopteris*). The myctophid layers exhibited a diel vertical migration pattern, rising in the water column during darkness. Although their scattering characteristics have not been identified, the euphausiid *Thysanoessa macrura*, three species of pteropods, and the polychaete *Tomopteris carpenteri* may have also contributed minor scatter.

During Survey D, a band of moderate to high integrated volume backscattering strength ($m^2/n.mi.^2$) was again apparent extending from the southwest to the northeast along the northern side of the South Shetland Islands (Figure 3.3). Dense discrete krill swarms were common throughout the eastern portion of the study area, while diffuse scattering layers were more often encountered in the offshore waters north of Elephant Island. Dense swarms were again encountered within 30km of the north and south shores of Elephant Island and north of King George Island. Krill densities were much higher over the eastern one third of the study area than the western two thirds. Estimated krill and myctophid densities during Survey D were reduced from those observed in January.

The IKMT samples contained relatively few krill in the eastern portion of the survey area. These krill were predominantly large mature forms ranging from 45-55mm in length. Unlike Leg I, virtually no juveniles or immature stages were encountered. Net-clogging phytoplankton, restricted to the northwest portion of the January survey area on Leg I, were found further to the east during Leg II, extending from Drake Passage towards Elephant Island (see "Direct krill and zooplankton sampling" report for more details).

Salps occurred in moderate concentrations to the south of Elephant Island in association with Weddell Sea water, but their distribution was not as extensive as during the previous two years. Salps occurred in moderate concentrations in the Bransfield Strait to the south and west of Elephant Island and to the north and northwest of Elephant Island. Their mean abundance was over two orders of magnitude less than in 1993 and 1994, and one order of magnitude less than in 1992. Also in contrast to previous years, these salps were predominantly small solitary forms (cf. aggregate forms) of 15-30mm internal body lengths. Two euphausiid taxa, *Thysanoessa macrura* and *Euphausia frigida*, as well as three species of pteropods and the polychaete worm *Tomopteris carpenteri*, may have also contributed some scatter.

Small-Area Surveys: Integrated volume backscattering strength ($m^2/n.mi.^2$) was interpolated for both small-area surveys and plotted topographically (Figures 3.4 and 3.5). Apparent on both maps are areas of high krill density in the shoal waters to the north of Elephant Island and in deeper water near sub-surface seamounts, northeast of Elephant Island. These areas of high krill density are within 10km of colonies of breeding penguins on Seal Island and 25km of colonies on the northeastern shore of Elephant Island. Further offshore, bands of high krill density appear to be extending into the survey area from the southwest.

During Surveys B and C, average densities were three to four times higher than those observed during the same time in 1994. Primary scatterers were identified through IKMT sampling as both adult and juvenile krill aggregations, as well as myctophid fish.

At the end of Leg II, post-spawning adult krill were mapped over the shelf-break immediately north of Elephant Island. Densities were higher between Seal Island and the eastern extension of Elephant Island that they were to the west of Elephant Island.

Drifters: The drift tracks of three barometer/SST drifters were compared with the computed geostrophic flow for Leg I (see "Physical oceanography" report). The drifter released in the Drake Passage Water (Station A27) moved in a meandering fashion at a mean speed of 0.4 knots. Drifters released between King George and Elephant Islands (Station A31) and in the Bransfield Strait (Station A34) moved in a more linear fashion from southwest to northeast at 0.3 and 0.2 knots, respectively.

The presence of eddies was indicated by the doubling back of the buoys on an otherwise northeasterly drift. Geostrophic currents, calculated from the CTD data, verified the presence of two eddies located in the northwest corner of the grid and southwest of Clarence Island. Similar flow patterns have been recorded during previous seasons, indicating that eddies are quasi-permanent features of the circulation.

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 David Demer, Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037; phone/fax - (619) 546-5603/7003; ddemer@ucsd.edu.

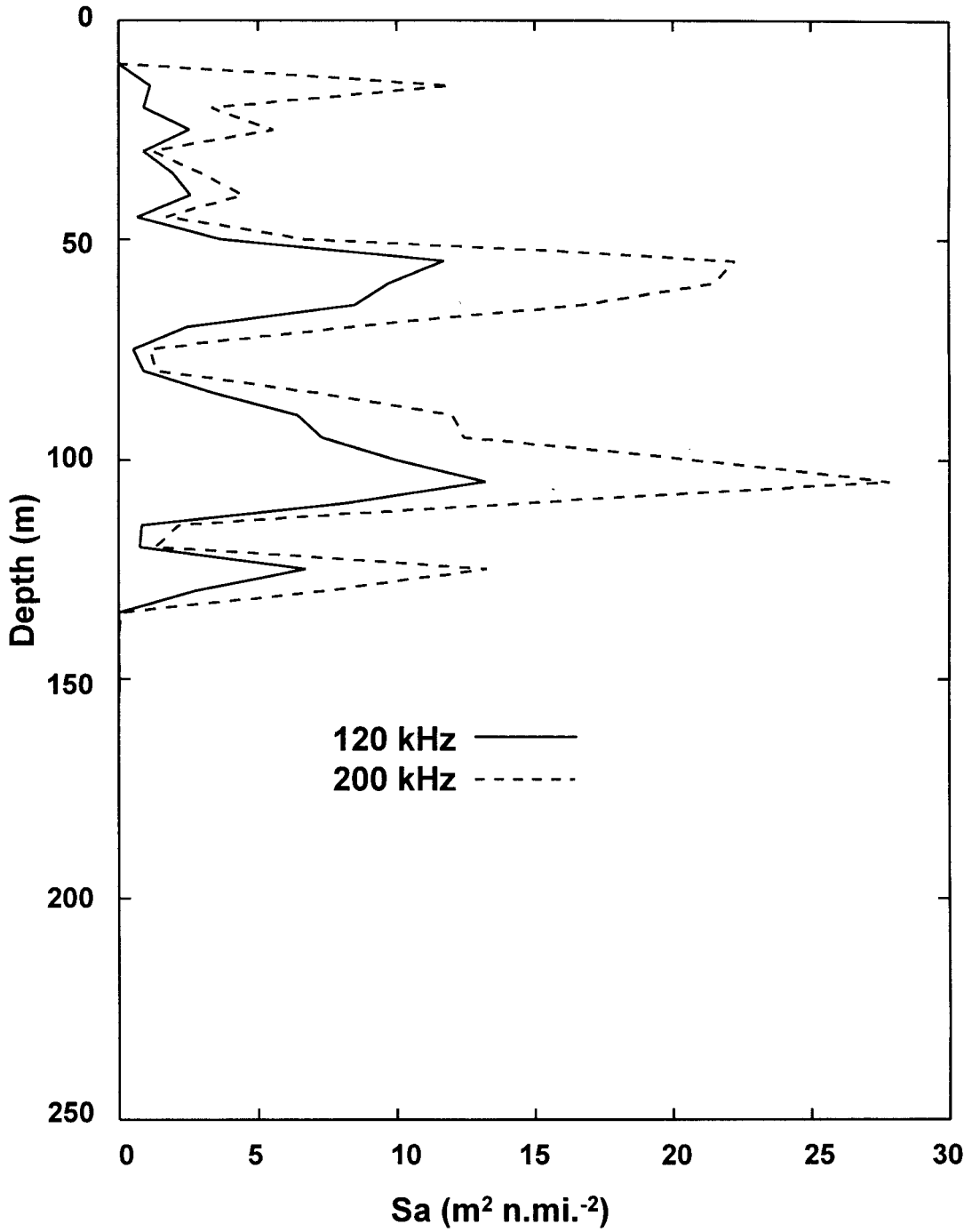


Figure 3.1 Admiralty Bay Survey AB1; vertical depth distribution of average volume backscattering strength integrated over 5m depth intervals (Sa) in units of m^2 of backscattering strength per $n.mi.^2$ of sea surface area.

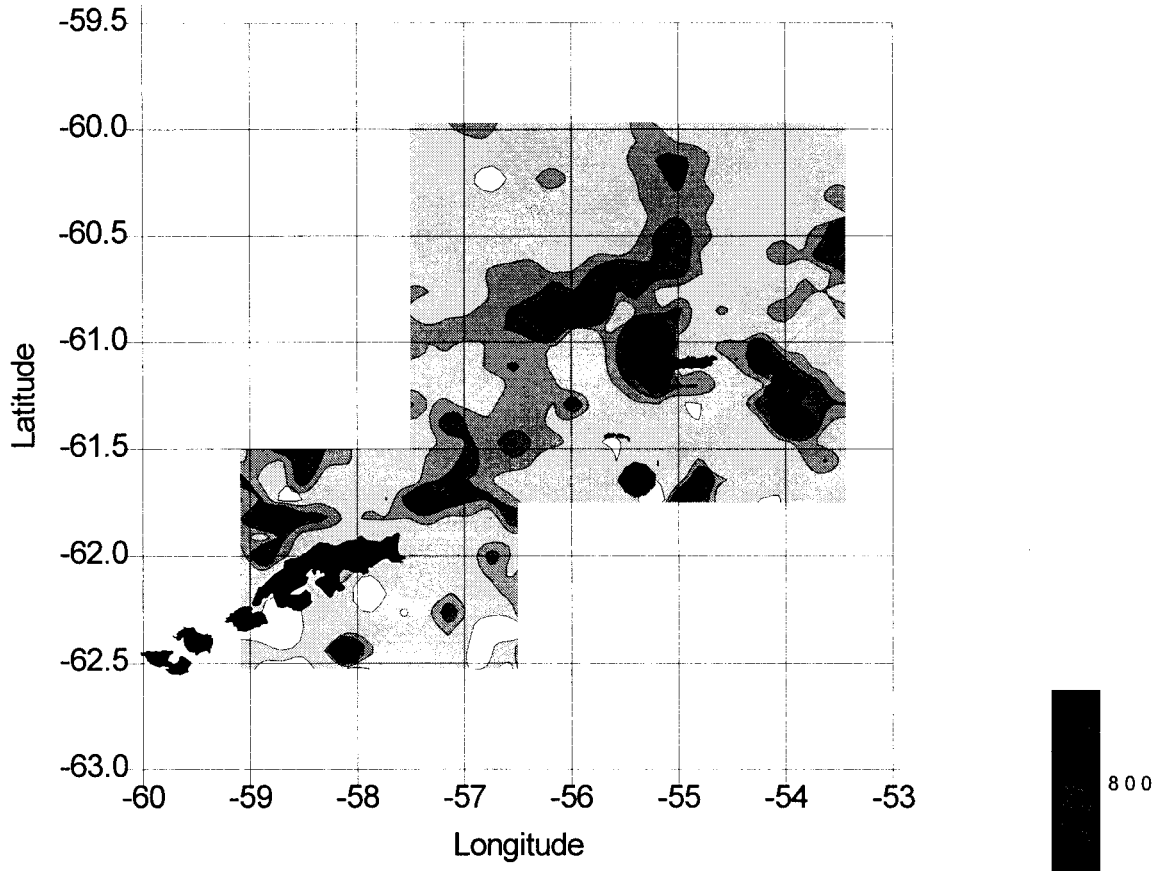


Figure 3.2 Distribution of integrated volume backscattering strength during Survey A (January 16-29).

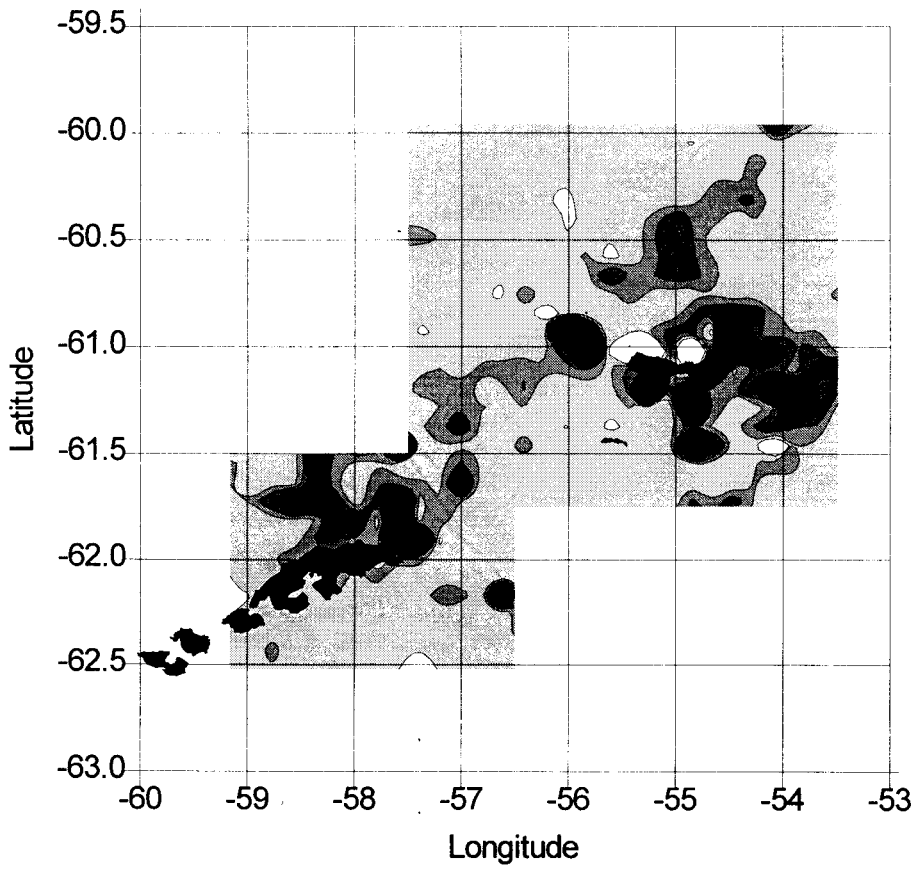


Figure 3.3 Distribution of integrated volume backscattering strength during Survey D (February 15-27).

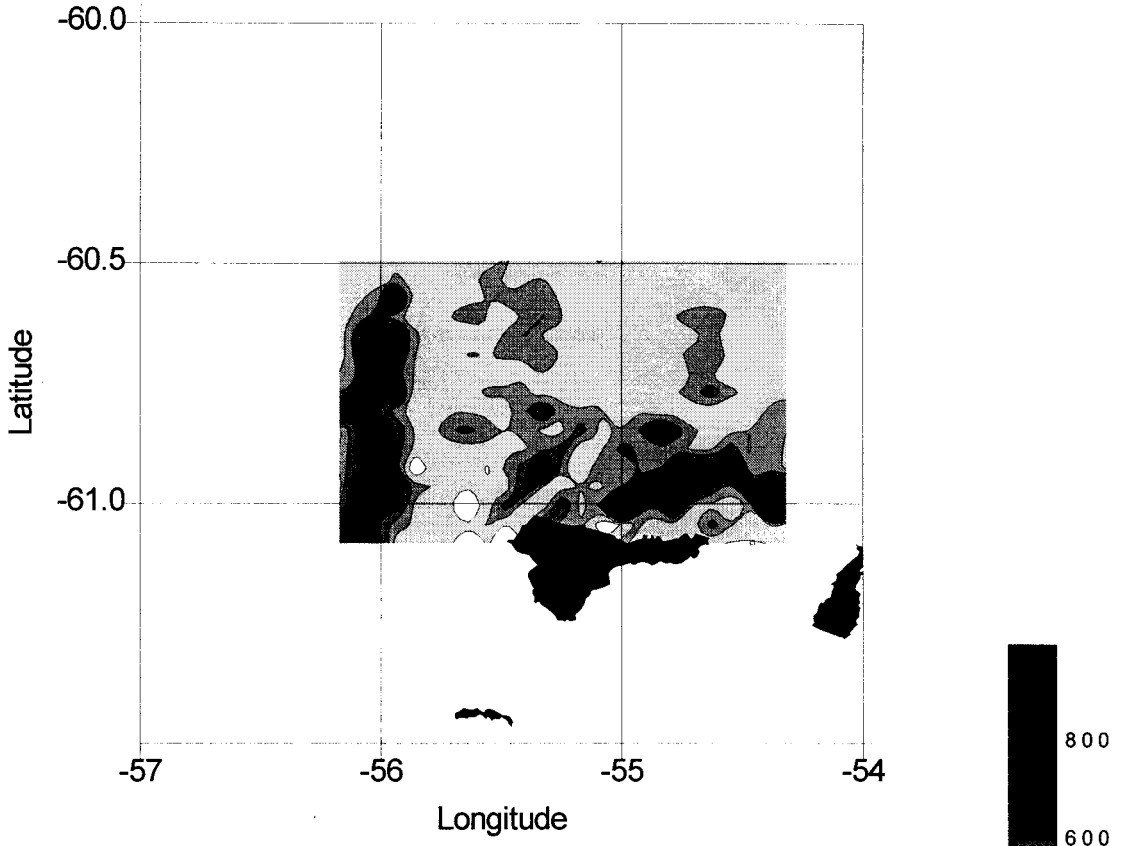


Figure 3.4 Distribution of integrated volume backscattering strength during Survey B (January 29 - February 1).

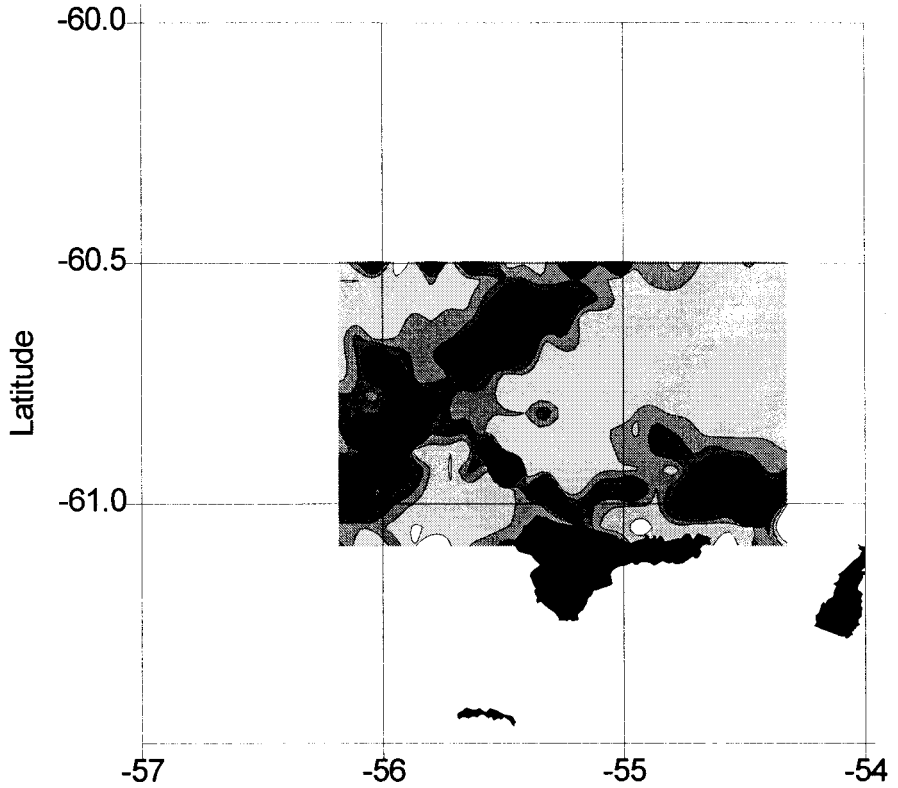


Figure 3.5 Distribution of integrated volume backscattering strength during Survey C (February 11-15).

4. Direct krill and zooplankton sampling; submitted by Valerie Loeb (Legs I and II), Debbie Nebenzahl (Legs I and II), Dawn Outram (Legs I and II), Michael Force (Legs I and II), Rick Phleger (Leg I), Jane Rosenberg (Leg II), Aaron Setran (Leg II), Gary Shigenaka (Leg I), and Cesar Zapata (Leg I).

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 macrozooplankton components in the AMLR study 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 the established CTD/rosette stations within the large-area surveys. Specific information on the maturity stage composition and size distribution of krill available for predators was obtained from tows made in the vicinity of penguin rookeries in Admiralty Bay, King George Island. Additional information useful for determining acoustic target identity and size distributions was derived from directed tows made at small-area survey stations located north of Elephant Island. Information on the abundance and distribution of other zooplankton components was obtained from the large- and small-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 and behavior of krill.

4.2 Accomplishments: Krill and zooplankton were obtained from a 6-foot Isaacs-Kidd Midwater Trawl (IKMT) fitted with a 505μm mesh plankton net. Flow volumes were measured using a calibrated General Oceanics flowmeter mounted on the frame in front of the net mouth opening. All tows were fished obliquely to a depth of approximately 170m or to about 20m above bottom in shallower waters. Tow depths were derived from a Wildlife time-depth recorder and/or a real-time depth recorder mounted on the trawl bridle and monitored in the acoustics lab. Tow speeds were ca. 2 knots.

Predominantly night-time targeted IKMT tows were conducted during the small-area surveys north of Elephant Island (Surveys B and C; see "Bioacoustic survey" report). The directed tows were done to provide the acoustics program with information on the taxonomic composition, relative abundance, and size of organisms associated with depth stratified acoustics targets within the upper 200m. These tows were made with a 6-foot IKMT frame fitted with a multiple mesh net grading from 2.5cm to 1.2cm and a 1mm mesh codend. Targeted tows were made with ship speeds of ca. 4 knots to minimize net avoidance; a flow meter was not employed. During Survey B, these tows were made by one oblique haul or by horizontal hauls of varying duration through the target layer. During Survey C, "yo-yo" tows were made as two or three oblique hauls through the target layers.

Shipboard Analyses:

Krill: Krill collected by the IKMT tows were examined on board to provide information on the relative abundance and composition of stocks encountered during the large- and small-area

surveys. The krill were removed and counted prior to other sample processing. All krill from samples containing <150 individuals were analyzed. For larger samples, a minimum of 100 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).

Salps: All salps were enumerated. Representative subsamples (generally 35-100 individuals) were removed prior to sample preservation; the two forms (aggregate/sexual and solitary/asexual) were enumerated and the internal body length and nucleus diameter (Foxton, 1966) were measured to the nearest millimeter.

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

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 were sorted from the samples, identified to the lowest taxon possible, and enumerated. The smaller constituents (e.g., copepods, chaetognaths, euphausiid larvae) in representative aliquots were enumerated using dissecting microscopes; these aliquots generally accounted for 10-25% 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.

Abundance estimates of krill, salps, and other zooplankton are expressed as numbers per m^2 and/or numbers per 1,000 m^3. Data are presented for the large-area surveys and for the more restricted "Elephant Island Area" (a box around Elephant Island, see Figure 4.3) to allow comparison with previous AMLR cruises.

Directed Samples: For the directed samples collected during Surveys B and C, only those taxa considered to be potential acoustics targets were analyzed. Krill and adult myctophids were processed as for the large-area survey samples. During Survey B salps were enumerated but not measured; other euphausiid species were noted only when abundant and were not measured. Data from these directed tows include krill, salp, and myctophid abundance and krill and myctophid lengths. Abundance estimates are as numbers caught per minute total tow duration. During Survey C total counts and measurements were made for salps (internal length, nucleus diameter) and the euphausiids *Thysanoessa macrura*, *Euphausia frigida*, and *E. triacantha* (standard lengths). Abundance estimates of specifically targeted taxa are as numbers per minute fished (i.e., total duration of upward hauls) within the targeted depth interval.

4.3 Results and Preliminary Conclusions:

Leg I, Admiralty Bay Survey.

During 15-16 January, six IKMT tows were made in the vicinity of Admiralty Bay to assess

the size composition of resident krill stocks in relation to the krill being fed upon by penguins in nearby rookeries (Survey AB1, Figure 4.1). The vast majority of the krill (4182 out of 4256 total) were derived from one sample at the mouth of the bay (Station AB03). The overall krill length-frequency distribution was bimodal, centered around 26mm and 39mm reflecting the predominance of juvenile (34%) and immature (32%) stages (Figure 4.2). Stomach contents of 15 penguins sampled by Wayne Trivelpiece during 15-17 January (752 krill) indicated that the birds were feeding on the larger sized krill fraction (Figure 4.2). The close correspondence between the length composition of this fraction in net hauls and penguin stomachs indicates that the IKMT adequately sampled the krill stocks providing food to the penguin rookeries at that time and suggests that the penguins were selectively feeding on the larger sized krill.

Leg I, Survey A.

Krill: A total of 90 non-targeted IKMT tows were made during the large-area survey of Leg I (Survey A) (Table 4.1A). A total of 7258 krill were collected in 79 (88%) of the tows; 2996 of these were measured, sexed and staged for demographic analyses. The largest catch was 2364 krill. The overall estimated mean abundance was $2.2m^{-2}$ (±6.3); the median value was $0.6m^{-2}$. Moderate krill catches (i.e. $>1m^{-2}$) extended from north of King George Island across to Elephant Island; increased frequency of moderate catches occurred to the east of Elephant Island (Figure 4.3). The largest catches (16.2 to $51.3m^{-2}$) occurred north of King George Island and to the east of Elephant Island; these concentrations were relatively small compared to the previous two years.

Krill lengths ranged from 21-58mm, but the overall frequency distribution (Figure 4.4) was dominated by large animals; more than 60% of the individuals were longer than 45mm, 20% were longer than 50mm, and 56-58mm lengths were not uncommon. The modal length was 48mm. Reproductively mature stages were the major component (78.7%); juveniles comprised 6.8%, and immature stages 14.5%, of the total (Table 4.2). Males slightly outnumbered females across the survey area. Most of the females (88.7%) were mature. The majority of these were in advanced stages of ovarian development (3c, 35.4%) or gravid (3d, 25.2%). Overall, 4.9% of the females collected in the large-area survey were spent (3e), but their occurrence increased over the sampling period. The majority of males (71.1%) were fully mature (3b).

Cluster analysis applied to the length frequency distributions from all stations represented by >17 krill resulted in two spatially separated groups with different size and maturity stage composition (Figure 4.5). Although both groups were dominated by large mature stages, Cluster 1 included substantially greater proportions of juveniles (1+ age group, 8.9%) and immature stages (2+ age group, 19.7%) than Cluster 2 (Figures 4.6 and 4.7). The larger krill lengths of Cluster 1 centered around 45-48mm; secondary size modes of 28mm and 39mm reflect the 1+ and 2+ age groups. Juvenile and immature stages were virtually absent from Cluster 2 (1+ age group, 0.9%; 2+ age group, 0.7%); 54.3% of the included krill were fully mature males, 35.4% were developing or fully gravid females, and 6.2% were spent females.

These krill were predominantly between 45mm and 55mm (51mm mode). Cluster 1 was distributed in the waters adjacent to King George, Elephant, and Clarence Islands and the eastern portion of the survey area. Cluster 2 occurred primarily in Drake Passage waters to the north of the islands (Figure 4.5).

Zooplankton: Seventy-six zooplankton species and taxonomic categories were identified (Table 4.3). Chaetognaths and copepods were the most frequent taxa, occurring in almost all of the samples. Copepods were numerically dominant with a mean abundance of 652.7 per 1000 m^3. Among the larger zooplankton constituents, adults of the euphausiid *Thysanoessa macrura* were most frequent (91.1% of tows) and abundant (96.4 per 1000 m^3). Although *T. macrura* was relatively abundant across much of the survey area, it was absent or rare at a number of stations to the northwest of Elephant Island (Figure 4.8). Krill comprised the next most frequent taxon (87.7% of tows), but they were much less abundant than *T. macrura* (14.5 per 1000 m^3). Salps (*S. thompsoni*) had a mean abundance similar to that of krill (16.0 per 1000 m^3) but were less frequent (66.7% of tows). Largest salp concentrations occurred primarily to the south and east of Elephant Island (Figure 4.9). Moderate salp concentrations also occurred in the northwest survey area. Salp lengths ranged from 4-88mm, but 80% of the measured individuals were smaller than 25mm (Figure 4.10). The solitary/asexual form predominated. Other relatively frequent taxa included the polychaete worm *Tomopteris carpenteri*, amphipod *Themisto gaudichaudii*, pteropods *Clio pyramidata* and *Spongiobranchaea australis*, and larvae of the myctophid *Electrona antarctica*. Krill larvae were encountered with increasing frequency as the survey progressed; these were especially abundant (>500 per 1000 m^3) at stations within Drake Passage waters to the north and east of Elephant Island.

Leg I, Survey B: Nine night time IKMT samples were collected during the small-area acoustics survey (Table 4.5). The first two tows were directed at presumed krill targets within the upper 25m. Tow DT01 netted 3324 large krill characteristic of Cluster 2; DT02 netted 430 krill of mixed sizes characteristic of Cluster 1. The remaining seven tows were directed at deeper target layers within the upper 200m that were believed to be fish. Adult myctophids, *Electrona antarctica* and *Gymnoscopelus opisthopterus*, were present in six of these tows. The *E. antarctica* ranged in size from 55-100mm SL; *G. opisthopterus* ranged from 78-100mm SL.

Leg I, Between year comparisons: The median krill catch in the Elephant Island area during January 1995 was similar to that during January 1994; these values were notably lower than during corresponding periods in 1992 and 1993 (Table 4.4). Salp abundance in January 1995 was the lowest recorded for this month over the past four years. This reflects a dramatic decrease from 1993 and 1994 when the median salp catch was over two orders of magnitude larger (246-582 per 1000 m^3 vs. 1.6 per 1000 m^3) and exceeded even the maximum catch size in 1995 (240 per 1000 m^3). The median abundance of *Thysanoessa macrura* in January 1995 was between 30% and 60% higher than in the previous three years.

Overall zooplankton diversity in the survey samples was much larger in January 1995 compared to January 1993 and 1994 (76 vs. 35 and 46 taxa, respectively; Table 4.3). This marked increase could in part result from sampling artifacts. The extreme salp dominance in 1993 and 1994 necessitated subsampling for salp abundance estimates and analysis of the other zooplankton taxa; at times these subsamples were small relative to the total sample volume (e.g., 1 liter out of 40-90 liters total volume). As a consequence, relatively uncommon and rare taxa were undoubtedly under-represented during those years. This is probably reflected in the increased frequency of occurrence of most taxa in the 1995 samples. In addition, increased use of the dissecting microscope for shipboard zooplankton analyses in 1995 resulted in the identification and enumeration of smaller taxa such as ostracods, larval krill, and small larval fish. The use of entire zooplankton samples and more accurate enumeration could also explain some of the vastly increased abundances of copepods and chaetognaths noted in 1995. However, it is also quite likely that substantially increased abundance of these taxa within the 0-170m water column sampled was a real phenomenon. Acknowledging the possible sources of bias, the abundance and occurrence of two amphipod species, *Vibilia antarctica* and *Cyllopus magellanicus*, were substantially lower in 1995 than in previous two years; these decreases are probably associated with the decreased salp abundance. Three taxa, the euphausiid *Euphausia frigida*, polychaete worm *Tomopteris carpenteri*, and pteropod *Limacina helicena* were more frequent and abundant than during the January 1993 and 1994 large-area surveys. Frequency of occurrence and abundance of the amphipod *Themisto gaudichaudii* and pteropod *Clio pyramidata* in both 1994 and 1995 were higher than in 1993.

Leg II, Survey C: Eleven directed IKMT tows were made during the small-area acoustic survey (Table 4.6). The first three tows were directed at deep target layers (between 70-250m) that were suspected to be fish. These tows collected 27 myctophids (23 *E. antarctica* and 4 *G. opisthopterus*) with standard lengths of 40-87mm. The deep tows also caught 118 krill (47-58mm lengths) and 94 *Euphausia triacantha* (24-40mm lengths), suggesting that the targets were a mixture of fish and large euphausiids. Three of the 8 tows directed at suspected krill targets in the upper water column (DT13, DT17, and DT20) caught substantial numbers of krill (914-6460 krill, 76-404 krill/minute) in the 29-55mm size range. Tows DT15 and DT18 had moderate krill catches (130-276 krill, 12-14 krill/minute). Large numbers of *E. frigida* in tows DT16, DT18, and DT19 (51-108/minute) and of *T. macrura* in tows DT15, DT16, and DT18 (19-40/minute) suggest that small euphausiids in the 10-26mm size range may have contributed to the associated target layers. Due to their low concentrations, salps probably did not comprise much of the acoustically detected targets.

Leg II, Survey D.

Krill: Eighty-nine tows were made during Leg II's large-area survey (Survey D) (Table 4.1B). Krill were present in 70 (79%) of these tows. A total of 2063 krill were collected; 1693 of these were used for demographic analyses. The overall mean and median abundance values, $1.0m^{-2}$ (± 2.1) and $0.3m^{-2}$, respectively, were about half those from Survey A. This is in accordance with the decreased acoustically detected krill biomass values reported for

Survey D (see "Bioacoustic survey" report). The maximum catch of 443 krill ($15.3m^{-2}$) was made east of Elephant Island (Figure 4.11). Relatively large catches were generally located within the eastern portion of the survey area, although a few occurred in the vicinity of King George Island.

Krill lengths ranged from 21-59mm, but the catches were dominated by the larger sizes (Figure 4.12). Individuals <40mm long were rare and made up less than 5% of the total. More than half of the krill were longer than 48mm, with sizes centered around 49-51mm. Juveniles (1+ age class) and immature forms (2+ age class) made up 2.3% and 5.3% of the total, respectively (Table 4.2). Most of the females were gravid (3d; 49.3%) or spent (3e; 46.5%), indicating a distinct seasonal progression in spawning condition from the January survey period. Most of the males were fully mature (3b; 81.6%).

Cluster analysis based on samples with >16 krill again provided two spatially separated krill groups (Figure 4.13). The overall size and maturity stage composition of these groups (Figures 4.14 and 4.15) were similar to those determined during January, but Cluster 1 included smaller proportions of juvenile (2.6%) and immature (7.5%) stages in the 20-40mm size range than during the previous survey. The majority of the krill were 46-52mm. Males and females were equally represented. Among the females, 46.0% were gravid (3d) and 49.7% were spent (3e). As during January, virtually no juvenile or immature stages were included in Cluster 2 and the majority of individuals were 48-53mm (51mm mode). This cluster was dominated by large mature males (3b, 73.7% of total; male:female ratio 3.5:1). Greater proportions of the females were gravid (57.2%) vs. spent (37.7%) compared to Cluster 1. Cluster 1 again was distributed around King George Island and to the east of Elephant Island, while Cluster 2 was distributed primarily within Drake Passage water. The pattern differed somewhat from that of Survey A in that Cluster 2 occurred to the south of Elephant Island during Survey D.

Zooplankton: Overall taxonomic diversity during February was slightly lower than during January (65 vs. 76 taxonomic categories), but overall zooplankton abundance was substantially greater due in large part to increased abundance of copepods, chaetognaths, and larval euphausiids (Table 4.7). Copepods and chaetognaths were present in all samples and again were the most frequent taxa collected. Their mean abundances during February were, respectively, about 5X and 4X those noted during the previous month. Krill larvae were present in 93.3% of the samples and were the numerically dominant taxon. Their mean abundance was an order of magnitude greater than during Survey A. Almost all of these were calyptopis stages; furcilia comprised only 0.4% of the total. The frequency of occurrence of furcilia larvae increased over the survey period, reflecting the seasonal progression of larval development. Although widely distributed, the larvae were most abundant in Drake Passage water in the northeastern portion of the survey area (Figure 4.16). Largest concentrations, ranging from 10,000 to over 167,000 per 1000 m^3, occurred northeast of Elephant Island. *Thysanoessa macrura* adults and larvae were the next most frequent and abundant taxa. The mean abundance of adults was about 1.5X, and that of the larvae was an order of magnitude larger, than during January. The adults were most abundant in Bransfield Strait and Weddell

Sea waters south of King George Island (Figure 4.17). Salps ranked eighth in abundance. Although their mean abundance was quite similar to that during January, they were somewhat less frequent (59.6% vs. 66.7% of stations). Largest salp concentrations were found south of Elephant Island and in Drake Passage water north of Elephant Island (Figure 4.18). The aggregate forms slightly out numbered solitary forms (1.7:1 ratio). Internal body lengths ranged from 71-130mm, but 80% of the individuals were smaller than 31mm (Figure 4.19). The overall size distribution reflects an increase of ca. 6mm over the previous month (Figure 4.20).

Among the other zooplankton the frequency and mean abundance of ostracods, the euphausiid *E. frigida*, larval fish *Electrona antarctica*, *Leptonotothen kempi*, and *Notolepis coatsi*, and the amphipods *Primno macropa* and *Cyllopus magellanicus* were notably greater during February than January. Notable reductions in frequency and abundance occurred for the polychaete *T. carpenteri*, pteropods *Clio pyramidata*, *Limacina helicina*, and *Clione limacina*, amphipod *Hyperiella dilitata*, and larval fish *Lepidonothen larseni*.

Leg II, Between year comparisons: The mean estimated krill abundance in the Elephant Island area during February was 1/3 of that noted during February-March 1994 and 1/7 that during both February-March 1993 and 1992 (Table 4.4). Larval krill, the dominant zooplankton taxon during February 1995, were not noted in the February-March samples during the previous two years (Table 4.8). This resulted from the subsampling, less microscopic analysis, and minor contribution (if any) of larval krill to the small zooplankton fraction during those years. Since relatively small numbers of female krill were found in gravid (3d) or spent (3e) stages during the 1993 and 1994 survey periods (Table 4.2), significant numbers of their larvae would not be expected to occur at that time. The widespread occurrence and at times extremely large abundance of krill larvae in 1995 most certainly resulted from the early and prolonged spawning season.

The median abundance of *T. macrura* in the Elephant Island area during February was similar to the 1993 and 1994 values; the mean abundance was similar to that in 1994 and both values were low compared to the same period in 1993 (Table 4.4). Overall abundance of this species in the large-area survey was fairly similar across the three years (Table 4.8). However, these abundance estimates may be biased due to inclusion of the larger larval stages in the 1993 and 1994. As during January, the salp abundance in February was dramatically lower (1-3 orders of magnitude) than during the previous two years (Table 4.4).

The overall taxonomic diversity during February was substantially greater than during the February-March 1993 and 1994 large-area surveys (65 vs. 24 and 33 taxonomic categories, respectively; Table 4.8). Again, this marked increase in numbers of predominantly uncommon and rare taxa is probably due to the low numbers of salps and greater reliance on dissecting microscopes for analyses of the small fraction during the 1995 cruises. The copepod abundance estimates for February-March 1994 and 1995 are quite similar and suggest a marked seasonal presence (e.g., late summer-fall) of copepods in the upper water column. The diminished abundance and frequency of occurrence of *Vibilia antarctica* and *Cyllopus*

magellanicus in February 1995 vs. the other years supports the idea that these amphipods are associated with salps.

Leg II, Admiralty Bay Survey: During 26-27 February, three IKMT tows were made in the vicinity of Admiralty Bay (Survey AB2) to further document the characteristics of krill prey available to the penguin colonies at the time. Two of these tows yielded a total of 28 krill. Krill lengths ranged from 31-52mm, but most were in the 41-48mm range. Wayne Trivelpiece reported that five Gentoo penguins feeding in the bay at this time had preyed predominantly on krill of 41-52mm lengths (83% of the 250 krill analyzed).

AMLR 95 Cruise Summary: The results of netting operations during the AMLR 95 cruise legs are quite exciting. Mean krill abundance in IKMT samples taken in the Elephant Island area during both large-area surveys was about 1/3 that observed during the previous three years. Mature forms of 45-55mm body lengths, probably krill of at least 4-5 years of age, totally dominated the catches. These results indicate relatively poor krill recruitment since the 1990/91 year class. This period of poor krill recruitment has been linked to below normal winter sea ice coverage and duration in the Antarctic Peninsula region over the past three years (Siegel and Loeb, in press). Poor recruitment during low ice years is believed to result from poor feeding conditions over the winter period and subsequent delayed reproduction until late in the summer. Late spawned larvae apparently have low survival rates. The past (1994) winter was marked by greater than normal sea ice conditions, and we predicted that the krill would respond to this through an early spawning season. Our predictions were supported by observations of relatively large proportions of gravid females in January and predominantly gravid and spent females in February. Spawning success was indicated by the appearance of early stage krill larvae in the January survey and widespread occurrence of these larvae in the February survey. These larvae were at times exceedingly abundant (up to 700,000 per sample) in Drake Passage water in the northeast portion of the survey area. As a consequence, we anticipate extremely good recruitment from this years spawn, the best since at least winter 1990/91.

Salps, which were the dominant taxon in the survey area during the past two years, were not very abundant this year. Their mean abundance in the Elephant Island area was over two orders of magnitude less than in 1993 and 1994, and one order of magnitude less than in 1992. Again, this appears to have resulted from the presence of above normal winter sea ice during 1994, as summer time salp abundance has been positively correlated with periods of extended ice free conditions during the previous winter (Siegel and Loeb, in press).

Under the conditions of relatively low concentrations of herbivorous krill and salps, we hypothesized that there would be greater concentrations of other herbivores such as copepods and/or there would be notably elevated levels of primary production. Both of these conditions were observed during 1995. The mean copepod abundance during January was an order of magnitude greater than during the same period in 1993 and 1994. Results from the phytoplankton program (see "Phytoplankton" report) indicate substantially higher levels of primary production in the survey area than observed in the history of the AMLR program.

4.4 Disposition of Data and Samples: All of the krill, salp, and other macrozooplankton data have been digitized and are available upon request from Loeb. Data on the krill and salps collected in the targeted IKMT samples have been submitted to the AERG. The krill and processed zooplankton (minus salps) are stored at the Southwest Fisheries Science Center. Myctophids collected by the IKMT are frozen and stored.

4.5 Problems and suggestions: The large-area survey is an extremely important component of the field sampling operations and should be conducted as thoroughly as possible with few, if any, stations not sampled due to poor weather conditions. The 15 days allocated to the large-area survey proved sufficient to conduct net sampling operations at almost all of the stations. This survey has unparalleled importance in context of a long-term dataset for the Antarctic marine environment. By pooling German and US AMLR datasets from the Elephant Island area, Siegel and Loeb (in press) have been able to establish large variability of krill recruitment and salp abundance over a 16-year period. This long term dataset has provided great insight into factors influencing the biology of the Antarctic Peninsula marine ecosystem. Based on this insight and the results of the 1995 AMLR field work, we predict extremely good krill year class success from the 1994/95 spawning season. It is critical that there is a 1995/96 AMLR field effort to test the value of this prediction. Continued annual field efforts in the Elephant Island area are essential to further refine our understanding of variations in this ecosystem, especially with regards to krill abundance fluctuations and krill availability to their predators.

The real-time depth recorder (RTDT) attached to the IKMT was a major improvement over the remote TDRs previously used. The RTDT proved to be an effective and reliable way of determining tow depth and permitted fishing known time intervals within defined target layers.

Shipboard analysis proved to be effective way of assessing krill and larger zooplankton distribution patterns relative to hydrographic conditions in a more or less real-time manner and should be continued. Round-the-clock (24 hour) efforts by two people dedicated to the operation permitted analysis of fresh zooplankton samples as they were collected. This operation was done with minimal use of formalin, thus providing a pleasant work environment. We were able to perform this work because of the exceptional stability of *Surveyor*.

4.6 References:

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TABLE 4.1 AMLR 1995 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	#/m2	#/1000m3
A01	16/01/95	0920	0947	D	170	1525	4071.9	0	0.0	0.0
A02	16/01/95	1221	1250	D	170	1685	4186.4	0	0.0	0.0
A03	16/01/95	1526	1555	D	162	671	4483.6	6	0.2	1.3
A04	17/01/95	0200	0231	T	170	1600	3882.2	1	0.0	0.3
A05	17/01/95	0507	0537	D	170	1850	4781.1	2	0.1	0.4
A06	17/01/95	0802	0831	D	170	1456	3909.0	1	0.0	0.3
A07	17/01/95	1112	1139	D	157	1980	4763.5	0	0.0	0.0
A08	17/01/95	1341	1352	D	53	85	1970.2	1	0.0	0.5
A09	17/01/95	1803	1835	D	122	280	6938.1	920	16.2	132.6
A10	17/01/95	2105	2134	D	138	1128	4997.6	26	0.7	5.2
A11	18/01/95	0112	0141	N	217	2452	3806.6	156	8.9	41.0
A12	18/01/95	0459	0529	D	135	991	6368.9	201	4.3	31.6
A13	18/01/95	0744	0811	D	125	282	5757.2	2364	51.3	410.6
A14	18/01/95	1056	1115	D	111	155	3042.2	5	0.2	1.6
A15	18/01/95	1415	1446	D	209	330	4476.4	14	0.7	3.1
A16	18/01/95	1730	1759	D	133	2075	6867.0	65	1.3	9.5
A17	18/01/95	2220	2245	T	166	378	2940.3	1	0.1	0.3
A18	19/01/95	0129	0202	N	248	750	6223.9	1	0.0	0.2
A19	19/01/95	0443	0512	D	149	2248	5599.8	33	0.9	5.9
A20	19/01/95	0748	0815	D	160	4043	4992.4	1	0.0	0.2
A21	19/01/95	1048	1116	D	232	4554	5221.7	12	0.5	2.3
A22	19/01/95	1346	1420	D	170	3762	5969.4	13	0.4	2.2
A23	19/01/95	1710	1740	D	160	2100	5606.5	21	0.6	3.7
A24	19/01/95	2031	2057	D	215	3866	4068.9	1	0.1	0.2
A25	19/01/95	2355	9916	N	171	3597	3602.1	3	0.1	0.8
A26	20/01/95	0306	0330	T	169	3771	3295.2	0	0.0	0.0
A27	20/01/95	0624	0657	D	170	2263	6001.4	26	0.7	4.3
A28	20/01/95	1000	1033	D	170	3666	6462.5	22	0.6	3.4
A29	20/01/95	1340	1415	D	170	2902	7363.7	52	1.2	7.1
A30	20/01/95	1652	1722	D	170	1687	6848.9	47	1.2	6.9
A31	20/01/95	1955	2016	D	172	487	5553.7	159	4.9	28.6
A32	20/01/95	2303	2321	N	172	414	3077.6	0	0.0	0.0
A33	21/01/95	0157	0229	N	173	662	5816.6	1	0.0	0.2
A34	21/01/95	0459	0526	D	170	1611	3999.3	0	0.0	0.0
A35	21/01/95	0843	0912	D	170	1540	5805.2	4	0.1	0.7
A36	21/01/95	1235	1310	D	173	505	6135.0	106	3.0	17.3
A37	21/01/95	1556	1630	D	170	515	8087.5	83	1.7	10.3
A38	21/01/95	1916	1952	D	179	390	6129.2	110	3.2	17.9
A39	21/01/95	2219	2242	T	170	2265	4345.1	26	1.0	6.0
A40	22/01/95	0112	0141	N	170	2656	4402.7	20	0.8	4.5
A41	22/01/95	0408	0443	T	169	3866	6616.1	3	0.1	0.5
A42	22/01/95	0723	0753	D	174	3762	4974.5	0	0.0	0.0
A43	22/01/95	1032	1056	D	174	3689	3584.4	13	0.6	3.6
A44	22/01/95	1348	1412	D	170	3722	3757.7	3	0.1	0.8
A45	22/01/95	1645	1715	D	177	3818	5218.2	5	0.2	1.0
A46	22/01/95	1950	2025	D	200	3887	6479.1	13	0.4	2.0
A47	22/01/95	2244	2309	N	177	2781	4883.7	55	2.0	11.3
A48	23/01/95	0131	0205	N	178	451	5617.5	10	0.3	1.8

TABLE 4.1 AMLR 1995 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	#/m2	#/1000m3
A49	23/01/95	0415	0434	T	126	160	3044.2	46	1.9	15.1
A50	23/01/95	0700	0730	D	174	373	4513.0	0	0.0	0.0
A51	23/01/95	0957	1025	D	236	757	4369.0	7	0.4	1.6
A52	23/01/95	1314	1340	D	171	2075	5745.3	5	0.1	0.9
A53	23/01/95	1808	1840	D	174	503	5902.1	0	0.0	0.0
A54	23/01/95	2102	2118	T	76	91	3194.3	0	0.0	0.0
A55	24/01/95	0026	0040	N	64	119	2540.0	35	0.9	13.8
A56	24/01/95	0350	0428	T	172	763	7973.8	189	4.1	23.7
A57	24/01/95	0736	0804	D	172	3662	4413.2	3	0.1	0.7
A58	24/01/95	1040	1105	D	172	3627	6032.9	8	0.2	1.3
A59	24/01/95	1350	1413	D	172	3572	2861.2	1	0.1	0.3
A60	24/01/95	1657	1720	D	171	3600	3900.4	0	0.0	0.0
A61	24/01/95	2010	2035	D	171	3382	4652.8	10	0.4	2.1
A62	24/01/95	2305	2326	N	173	3442	3184.7	20	1.1	6.3
A63	25/01/95	0155	0222	N	169	3291	4223.1	11	0.4	2.6
A64	25/01/95	0441	0513	D	170	446	5292.7	15	0.5	2.8
A65	25/01/95	1110	1138	D	161	176	5190.4	39	1.2	7.5
A66	25/01/95	1414	1447	D	172	1347	4869.0	0	0.0	0.0
A67	25/01/95	1722	1742	D	172	2060	3321.2	15	0.8	4.5
A68	25/01/95	2025	2046	D	170	602	2947.8	86	5.0	29.2
A69	25/01/95	2322	2350	T	172	1513	4864.5	20	0.7	4.1
A70	26/01/95	0226	0253	N	170	760	3979.3	28	1.2	7.0
A71	26/01/95	0502	0520	D	100	464	2962.5	43	1.5	14.5
A72	26/01/95	0836	0904	D	172	1012	4753.2	16	0.6	3.4
A73	26/01/95	1130	1153	D	171	3240	3947.8	33	1.4	8.4
A75	26/01/95	2120	2153	T	173	3250	6529.2	25	0.7	3.8
A76	27/01/95	0034	0100	N	170	3131	3940.0	71	3.1	18.0
A77	27/01/95	0330	0357	T	170	2789	3666.9	17	0.8	4.6
A78	27/01/95	0635	0710	D	171	3039	7095.8	66	1.6	9.3
A79	27/01/95	0952	1024	D	171	1847	5047.6	70	2.4	13.9
A80	27/01/95	1313	1347	D	172	1254	6715.8	981	28.3	164.4
A81	27/01/95	1645	1708	D	171	352	5425.8	269	8.5	49.6
A82	27/01/95	2000	2020	D	172	780	3041.6	7	0.4	2.3
A83	27/01/95	2248	2315	N	170	331	4531.5	28	1.1	6.2
A84	28/01/95	0150	0217	N	172	539	2997.4	36	2.1	12.0
A85	28/01/95	0500	0531	D	172	750	4983.3	67	2.3	13.4
A86	28/01/95	0818	0845	D	194	1061	4096.9	83	3.9	20.3
A87	28/01/95	1237	1304	D	172	2030	4214.4	107	4.4	25.4
A88	28/01/95	1620	1643	D	171	597	3234.3	17	0.9	5.3
A89	28/01/95	1923	1949	D	172	2261	3927.4	24	1.1	6.1
A90	28/01/95	2220	2245	N	171	2400	5373.0	11	0.4	2.0
A91	29/01/95	0121	0149	N	172	3306	3989.4	143	6.2	35.8

SURVEY A AREA	NO.	90	7258	
	MEAN		2.2	14.6
	STD		6.3	47.7
	MEDIAN		0.5	2.8
ELEPHANT ISLAND AREA	NO.	71	3491	
	MEAN		1.6	9.5
	STD		3.5	20.6
	MEDIAN		0.6	3.5

TABLE 4.1 AMLR 1995 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	#/m2	#/1000m3
D01	26/02/95	0845	0911	D	170	1645	3737.6	0	0.0	0.0
D02	26/02/95	0603	0622	D	170	1677	2373.4	5	0.4	2.1
D03	26/02/95	0308	0335	N	170	367	3011.8	27	1.5	9.0
D04	26/02/95	0017	0045	N	170	1570	3154.6	2	0.1	0.6
D05	25/02/95	2122	2145	N	170	1845	3283.8	12	0.6	3.7
D06	25/02/95	1833	1900	D	225	1515	3756.0	7	0.4	1.9
D07	25/02/95	1520	1547	D	170	1985	4377.2	2	0.1	0.5
D08	25/02/95	1239	1307	D	170	398	5142.9	18	0.6	3.5
D09	27/02/05	0509	0637	T	170	272	3871.1	169	7.4	43.7
D10	27/02/95	1345	1402	D	170	896	2727.1	40	2.5	14.7
D11	27/02/95	1655	1722	D	215	2325	4094.5	53	2.8	12.9
D12	27/02/95	1016	1049	D	170	1029	5113.5	22	0.7	4.3
D13	27/02/95	0718	0741	D	170	286	3218.6	18	1.0	5.6
D14	24/02/95	2345	0007	N	130	157	2847.0	59	2.7	20.7
D16	24/02/95	1805	1827	D	169	2073	2690.7	8	0.5	3.0
D17	24/02/95	1221	1251	D	170	363	5090.1	63	2.1	12.4
D18	24/02/95	0942	1010	D	170	623	3778.5	2	0.1	0.5
D19	24/02/95	0705	0730	D	170	2668	3055.5	3	0.2	1.0
D20	24/02/95	0410	0434	N	170	4129	3468.3	2	0.1	0.6
D21	24/02/95	0121	0143	N	170	4681	2750.7	1	0.1	0.4
D22	23/02/95	2232	2255	N	170	3784	3070.6	5	0.3	1.6
D23	23/02/95	1940	1958	D	171	2137	2668.3	0	0.0	0.0
D24	23/02/95	1454	1524	D	170	3843	5750.1	0	0.0	0.0
D25	23/02/95	1152	1214	D	170	3595	2760.5	0	0.0	0.0
D26	23/02/95	0858	0920	D	170	1418	2486.9	0	0.0	0.0
D27	23/02/95	0553	0617	T	170	2068	3366.8	0	0.0	0.0
D28	23/02/95	0242	0305	N	170	3596	3532.3	0	0.0	0.0
D29	22/02/95	2340	0005	N	170	2465	3160.3	11	0.6	3.5
D30	22/02/95	2047	2111	T	170	1748	3553.7	3	0.1	0.8
D31	22/02/95	1745	1807	D	170	500	3341.8	2	0.1	0.6
D32	22/02/95	1447	1510	D	170	440	3607.6	0	0.0	0.0
D33	22/02/95	1116	1141	D	170	681	3418.1	3	0.1	0.9
D34	22/02/95	0831	0854	D	170	1622	2769.7	2	0.1	0.7
D35	22/02/95	0452	0520	T	170	1655	3895.2	34	1.5	8.7
D36	22/02/95	0141	0205	N	170	553	3021.5	11	0.6	3.6
D37	21/02/95	2305	2325	N	170	500	2409.9	0	0.0	0.0
D38	21/02/95	2030	2055	T	170	333	3548.6	18	0.9	5.1
D39	21/02/95	1752	1815	D	170	2185	3404.0	0	0.0	0.0
D40	21/02/95	1449	1515	D	170	2656	3783.5	0	0.0	0.0
D41	21/02/95	1151	1222	D	170	3906	4016.7	0	0.0	0.0
D43	21/02/95	0634	0652	D	179	3650	1814.3	0	0.0	0.0
D44	21/02/95	0340	0400	N	170	3716	2428.7	0	0.0	0.0
D45	21/02/95	0054	0115	N	170	3884	2791.4	0	0.0	0.0
D46	20/02/95	2154	2215	N	170	3896	2927.3	0	0.0	0.0
D47	20/02/95	1844	1912	D	170	2283	3630.4	0	0.0	0.0
D48	20/02/95	1533	1553	D	170	293	2511.1	10	0.7	4.0
D49	20/02/95	1247	1315	D	160	185	4317.0	11	0.4	2.5
D50	20/02/95	1016	1038	D	170	340	2854.2	11	0.7	3.9

TABLE 4.1 AMLR 1995 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	#/m2	#/1000m3
D51	20/02/95	0741	0803	D	170	776	2681.3	4	0.3	1.5
D52	20/02/95	0257	0318	N	170	2061	2400.9	3	0.2	1.2
D53	20/02/95	0007	0032	N	170	500	2959.1	6	0.3	2.0
D54	19/02/95	2136	2145	N	50	72	1140.0	0	0.0	0.0
D55	19/02/95	1829	1841	D	70	66	1895.9	2	0.1	1.1
D56	19/02/95	1529	1603	D	170	3466	3373.7	36	1.8	10.7
D57	19/02/95	1231	1259	D	170	3635	3527.9	1	0.0	0.3
D58	19/02/95	0936	1002	D	170	3541	3536.7	6	0.3	1.7
D59	19/02/95	0648	0711	D	170	3572	2869.9	0	0.0	0.0
D60	19/02/95	0354	0412	N	170	3159	1952.4	13	1.1	6.7
D61	19/02/95	0056	0128	N	170	3370	3926.9	4	0.2	1.0
D62	18/02/95	2212	2235	N	170	3443	3066.2	14	0.8	4.6
D63	18/02/95	1932	1955	D	170	3314	3356.9	20	1.0	6.0
D64	18/02/95	1633	1700	D	170	535	3722.6	4	0.2	1.1
D65	18/02/95	1136	1153	D	130	160	2164.3	22	1.3	10.2
D66	18/02/95	0913	0937	D	170	890	2388.1	12	0.9	5.0
D67	18/02/95	0631	0657	D	170	2148	3211.0	29	1.5	9.0
D68	18/02/95	0333	0402	N	170	795	4128.9	5	0.2	1.2
D69	18/02/95	0029	0101	N	170	1600	4339.3	24	0.9	5.5
D70	17/02/95	2127	2150	N	170	540	2478.1	21	1.4	8.5
D71	17/02/95	1833	1856	D	219	600	2773.3	101	8.0	36.4
D72	17/02/95	1538	1605	D	170	2761	3797.6	13	0.6	3.4
D73	17/02/95	1239	1304	D	170	3235	3456.2	4	0.2	1.2
D74	17/02/95	0924	0956	D	170	3037	5047.3	17	0.6	3.4
D75	17/02/95	0616	0637	T	170	3250	2362.9	1	0.1	0.4
D76	17/02/95	0301	0332	N	170	3048	5440.4	5	0.2	0.9
D77	17/02/95	0112	0041	N	170	2767	4141.0	98	4.0	23.7
D78	16/02/95	2117	2144	T	170	3035	3686.6	16	0.7	4.3
D79	16/02/95	1819	1845	D	170	1654	4012.1	16	0.7	4.0
D80	16/02/95	1510	1537	D	170	1202	4920.8	443	15.3	90.0
D81	16/02/95	1151	1230	D	199	1328	7816.6	132	3.4	16.9
D82	16/02/95	0901	0929	D	170	760	3800.7	10	0.4	2.6
D83	16/02/95	0558	0633	D	181	333	5566.2	47	1.5	8.4
D84	16/02/95	0332	0402	T	170	544	4554.3	118	4.4	25.9
D85	16/01/95	0038	0102	N	170	716	2504.8	1	0.1	0.4
D86	15/02/95	2122	2149	N	174	1164	3646.9	1	0.0	0.3
D87	15/02/95	1806	1845	D	170	2000	8061.7	115	2.4	14.3
D88	15/02/95	1500	1530	D	170	569	4720.4	16	0.6	3.4
D89	15/02/95	1202	1229	D	170	2525	3753.2	27	1.2	7.2
D90	15/02/95	0905	0932	D	170	2397	3705.1	20	0.9	5.4
D91	15/02/95	0437	0514	T	170	3341	6023.5	2	0.1	0.3

SURVEY D AREA	NO.	89	2063		
	MEAN			1.0	5.7
	STD			2.1	11.7
	MEDIAN			0.3	1.9
ELEPHANT ISLAND AREA	NO.	71	1582		
	MEAN			0.9	5.2
	STD			2.1	12.0
	MEDIAN			0.2	1.2

Table 4.2 Maturity stage composition of krill collected in the large survey areas and Elephant Island area during 1995 compared to the Elephant Island area during 1992, 1993 and 1994.

	E. superba January				
Area	1995 Survey A	1995 Elephant I.	1994 Elephant I.	1993 Elephant I.	1992 Elephant I.
	%	%	%	%	%
Juveniles	6.8	4.6	4.0	7.2	37.1
Immature stages	14.5	4.0	18.8	30.7	19.1
Mature stages	78.7	91.4	77.2	62.2	43.9
Females:					
F2	4.8	0.1	2.3	7.8	0.8
F3a	4.4	0.2	18.0	11.7	0.6
F3b	5.6	1.2	19.3	14.3	12.3
F3c	15.2	15.3	20.1	5.1	9.2
F3d	10.8	17.7	2.3	1.2	0.4
F3e	2.1	3.7	0.0	0.0	0.0
Males:					
M2a	2.8	0.9	0.3	6.8	8.7
M2b	4.1	1.5	9.4	11.9	7.3
M2c	2.8	1.5	6.8	4.2	2.3
M3a	4.8	4.4	4.3	3.7	2.8
M3b	35.8	48.9	13.2	26.2	18.7
Male:Female ratio	1.2:1	1.5:1	0.5:1	1.3:1	1.7:1
No. measured	2996	2294	2078	4283	2472

	E. superba February-March				
Area	1995 Survey D	1995 Elephant I.	1994 Elephant I.	1993 Elephant I.	1992 Elephant I.
	%	%	%	%	%
Juveniles	2.3	1.1	3.7	3.5	33.6
Immature stages	5.3	2.5	6.2	51.4	27.1
Mature stages	92.5	96.4	90.1	45.1	39.2
Females:					
F2	0.3	0.3	0.7	21.8	0.8
F3a	0.0	0.0	3.5	12.4	10.3
F3b	0.0	0.0	7.8	6.2	10.2
F3c	1.5	2.0	4.3	3.7	4.3
F3d	21.2	21.8	4.6	1.1	1.2
F3e	20.0	20.4	0.9	1.2	<0.01
Males:					
M2a	1.5	0.7	0.2	6.9	4.3
M2b	1.7	0.4	1.2	19.1	19.8
M2c	1.8	1.1	4.2	3.6	2.2
M3a	5.1	4.4	24.1	2.1	2.5
M3b	44.7	47.8	44.7	18.4	10.7
Male:Female ratio	1.3:1	1.2:1	3.4:1	1.1:1	1.5:1
No. measured	1693	1271	1155	3669	3646

Table 4.3 Zooplankton taxa present in the large survey area samples during January 1995 compared to January 1994 and January 1993. F is the frequency of occurrence (%) in tows. n.a. indicates taxon was present but not enumerated. ? indicates that the taxon was probably present but not noted.

Taxon	Survey A January 1995		Survey A January 1994		Survey A January 1993	
	F(%) (90 tows)	Mean #/1000 m3	F (81 tows)	Mean #/1000 m3	F (87 tows)	Mean #/1000 m3
*Chaetognatha**	98.9	79.7	n.a.	n.a.	56.3	9.2
*Sagitta gazellae**	48.9	3.4	20.0	0.4	n.a.	n.a.
*Eukronia hamata**	10.0	0.1	21.3	0.2	n.a.	n.a.
Copepoda	98.9	652.7	30.0	41.3	31.0	38.1
Thysanoessa macrura (adults)	91.1	96.4	90.0	79.7	95.4	51.5
Euphausia superba	87.8	14.5	77.5	27.1	90.8	44.1
Tomopteris carpenteri	84.4	4.2	37.5	2.5	33.3	0.5
Themisto gaudichaudii	76.7	4.9	83.8	10.6	50.6	0.8
Clio pyramidata	72.2	5.3	40.0	5.4	6.9	0.2
Salpa thompsoni	66.7	16.0	100.0	818.3	100.0	1001.5
Spongiobranchaea australis	64.4	0.5	11.3	0.1	40.2	0.6
Electrona antarctica (larvae)	61.1	2.5	2.5	0.02	2.3	0.0
Ostracods	56.7	9.7	n.a.	n.a.	n.a.	n.a.
Hyperiella dilatata	54.4	0.3	18.7	0.3	6.9	0.0
Diphyes antarctica	58.9	1.0	20.0	0.3	20.7	0.5
Euphausia frigida	50.0	9.8	17.5	3.8	26.4	3.6
Limacina helicina	43.3	1.9	6.3	0.3	----	----
Clione limacina	41.1	0.5	13.8	0.3	4.6	0.1
Lepidonothen larseni (larvae)	40.0	1.1	6.3	0.7	16.1	0.2
Thysanoessa macrura (larvae)	36.7	15.9	?	?	?	?
Euphausia triacantha	33.3	1.5	7.5	1.2	25.3	1.0
Notolepis coatsi (larvae)	27.8	0.1	----	----	----	----
Notolepis annulata (larvae)	13.3	0.0	----	----	----	----
Notolepis spp. (larvae)	----	----	----	----	12.6	0.1
Dimophyes arctica	25.6	0.8	7.5	0.0	3.4	0.0
Sipunculids	24.4	0.1	----	----	---	---
Cyllopus magellanicus	24.4	0.2	82.5	6.3	18.4	0.5
Hyperiella macronyx	23.3	0.1	----	----	1.1	0.0
Vibilia antarctica	22.2	0.2	98.8	11.8	64.4	1.6
Cyllopus lucasii	22.2	0.5	16.3	0.7	11.5	0.4
Euphausia superba (larvae)	22.2	135.8	?	?	?	?
Acanthephyra pelagica (larvae)	22.2	0.1	----	----	----	----
Eusirus perdentatus	22.2	0.1	----	----	----	----
Lepidonotothen kempi (larvae)	20.0	0.1	6.3	0.3	5.7	0.1
Primno macropa	20.0	0.1	6.3	0.5	3.4	0.0
Hyperoche medusarum	18.9	0.0	----	----	---	---
Vanadis antarctica	15.6	0.1	2.5	0.0	4.6	0.0
Electrona antarctica (adults)	13.3	0.1	2.5	0.0	10.3	0.0
Beroe cucumis	12.2	0.0	15.0	0.1	2.3	0.0
Nototheniops nudifrons (larvae)	8.9	0.1	1.3	0.2	1.1	0.1
Epimeriella macronyx	8.9	0.0	----	----	----	----
Bathylagus antarcticus (larvae)	8.9	0.0	----	----	----	----

Contd.

Table 4.3 Contd.

Taxon	Survey A January 1995		Survey A January 1994		Survey A January 1993	
	F(%) (90 tows)	Mean #/1000 m3	F (81 tows)	Mean #/1000 m3	F (87 tows)	Mean #/1000 m3
Gymnoscopelus opisthopteris (adults)	7.8	0.0	----	----	---	---
Atolla wyvillei	7.8	0.0	----	----	1.1	0.0
Ctenophora	6.7	0.0	----	----	----	----
Hydromedusae	6.7	0.1	----	----	----	----
Orchomene rossi	5.6	0.0	----	----	----	----
Byglides pelagica	5.6	0.0	----	----	----	----
Fish eggs	4.4	0.0	----	----	----	----
Eusirus microps	4.4	0.0	----	----	2.3	0.0
Cyphocaris richardi	4.4	0.0	----	----	1.1	0.0
Euphausia crystallorophias	4.4	0.0	----	----	1.1	0.0
Orchomene plebs	4.4	0.0	1.3	0.0	3.4	0.1
Siphonophora no 2	4.4	0.6				
Hyperia macrocephala	3.3	0.0	1.3	0.0	1.1	0.4
Rhynchonereella bongraini	3.3	0.1	----	----	----	----
Gosea brachyura	3.3	0.0	----	----	----	----
Cephalopoda	2.2	0.0	----	----	---	---
Hyperiella antarctica	2.2	0.0	----	----	2.3	0.0
Euphysora gigantea	2.2	0.0	----	----	----	----
Pleurogramma antarcticum (juv.)	2.2	0.0	----	----	----	----
Isopoda	2.2	0.0	----	----	----	----
Periphylla periphylla	1.1	0.0	----	----	4.6	0.0
Travisiopsis levinseni	1.1	0.0	----	----	2.3	0.0
Heteropoda (pteropod) sp.	1.1	0.0	2.5	0.0	----	----
Notothenia coriiceps (larvae)	1.1	0.0	1.3	0.0	----	----
Calycopsis borchgrevinki	1.1	0.0	1.3	0.0	1.1	0.0
Botrynema brucei	1.1	0.0	----	----	----	----
Pegantha martagon	1.1	0.0	----	----	----	----
Pycnogonid	1.1	0.0	----	----	----	----
Gymnoscopelus nicholsi (adult)	1.1	0.0	----	----	----	----
Notothenia gibberifrons (larvae)	1.1	0.0	----	----	----	----
Tomopteris sp #1	1.1	0.0	----	----	----	----
Gymnodraco acuticeps (larvae)	1.1	0.0	----	----	----	----
Artededraco mirus	1.1	0.0	----	----	----	----
Scyphomedusae sp. 4	----	----	----	----	2.3	0.0
Chionodraco rastrospinosus (larvae)	----	----	----	----	2.3	0.0
Chaenodraco wilsoni (larva)	----	----	----	----	1.1	0.0
Scyphomedusae sp. 3	----	----	----	----	1.1	0.0
Beroe forskalii	----	----	----	----	1.1	0.0
Decapoda sp. (larva)	----	----	----	----	1.1	0.0
Scyphomedusae sp. 2	----	----	----	----	1.1	0.0
Kreftichthys anderssoni (juv.)	----	----	2.5	0.0	----	----
Schyphomedusae sp. 1	----	----	1.3	0.0	2.3	0.0

* All chaetognath species, including E. hamata and S. gazellae, were combined as one category in 1993.

A.	January														
	E. superba					*T. macrura*					*S. thompsoni*				
Area	1995 Survey A	1995 Elephant I.	1994 Elephant I.	1993 Elephant I.	1992 Elephant I.	1995 Survey A	1995 Elephant I.	1994 Elephant I.	1993 Elephant I.	1992 Elephant I.	1995 Survey A	1995 Elephant I.	1994 Elephant I.	1993 Elephant I.	1992 Elephant I.
No. Tows	90	71	63	70	63	90	71	63	70	63	90	71	63	70	63
Abundance: No./1000 m3															
Median	3.0	3.6	3.1	8.2	5.7	42.6	36.1	25.4	27.5	22.5	0.5	1.6	582.3	245.8	14.0
Mean	14.6	9.5	34.5	28.8	23.7	96.4	104.1	74.6	48.6	48.1	16.0	20.2	931.9	1213.4	94.3
Std. Dev.	47.7	20.6	94.2	64.4	78.0	208.6	231.9	144.3	60.1	57.0	42.1	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	9.5	6.9	0.0
Maximum	410.6	146.1	495.9	438.9	594.1	1859.0	239.9	901.6	307.1	233.7	239.9	239.9	4781.7	16078.8	1231.1

B.	February-March														
	E. superba					*T. macrura* (*Includes larval stages)					*S. thompsoni*				
Area	1995 Survey	1995 Elephant I.	1994 Elephant I.	1993 Elephant I.	1992 Elephant I.	1995 Survey	1995 Elephant I.	1994* Elephant I.	1993* Elephant I.	1992 Elephant I.	1995 Survey	1995 Elephant I.	1994 Elephant I.	1993 Elephant I.	1992 Elephant I.
No. Tows	89	71	70	67	67	89	71	70	67				70	67	
Abundance: No./1000 m3															
Median	1.9	1.2	0.4	3.0	7.1	35.6	22.2	23.8	22.1	n.a.	0.4	0.7	242.6	605.9	n.a.
Mean	5.7	5.2	17.1	35.0	38.0	161.3	79.7	77.1	128.9	n.a.	16.5	20.6	495.1	1585.9	n.a.
Std. Dev.	11.7	12.0	63.5	89.7	77.4	513.0	138.5	132.6	235.1	n.a.	59.9	66.5	579.4	2725.5	n.a.
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	n.a.	0.0	0.0	5.3	2.2	n.a.
Maximum	90.0	90.0	371.1	542.0	389.9	4661.1	664.9	815.9	1141.5	n.a.	391.9	391.9	2377.5	16662.5	n.a.

Table 4.4. Abundance of krill and dominant zooplankton species collected in the large survey areas and Elephant Island area during (A) January and (B) February 1995 compared to similar sampling periods in 1992, 1993, and 1994. Zooplankton data are not available for February-March 1992.

Table 4.5 AMLR 1995 Small-area Survey B directed IKMT tow information. Abundance expressed as numbers collected per minute of total tow duration.

Station #	Date	Start Time	End Time	Diel	Bottom Depth (m)	Tow Depth (m)	Tow Duration (Min.)	KRILL Total	KRILL #/Min.	SALPS Total	SALPS #/Min.
DT01	30/01/95	0040	0107	N	683	21	27	3324	123.11	-----	-----
DT02	30/01/95	0205	0222	N	486	21	17	430	25.29	-----	-----
DT03	30/01/95	0355	0431	T	673	126	36	19	0.53	68	1.89
DT04	31/01/95	0042	0148	N	3662	211	66	41	0.62	-----	-----
DT05	31/01/95	0235	0326	N	3485	204	51	5	0.10	-----	-----
DT06	31/01/95	2300	2326	N	1589	43	26	14	0.54	-----	-----
DT07	31/01/95	2354	0025	N	1654	132	31	3	0.10	71	2.29
DT08	01/02/95	0117	0138	N	1481	77	21	3	0.14	25	1.19
DT09	01/02/95	0207	0238	N	1483	200	31	44	1.42	9	0.29

FISH

Station #	*Electrona antarctica* Abundance Total	*Electrona antarctica* Abundance #/Min.	*Electrona antarctica* Length (mm SL) Range	*Electrona antarctica* Length (mm SL) Mean	*Gymnoscopelus opisthopterus* Abundance Total	*Gymnoscopelus opisthopterus* Abundance #/Min.	*Gymnoscopelus opisthopterus* Length (mm SL) Range	*Gymnoscopelus opisthopterus* Length (mm SL) Mean
	-----	-----	-----	-----	-----	-----	-----	-----
DT02	-----	-----	-----	-----	-----	-----	-----	-----
DT03	-----	-----	-----	-----	-----	-----	-----	-----
DT04	5	0.08	77-84	79	2	0.03	78-100	89
DT05	6	0.12	62-100	81	1	0.02	90	90
DT06	1	0.04	55	55	-----	-----	-----	-----
DT07	2	0.06	61-81	71	1	0.03	95	95
DT08	10	0.48	77-88	83	-----	-----	-----	-----
DT09	3	0.10	78-85	83	-----	-----	-----	-----

Table 4.6. AMLR 1995 Small-area Survey C directed IKMT tow information. Abundances as numbers collected per minute of tow duration within the targeted depth interval.

Station #	Date	Start Time	End Time	Diel	Bottom Depth	Tow Depth	Target	Target Depth	Min. Fished	KRILL Abundance Total	KRILL Abundance #/Min.	KRILL Length (mm) Range	KRILL Length (mm) Mean
DT10	11/02/95	2327	0025	N	3015	200	FISH	125-200	20	12	0.4	48-55	50
DT11	12/02/95	0116	0216	N	2764	250	FISH	200-250	17	55	1.4	47-57	52
DT12	12/02/95	2345	0025	N	3758	148	FISH	70-148	18	51	2.1	45-58	51
DT13	13/02/95	0201	0221	N	198	44	KRILL	0-44	11	1712	155.6	29-53	42
DT14	13/02/95	0837	0910	D	330	125	KRILL	15-125	18	41	2.2	35-55	49
DT15	13/02/95	1935	2005	D	247	51	KRILL	25-51	16	276	14.5	40-57	49
DT16	13/02/95	2047	2110	T	530	103	KRILL?	60-103	11	22	1.5	45-54	50
DT17	13/02/95	2215	2242	N	270	45	KRILL?	0-45	16	6460	403.8	38-55	48
DT18	14/02/95	0005	0025	N	365	25	KRILL	0-25	11	130	11.8	30-55	50
DT19	14/02/95	0122	0156	N	507	45	?	0-45	20	64	3.2	37-59	50
DT20	14/02/95	0300	0322	N	244	50	KRILL	0-50	12	914	76.2	31-55	46

	OTHER EUPHAUSIIDS											
	Euphausia frigida				*Euphausia triacantha*				*Thysanoessa macrura*			
Station	Abundance		Length (mm)		Abundance		Length (mm)		Abundance		Length (mm)	
#	Total	#/Min.	Range	Mean	Total	#/Min.	Range	Mean	Total	#/Min.	Range	Mean
DT10	5	0.2	18-20	19	18	0.6	28-42	36	-----	-----	-----	-----
DT11	73	1.9	10-24	17	57	1.5	24-43	34	16	0.4	15-33	22
DT12	94	3.9	10-21	17	19	0.8	25-40	35	751	31.3	13-24	17
DT13	-----	-----	-----	-----	-----	-----	-----	-----	85	7.7	10-20	16
DT14	-----	-----	-----	-----	-----	-----	-----	-----	6	0.3	12-24	17
DT15	-----	-----	-----	-----	-----	-----	-----	-----	766	40.3	14-24	18
DT16	767	51.1	12-22	17	3	0.2	25-36	30	337	22.5	13-24	17
DT17	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
DT18	755	68.6	10-22	17	-----	-----	-----	-----	210	19.1	12-30	17
DT19	2160	108.0	12-26	20	-----	-----	-----	-----	80	4.0	12-21	18
DT20	6	0.5	n.a.	n.a.	-----	-----	-----	-----	-----	-----	-----	-----

	SALPS				FISH							
	Salpa thompsoni				*Electrona antarctica*				*Gymnoscopelus opisthopteris*			
Station	Abundance		Length (mm)		Abundance		Length (mm)		Abundance		Length (mm)	
#	Total	#/Min.	Range	Mean	Total	#/Min.	Range	Mean	Total	#/Min.	Range	Mean
DT10	65	2.2	13-51	29	5	0.3	47-85	73	-----	-----	-----	-----
DT11	76	1.9	9-65	27	6	0.4	40-83	69	2	0.1	75-87	81
DT12	-----	-----	-----	-----	12	0.7	40-86	71	2	0.1	68-85	76
DT13	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
DT14	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
DT15	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
DT16	32	2.1	16-23	21	-----	-----	-----	-----	-----	-----	-----	-----
DT17	-----	-----	-----		-----	-----	-----	-----	-----	-----	-----	-----
DT18	14	1.3	22-35	33	1	0.1	83	83	-----	-----	-----	-----
DT19	-----	-----	-----		1	0.1	84	84	-----	-----	-----	-----
DT20	-----	-----	-----		-----	-----	-----	-----	-----	-----	-----	-----

Table 4.7 Zooplankton collected in large-area Surveys A and D. Abundance is numbers per 1000 m3. F(%) is percent frequency of occurrence in tows.

	SURVEY A JANUARY 1995				SURVEY D FEBRUARY 1995			
TAXON	F(%)	Mean	Std	Median	F(%)	Mean	Std	Median
Copepoda	98.9	652.7	961.2	343.7	100.0	3189.1	5255.7	1422.0
Chaetognatha	98.9	79.7	147.6	30.5	100.0	296.4	379.1	152.8
Euphausia superba larvae	22.2	135.8	863.9	0.0	93.3	3690.0	18058.1	145.3
Thysanoessa macrura (adults)	91.1	96.4	208.6	42.6	93.3	161.3	513.0	35.6
Thysanoessa macrura (larvae)	36.7	15.9	67.3	0.0	79.8	276.9	547.5	28.8
Euphausia superba	87.8	14.5	47.3	3.5	78.7	5.7	11.7	1.9
Ostracods	56.7	9.7	22.6	1.1	75.3	43.4	97.4	12.6
Themisto gaudichaudii	76.7	4.9	9.8	0.9	74.2	3.6	10.3	1.2
Electrona antarctica (larvae)	61.1	2.5	5.5	0.3	62.9	5.2	15.1	0.3
Euphausia frigida	50.0	9.8	28.9	0.1	60.7	16.7	34.0	1.0
Spongiobranchaea australis	64.4	0.5	0.6	0.2	60.7	0.4	0.6	0.3
Salpa thompsoni	66.7	16.0	42.1	0.5	59.6	16.5	59.9	0.4
Sagitta gazellae	48.9	3.4	6.6	0.0	59.6	3.0	6.3	0.4
Tomopteris carpenteri	84.4	4.2	5.5	2.2	57.3	1.3	2.6	0.3
Lepidonotothen kempi (larvae)	20.0	0.1	0.4	0.0	48.3	0.4	0.7	0.0
Notolepis coatsi (larvae)	27.8	0.1	0.3	0.0	36.0	0.2	0.5	0.0
Eukronia hamata	10.0	0.1	0.2	0.0	33.7	0.8	2.0	0.0
Primno macropa	20.0	0.1	0.1	0.0	31.5	0.4	1.0	0.0
Euphausia triacantha	33.3	1.5	3.8	0.0	28.1	1.6	4.1	0.0
Cyllopus magellanicus	24.4	0.2	0.5	0.0	25.8	0.7	2.0	0.0
Hyperiella dilatata	54.4	0.3	0.5	0.2	24.7	0.1	0.3	0.0
Cyllopus lucasii	22.2	0.5	1.7	0.0	23.6	0.5	2.3	0.0
Diphyes antarctica	58.9	1.0	2.1	30.5	23.6	0.4	1.2	0.0
Vibilia antarctica	22.2	0.2	0.6	0.0	23.6	0.2	0.5	0.0
Rhynchonereella bongraini	3.3	0.1	0.4	0.0	20.2	0.1	0.3	0.0
Electrona antarctica (adults)	13.3	0.1	0.2	0.0	15.7	0.1	0.2	0.0
Bathylagus antarcticus (larvae)	8.9	0.0	0.1	0.0	14.6	0.0	0.1	0.0
Dimophyes arctica	25.6	0.8	3.6	0.0	13.5	0.3	1.9	0.0
Scyphomedusae	4.4	0.0	0.0	0.0	13.5	0.1	0.2	0.0
Hyperiella macronyx	23.3	0.1	0.2	0.0	13.5	0.0	0.2	0.0
Clio pyramidata	72.2	5.3	15.0	1.0	12.4	0.0	0.1	0.0
Hyperoche medusarum	18.9	0.0	0.1	0.0	12.4	0.0	0.1	0.0
Calycopsis borchgrevinki	1.1	0.0	0.0	0.0	11.2	0.0	0.1	0.0
Gymnoscopelus opisthopteris (adults)	7.8	0.0	0.1	0.0	10.1	0.0	0.1	0.0
Lepidonothen larseni (larvae)	40.0	1.1	4.6	0.0	10.1	0.0	0.1	0.0
Sipunculid	24.4	0.1	0.3	0.0	9.0	0.0	0.1	0.0
Eusirus perdentatus	22.2	0.1	0.2	0.0	6.7	0.1	0.9	0.0
Vanadis antarctica	15.6	0.1	0.2	0.0	6.7	0.0	0.1	0.0
Orchomene rossi	5.6	0.0	0.1	0.0	6.7	0.0	0.1	0.0
Epimeriella macronyx	8.9	0.0	0.2	0.0	5.6	0.6	5.2	0.0
Hydromedusae	6.7	0.1	0.3	0.0	5.6	0.0	0.2	0.0
Acanthephyra pelagica (larvae)	22.2	0.1	0.2	0.0	5.6	0.0	0.1	0.0
Hyperia macrocephala	3.3	0.0	0.1	0.0	5.6	0.0	0.1	0.0
Limacina helicina	43.3	1.9	7.5	0.0	4.5	0.0	0.1	0.0
Beroe cucumis	12.2	0.0	0.1	0.0	4.5	0.0	0.1	0.0
Cyphocaris richardi	4.4	0.0	0.0	0.0	3.4	0.1	0.6	0.0
Orchomene plebs	4.4	0.0	0.1	0.0	3.4	0.0	0.2	0.0

Contd.

Table 4.7 Contd.

	SURVEY A JANUARY 1995				SURVEY D FEBRUARY 1995			
TAXON	F(%)	Mean	Std	Median	F(%)	Mean	Std	Median
Notolepis annulata (larvae)	13.3	0.0	0.1	0.0	3.4	0.0	0.1	0.0
Nototheniops nudifrons (larvae)	8.9	0.1	0.2	0.0	3.4	0.0	0.1	0.0
Ctenophora	6.7	0.0	0.1	0.0	3.4	0.0	0.1	0.0
Pleurogramma antarcticum (juv.)	2.2	0.0	0.0	0.0	2.2	0.0	0.4	0.0
Byglides pelagica	5.6	0.0	0.0	0.0	2.2	0.0	0.3	0.0
Cyllopus spp.	1.1	0.0	0.0	0.0	2.2	0.0	0.1	0.0
Notolepis spp. (larvae)	0.0	0.0	0.0	0.0	2.2	0.0	0.1	0.0
Harpagifer antarcticus	0.0	0.0	0.0	0.0	1.1	0.0	0.1	0.0
Gymnoscopelus nicholsi (adults)	1.1	0.0	0.0	0.0	1.1	0.0	0.1	0.0
Scina antarctica	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0
Pagetopsis macropterus	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0
Beroe forskalii	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0
Periphylla periphylla	1.1	0.0	0.0	0.0	1.1	0.0	0.0	0.0
Polychaete sp. 1	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0
Fish eggs	4.4	0.0	0.0	0.0	1.1	0.0	0.0	0.0
Champsocephalus gunnari	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0
Lepidonothen larseni (juv.)	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0
Travisiopsis coniceps	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0
Chaenodraco wilsoni (larvae)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gosea brachyura	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cephalopoda	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gymnodraco acuticeps (larvae)	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tomopteris sp #1	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Travisiopsis levinseni	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Artededraco mirus	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Atolla wyvillei	7.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Botrynema brucei	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hyperiella antarctica	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gymnoscopelus sp. (adults)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Notothenia neglecta (juv.)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eusirus microps	4.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Heteropoda (pteropod) sp.	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Notothenia gibberifrons (larvae)	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Euphausia crystallorophias	4.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Euphysora gigantea	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Notothenia coriiceps (larvae)	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pycnogonid	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Clione limacina	41.1	0.5	1.8	0.0	0.0	0.0	0.0	0.0
Chionodraco rastrospinosus (larvae)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hyperiella spp.	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kreftichthys anderssoni (juv.)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Isopoda	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pegantha martagon	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL		898.2	1090.3	583.3		7717.1	25043.6	1802.7

Table 4.8 Zooplankton taxa present in the large-area survey samples during February 1995 compared to February-March 1994 and 1993. F (%) is the frequency of occurrence in tows. n.a. indicates that the taxon was present but not enumerated. ? indicates that the taxon was probably present but not noted.

	Survey D February 1995		Survey D February-March 1994		Survey E February-March 1993	
Taxon	F(%) (89 tows)	Mean #/1000m3	F(%) (89 tows)	Mean #/1000m3	F(%) (89 tows)	Mean #/1000m3
Copepoda	100.0	3189.1	89.9	3090.2	n.a.	n.a.
*Chaetognatha**	100.0	296.4	n.a.	n.a.	n.a.	n.a.
Euphausia superba (larvae)	93.3	3690.0	?	?	?	?
Thysanoessa macrura (adults)	93.3	161.3	91.0	118.9	96.3	141.5
Thysanoessa macrura (larvae)	79.8	276.9	n.a.	n.a.	n.a.	n.a.
Euphausia superba	78.7	5.7	66.3	18.4	83.8	35.0
Ostracods	75.3	43.4	n.a.	n.a.	n.a.	n.a.
Themisto gaudichaudii	74.2	3.6	94.4	11.8	60.0	2.3
Electrona antarctica (larvae)	62.9	5.2	11.2	0.2	5.0	0.1
Euphausia frigida	60.7	16.7	61.8	25.9	7.5	1.0
Spongiobranchaea australis	60.7	0.4	14.6	0.1	20.0	0.3
Salpa thompsoni	59.6	16.5	98.9	523.5	100.0	1567.1
*Sagitta gazellae**	59.6	3.0	34.8	3.8	n.a.	n.a.
Tomopteris carpenteri	57.3	1.3	24.7	0.6	12.5	0.2
Lepidonotothen kempi (larvae)	48.3	0.4	6.7	0.1	1.3	0.0
Notolepis coatsi (larvae)	36.0	0.2	-----	-----	-----	-----
*Eukronia hamata**	33.7	0.8	3.4	0.1	n.a.	n.a.
Primno macropa	31.5	0.4	10.1	0.1	-----	-----
Euphausia triacantha	28.1	1.6	11.2	1.0	21.3	1.0
Cyllopus magellanicus	25.8	0.7	79.8	4.4	32.5	0.9
Hyperiella dilatata	24.7	0.1	36.0	0.6	1.3	0.0
Cyllopus lucasii	23.6	0.5	89.9	6.1	37.5	1.5
Diphyes antarctica	23.6	0.4	13.5	0.1	15.0	0.3
Vibilia antarctica	23.6	0.2	85.4	6.4	47.5	1.6
Rhynchonereella bongraini	20.2	0.1	-----	-----	-----	-----
Electrona antarctica (adults)	15.7	0.1	13.5	0.1	3.8	0.0
Bathylagus antarcticus (larvae)	14.6	0.0	-----	-----	-----	-----
Dimophyes arctica	13.5	0.3	10.1	0.0	6.3	0.2
Scyphomedusae	13.5	0.1	-----	-----	-----	-----
Hyperiella macronyx	13.5	0.0	-----	-----	-----	-----
Clio pyramidata	12.4	0.0	9.0	0.2	1.3	0.0
Hyperoche medusarum	12.4	0.0	5.6	0.1	-----	-----
Calycopsis borchgrevinki	11.2	0.0	10.1	0.1	-----	-----
Gymnoscopelus opisthopteris (adults	10.1	0.0	2.2	0.0	-----	-----
Lepidonothen larseni (larvae)	10.1	0.0	-----	-----	5.0	0.2
Sipunculids	9.0	0.0	3.4	0.0	-----	-----
Eusirus perdentatus	6.7	0.1	-----	-----	-----	-----
Vanadis antarctica	6.7	0.0	7.9	0.1	-----	-----
Orchomene rossi	6.7	0.0	-----	-----	-----	-----
Epimeriella macronyx	5.6	0.6	-----	-----	-----	-----
Hydromedusae	5.6	0.0	-----	-----	-----	-----

Contd.

Table 4.8 Contd.

Taxon	Survey D February 1995 F(%) (89 tows)	Survey D February 1995 Mean #/1000m3	Survey D February-March 1994 F(%) (89 tows)	Survey D February-March 1994 Mean #/1000m3	Survey E February-March 1993 F(%) (89 tows)	Survey E February-March 1993 Mean #/1000m3
Acanthephyra pelagica (larvae)	5.6	0.0	-----	-----	-----	-----
Hyperia macrocephala	5.6	0.0	-----	-----	-----	-----
Limacina helicina	4.5	0.0	-----	-----	-----	-----
Beroe cucumis	4.5	0.0	2.2	0.0	1.3	0.0
Cyphocaris richardi	3.4	0.1	-----	-----	-----	-----
Orchomene plebs	3.4	0.0	2.2	0.1	---	---
Notolepis annulata (larvae)	3.4	0.0	-----	-----	-----	-----
Nototheniops nudifrons (larvae)	3.4	0.0	-----	-----	-----	-----
Ctenophora	3.4	0.0	-----	-----	-----	-----
Pleurogramma antarcticum (juv.)	2.2	0.0	-----	-----	-----	-----
Byglides pelagica	2.2	0.0	-----	-----	-----	-----
Polychaete sp. 1	2.2	0.0	-----	-----	-----	-----
Notolepis spp. (larvae)	2.2	0.0	5.6	0.0	3.8	0.1
Gymnoscopelus nicholsi (adult)	1.1	0.0	-----	-----	-----	-----
Scina antarctica	1.1	0.0	-----	-----	-----	-----
Pagetopsis macropterus	1.1	0.0	-----	-----	-----	-----
Beroe forskalii	1.1	0.0	3.4	0.1	---	---
Periphylla periphylla	1.1	0.0	3.4	0.0	---	---
Champsocephalus gunnari	1.1	0.0	-----	-----	-----	-----
Fish eggs	1.1	0.0	7.9	0.1	---	---
Lepidonothen larseni (juv)	1.1	0.0	-----	-----	-----	-----
Travisiopsis coniceps	1.1	0.0	-----	-----	-----	-----
Notothenia coriiceps (larvae)	-----	-----	----	----	11.3	0.1
Euphausia crystallorophias	-----	-----	----	----	5.0	0.2
Eusirus microps	-----	-----	----	----	1.3	0.0

* All chaetognath species, including E. hamata and S. gazellae, were combined as one category in 1993.

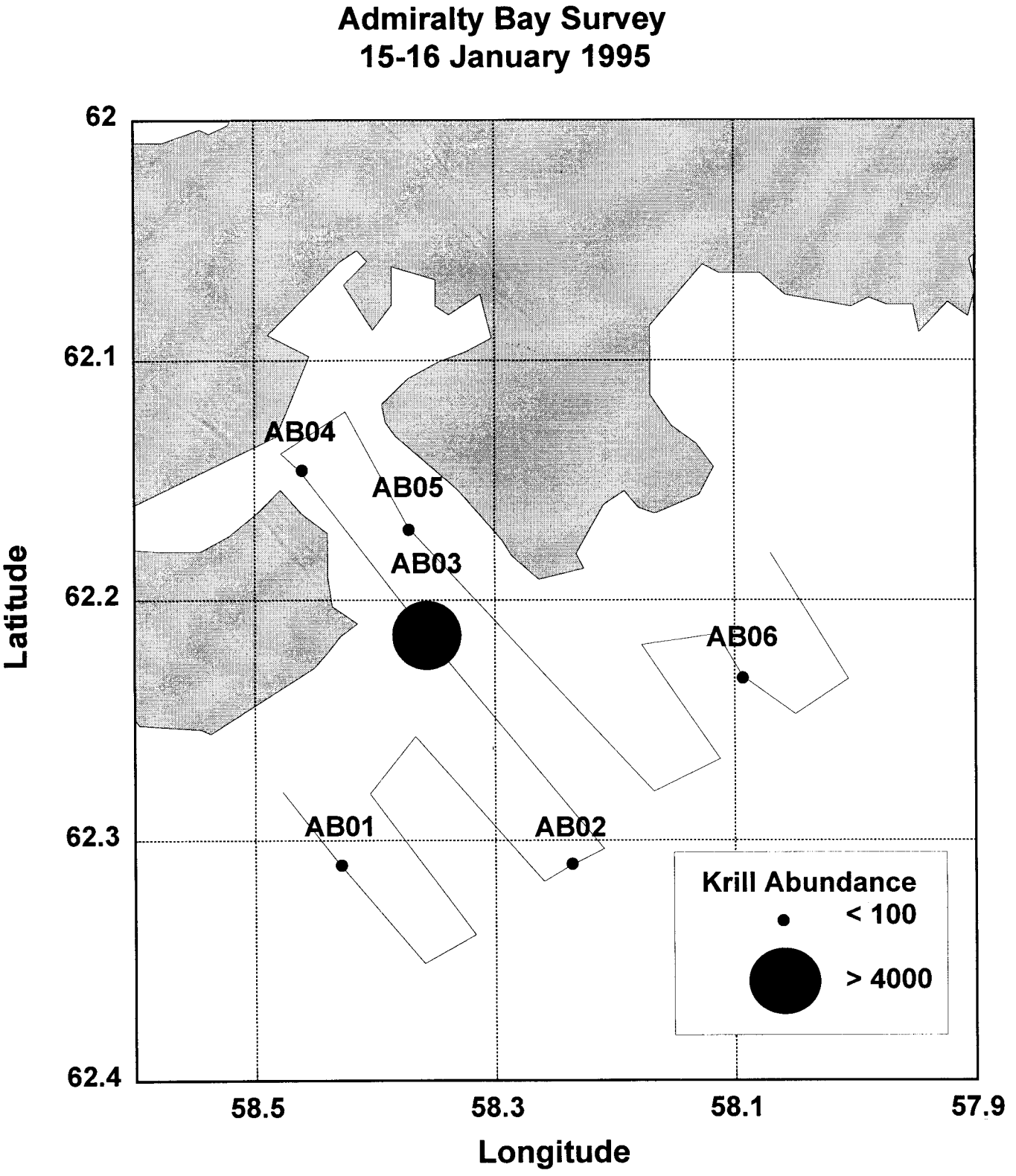


Figure 4.1 Krill abundance in IKMT tows collected during the Admiralty Bay Survey, 15-16 January (Survey AB1).

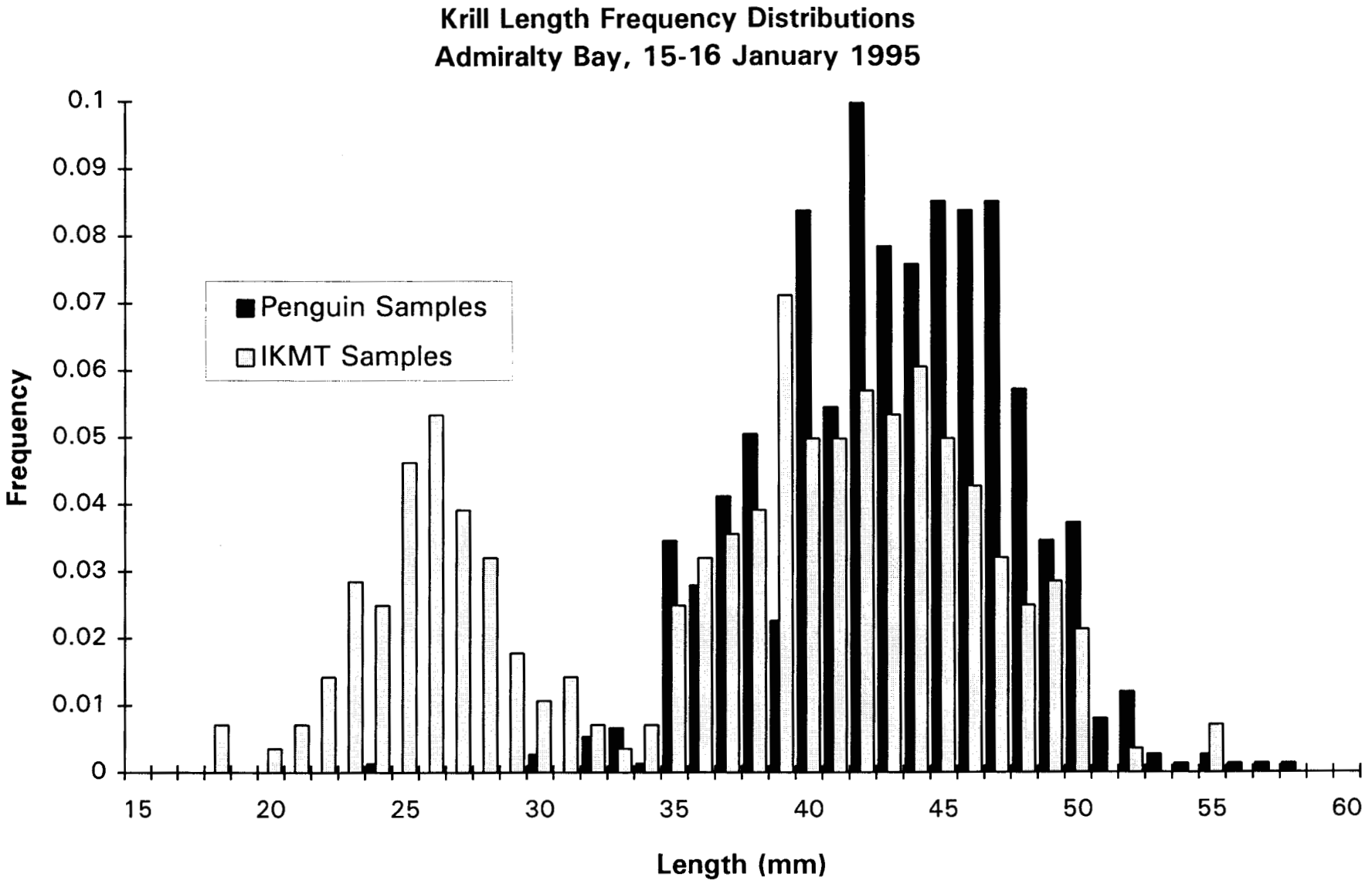


Figure 4.2 Length frequency distributions of krill obtained from penguin stomachs compared to those in the IKMT samples collected during Survey AB1.

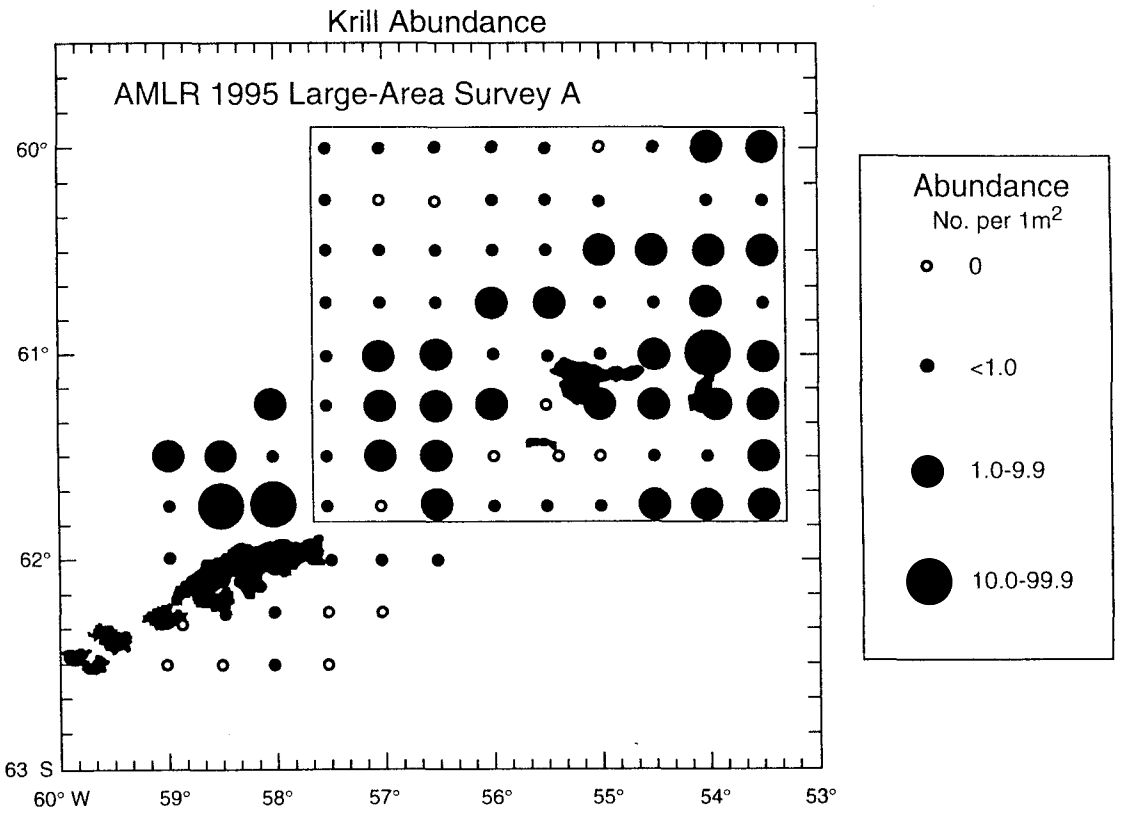


Figure 4.3 Krill abundance in IKMT tows collected during Survey A. The outlined stations are included in the "Elephant Island area" used for between-year comparisons.

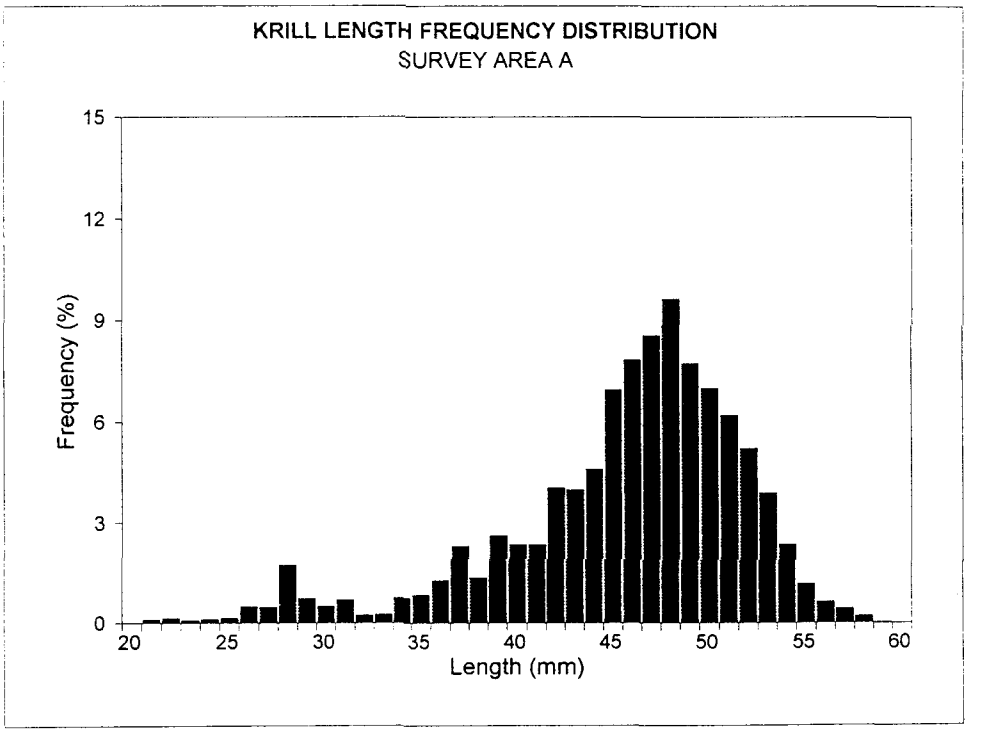


Figure 4.4 Overall length frequency distribution of krill collected during Survey A.

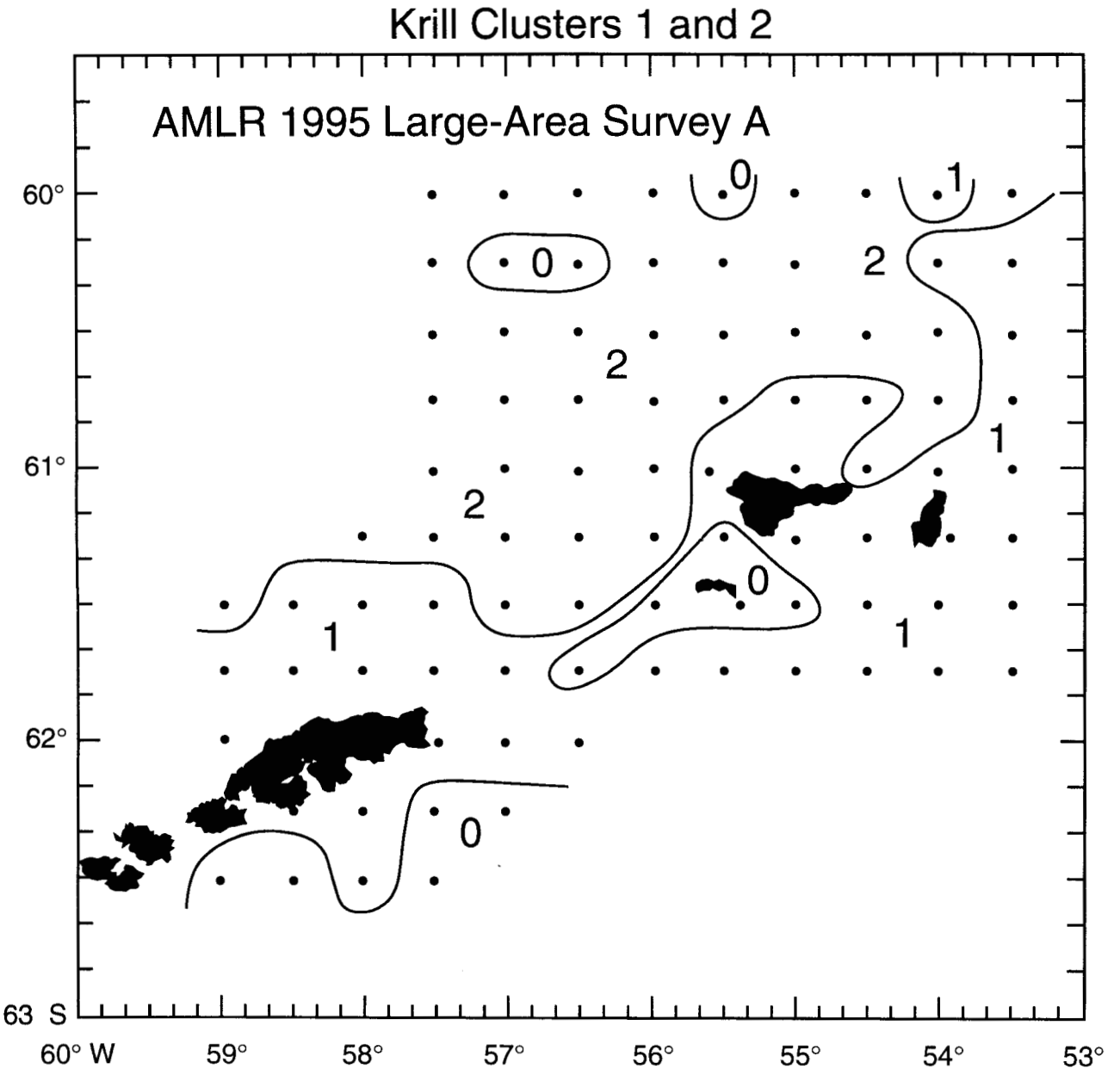
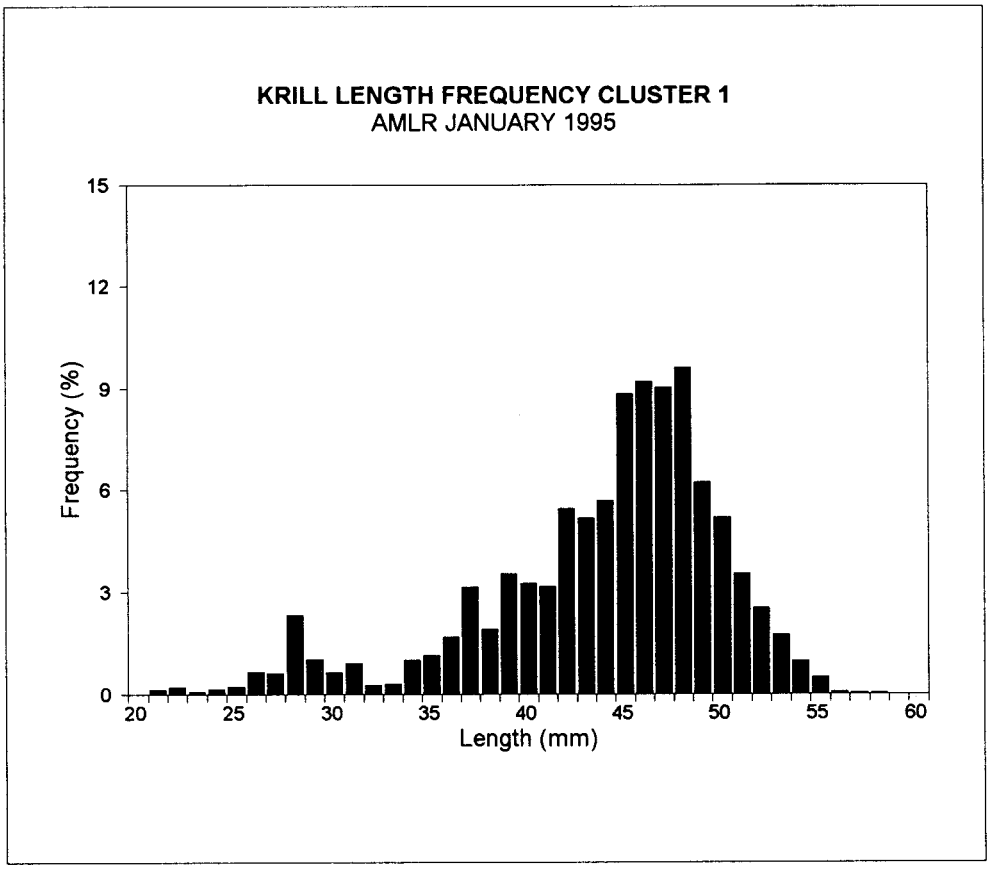


Figure 4.5 Distribution of krill belonging to two different length frequency categories (Clusters 1 and 2) in the Survey A area.



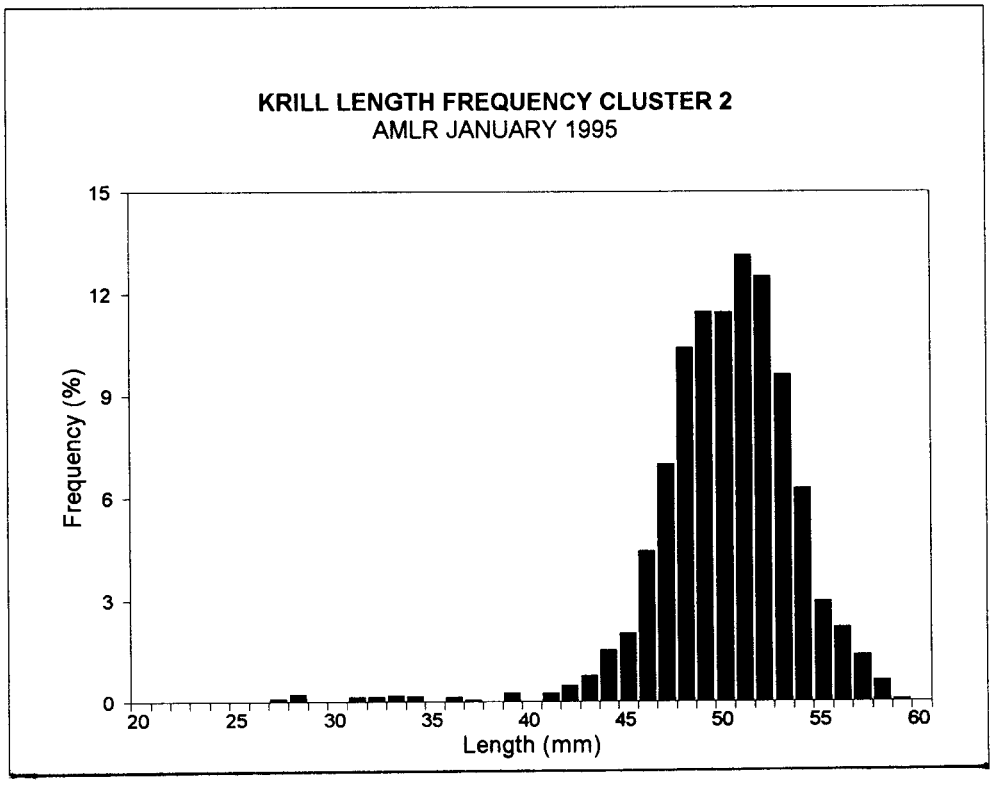


Figure 4.6 Length frequency distributions of krill belonging to two different length categories (Clusters 1 and 2) present in the Survey A area as determined by cluster analysis.

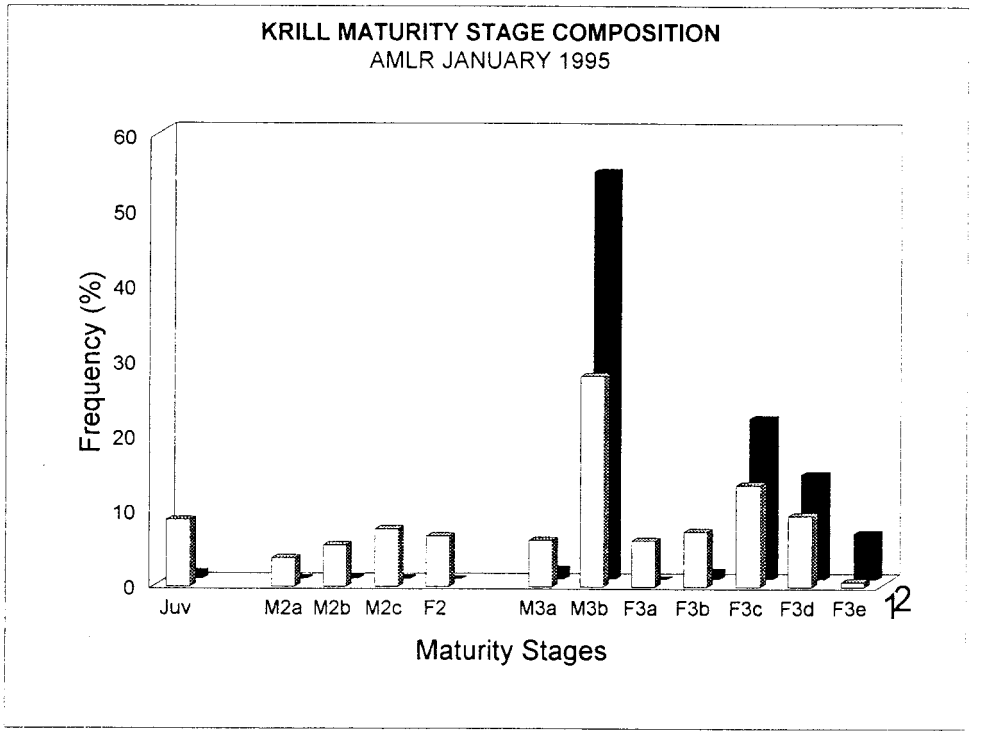


Figure 4.7 Maturity stage composition of krill associated with the two different length categories (Clusters 1 and 2) present in the Survey A area.

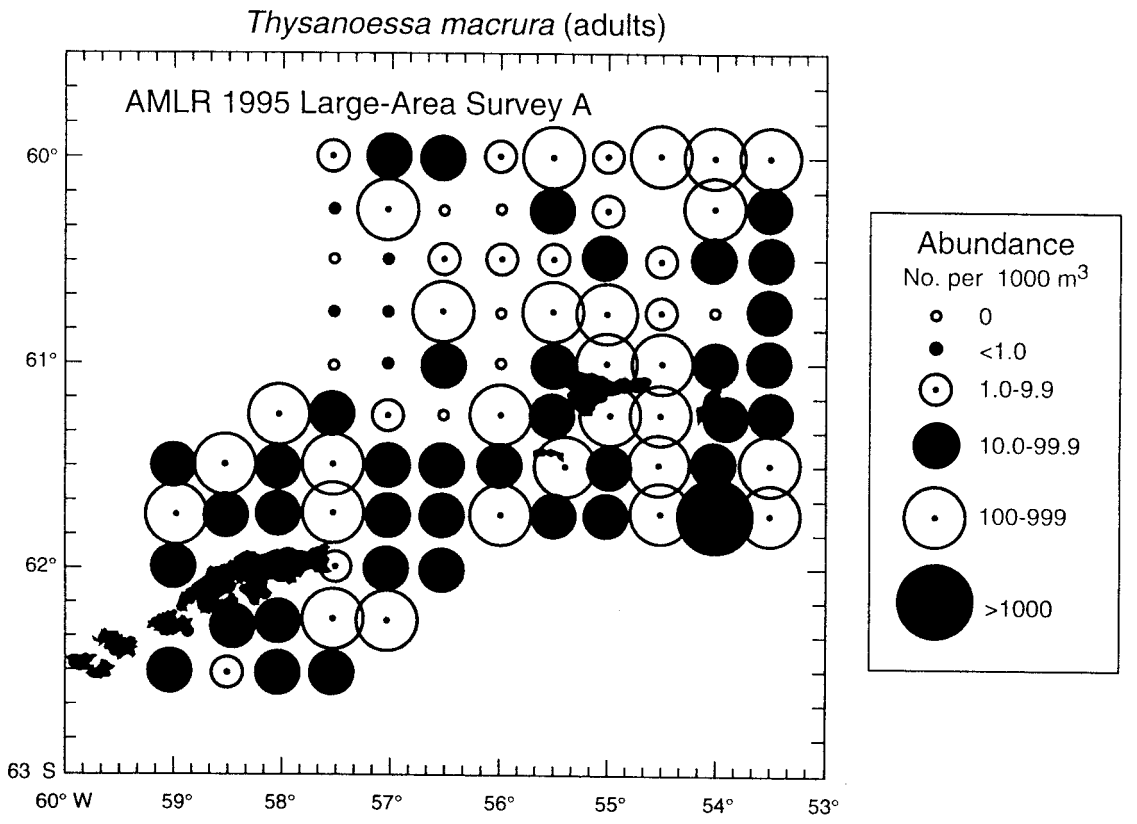


Figure 4.8 Distribution and abundance of adult *Thysanoessa macrura* in the Survey A area.

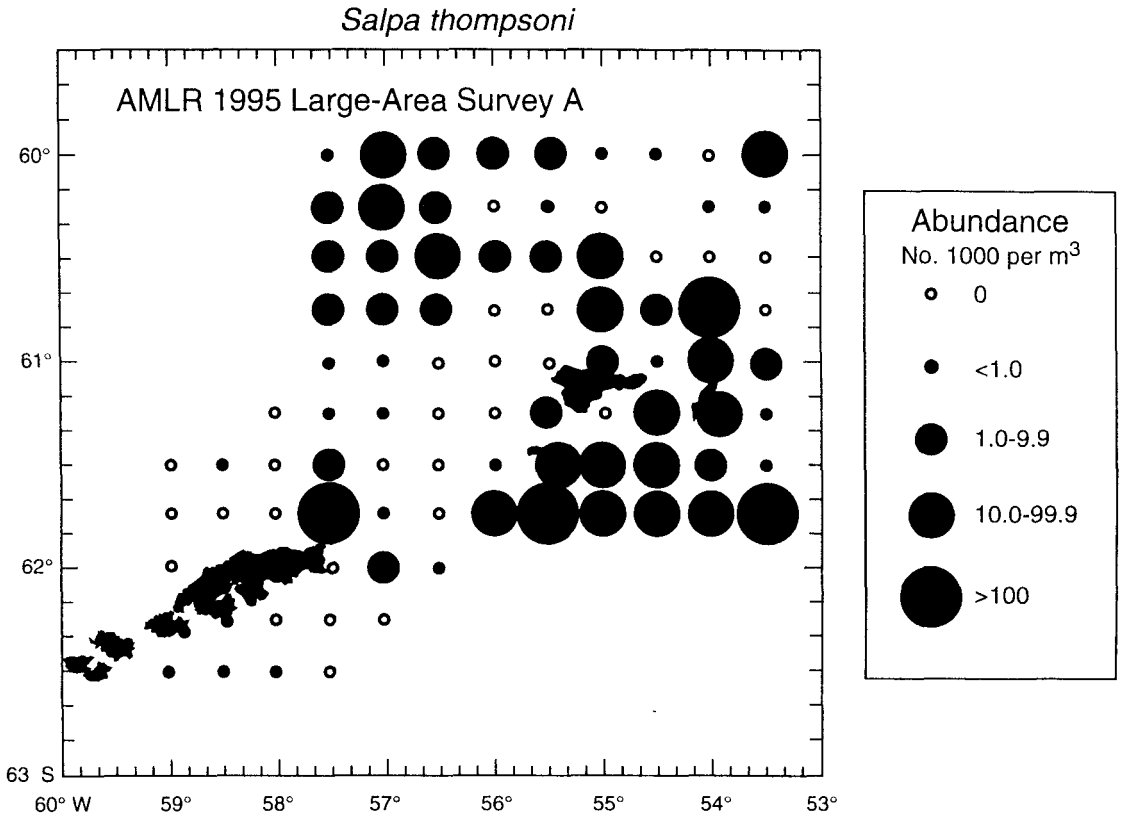


Figure 4.9 Distribution and abundance of *Salpa thompsoni* in the Survey A area.

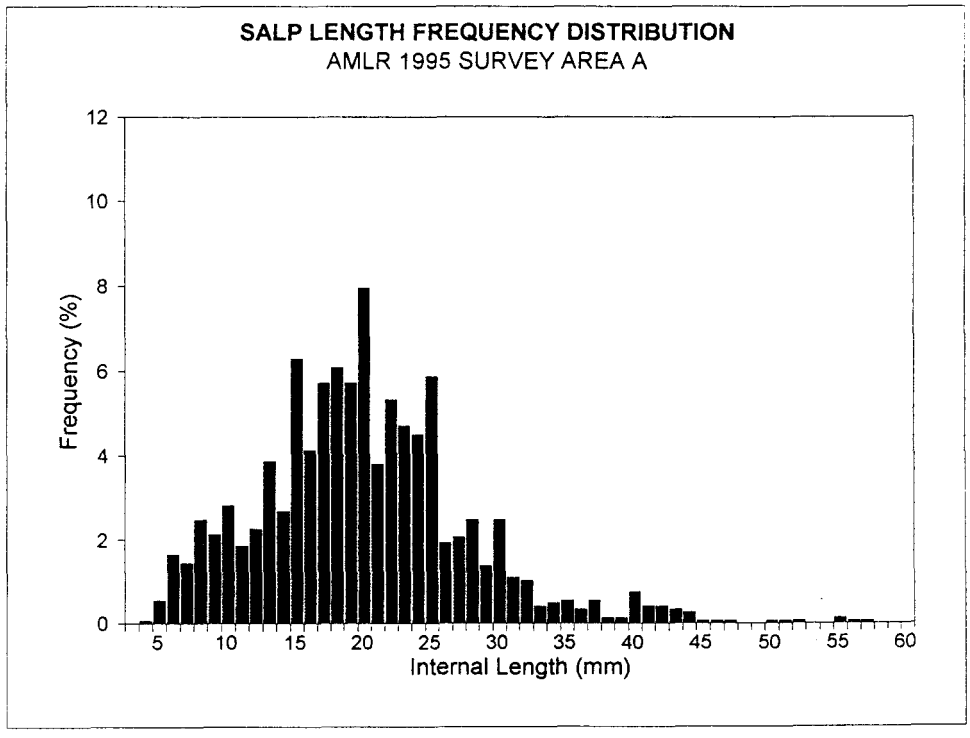


Figure 4.10 Length frequency distribution of salps in the Survey A area.

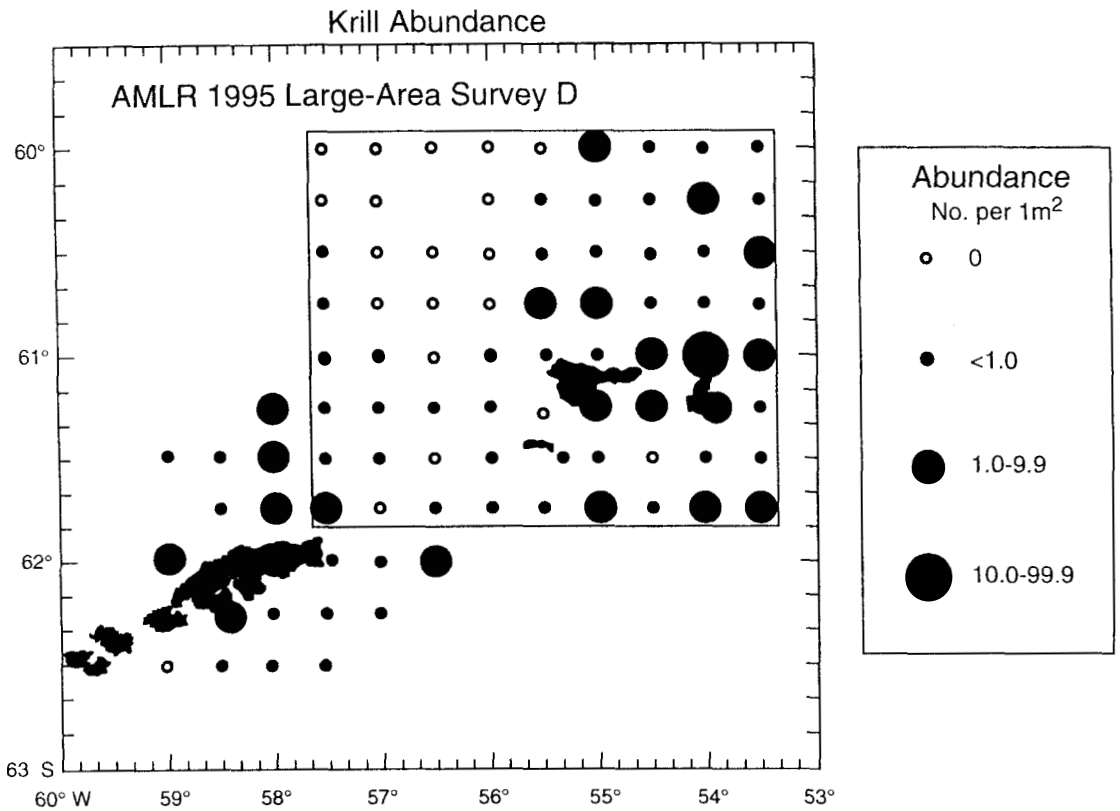


Figure 4.11 Krill abundance in IKMT tows collected during Survey D.

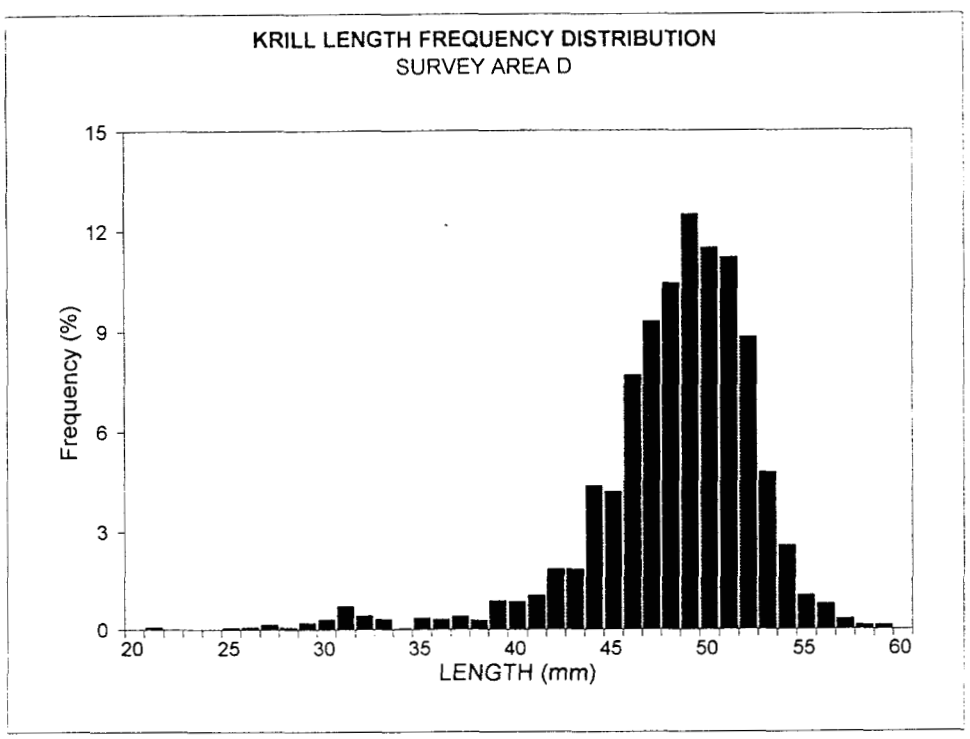


Figure 4.12 Overall length frequency distribution of krill collected during Survey D.

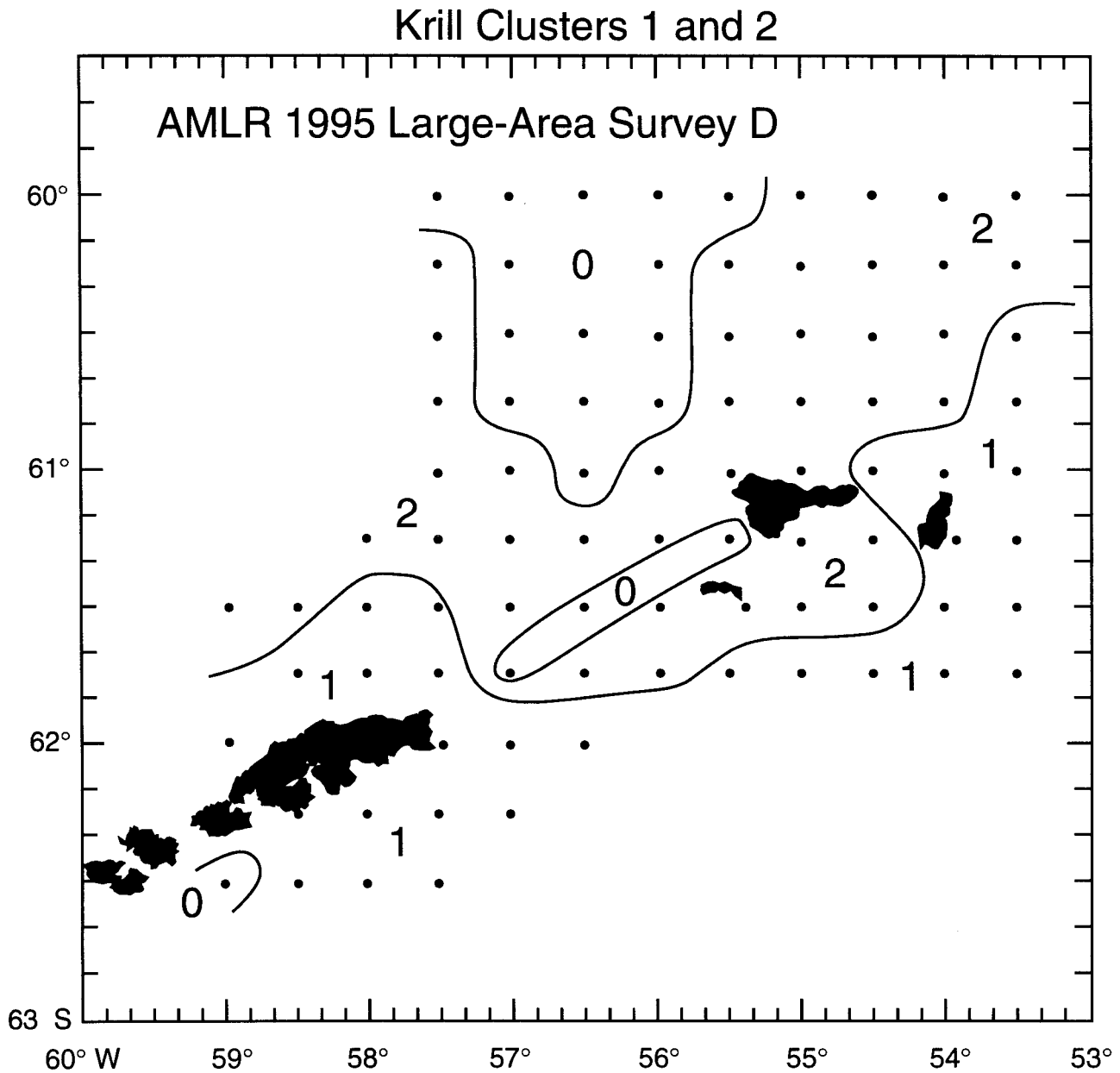
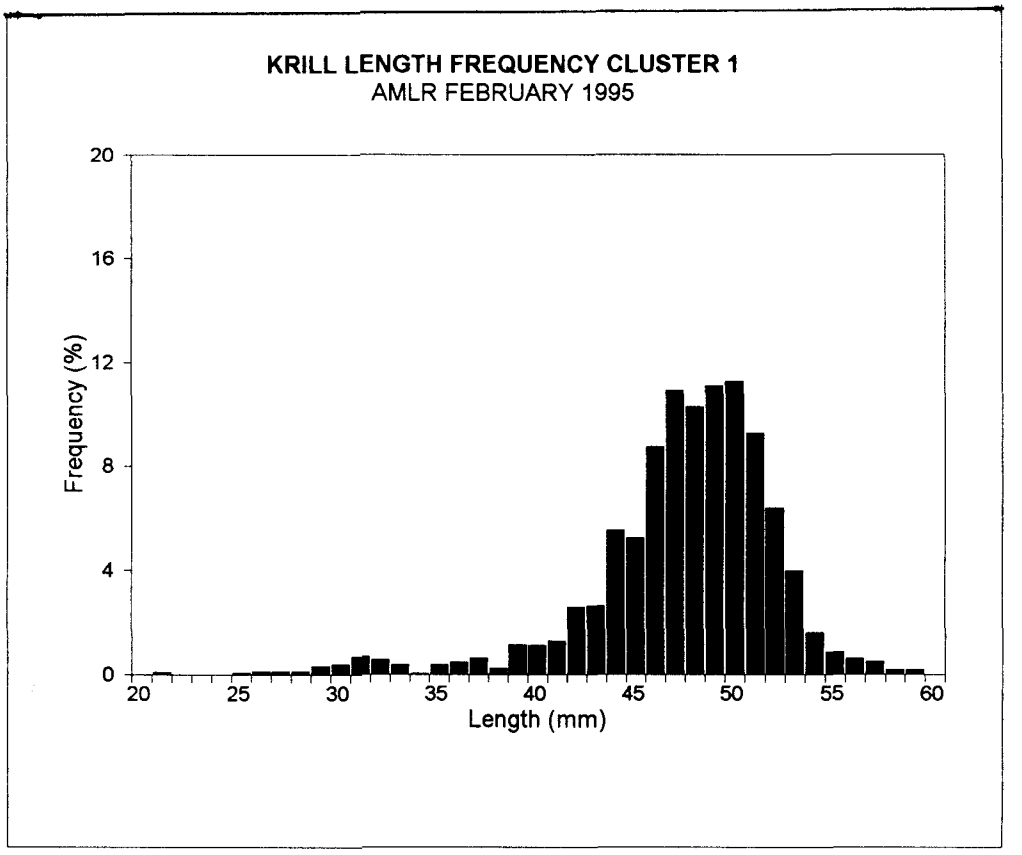


Figure 4.13 Distribution of krill belonging to two different length frequency categories (Clusters 1 and 2) in the Survey D area.



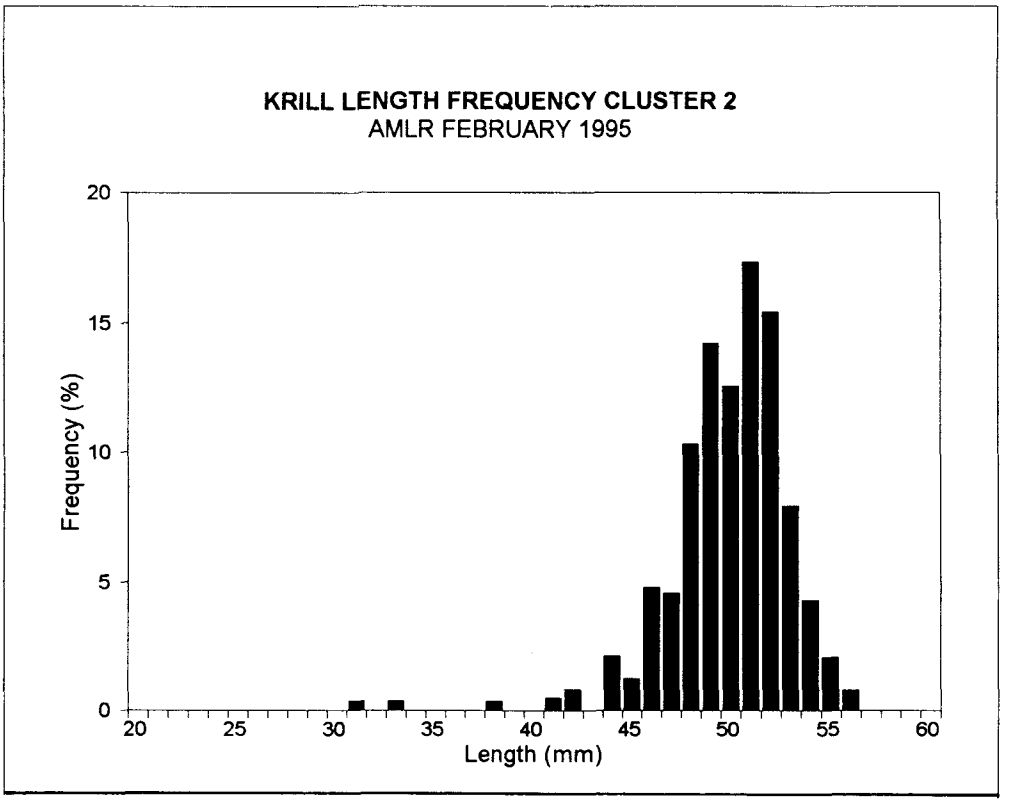


Figure 4.14 Length frequency distributions of krill belonging to two different length categories (Clusters 1 and 2) present in the Survey D area as determined by cluster analysis.

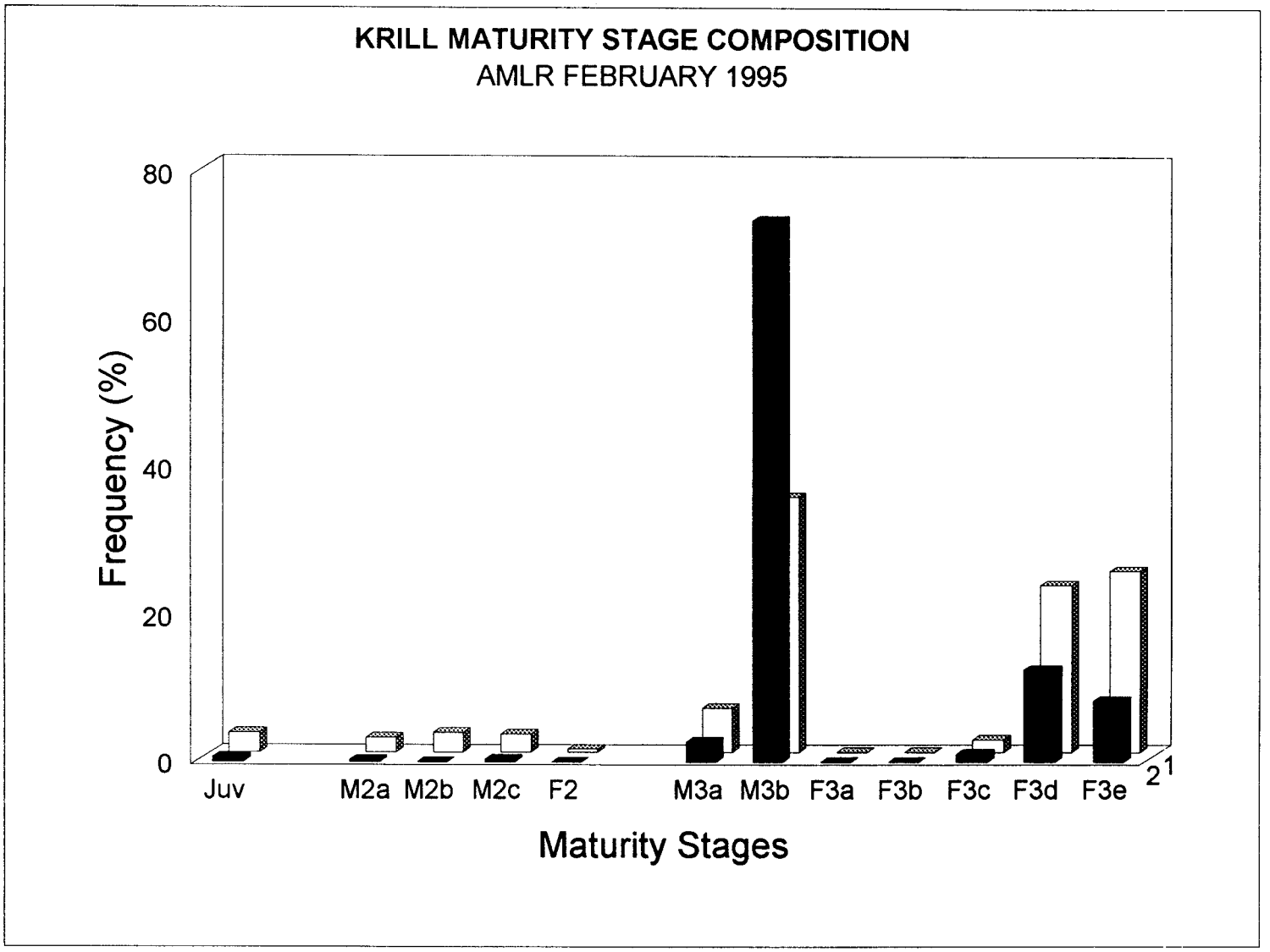


Figure 4.15 Maturity stage composition of krill associated with the two different length categories (Clusters 1 and 2) present in the Survey D area.

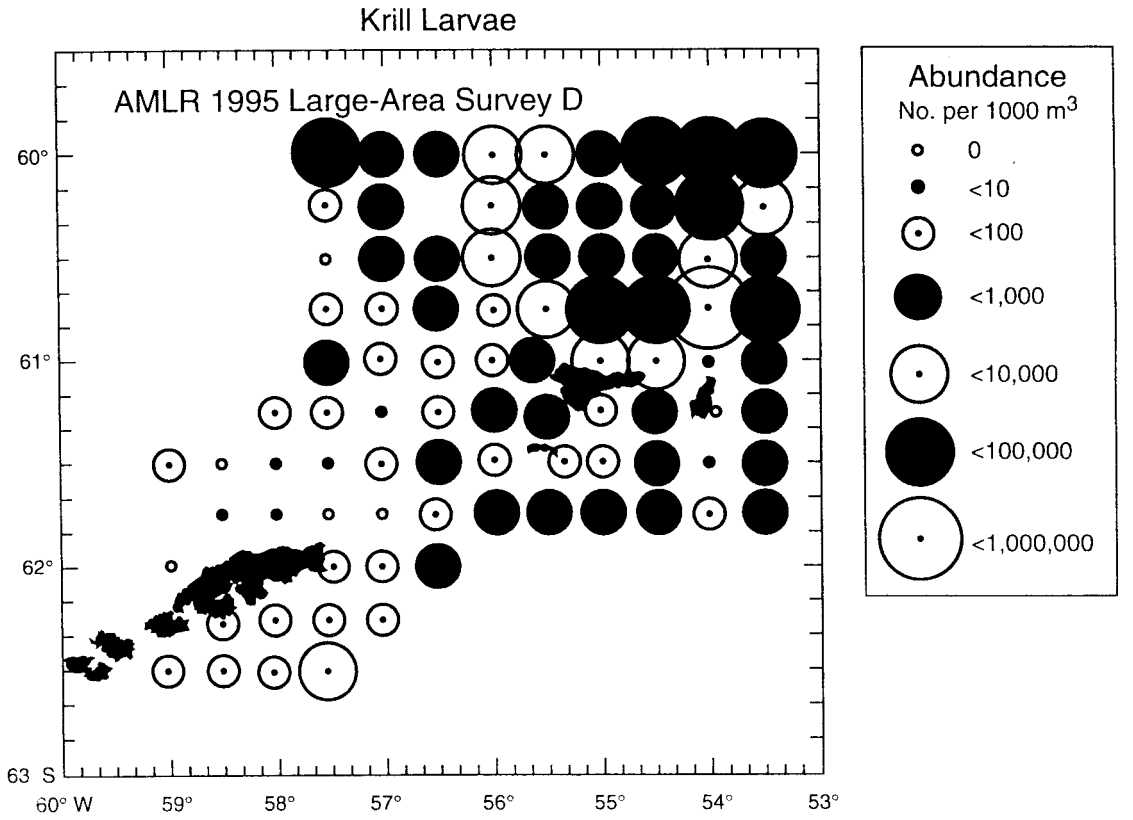


Figure 4.16 Distribution of krill larvae in the Survey D area.

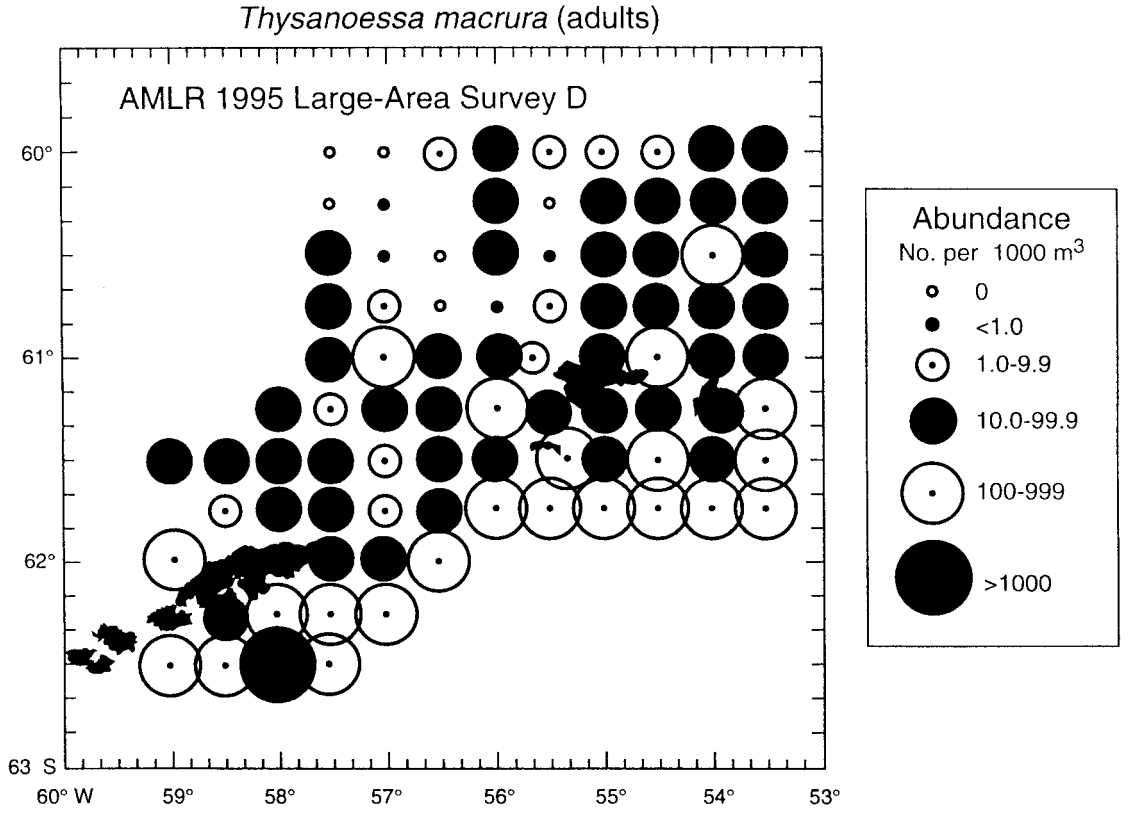


Figure 4.17 Distribution and abundance of adult *Thysanoessa macrura* in the Survey D area.

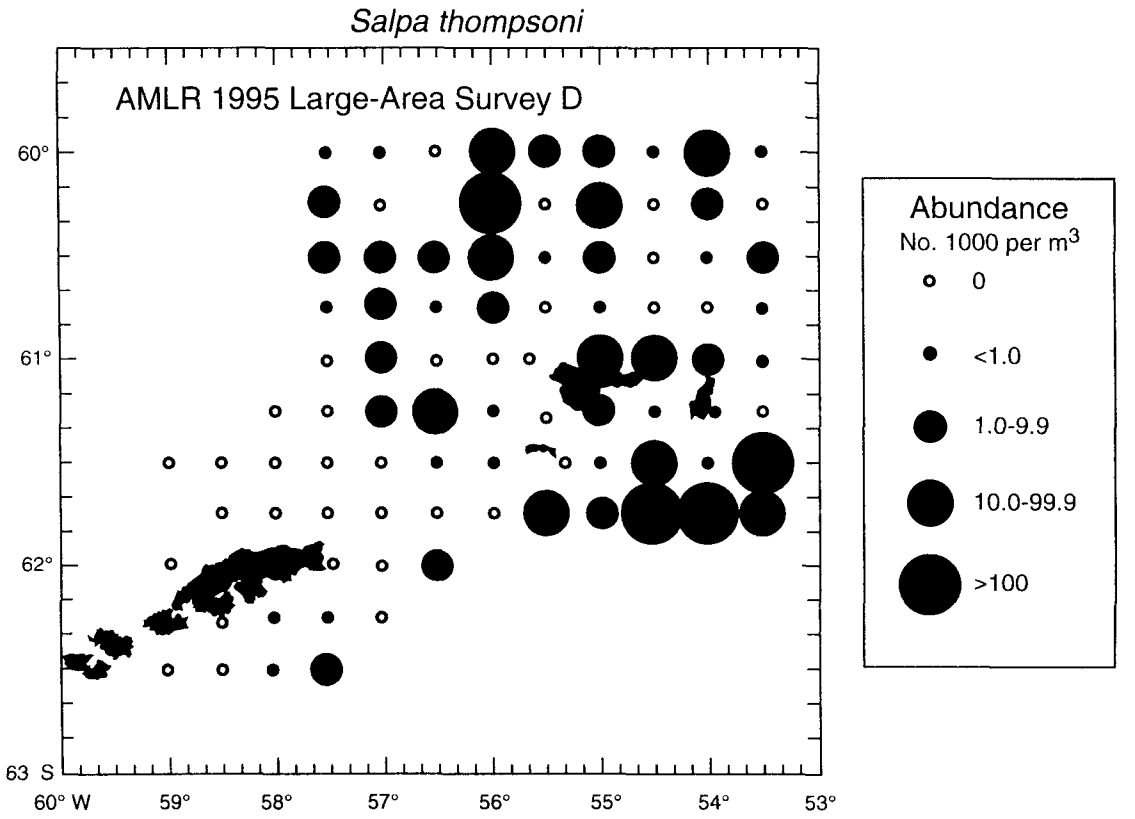


Figure 4.18 Distribution and abundance of salps (*Salpa thompsoni*) in the Survey D area.

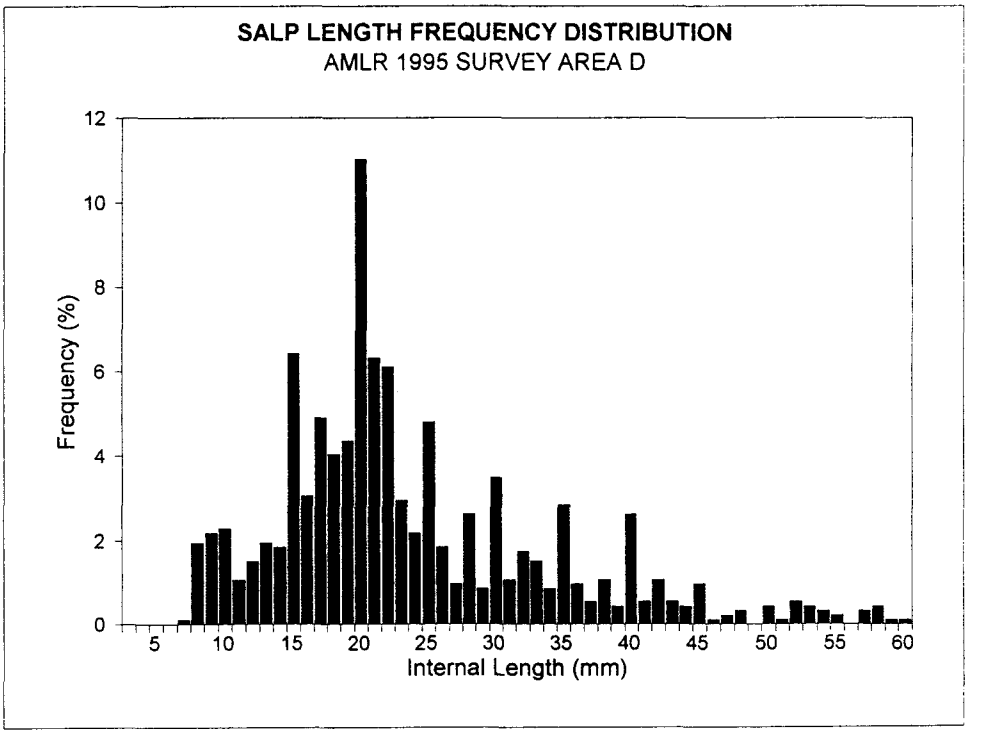


Figure 4.19 Length frequency distribution of salps in the Survey D area.

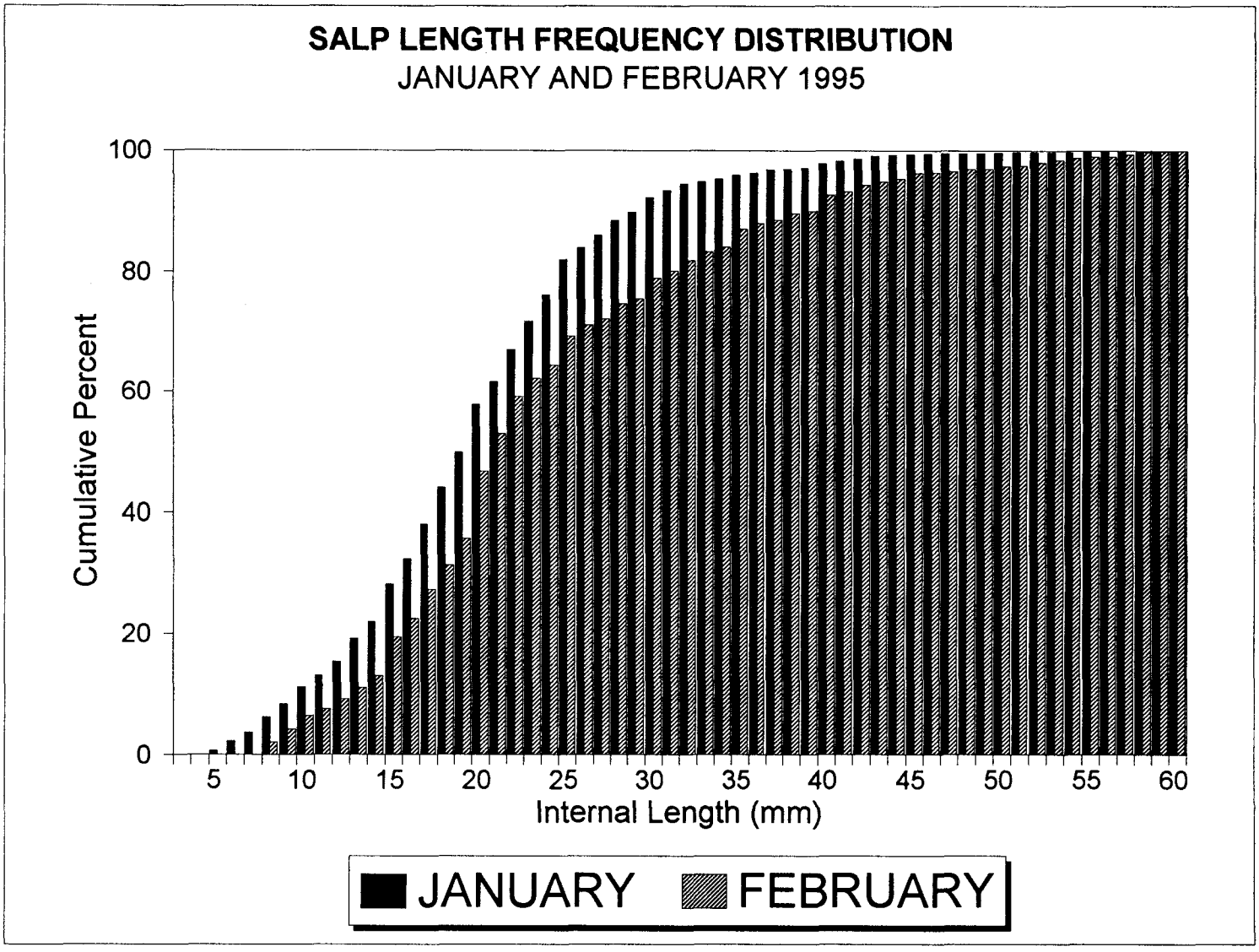


Figure 4.20 Cumulative size frequency distributions (%) of salps in the large-area surveys (January and February 1995), showing overall growth across the survey period.

5. Marine bird and mammal observations; submitted by Michael Force (Legs I and II).

5.1 Objectives: The primary objective of the marine bird and mammal observations was to determine the relative abundance and distribution of birds and mammals in the study area in relation to the distribution of krill. Shipboard observations in conjunction with detailed acoustic surveys provided additional information on the link between marine bird and mammal distribution and their prey.

5.2 Accomplishments: The methodology used was a modified strip transect similar to that of previous years. All birds detected within a visually defined $100m^2$ area, 50m in front of the ship were recorded. The number of birds, observed behaviors, association, and any feeding activity were recorded timed to the nearest minute. Birds following the ship were problematic and were treated separately. As a general rule, these birds were counted once at the beginning of the transect and periodically thereafter. If an increase was noted, then the estimate was revised to reflect the presumed influx of new individuals.

During the transect, 180° scans forward of the ship were made every 5 to 10 minutes for marine mammals using 8X42 hand-held binoculars. All marine mammals within approximately 2 n.mi. were recorded. Identification of distant individuals was confirmed using 20X60 prism-stabilized, hand-held binoculars.

Total transect effort during the small-area surveys (Surveys B and C, Figure 5.1) was 1100 minutes (n=11, mean effort per transect = 100 minutes). An additional 6 transects representing 516 minutes of effort were conducted during the Admiralty Bay surveys (Surveys AB1 and AB2) (mean effort per transect = 86 minutes). In total, 155.8 n.mi. and 69.2 n.mi., respectively, were surveyed. Transects conducted during the small-area surveys recorded 1683 individual birds of 21 species (Table 5.1). Transects conducted during the Admiralty Bay surveys recorded 153 individuals of 10 species (Table 5.2).

Marine mammals were infrequently recorded despite repeated scans for sighting cues. This may have been due to the fairly high sea state encountered on most transects (mean Beaufort=4, maximum=7). This greatly reduces the probability of sighting solitary and/or small groups of animals. Table 5.3 summarizes all marine mammals sighted while on transect.

5.3 Tentative Conclusions: Of the 1683 birds seen during the small-area surveys, 894 (53%) were chinstrap penguins (*Pygoscelis antarctica*). These birds were not evenly dispersed throughout the study area; there was a marked concentration of them several nautical miles off the northeast side of Elephant Island just west of Cape Valentine. Seven hundred and fifty-nine (85%) chinstrap penguins were seen in this relatively small area on transect 3001 just north of waypoints 17 and 16 (Figure 5.1). The low sea state (Beaufort 1) provided excellent sighting conditions and hundreds more were present but outside the strip transect boundaries. Collected acoustic data revealed a high krill density in this area. This concentration of chinstrap penguins was also recorded later at the south end of transect 4501 and again when

the ship transited this area at the end of Leg I. These birds may have been optimizing their foraging effort by taking advantage of a locally stable food source.

It is difficult to draw any tentative conclusions based on the small number of marine mammals sighted. For example, all of the Fin whales were in three small groups within 2 to 3 n.mi. of one another. The acoustic data showed no significant concentrations of krill in the area, and the majority of birds present were prions and storm-petrels which are not known to be krill specialists. The whales were spending most of their time at the surface and may have been traveling between feeding areas.

5.4 Disposition of Data: All transect data are on 3.5" floppy disk in an Excel spreadsheet for Macintosh format. It is available from Michael Force, c/o Dr. Roger Hewitt, Antarctic Ecosystem Research Group, Southwest Fisheries Science Center, P.O. Box 271, La Jolla California, USA 92038.

5.5 Problems and Suggestions: Abundance and distribution data of marine birds and mammals collected on shipboard transects are highly dependent on environmental conditions. Seastate, glare, precipitation and fog are just a few of the factors which affect detectibility. Fog was particularly troublesome during the small-area surveys and was a major factor in the uneven coverage (Figure 5.1). It is recommended that there be a dedicated observer, familiar with the identification of all the expected bird and mammal species, to ensure a more uniform and complete coverage of the study area. An ideal situation would be a team of two experienced observers, working in rotation to minimize fatigue, thereby maintaining a constant vigil of the trackline during daylight hours. An additional problem concerns the wind deflector on the forward bulkhead of the ship's flying bridge. A strong glare frequently reflects off this surface and interferes with observations, particularly with a dark sea, and greatly accelerates eye fatigue. A simple solution would be to paint it matte black or to temporarily cover it with some non-reflective material.

5.6 Acknowledgments: I would like to thank *Surveyor's* bridge watchstanders for their assistance and to Chief Scientist Dr. R. Hewitt for his advice and suggestions in the preparation of this report. The environmental data, made available by Anthony Amos, are also gratefully appreciated.

Table 5.1 Summary of birds seen on transects conducted during the small-area surveys.

SPECIES	TOTAL	DETECTIONS	BIRDS PER DETECTION	BIRDS PER NM
Chinstrap Penguin *(Pygoscelis antarctica)*	894	105	8.51	5.74
Cape Petrel *(Daption capense)*	457	26	17.58	2.93
Black-bellied Storm-Petrel *(Fregatta tropica)*	103	70	1.47	0.66
Wilson's Storm-Petrel *(Oceanites oceanicus)*	61	44	1.39	0.39
Antarctic Prion *(Pachyptila desolata)*	61	33	1.85	0.39
Black-browed Albatross *(Diomedea melanophris)*	21	19	1.11	0.13
Southern Giant Petrel *(Macronectes giganteus)*	14	14	1.00	0.09
unidentified penguin *(Pygoscelis* species)	13	6	2.17	0.08
Antarctic Fulmar *(Fulmarus glacialoides)*	10	9	1.11	0.06
White-chinned Petrel *(Procellaria aequinoctialis)*	6	6	1.00	0.04
Gray-headed Albatross *(Diomedea chrysostoma)*	5	5	1.00	0.03
Antarctic Skua *(Catharacta antarctica)*	3	3	1.00	0.02
Gentoo Penguin *(Pygoscelis papua)*	2	2	1.00	0.01
Wandering Albatross *(Diomedea exulans)*	2	2	1.00	0.01
Light-mantled Sooty Albatross *(Phoebetria palpebrata)*	2	2	1.00	0.01
Blue Petrel *(Halobaena caerulea)*	2	2	1.00	0.01
Antarctic Tern *(Sterna vittata)*	2	2	1.00	0.01
Royal Albatross *(Diomedea epomophora sandfordi)*	1	1	1.00	0.01
Soft-plumaged Petrel *(Pterodroma mollis)*	1	1	1.00	0.01
unidentified prion *(Pachyptila* species)	1	1	1.00	0.01
South Polar Skua *(Catharacta maccormicki)*	1	1	1.00	0.01
Kelp Gull *(Larus dominicanus)*	1	1	1.00	0.01
American Sheathbill *(Chionis alba)*	1	1	1.00	0.01

Table 5.2 Summary of birds seen on transects conducted during the Admiralty Bay surveys.

SPECIES	TOTAL	DETECTIONS	BIRDS PER DETECTION	BIRDS PER NM
Gentoo Penguin *(Pygoscelis papua)*	41	21	1.95	0.59
Wilson's Storm-Petrel *(Oceanites oceanicus)*	30	26	1.15	0.43
Black-bellied Storm-Petrel *(Fregatta tropica)*	19	12	1.58	0.27
Antarctic Tern *(Sterna vittata)*	19	18	1.06	0.27
Chinstrap Penguin *(Pygoscelis antarctica)*	11	8	1.38	0.16
unidentified penguin *(Pygoscelis* species)	9	7	1.29	0.13
Antarctic Skua *(Catharacta antarctica)*	9	6	1.50	0.13
Southern Giant Petrel *(Macronectes giganteus)*	9	8	1.13	0.13
unidentified giant petrel (*Macronectes* species)	2	2	1.00	0.03
South Polar Skua *(Catharacta maccormicki)*	2	2	1.00	0.03
Black-browed Albatross *(Diomedea melanophris)*	1	1	1.00	0.01
Cape Petrel *(Daption capense)*	1	1	1.00	0.01

Table 5.3 Marine mammals seen on transects conducted during the Admiralty Bay and small-area surveys.

SPECIES	TOTAL	NUMBER OF SIGHTINGS	TRANSECT
Antarctic Fur Seal *(Arctocephalus gazella)*	1	1	3001
Antarctic Fur Seal *(Arctocephalus gazella)*	2	1	AB
Southern Elephant Seal *(Mirounga leonina)*	1	1	4301
Southern Elephant Seal *(Mirounga leonina)*	1	1	AB
Humpback Whale *(Megaptera novaeangliae)*	4	2	AB
Fin Whale *(Balaenoptera physalus)*	11	3	3002
Southern Bottlenose Whale *(Hyperoodon planifrons)*	1	1	3003
Killer Whale *(Orcinus orca)*	6	1	AB
Hourglass Dolphin *(Lagenoryhncus cruciger)*	5	1	4401

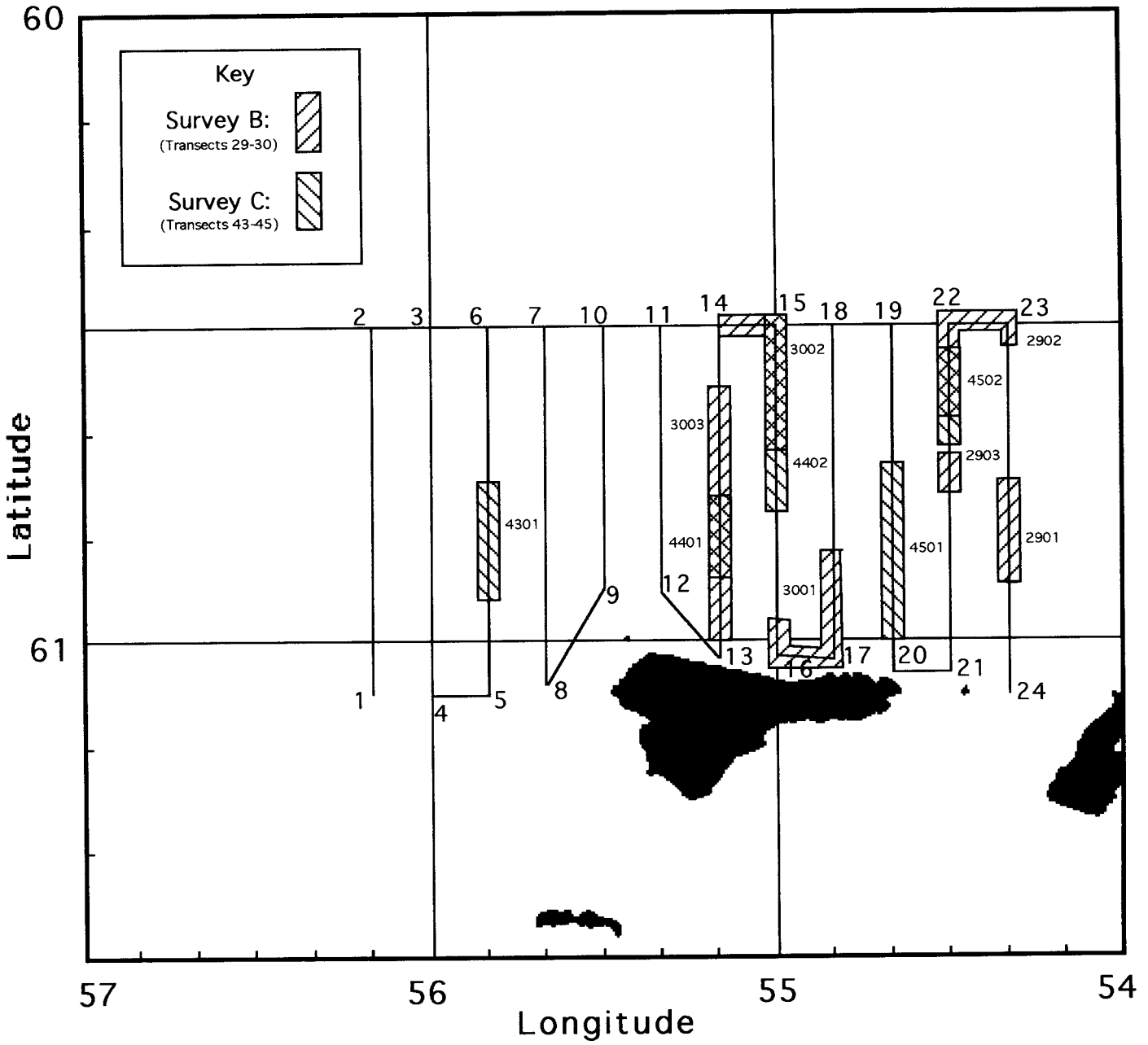


Figure 5.1 Marine bird and mammal transects, Surveys B and C.

6. Operations and logistics at Seal Island, Antarctica, during 1994/95; submitted by J.K. Jansen, L.M. Hiruki, R.S. Holt, and W.R. Meyer.

6.1 Objectives: The AMLR program has maintained a field camp at Seal Island, South Shetland Islands, Antarctica (60°59'14"S, 55°23'04"W) in support of land-based research on marine mammals and birds. The camp was occupied during the austral summer field season (December through February, 1994/95). The main logistics objectives of the 1994/95 season were:

1. To deploy the six member field team in late November aboard the M/V *Explorer* in order to arrive at Seal Island in time to monitor Antarctic fur seal (*Arctocephalus gazella*) pupping and chinstrap penguin (*Pygoscelis antarctica*) chick hatching;

2. To deploy three members from Seal Island aboard the Japanese R/V *Kaiyo Maru* in both late December and late January to participate in at-sea tracking of fur seals and chinstrap penguins;

3. To deploy to Seal Island two additional field team members via the NOAA Ship *Surveyor* in mid-January to assist in field studies;

4. To resupply the field camp with provisions, which were transported from the United States aboard *Surveyor*;

5. To maintain effective communications systems on the island and to maintain daily radio contact with either Palmer Station or *Surveyor*;

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

7. To retrograde trash and other cargo from the island and to transport the field team to Chile at the end of the season aboard *Surveyor*.

6.2 Accomplishments: A six person field team departed the U.S. on 18 November 1994 and embarked the tour ship M/V *Explorer* in Stanley, Falkland Islands, on 21 November. Because of rough sea conditions, the team remained aboard the ship until it completed its tour of the Antarctic Peninsula. On its return north, the ship disembarked the field team at Seal Island on 30 November. Good weather resulted in an efficient landing at the camp beach. Camp structures over-wintered well and without damage. The main tent, which serves as the principal accommodation, was erected within a day of the team's arrival.

The Japanese R/V *Kaiyo Maru* arrived at Seal Island on 16 December. The Mark II zodiac and outboard motor stored on Seal Island were used for cargo operations between Seal Island and *Kaiyo Maru*. Cargo operations went smoothly. Three researchers from Seal Island embarked *Kaiyo Maru* for a 10-day predator tracking study.

On 25 December, *Kaiyo Maru* returned to Seal Island and disembarked one researcher. The Seal Island Mark II zodiac was used for cargo operations, which proceeded smoothly. Two researchers remained aboard *Kaiyo Maru* for its return trip to South America.

Surveyor arrived and off-loaded cargo and two researchers at Seal Island on 14 January 1995. Cargo operations went smoothly with favorable weather conditions. As in past seasons, two Mark V zodiacs were used to transport supplies ashore. The assistance of the ship's personnel and members of the scientific party expedited cargo operations. In addition to the persons who came ashore to help unload and carry cargo up to camp, four swimmers in dry suits were stationed to steady the zodiacs during unloading.

Kaiyo Maru returned to Seal Island on 18 January and disembarked three members of a Japanese film crew. The film crew's Mark III zodiac was used for cargo operations. On 19 January, the three film crew members and three researchers from Seal Island embarked *Kaiyo Maru* for a 10-day predator tracking study.

On 29 January, *Kaiyo Maru* returned to Seal Island and disembarked the three Seal Island researchers. The Seal Island Mark II zodiac and the film crew's Mark III zodiac were used for cargo operations. Weather conditions were favorable, and operations were completed efficiently.

On 1 February, *Surveyor* returned to Seal Island, embarking two researchers to the ship for the return trip to Chile. *Surveyor* returned again to Seal Island on 11 February to off-load fresh supplies. The camp was closed and the field team embarked *Surveyor* on 28 February for the return to Chile.

Daily radio communications were maintained with Palmer Station from 1 December to 14 January (prior to the arrival of *Surveyor* in the operations area) and from 2 February to 9 February when *Surveyor* returned to port in Chile. Daily contact was maintained with *Surveyor* from 14 January to 2 February and from 10 February until 28 February using single side-band or VHF radio when the ship was within radio range of the island. In addition to these regular schedules, radio contacts were made with biologists and other personnel at Palmer Station, Anvers Island (U.S.); Copacabana camp, King George Island (U.S.); Cuverville camp, Cuverville Island (U.K.); and M/V *Explorer* (U.S.). Communications were also maintained with various offices in the U.S. via the ATS-3 satellite system. No significant difficulties were experienced with any of the camp's communication systems.

Routine maintenance of camp facilities was undertaken as necessary. Obsolete and unneeded equipment was identified and removed from the island for shipment to the U.S. As ice washed ashore, it was gathered and stored for use as drinking and shower water. The control unit for the solar tracker array was broken upon arrival but was replaced during the first resupply. A barrier of plastic barrels, filled with salt water, was erected to protect areas of the camp from rockfalls. Safety equipment and emergency rations were moved to the Parking Lot blind from a storage area behind camp.

During the initial resupply of Seal Island on 14 January, trash from the early part of the season was transported to *Surveyor* for proper disposal. Additional trash and retrograde cargo was transported to *Surveyor* each time that the ship called at Seal Island to minimize the amount of cargo necessary to off-load at the end of the season. All remaining trash and cargo was loaded onto the ship on 28 February, when the camp was closed and the field team embarked the ship for transport to Chile.

6.3 Recommendations: Once again, the excellent support provided by *Surveyor* made a significant contribution to the success of the field season at Seal Island. Cargo and small boating operations went very smoothly. The practice of providing four swimmers in dry suits to assist landings and launchings of Zodiacs has proven to be very successful and should be continued in future seasons.

An arrival date in late November was ideal for initiating fur seal studies prior to the peak of pupping. The timing of this arrival date provides good access to female fur seals during their perinatal period, a requisite for the CCAMLR standard method for monitoring completion of foraging trip duration.

7. Pinniped research at Seal Island, Antarctica, during 1994/95; submitted by L.M. Hiruki, J.L. Bengtson, P.L. Boveng, W.T. Cobb, and W.R. Meyer.

7.1 Objectives: In 1994/95, pinniped research continued on Seal Island as part of the CCAMLR Ecosystem Monitoring Program (CEMP). This multi-national program is designed to detect significant changes, due to natural causes or commercial fisheries, in the Southern Ocean ecosystem. A major objective of this research is to determine factors influencing the population dynamics and ecology of antarctic pinnipeds. On Seal Island, Antarctic fur seals (*Arctocephalus gazella*) were studied as an indicator species to gain understanding of wider patterns in pinniped population dynamics. Research objectives for the 1994/95 field season were:

1. To monitor Antarctic fur seal pup growth rates and adult female foraging according to CEMP protocols;

2. To conduct cooperative research on fur seal foraging patterns and prey availability with scientists from the Japanese R/V *Kaiyo Maru*;

3. To conduct directed research on fur seal pup production, female foraging behavior, diet, abundance, survival and recruitment;

4. To determine offshore foraging areas of fur seals, using an automatic direction-finding (ADF) system; and

5. To monitor the abundance of all other pinniped species on the island.

7.2 Accomplishments:

Pup Growth Rates: Antarctic fur seal pups were weighed at two week intervals throughout the 1994/95 field season (30 December to 25 February; CEMP Standard Method C.2; Table 7.1). The growth rate for male pups was 123.3 grams per day (g/day) (SE=13.1), while the growth rate for female pups was 96.3 g/day (SE=8.0). Growth rates of both males and females were lower than in the past two seasons (males, 1992/93: 134.6 g/day; males, 1993/94: 132.7 g/day; females, 1992/93: 100.6 g/day; females, 1993/94: 102.4 g/day). However, the mean weight for both males and females at the end of the season was similar to previous years [males, 15.74 kilograms (kg) as compared to 15.97kg in 1992/93 and 15.86kg in 1993/94; females, 13.52kg as compared to 13.05kg in 1992/93 and 13.79kg in 1993/94].

Foraging Behavior and Attendance Ashore: Female fur seal attendance on Seal Island was monitored using radio transmitters (CEMP Standard Method C.1). Long-pulse transmitters (0.3ms pulse; 164-165 MHz frequencies), with a booster circuit for greater transmission strength, were attached to the backs of forty perinatal fur seal females from 4 to 10 December. Twenty-eight of the 40 females instrumented on Seal Island this season completed six foraging trips while nursing pups, the standard used by CEMP for calculation of foraging

duration statistics. However, two of these females lost their radio transmitters before the end of the sixth trip. Data logging computers located at the North Cove (NC) breeding colony recorded attendance every 15 minutes for each instrumented female.

Wildlife Computers TDRs were deployed on 18 of the 40 females instrumented with radio transmitters. These instruments provided detailed information on the diving behavior of the fur seals while at sea. All 18 TDRs were retrieved successfully between 24 December and 15 February. All TDR records will be analyzed at the National Marine Mammal Laboratory (NMML).

In addition to the 40 female fur seals instrumented with radio transmitters, 10 females were instrumented with satellite-linked transmitters on 13 and 15 December, as part of the cooperative predator tracking study with Japanese scientists. Data from the satellite-linked transmitters will give more detailed information on foraging locations of these females.

Cooperative Predator Tracking Study with *Kaiyo Maru*: A cooperative study of predator/prey tracking was undertaken during the 1994/95 field season with scientists from the National Institute of Far Seas Fisheries of Japan. Major objectives of the study were to track predators (fur seals and chinstrap penguins) as they left Seal Island on foraging trips, and to sample the water column close to tracked animals (acoustically and with net tows) to determine the type and density of prey. In conjunction with the acoustic and net tow data, TDR records from the tracked animals will be analyzed to determine how the type and density of prey available influences the diving behavior of the predators. Fur seals and penguins were tracked during two cruise legs on *Kaiyo Maru*, 16-26 December and 19-28 January. Two fur seals and one penguin were tracked during the first leg, and four fur seals and five penguins during the second leg. Over 170 acoustic stations and numerous net tows were conducted in close proximity to the tracked animals.

Pup Production: Fur seal pups, both live and dead, were counted daily at the NC and North Annex (NA) colonies to estimate the total number of births in the main breeding areas. The maximum number of live pups recorded at NC was 195 on 29 December, and the maximum number of live pups recorded at NA was 74 on 29 December. Including a count of 1 dead pup at NC and 1 dead pup at NA prior to 29 December, pup production was estimated to be at least 271 seals for the two major breeding colonies on Seal Island.

In addition to the two breeding colonies at NC and NA, the small breeding colony (Big Booté) on the east side of the island was censused periodically to estimate pup production. On 17 December, the maximum pup count of 15 (14 live, 1 dead) was recorded in this colony.

A census of the fur seal colony on Large Leap Island, 1km north of Seal Island, was conducted on 14 January. A total of 319 live pups were counted in this colony, higher than the 1994 live pup count of 304. Censuses were also conducted at Saddle Rock, an island in the middle of the Seal Island archipelago, and at Transmitter Island, the northwestern-most

island in the archipelago. A total of 90 live pups (and 1 dead pup) were counted at Saddle Rock on 14 January, and 3 pups were counted at Transmitter Island on 2 February.

Abundance, Survival and Recruitment: Because the pup cohort is the only age group that stays entirely in the breeding colony area during a particular census period, pup counts may be used as an estimate of the total number of breeding females for that year. The maximum number of pups counted at NC in 1994/95 was 196 (195 live pups, 1 dead), a decrease from the 1993/94 peak count of 208. The maximum pup count at NA decreased in 1994/95 to 75 (74 live, 1 dead), from the 1993/94 peak count of 79 pups. Fifteen pups (14 live, 1 dead) were recorded at Big Booté colony, up from 12 pups in 1993/94. The total number of pups estimated in the three breeding colonies for 1994/95 was 286, a decrease from the 1993/94 total of 299 pups.

Leopard seal (*Hydrurga leptonyx*) predation on fur seal pups was directly observed only on two days this season. Eight pups were observed taken by one female leopard seal (four on 15 January, four on 16 January). This female, identified by a tag applied last year, was the same leopard seal observed hunting pups in the 1993/94 season. Although only this tagged female was observed hunting, a second adult leopard seal was observed at the entrance to NC on two days while she was hunting, and it appeared that the tagged seal released the pups to the other seal before proceeding to capture another pup. This is the first observation of leopard seals feeding together at Seal Island. Similar to previous seasons, pup numbers decreased significantly during periods when leopard seals were observed in the NC area.

All fur seals present at NC and NA were censused daily during the month of December. All fur seals at Beaker Bay beach were censused at weekly intervals throughout the season (Table 7.2). Fur seals were classified into six groups: pups, females, adult males with females, adult males without females, sub-adult males, and juveniles of undetermined sex.

Daily observations of tagged female fur seals were made to assess female survival, reproductive rates, and tag loss. Of 97 tagged (but not instrumented) females observed during the 1993/94 season, 84 (87%) were observed again in the 1994/95 season. Sixty-five of these 84 females (77%) had pups in 1994/95. Of 41 tagged females instrumented with radio transmitters or TDRs in 1993/94, 36 (88%) were observed again on Seal Island this season. Twenty-four of these 36 (67%) had pups. During the field season, 30 new tags were placed on adult females of unknown age. This includes four females retagged with new All-Flex tags due to the loss of one previously applied All-Flex tag.

Fur seal pups have been tagged at both NC and NA each year since 1986/87. In the 1994/95 season, 96 known-age individuals (tagged in previous seasons) were observed on Seal Island (Table 7.3). Of 48 known-age females observed, 18 had pups this season. No pups were tagged this season at Seal Island. Two adult males were seen with tags from other locations (Table 7.4); both of these males were also seen during the 1993/94 season.

Diet: Fur seal scat samples were collected opportunistically from female fur seals in NC and NA. Emphasis was placed on collecting samples from females instrumented with TDRs. Four scat samples were collected from instrumented females, and one spew sample was collected from a non-instrumented female. The scat samples were put in frozen storage, and the spew sample was preserved in 5% formalin for subsequent analysis of prey remains at NMML.

Offshore Foraging Areas: During operation of the ADF system on Seal Island, the 18 female fur seals with transmitters for attendance studies and TDRs for dive behavior studies were tracked through the season. Based on a comparison of the relative gain strength determined by four directional antennas (N, S, E and W) set up to receive radio signals from animals travelling to and from Seal Island, data on the direction and distance to foraging areas were collected. To calibrate the ADF system, a set of reference transmitters was towed by *Kaiyo Maru* on 28 January, and by *Surveyor* on 2 February, at known courses and distances from Seal Island.

Abundance of Other Pinniped Species: Counts of other pinniped species that use Seal Island as a haul-out location were done in conjunction with weekly counts of fur seals on Beaker Bay beach. Southern elephant seals (*Mirounga leonina*), Weddell seals (*Leptonychotes weddelli*) and leopard seals were observed (Table 7.5).

Leopard seals were photographed and identified opportunistically. In the 1994/95 season, 53 sightings of leopard seals were recorded. At least 10 individual leopard seals were identified, including 2 sub-adults (both male). A female leopard seal, tagged at a location other than Seal Island, was observed on 18 January (Table 7.4).

Fur Seal Entanglements and Marine Debris: Five items of marine debris were found on Seal Island in 1994/95: one plastic float, a small styrofoam piece, a 2-liter plastic bottle, a partially full 55-gallon steel drum, and a perfume container. No seals were observed entangled in debris this season.

7.3 Tentative Conclusions: Pup production and pup growth rates were lower in 1994/95 than in previous seasons. However, the mean weight of both male and female pups during the last weighing session were similar to previous years, indicating that female fur seals were able to forage adequately to feed their offspring. Analysis of the TDR data in conjunction with acoustic and net tow data collected during the cooperative predator tracking study with *Kaiyo Maru* will provide more information about the diving and foraging behavior of female fur seals.

Table 7.1 Mean weights, standard deviations, and sample sizes of male and female fur seal pups weighed during five sampling intervals, 30 December 1994 - 25 February 1995.

	Sampling Dates:				
	30 Dec.	11 Jan.	27 Jan.- 28 Jan.	9 Feb.	24 Feb.- 25 Feb.
MALE PUPS:					
Mean wt. (kg)	9.23	10.87	12.91	15.28	15.74
Std. dev.	1.60	1.74	1.98	1.57	2.42
N	51	46	54	58	60
FEMALE PUPS:					
Mean wt. (kg)	8.30	9.70	11.15	12.90	13.52
Std. dev.	1.11	1.30	1.31	1.59	1.56
N	49	54	46	42	40

Table 7.2 Weekly counts of Antarctic fur seals, by sex and reproductive status, at Seal Island, Antarctica, 1994/95. These counts were made in a standard census area (which excludes the small fur seal rookery at Big Booté and other small haulout areas on the north-eastern side of the island) until 28 December. Afterwards, all counts excluding pups were made on Beaker Bay Beach only.

Date	Pups	Adult females	Adult males with females	Adult males without females	Sub-adult males	Juveniles	Total
7 Dec	111	137	31	54	25	0	358
14 Dec	204	175	33	46	6	0	464
21 Dec	247	147	29	51	57	0	531
28 Dec	255	140	23	65	33	0	516
4 Jan	*267	0	0	14	23	1	305
11 Jan	264	0	0	3	27	0	294
18 Jan	190	0	0	1	80	0	271
25 Jan	189	0	0	0	103	0	291
1 Feb	*186	0	0	3	257	0	446
8 Feb	168	0	0	37	273	1	479
15 Feb	*159	0	0	18	274	0	451
22 Feb	150	0	0	19	297	4	466

*Jan 3, Jan 31, and Feb 14 pup count values used, as a pup count was not conducted on the same day as the weekly census.

Table 7.3 Numbers of known-aged fur seals observed on Seal Island, 1994/95. Numbers of females observed with pups in each cohort are in parentheses.

Cohort	Males	Females	Females with pups	Total
1986/87	1	3	(3)	4
1987/88	10	4	(4)	14
1988/89	4	9	(7)	13
1989/90	1	1	(1)	2
1990/91	6	6	(2)	12
1991/92	17	14	(1)	31
1992/93	8	11	(0)	19
1993/94	1	0	(0)	1

Table 7.4 Seals sighted at Seal Island with tags from other research locations, 1994/95.

Date	Size and Species	Sex	Left/ Right	Number	Color	Tag type	Comments
18 Jan	Adult Leopard Seal	F	R	3202	Bright Green	Rototag	Newer tag, not faded
8 Feb	Adult Fur Seal	M	L & R	L: 2928 R: 2929	White	Large Rototag	
9 Feb	Adult Fur Seal	M	L	--	Aqua Blue	Plastic	Tag hole right flipper

Table 7.5 Weekly counts of pinnipeds other than Antarctic fur seals at Seal Island, Antarctica, 1994/95 (these counts reflect those seals hauled out at the specific time of the day's census on Beaker Bay Beach).

Date	Elephant Seals	Weddell Seals	Leopard Seals
7 Dec	26	5	0
14 Dec	29	8	1
21 Dec	29	7	0
28 Dec	15	3	0
4 Jan	13	4	0
11 Jan	8	5	0
18 Jan	4	6	1
25 Jan	11	6	0
1 Feb	26	7	0
8 Feb	24	10	1
15 Feb	9	5	0
22 Feb	9	0	0

8. Seabird research at Seal Island, Antarctica, during 1994/95; submitted by J.K. Jansen, W.R. Meyer, R.S. Holt, and J.L. Bengtson.

8.1 Objectives: Studies on the life history of seabirds have provided valuable information about marine environments adjacent to breeding colonies. Successful rearing of offspring depends, in part, on the ability to find, exploit, and transport resources back to the colony to provision chicks. Thus, aspects of seabird reproductive and foraging behavior can be used to monitor changes in the local marine habitat. The seabird research at Seal Island focuses on the ecology of chinstrap (*Pygoscelis antarctica*) and macaroni penguins (*Eudyptes chrysolophus*). Other seabirds that breed on Seal Island include: cape petrels (*Daption capensis*), Wilson's storm petrels (*Oceanites oceanicus*), and kelp gulls (*Larus dominicanus*). Southern giant petrels (*Macronectes giganteus*) and blue-eyed shags (*Phalacrocorax albiventer*) breed on adjacent islands. Penguins are particularly useful for monitoring studies due to ease in relocating individuals throughout the four to five month breeding season. Their flightlessness and corresponding reduced foraging range make these birds important indicators of offshore conditions.

The ecological monitoring at Seal Island was conducted as part of the AMLR program's participation in the CCAMLR Ecosystem Monitoring Program (CEMP). Seal Island was chosen as one of two AMLR sites in the Antarctic Peninsula region for the study of krill-consuming seabirds. The principal research objectives for the 1994/95 field season were:

1. To monitor the breeding success, fledgling size, reproductive chronology, foraging behavior, diet, abundance, survival, and recruitment of chinstrap and macaroni penguins according to CEMP protocols;

2. To conduct directed research on seasonal and diel patterns in the diving behavior of chinstrap penguins to assess changes in foraging patterns and effort as physical and biological components change through the breeding season;

3. To collect data on locations of offshore foraging areas of chinstrap penguins (instrumented with transmitters) using an automated data collection computer and an array of directional antennas on top of the island; and

4. To conduct a cooperative study with Japanese scientists on board the R/V *Kaiyo Maru* examining interactions between chinstrap penguins and their prey by tracking birds (equipped with radio transmitters) on foraging trips while simultaneously conducting oceanographic sampling.

8.2 Accomplishments:

Reproductive Success and Chronology: Breeding success was estimated according to CEMP Standard Methods A.6.B. (observations of 100 nest plots) and A.6.C. (discrete counts of colonies). Method A.6.B. is designed to determine the number of chicks raised to the creche

stage for a sample of nests. Rectangular plots were marked by stakes in two colonies, and individual chinstrap nests were identified [103 and 116 nests in the North Cove (NC) and Parking Lot (PL) study plots, respectively]. Twenty-five macaroni penguin nests at Mac Top colony were also monitored. These nests were observed usually every day from a blind using a spotting scope (without entering the colony), and the number of incubated eggs and/or brooded chicks was recorded. Overall, the number of chicks surviving to creche from chinstrap nests active at the commencement of observations (6 and 7 December for NC and PL plots, respectively), was 1.23 and 1.34 chicks per active nest for NC and PL colonies, respectively. Table 8.1 presents selected indices of breeding success for all years since 1989/90.

The NC and PL study plots were also used to determine the chronology of penguin reproductive events at Seal Island through creching (Table 8.2). Chinstrap hatching began on 21 and 24 December, while the rate of hatching peaked on 27 and 31 December, and was completed by 5 and 12 January in the PL and NC study plots, respectively. Median hatching dates were 27 and 30 December for PL and NC, respectively. Creching began 26 January at both colonies and peaked on 29 January and 7 February at PL and NC colonies, respectively. Median creching dates were 31 January and 7 February, while creching was completed on 8 and 15 February at PL and NC, respectively. Upon completion of creching, the number of creched chinstrap chicks was counted every other day in colony 66 (a colony of about 300 nests) to provide an estimate of the progression of fledging. Fledging began on 17 February, and the fledging rate peaked around 19 February. We were unable to determine when the completion of fledging occurred due to our earlier than usual departure from the island. Table 8.2 presents a summary of chinstrap breeding chronology for all years since 1989/90.

Hatching of macaroni chicks began on 24 December, hatching rate peaked around 26 December, and was completed by 1 January. Macaroni creching began on 18 January and was completed by 26 January. Fledging began around 21 February and was completed on 27 February. The number of macaroni chicks raised to creching (per active nest when observations were initiated) at Mac Top was 0.88.

According to CEMP Standard Method A.6.C., three censuses were made of 10 geographically discrete chinstrap penguin colonies (9, 21, 24, 31, 32, 33, 42, 51, 54, and 66) undisturbed by other activities at completion of laying, completion of hatching, and completion of creching. During the incubation and creche phase censuses, three replicate counts were made of each colony on the same day. In an effort to minimize disturbance during the completion of hatching phase a single count was made. If one of the three counts differed by more than 10% of any other count, a fourth count was made. Each of the five macaroni penguin colonies was also censused. Data from this season's macaroni and chinstrap penguin census effort are presented in Tables 8.3 and 8.4, respectively.

Foraging Behavior: Foraging trip duration of adult chinstrap penguins was monitored to determine the amount of time at sea required to meet their own energetic needs and procure food for chicks, serving as an indicator of foraging effort and prey availability (CEMP

Standard Method A.5.). Thirty-eight adult chinstrap penguins were equipped with radio transmitters (12 nests with one member of each nest instrumented and 13 nests with both members of the pair instrumented) An automatic scanning radio receiver and data logger recorded the attendance of radio-tagged birds every fifteen minutes. Nests of instrumented birds were checked regularly for survival of chicks, and data from failed nests were excluded from subsequent analysis. Hatching dates for all study nests were determined to allow better discrimination of the effects of chick growth and increasing energetic demands on adult foraging effort. Understanding this source of variability will increase our ability to detect potential inter-annual trends in foraging trip duration. By deploying a portion of the transmitters on mated pairs, we hope to examine how closely a pair's foraging behavior are coupled. This will allow for a more useful interpretation of the timing and duration of an individual's foraging behavior through an understanding of the influence of its mates foraging patterns.

Twenty-seven transmitters were also deployed on chinstrap penguins (twenty-one with TDRs) at colony 72, as part of the *Kaiyo Maru* tracking study conducted offshore. Eleven were deployed during the first cruise leg and sixteen during the second leg (see below for details of cooperative study). All transmitters utilized during the first leg were recovered with the TDRs at the completion of the leg. Of the sixteen transmitters deployed during the second leg, six were deployed without TDR's. When TDRs were recovered at the conclusion of the second leg, transmitters were left on the birds and data on the attendance behavior of these ex-TDR birds and the six birds that never had TDRs were collected until 26 February.

To provide detailed information on chinstrap penguin diving behavior at sea and how that behavior may change with the progression of the breeding season, a total of 34 chinstrap penguins were equipped with time-depth recorders (TDRs) which recorded depth while diving, time spent at the surface between dives, and time ashore; 11 during incubation, 7 during the early guard stage, 10 during the late guard stage, and 6 during the creche stage. Of these deployments, 29 records were obtained. The dive records will be analyzed at NMML to estimate changes in foraging effort within and between seasons.

Abundance, Survival, and Recruitment: After the completion of egg laying, the number of breeding pairs in all penguin colonies on the island was counted. The timing of this count, performed annually on 17 December, was determined by the field team's usual arrival on the island after egg-laying had begun. Due to logistical limitations, the field team has arrived after the initiation of egg-laying in all past seasons. All birds lying down in some sort of nest structure were assumed to be occupying a nest site, and were thus considered breeding. Large colonies (3, 4, 14, 25, 26, 58, and 61) were counted from photographs. The total number of chinstrap pairs nesting in 1994/95 will be determined pending the analysis of these photographs. A total of 250 pairs of macaroni penguins attempted to breed on Seal Island in 1994/95; this is a 16% decrease from last season (299 nests).

Due to uncertainties in the planning of future field seasons at Seal Island, macaroni and chinstrap chicks were not banded this season. Nevertheless, both systematic and opportunistic

surveys to resight banded birds were conducted throughout the season to provide an index of age-specific survival and fecundity.

Fledging Condition: Following the initiation of chinstrap penguin fledging on 11 February, daily samples of fledglings present on Beaker Bay were weighed (CEMP Standard Method A.7.A.) until the completion of fledging, about 3 March. A total of 343 fledglings were weighed and measured. Average (± sd) fledgling measurements were: weight 3.11kg (± 0.33); culmen length 43.49mm (± 2.49); culmen depth 14.61mm (± 0.99); wing chord 111mm (± 4.39). Fledging peaked on 19 February, only one day later than in the 1993/94 season.

Offshore Foraging Areas: An important component of understanding penguins' foraging ecology is knowing the locations of their principal offshore feeding areas. TDRs have been used successfully to provide information about the vertical distribution of prey resources, but obtaining data on the horizontal distribution of prey has been difficult. Previous efforts have included radio-tracking penguins from research vessels, but such operations are expensive and logistically inefficient. This season we collected data from a land-based ADF system, which was designed to indicate the general locations offshore where birds were foraging. The system monitored the relative compass bearing of signals from radio frequency transmitters that had been attached to the penguins. Some hardware problems were encountered during the season; however, preliminary indications are that this system may be able to monitor the location of penguins feeding up to 10 n.mi. offshore. If this objective can be achieved, it would allow analysis of how foraging areas change within and between seasons, and how these locations compare to the distribution of krill as estimated by acoustic surveys.

Cooperative Predator-Prey Interaction Study: A cooperative study was conducted with Japanese scientists from the National Institute of Far Seas Fisheries who were working aboard *Kaiyo Maru*. The study was designed to examine composition and availability of prey at sampling stations that overlap, both spatially and temporally, with foraging penguins and fur seals (see "Pinniped" report for greater detail). As part of the land-based portion of the cooperative study, five diet samples were lavaged from breeding chinstrap penguins at the conclusion of each of the two cruise legs.

8.3 Preliminary Conclusions: The number of chinstrap penguins attempting to breed this season was the lowest in all past seasons except 1990/91 as suggested by our first census. Of those eggs that hatched (79%), their success was the second highest recorded (89%) in all past seasons (92% of chicks survived to creche in 1992/93). These trends suggest that conditions prior to the breeding season were not optimal, although the nests that produced chicks were successful at obtaining sufficient resources to raise their chicks to the creche phase. Mean fledgling weight was also higher than most seasons which again might be a reflection of ample food supply offshore. Interestingly, the number of macaroni penguins attempting to breed also took a sharp decline this year (16%). It appears that whatever constraint influenced the chinstrap penguins might also have affected the macaroni penguins. The numbers of macaroni penguins attempting to breed was the lowest recorded in all past seasons. More detailed conclusions will result from analyses of data on foraging behavior.

Table 8.1 Nesting chronology of chinstrap penguins at Parking Lot study plot on Seal Island, 1989/90 through 1994/95.

	1989/90	1990/91	1991/92	1992/93	1993/94	1994/95
Start hatching	20 Dec	23 Dec	20 Dec	20 Dec	18 Dec	21 Dec
Peak hatching	23 Dec	26 Dec	27 Dec	27 Dec	23 Dec	27 Dec
Start creching	20 Jan	22 Jan	23 Jan	25 Jan	20 Jan	26 Jan
Peak creching	22 Jan	30 Jan	31 Jan	28 Jan	22 Jan	29 Jan
Start fledging	5 Feb	16 Feb	19 Feb	13 Feb	12 Feb	17 Feb
Peak fledging	21 Feb	28 Feb	21 Feb	22 Feb	17 Feb	19 Feb

Table 8.2 Indicators of chick rearing success of chinstrap penguins nesting at Seal Island, Antarctica from 1989/90 through 1994/95. Reproductive success is calculated as the average of the North Cove and Parking Lot study plots.

Year	**1989/90**	**1990/91**	**1991/92**	**1992/93**	**1993/94**	**1994/95**
Mean fledging weight (kg)	3.0	2.90	3.13	3.08	2.92	3.11
Chicks creched per # of initial active nests	1.20	1.35	1.40	1.25	1.35	1.29
Chicks/active nest (post-creche)	1.45	1.45	1.60	1.60	1.65	1.65
Chicks hatched (of total eggs)	0.84	0.79	0.81	0.72	0.77	0.79
Chicks creched (of hatched)	0.68 * (79/56)	0.73 **	0.84	0.92	0.89	0.89
Chicks creched (of total eggs)	0.57 * (67/47)	0.61 **	0.68	0.67	0.69	0.70

* High waves at NC during chick rearing caused significant mortality within the study plot. Values in parentheses partition the parameter for PL and NC study plots, respectively.

** NC colony destroyed by high waves. Only data from PL were available for this calculation.

Table 8.3 Summary of censuses of macaroni colonies at Seal Island, Antarctica, during the 1994/95 field season. Mac Pass colony was first established this season and was not discovered until our second census.

Colony	Census				
	Post egg-laying (5 Dec 1994)	Island-wide (17-19 Dec 1995)	End of Hatching (31 Dec 1994)		End of Creching (26 Jan 1995)
	# of active nests	# of active nests	# eggs	#chicks	# of chicks
Mac Top	29	28	1	25	22
Macaroon	58	55	4	49	43
Macadamia	124	97	0	91	74
Mac Peak	34	29	2	24	21
Macito	5	4	0	3	4
Mac Pass	not discovered	5	0	4	4
Total	250	218	7	196	168

Table 8.4 Summary of censuses of ten selected (CCAMLR) chinstrap colonies at Seal Island, Antarctica during the 1994/95 field season.

Colony	Census					
	Post egg-laying (5 Dec 1994)	Island-wide (17-19 Dec 1995)	End of hatching (8 Jan 1995)		Two-thirds creched (5 Feb 1995)	End of creching (26 Jan 1995)
	# of active nests	# of active nests	# eggs	#chicks	# of chicks	# of chicks
9	306	308	42	336	265	263
21	80	79	10	116	167	105
24	15	15	0	30	27	26
31	272	263	47	344	346	336
32	31	24	4	28	21	21
33	96	96	19	124	111	108
42	135	130	16	161	156	151
51	43	39	7	60	58	58
54	213	176	30	232	205	205
66	208	204	15	187	184	179
Total	1398	1334	190	1604	1540	1452

9. Leg III: Crab and epifaunal surveys of bays, anchorages, and fjords around South Georgia; submitted by George Watters, Bo Bergström, Julian Gutt, Jan-Otto Pettersson, Jane Rosenberg, Aaron Setran, and Claudia Valenzuela.

9.1 Objectives: Two sets of objectives governed scientific operations conducted during Leg III of the 1995 AMLR cruise. The primary set of objectives was developed to direct a survey of the crab (*Paralomis* spp.) stocks living around South Georgia. These objectives were:

1. To determine the feasibility of conducting a fishery-independent survey of the crab stocks around South Georgia using video data collected with a remotely operated vehicle (ROV);

2. To map the distribution of crabs around South Georgia, especially in offshore waters along the north and east coasts of the island;

3. To estimate crab density/abundance from video data collected with a ROV;

4. To use Seabeam (a hydrographic survey system) for creating detailed bathymetric maps of the survey area and categorizing the types of habitat available to crabs; and

5. To correlate crab density/abundance with habitat type (i.e. integrate the video data and the bathymetry data).

The second set of objectives was developed to direct an epifaunal survey of the benthic organisms living in various bays, anchorages, and fjords (BAFs) around South Georgia. These objectives were necessary because it was uncertain whether it would be possible to successfully complete the crab survey. The secondary objectives were:

1. To describe epibenthic community structure in various BAFs along the coast of South Georgia using video data collected with a ROV;

2. To use video data for estimating the densities/abundances of epibenthic organisms living in those BAFs;

3. To compare epibenthic community structures in BAFs with different physical characteristics; and

4. To collect specimens from the surveyed BAFs for providing positive species identifications of the animals observed with the ROV.

9.2 Methods and Accomplishments: Both surveys required video data to be collected from transects routed across the seafloor. A Sutec Sea Owl MkII was used to collect these data. The Sea Owl Mk II is an unmanned, tethered ROV which can be operated to a maximum depth of 350m. The Sea Owl's basic system consists of a submersible, an umbilical cable, a control console, and a power unit. The submersible is propelled by 7 thrusters and houses a color video camera mounted behind a glass dome. Video cassette recorders are connected to the control console so that data collected by the camera and transmitted through the umbilical can be recorded

for future analysis. Bergström et al. (1987, 1992) describe the Sea Owl Mk II system in more detail. The ROV used in this study was also fitted with a high frequency, scanning sonar (Mesotech, 675kHz) and a small red laser. The scanning sonar was primarily used for navigating the submersible. The laser was mounted parallel to the optical axis of the video camera so that a red spot appeared in the camera's field of view. This spot was always 220cm from the center of the recorded video image and provided a measurement scale for measuring width of field (transect width). The laser spot was also used to measure perpendicular distances from the transect lines to various animals identified during the dives.

The length of each transect was estimated by determining the position of the ROV at approximately two minute intervals (positions were fixed more frequently if it was difficult to hold the ROV on a steady course). ROV positions were estimated by integrating data from the ship's GPS and a Simrad Hydroacoustic Position Reference (HPR) system (Simrad HPR 300P). The HPR system enabled accurate positioning of the ROV relative to the ship. It consisted of a transducer mounted beneath the ship's hull and a transponder mounted directly to the submersible. The HPR provided range and bearing from the ship's GPS antenna to the submersible with an accuracy of ± 0.5m. The ship's position was determined with a Precision Code (commonly known as "P-Code") GPS receiver (Trimble Centurion) that gave a minimum accuracy of ± 10m. Transect lengths were estimated by integrating the HPR and GPS data, plotting a reconstructed version of the submersible's path across the sea floor, and measuring that path with dividers and a meter bar.

The ROV was launched from *Surveyor*'s starboard J-frame, using a capstan and a tag line attached to a gravity-triggered release mechanism. The release mechanism mated to a strain relief on the ROV umbilical, and the vehicle was disconnected when it entered the water. After disconnecting from the tag line, the ROV was kept on the surface and steered away from the ship. When the ROV was about 30m off the ship's starboard beam, it was submerged. While the ROV was at depth, it was kept on a safe heading (i.e. the ROV was not allowed to travel under the ship's hull or towards the ship's propeller) by coordinating vehicle navigation with a ship's officer stationed on the boat deck. The deck officer provided the ROV pilot with regular heading recommendations that were used to keep the vehicle steered in a safe direction. During each dive the umbilical cable was tended by a team of three to five people. The cable tending team maintained the proper amount of tension on the umbilical and made sure that it was neatly coiled on deck.

Crab Survey Accomplishments: It was not possible to complete the crab survey and accomplish Leg III's primary objectives. The crab survey required operations to be conducted at offshore sample stations, and it was not possible to coordinate the movements of the ship and the ROV in this environment. The survey was canceled after finishing five offshore transects and nearly losing the ROV on three of these five dives. It was not acceptable to continually risk losing the ROV. Three major factors contributed to the risk associated with conducting operations in the offshore environment: (1) high, variable winds made it difficult to safely launch and recover the ROV, (2) it was difficult to maneuver the ship while the ROV was deployed (*Surveyor* is a single-screw steam ship without thrusters), and (3) the ROV did not have enough power to compensate for the high winds and poor maneuverability of the ship.

The five transects that were conducted in the offshore environment provided interesting and useful video data. These data have been appended to the data collected during the BAFs Survey (see below) and will facilitate future comparisons between offshore and inshore communities of benthic organisms. The five offshore transects were conducted at three sample stations; in total, approximately 2,820m of sea floor were surveyed on these transects (Table 9.1). Figures 9.1 and 9.2 diagram the position of each offshore station and list the most abundant animals observed at these three locations. The ship's Seabeam system was used to make bathymetric maps of the three offshore stations. The habitat at the five dive sites could be characterized as continental shelf with a silty, gently sloped bottom (Table 9.2).

During the last two days of Leg III, the Seabeam system was used to construct a bathymetric map of an area where crabs were commercially harvested during 1992. The mapped area defines the offshore boundaries of a large submarine canyon found off the north coast of South Georgia. Figure 9.3 is a smoothed version of the bathymetry map produced during this hydrographic survey. The map will be used to categorize commercial fishery data by habitat type and provide a greater understanding of various ecological questions concerning South Georgian crab stocks.

BAFs Survey Accomplishments: Fifty two transects were run at thirteen inshore stations located along the northern and eastern coasts of South Georgia; a total of 14,764m of trackline were recorded on video tape. Table 9.1 provides a breakdown, by station, of the number and length of each transect conducted during the BAFs Survey. When possible, a minimum of three transects were run at each station so that station-specific variances in organism density could be estimated. Figures 9.4 to 9.7 map the location of each station occupied during the BAFs Survey. The ship was anchored at each station during sampling operations.

Dredge samples were collected at eleven of the fifteen stations occupied during the BAFs Survey (Table 9.1). These samples were collected to provide positive species identifications of the animals observed with the ROV. The dredge was triangular with 0.9m sides; its bag was about 1m long and made of nylon netting with a stretched mesh size of 1 inch (2.54cm). The dredge was deployed from the fantail while the ship was at anchor, and on most hauls a zodiac was used to tow the dredge away from the ship. When the zodiac was several hundred meters away from the ship, the dredge was dropped out of the zodiac, allowed to sink to the bottom, and retrieved by the ship's winch. If the weather conditions were such that the ship was swinging on its anchor chain, the dredge was lowered directly into the water from the fantail at the ship's maximum starboard swing. Wire was then paid out until the ship was at its maximum port swing. The dredge was retrieved when the ship started to swing back to starboard. Gross sorting of the catch from each haul was conducted on the fantail. Fine scale sorting and specimen preservation were conducted in the ship's aft oceanographic laboratory.

The BAFs stations were chosen so that ROV dives would be made at locations that differed according to four physical factors. These factors were exposure to wave action/storm surge, slope of the bottom, proximity to large glaciers, and proximity to abandoned whaling stations. Proximity to abandoned whaling stations was selected as an important physical factor because the scientific party expected to find debris (whale bones, sunken ships, discarded equipment, etc.) near the whaling stations and wondered whether this debris could provide a unique type of substrate for benthic invertebrates. Table 9.2 provides a general physical characterization of all the stations

occupied during the BAFs Survey (including Stations 1-3 from the Crab Survey). Note that this table does not provide a complete, physical description of each station; it merely illustrates the spectrum of physical conditions encountered during the BAFs Survey.

All of the video transect data were viewed to make preliminary assessments of the types and relative densities of organisms living at each of the BAFs Survey stations. The results of this work are presented in Table 9.3. For this preliminary assessment, animals were identified according to gross morphological and coloration characteristics; exact species names cannot be assigned to each type of animal until the dredge-caught specimens are examined. Ninety six distinct morphological/coloration types were identified from all of the video data collected during Leg III; these types probably represent a minimum of 110 species. Station 11 (Gold Harbor--Inside) had the lowest diversity with only four recorded animal types. Station 1 had the highest diversity with fifty seven recorded animal types. Frequently recorded animal types included various species of sponges, soft corals, bryozoans, sea anemones, polychaetes, isopods, starfish, brittlestars, sea urchins, ascidians, and fish. Figures 9.4 to 9.7 list the most abundant animal types observed at each station.

9.3 Tentative Conclusions:

Crab Survey: Despite the difficulties encountered during Leg III (see Methods and Accomplishments above, and Problems and Suggestions below), conducting a crab abundance survey with a ROV is still feasible. In the future, a survey can only be successful if the capabilities of the research ship and the ROV are well matched; the suggestions outlined in the Problems and Suggestions section of this report should be given serious consideration if there is another attempt to survey South Georgian crab stocks with a ROV. It should be noted that a future crab survey is likely to be very expensive. The potential costs of such a survey should be weighed against the importance of obtaining fishery-independent data and the likelihood of overexploiting the stock given current levels of fishing effort.

BAFs Survey: Table 9.3 provides some insight into the distribution patterns of the major groups of animals identified during the BAFs Survey. A preliminary interpretation of the data presented in Table 9.3 appears in the following paragraphs.

- Anemones: Station-specific anemone abundances were quite variable and did not appear to be correlated with the physical characteristics identified in Table 9.2. Five of ten anemone types were rare and were identified at only one or two stations.

- Ascidians: Ascidians were frequently one of the most abundant animal types found at each station (they were very abundant, relative abundance index = 1 or 2, at 9 of 16 stations). Interestingly, compound ascidians (Synascidiacea) were not abundant when simple ascidians were the most abundant. The reverse was also true; simple ascidians were not abundant when compound ascidians were the most abundant. Given the physical characteristics identified in Table 9.2, it appeared that compound ascidians were most abundant at highly exposed stations (except for Station 6). Simple ascidians appeared to be most abundant at protected stations (except for Station 6).

• Bryozoans: Given the physical characteristics identified in Table 9.2, bryozoans were very abundant at inshore stations that are exposed to wave action and have gently sloping bottoms. Bryozoans were nearly absent from the protected stations (although some were identified at the offshore stations).

• Fish: Fish were present at all of the BAFs Survey stations. Fish were very abundant at five of the sixteen stations, but it was not possible to correlate their abundance with any of the physical characteristics identified in Table 9.2. It should be noted that this was the most speciose animal type (≥ 8 species), and these conclusions may change when the species are identified.

• Ophiuroids: Ophiuroids occurred at fourteen of sixteen stations, and, during the BAFs Survey, the 6-armed yellow-grey type was the most frequently identified single animal type. When ophiuroids were present, they were usually very abundant. Ophiuroid abundance did not appear to be correlated with the physical characteristics identified in Table 9.2.

• Polychaetes: Only five types of polychaetes were identified during the BAFs Survey, but they were very abundant at seven of the sixteen stations. Given the physical characteristics in Table 9.2, it tentatively appeared that calcareous tube builders were very abundant at exposed stations with gentle slopes, and *Sabellids* were very abundant at protected stations with gentle slopes. Polychaetes were not abundant at the offshore stations (Stations 1-3).

• Sponges: Nineteen types of sponges were identified during the BAFs Survey, and single stations often exhibited a high diversity of sponge types. Station-specific sponge abundances were quite variable and did not appear to be correlated with the physical characteristics outlined in Table 9.2.

• Starfish: Starfish were present at every station occupied during the BAFs Survey, but they were generally not very abundant. Fourteen types of starfish were identified during the survey, and single stations often exhibited a high diversity of starfish types.

BAFs Survey Stations 9 and 11 were near the feet of large glaciers. At Station 9, the glacier was retreating, and the seafloor was covered with a thick layer of fine sediment. At Station 11, the glacier appeared as if it calved frequently, and the seafloor was bare rock with scratch marks leading away from the glacier's foot. The diversity of animal types was low at both stations (Table 9.3), and it tentatively appears that glaciers can have a strong impact on benthic community structure around South Georgia. In some areas glacial sedimentation may be so high that most filter feeding invertebrates cannot survive. In other areas glaciers may calve icebergs that scour the bottom and prevent the development of epifaunal communities.

It was difficult to find trends in animal abundance and diversity associated with bottom slope and proximity to whaling stations. While bottom slope did not appear to be correlated with animal abundance or diversity, this physical parameter probably helps determine substrate grain size, and grain size is likely to be important for structuring epibenthic communities around South Georgia. In the future, the video data should be examined to characterize grain size and determine whether

this parameter affects benthic community structure. Stations 5 and 7 were in close proximity to abandoned whaling stations, and some debris from these stations were identified in the video transect data. Preliminary results indicated that the benthic communities using the debris as an attachment substrate did not differ from the communities living on the floors of these stations.

The ROV's video camera is an useful tool for studying relationships between epibenthic organisms, and some interesting interspecific interactions were identified during the BAFs Survey. The most noticeable interactions were associations between large animals and small animals; in these instances small animals used large animals as a substrate. At Rosita Harbor (Station 4), large (up to 1m tall) Hexactinellid sponges acted as a substrate for dense aggregations of spiny-armed Ophiuroids and various types of starfish. At Jason Harbor (Station 8), small isopods from the genus *Antarcturus* used tube building polychaetes as a substrate. At Moltke Harbor (Station 15), *Antarcturus* isopods used pink soft corals as a substrate. It is interesting to note that Stations 4, 8, and 15 have similar physical characteristics; they are protected from wave action and have gently sloping bottoms (Table 9.2). All three of these stations had fine sediment on the seafloor, and it tentatively appears that small animals use large animals to climb above the sediment and feed.

9.4 Disposition of Data and Specimens: There are currently three copies of all the video data collected during Leg III. One copy each is stored at the Southwest Fisheries Science Center (La Jolla, USA), Kristineberg Marine Research Station (Fiskebäckskil, Sweden), and the Alfred Wegener Institute for Polar and Marine Research (Bremerhaven, Germany). These video tapes are under the care of George Watters, Dr. Bo Bergström, and Dr. Julian Gutt, respectively.

Most of the specimens collected by the triangle dredge are currently stored with the AERG at the Southwest Fisheries Science Center in La Jolla. However, arrangements are being made to have the specimens sent to Sweden (Kristineberg Marine Research Station) where the animals will be sorted and prepared for identification. Drs. Bergström and Gutt are currently maintaining a few, individual specimens that will be sent to various invertebrate taxonomy experts for more timely identification.

9.5 Problems and Suggestions: During all segments of the ROV operations, the ship's command provided a deck officer to coordinate communications between the bridge and the ROV pilots in the laboratory van. The deck officer was vital to the success of each ROV deployment. In the future, an officer should continue to be present on deck during deployment of the ROV.

Offshore ROV Operations (Crab Survey): The crab abundance survey could not be completed because of the factors outlined in the Methods and Accomplishments section of this report. These factors were manifested in three ways: (1) during two offshore deployments, the umbilical cable was almost tangled in the ship's propeller; (2) during one deployment, the umbilical caught on an unidentified hull projection (probably one of the ship's sonar pods); and (3) during periods of all five offshore deployments, the ship drifted faster than the ROV could propel itself; this made it difficult for the ROV to maintain video contact with the bottom.

Given the problems associated with deploying the Sea Owl Mk II from *Surveyor* in the offshore environment, the following recommendations should be considered if there are future attempts to conduct a ROV survey of the crab stocks around South Georgia:

1. Ship requirements: In the future, it would be easier/less risky to deploy a ROV from a ship that is not steam driven. A diesel powered ship with a bow thruster, a stern thruster, and twin propellers would be optimal.

2. ROV requirements: To conduct future crab surveys, the ROV should be able to work down to 500m (however, working depths down to 1000m would be preferable). Also, the ROV should be provided with ample (i.e. greater than 500m) umbilical to facilitate line transect work. Note that with a long umbilical, the ROV's submersible unit would have to be propelled by relatively powerful thrusters (cable drag would be significant). A ROV system with an open-ocean cage deployment system (such as the *Sprint* system operated by the Alfred Wegener Institute for Polar and Marine Research) would be optimal for an offshore crab survey.

Inshore ROV Operations (BAFs Survey): Only one problem occurred while deploying the ROV from the anchored ship in protected waters. In this instance, a strong gust of wind moved the ship's stern across the umbilical cable, and the cable was tangled in the ship's propeller. The submersible unit was recovered, but approximately 50m of umbilical cable was damaged. The tangled cable was cut and removed from the ship's propeller and then respliced so that ROV operations could continue. After this incident, the ship's jacking gear was engaged whenever the ROV was deployed. In the future, the ROV should only be deployed if the ship's propeller is completely stopped. Also, for inshore work it would be useful to have the option of deploying the ROV off a small work boat. This small boat would allow the ROV to make dives in areas where a large ship cannot safely anchor.

9.6 Acknowledgments: We are especially thankful to the officers and crew of *Surveyor*. Ship's personnel adapted well to a new and difficult situation. We would also like to thank *Surveyor*'s Survey Department; the hydrographic survey operations were very successful.

9.7 References:

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Station #	Location	Transect #	Transect Length (m)
1	Offshore	1	130
		2	450
		3	890
2	Offshore	1	690
3	Offshore	1	660
4*	Rosita Harbor	1	283
		2	334
		3	338
		4	158
		5	207
5*	Stromness Harbor	1	203
		2	405
		3	651
6	Stromness Pinnacle	1	319
		2	365
		3	357
7*	Leith Harbor	1	316
		2	450
		3	450
8*	Jason Harbor	1	206
		2	196
		3	576
		4	435
9*	Fortuna Bay	1	307
		2	313
		3	172
		4	130
10*	Godthul	1	283
		2	291
		3	245
		4	62
		5	187
		6	215
11	Gold Harbor -- Inside	1	140

Station #	Location and Depth	Transect #	Transect Length (m)
12*	Gold Harbor -- Outside	1	319
		2	109
		3	176
		4	117
		5	337
		6	312
		7	179
14*	Drygalski Fjord	1	482
		2	202
		3	293
		4	79
15*	Moltke Harbor	1	296
		2	229
		3	180
		4	456
16*	Cape Crewe	1	340
		2	313
		3	337
		4	304
17*	Right Whale Bay	1	289
		2	93
		3	421
		4	307

Table 9.1 BAFs survey station locations and transect lengths. The table includes three stations occupied during the crab survey; these three stations are labeled as "offshore" locations. Asterisks indicate that a triangle dredge sample was collected at that particular station.

Table 9.2 Physical characteristics of the BAFs survey stations.

Station #	Location and Depth	Exposure to Wave Action	Slope of the Bottom	Proximity to Glacier	Proximity to Whaling Station
1	Offshore 109-121m	Low	Gentle	Far	Far
2	Offshore 160-177m	Low	Gentle	Far	Far
3	Offshore 186-205m	Low	Gentle	Far	Far
4	Rosita Harbor 38-55m	Low	Gentle	Far	Far
5	Stromness Harbor 58-71m	Low	Gentle	Far	Near
6	Stromness Pinnacle 80-103m	High	Steep	Far	Far
7	Leith Harbor 57-72m	Low	Gentle	Far	Near
8	Jason Harbor 28-33m	Low	Gentle	Far	Far
9	Fortuna Bay 34-49m	Low	Gentle	Near	Far
10	Godthul 63-65m	Low	Gentle	Far	Near*
11	Gold Harbor -- Inside	High	Gentle	Near	Far
12	Gold Harbor -- Outside 27-42m	High	Gentle & Steep	Far	Far
14	Drygalski Fjord 90-102m	High	Gentle & Steep	Far	Far
15	Moltke Harbor 26-33m	Low	Gentle	Far	Far
16	Cape Crewe 63-73m	High	Gentle	Far	Far
17	Right Whale Bay 26-37m	Low	Gentle	Far	Far

* Godthul does not have a major whaling station on its shore, but this small bay contains thousands of whale bones that washed ashore after whale carcasses were set adrift.

Table 9.3 Animal types identified during the BAFs survey. The numbers appearing inside the dotted box are relative abundance indices. These indices are subjective and only apply within a station; they are not comparable between stations. An index of 1 indicates that the animal type was the most abundant at that station, and an index of 6 indicates the animal type was the least abundant at that station. Abundant animal types (1's and 2's) are surrounded by a bold box.

Animal Type	# spp.	Station Number 1	2	3	4	5	6	7	8	9	10	11	12	14	15	16	17	Presence (%)
Porifera	1							4										6
Porifera, encrusting, yellow	1	6	6													4		19
Porifera, encrusting, white	1	6											5			3		19
Porifera, encrusting, orange	1															4		6
Porifera, fan-shaped, stalked, non-folded	1	5			6								5	4		4		31
Porifera, fan-shaped, branched	1			4									5			4		19
Porifera, fan-shaped, non-stalked, folded	1	6						4					5	5		4		31
Demospongia, spheric, several oscula	1	4	4	**2**										3		4		31
Demospongia, yellow, several holes	1	**2**	5	4			**2**	3	4				5	4		4		56
Demospongia, conical osculum	1		3	**2**														13
Demospongia, stalked, elongate	1				4	4				**2**	5				**2**	4		38
Demospongia, stalked, spheric	1	6	6	4									5	4		4		38
Demospongia, intensive red, few rel. large holes	1				4			4			4			4		**2**		31
Demospongia, orange, many oscula	1												5	5		4		19
Demospongia, yellow, flat or half-spheric, large, large and small oscula	1				4									4		**2**		19
Demospongia, yellow, unisized oscula	1	6			4													13
Demospongia, yellow, several tall tubes	1				4													6
Hexactinellida, *Rossella racovitzae* (?)	1	6		4	3	3	**2**	3	5		5					4		56
Hexactinellida, *Rossella nuda* (?)	1															4		6
Hydrozoa	≥1													4				6
Hydrozoa, solitary, black, tall	1						3											6
Pennatularia, *Thouarella* (?)	1	5	6											4				19
Pennatularia, *Primnoella* (?)	1	5																6
Pennatularia, slim	1	**2**	6											4		4		25
Alcyonaria, white, one stem	1	5	5	4			**1**				4					4		38
Alcyonaria, white, branched	1	6		4														13
Alcyonaria, white, encrusting on tubes	1				3			**2**										13
Alcyonaria, pink	1														**2**			6
Bryozoa, Austroflustra-type	1	6																6
Bryozoa, calcareous, fan-shaped	≥1	6												**2**		4		19
Bryozoa, fan-shaped, branched	≥1	5	5	4									4	**2**		**1**		38
Bryozoa (?) bushy, red	1							4						3		**1**		19
Bryozoa, gray, bushy	1													4		4		13
Actinaria, gray-brown, rough surface, white tentacles	1	**2**	4	**2**			**2**	4	5							**1**		44
Actinaria, orange, taller than wide	≥2	6		4		4	**1**	3		4	4					4		50
Actinaria, orange, wider than tall	≥1	5	5	4	4		3				5							38
Actinaria, white, taller than wide	1	5		4			**2**							**2**				25
Actinaria, white, wider than tall	≥1	6	4	**1**										5				25
Actinaria, intensive red	1													3				6
Actinaria, orange, very flat, knob-like tentacles	1	6																6
Actinaria, between tentacles and body brown	1	6																6
Actinaria, gray-orange, protruding mouth	1													4				6
Ceriantharia (?)	1	5		4														13
Corals (or Bryozoans)	≥1	5																6
Corals, solitary	1	3																6
Polychaeta, Polynoidea	≥1	6	6	3														19
Polychaeta, calcareous tubes	≥1													**1**		**1**		13
Polychaeta, *Sabellida* (?), 2mm diameter	1				**2**	**1**		**2**			**1**							25
Polychaeta, *Sabellida* (?), tubes with rough surface, 5mm	≥1		6	4	3	4	3	4	**2**	3								50
Polychaeta, tubes (50x5mm) on substratum	1										3							6
Opistobranchia	≥1	6					3	4	5		5	**2**	5		4		**2**	56
Bivalvia	1												4					6
Nudibranchia	≥2	6		4	4	3		4			5					3		44

Table 9.3 Contd.

Animal Type	# spp.	Station Number 1	2	3	4	5	6	7	8	9	10	11	12	14	15	16	17	Presence (%)
Octopoda	≥1		6											4				13
Crustacea, Euphausiacea	1			X	X													0
Crustacea, Natantia	1		6								5							13
Crustacea, Isopoda, Arcturidae	≥4	6			3	3			1	3	5			5	2			50
Crustacea, Isopoda, Serolis	1																2	6
Pycnogonida	≥1	6					3											13
Asteroidea, orange, flat, triangular arms	≥1	6	6															13
Asteroidea, white, thick, triangular long arms	≥1	6		4														13
Asteroidea, brown at margin bright	≥1	6	5	4	4						5		5			4		44
Asteroidea, thick, orange, triangular arms	≥1	6		4									5					19
Asteroidea, white, small	≥1	6			4	4	3	4			5		5			4		50
Asteroidea, white, large keeled arms	1	6	6		4		3							5		4		38
Asteroidea, white, short triangular arms	≥1	6						4						5				19
Asteroidea, white, roundish arms, smooth surf.	≥1	6							5									13
Asteroidea, brown, rough surf. roundish arms	1	6				4	3				5	2	5	5	4	4	3	63
Asteroidea, very, large, black band at tips	1	6	6	4														19
Asteroidea, yellow, long triangular arms	≥1	6		4	4			4	5	3	5		5		4	4	3	69
Asteroidea, red, flat, short triangular arms	1		6										5		4			19
Asteroidea, short arms, dark, margin white	≥1				4				5									13
Asteroidea, multi-armed	1	6			3		3											19
Ophiuroidea, 5-armed	≥3		5						2				2					19
Ophiuroidea, 6-armed, yellow-gray	1	1	1	2	2	2	3	2	3	1	2		1		1	1		81
Ophiuroidea, 6 spiny arms, brown (*Ophiacantha vivipara*)	1	5		3	1									2		4		31
Ophiuroidea, 5-armed, orange	1												3					6
Astrotoma agassizii	1	2	4	4														19
Echinoidea, Cidaroidea	1	3	4	1	3		3		5					3				44
Echinoidea, Irregularia	1	3	4	4			2	4										31
Echinoidea, Regularia	1				4								3	5		3		25
Crinoidea	≥1	6	5	3				4	5									31
Holothuroidea, Cucumariidae, orange	1				3			4			5		3					25
Holothuroidea, Cucumariidae, pink	≥1													3				6
Echiuroidea	1				4			4	5				5		3	3	3	44
Sipunculida	1										5							6
Ascidiacea, stalked, transparent	≥1	3	6	3	4	4	2	4	5	3				4				63
Ascidiacea, transparent	≥1	6		4	4		2	4		4	5							44
Ascidiacea, stalked, gray	1	6		4	4	2	1	1	5		3		1			3		63
Ascidiacea, gray	1	6	6		4	2	3	2	2	?	5			3				56
Ascidiacea, long siphons	1		1	3			1	4										25
Ascidiacea, white	1	6																6
Synascidiacea, intesive orange	1											1	3					13
Synascidiacea, intensive yellow	1	6		4	3								5	2		1		38
Synascidiacea, orange	1															4		6
Fish	≥8	4	6	1	3	3	2	3	5	3	4	2	4	3	3	2	1	100
Number of animal types (total animal types = 96)	≥110	57	31	35	31	14	24	27	18	9	23	4	26	33	10	38	6	

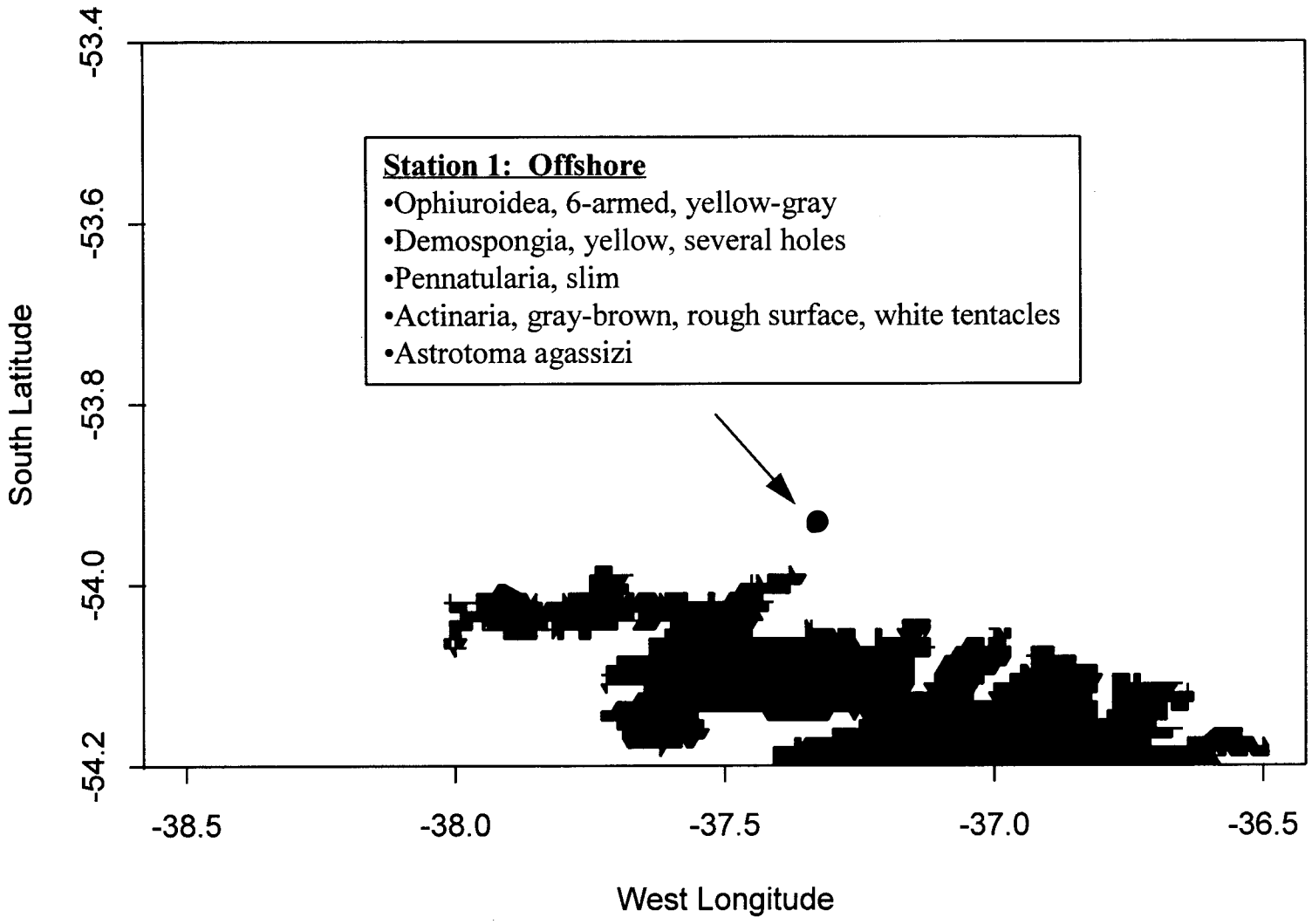

Figure 9.1 BAFs survey station 1. Listed animal types are the most abundant animals identified at this station (see Table 9.3). This station was occupied during the crab survey and is considered to be offshore.

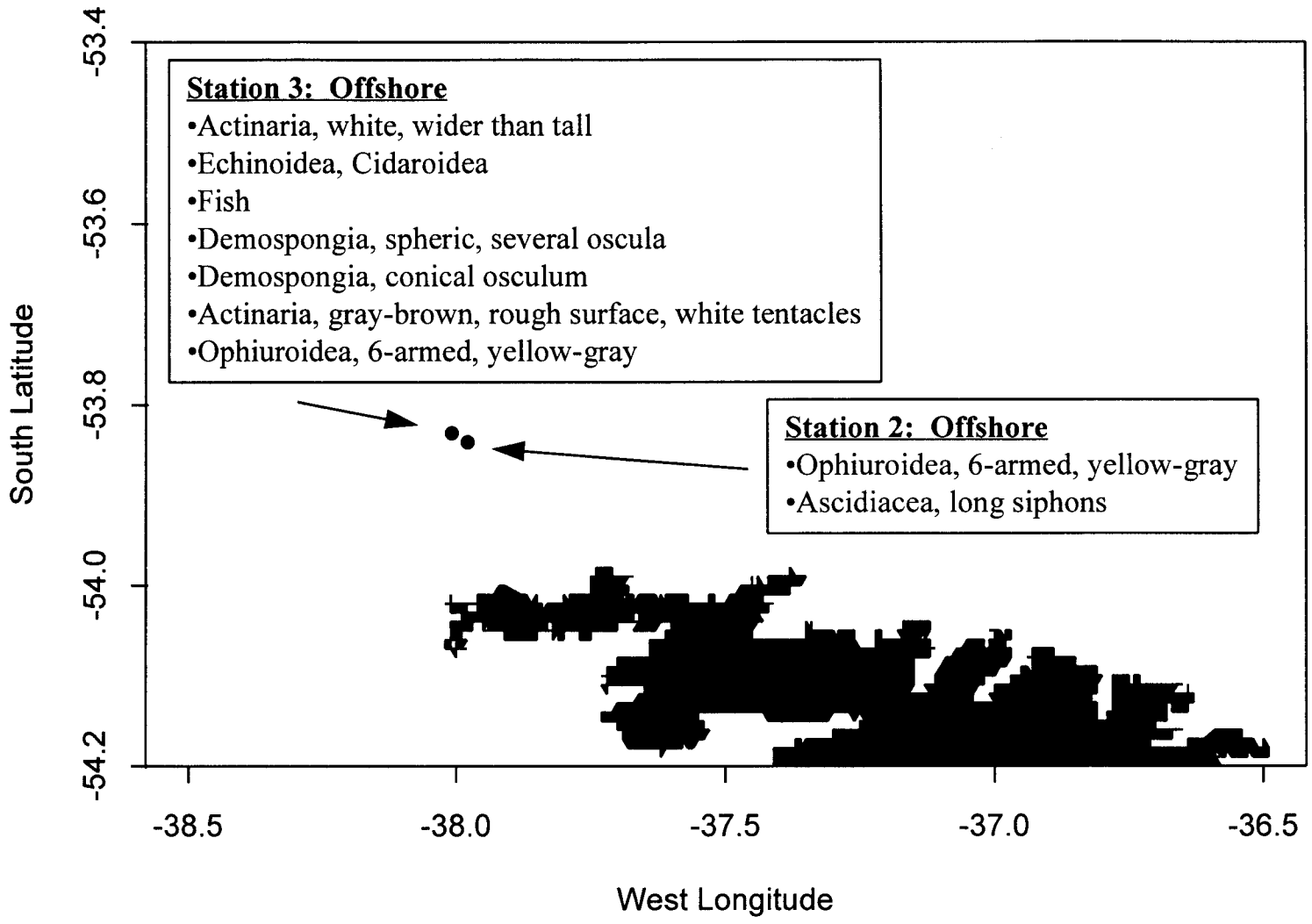

Figure 9.2 BAFs survey stations 2 and 3. Listed animal types are the most abundant animals identified at these stations (see Table 9.3). These stations were occupied during the crab survey and are considered to be offshore.

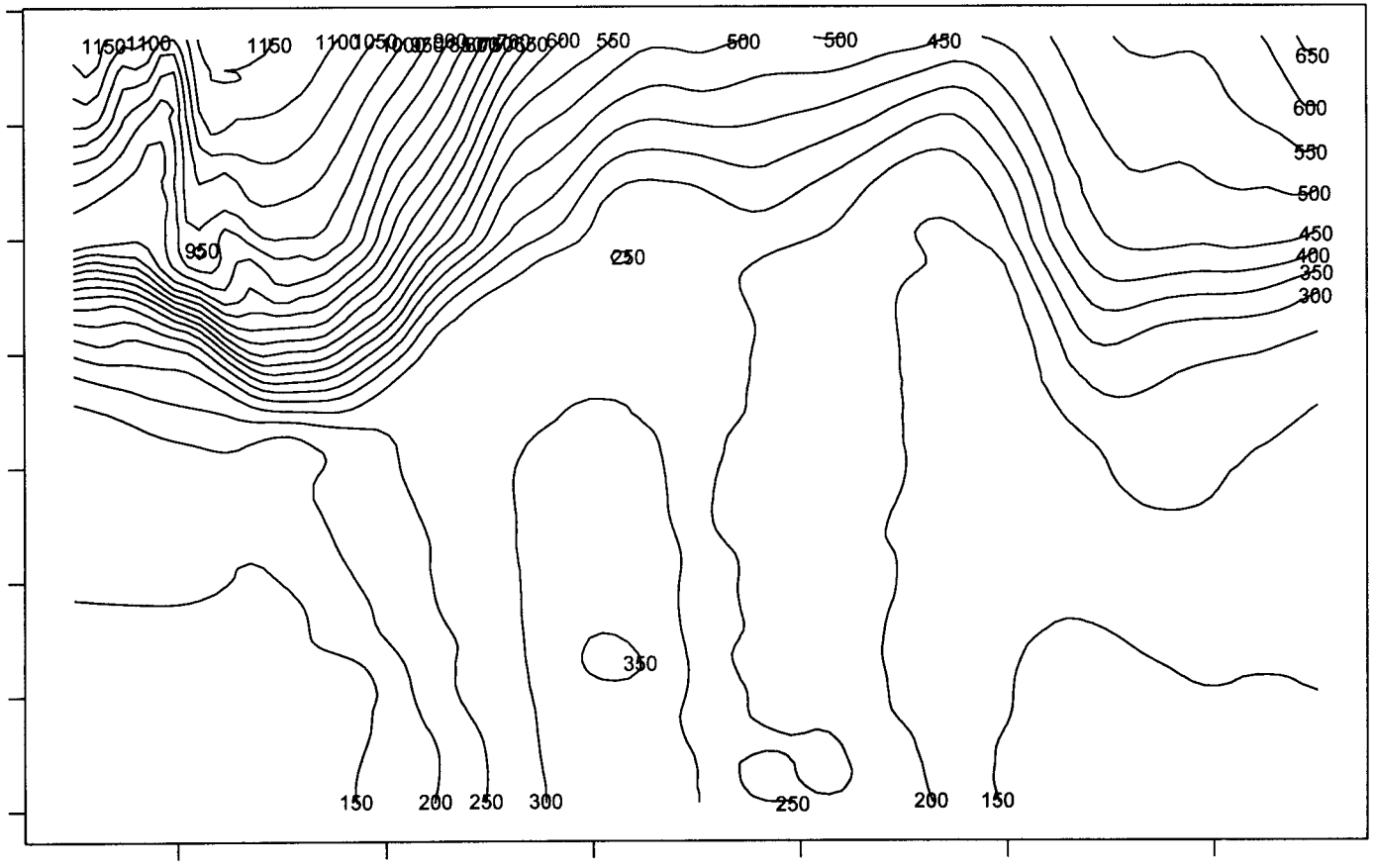

Figure 9.3 Smoothed version of the bathymetric map produced by the Seabeam system during the last two days of Leg III. Contour intervals are depths in meters. The map depicts the topography of a submarine canyon's offshore margin. Latitude and longitude are not displayed because this map may be associated with proprietary fishery data.

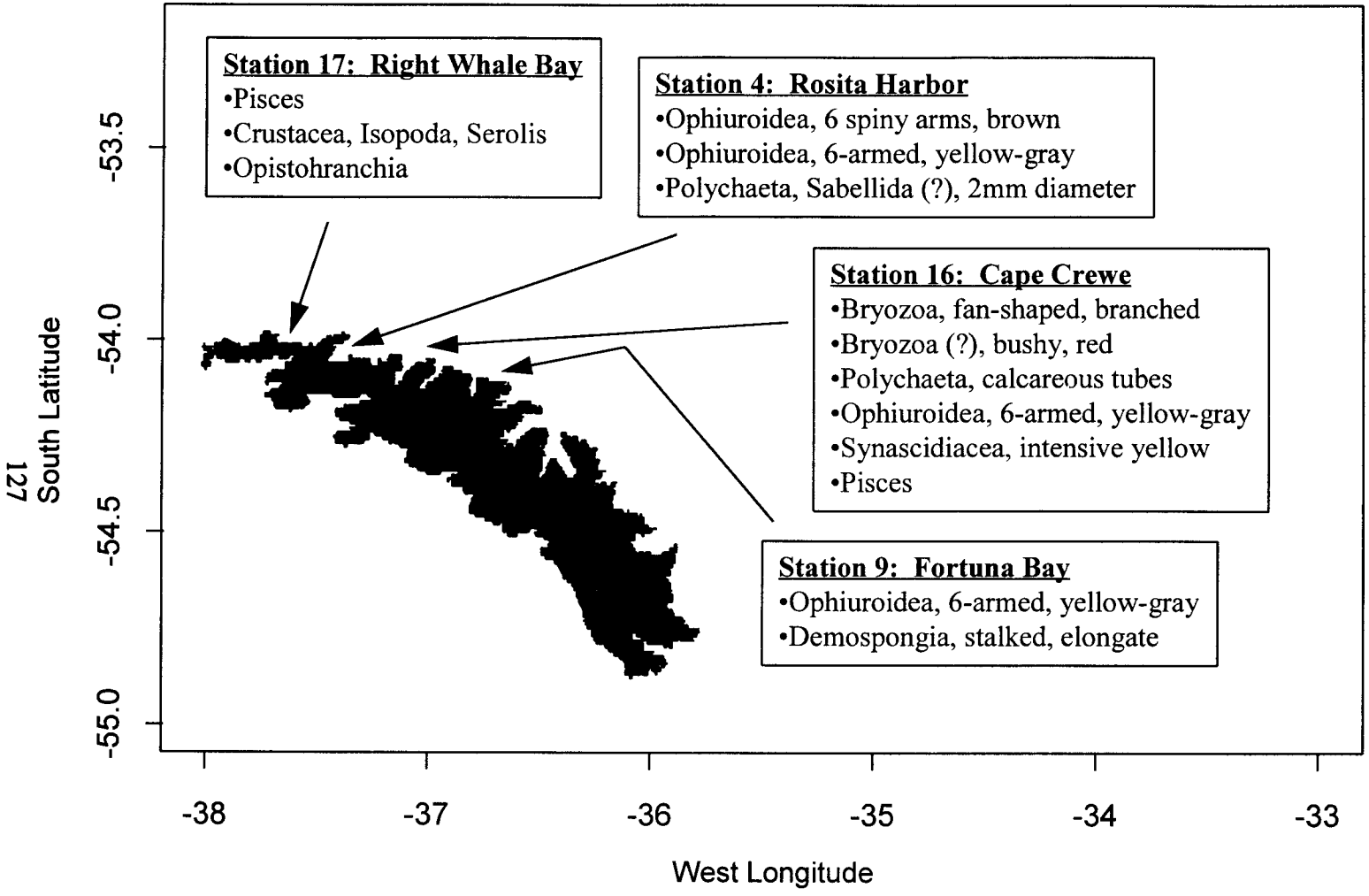

Figure 9.4 BAFs survey stations 4, 9, 16, and 17. Listed animal types are the most abundant animals identified at these stations (see Table 9.3). These stations are considered to be inshore.

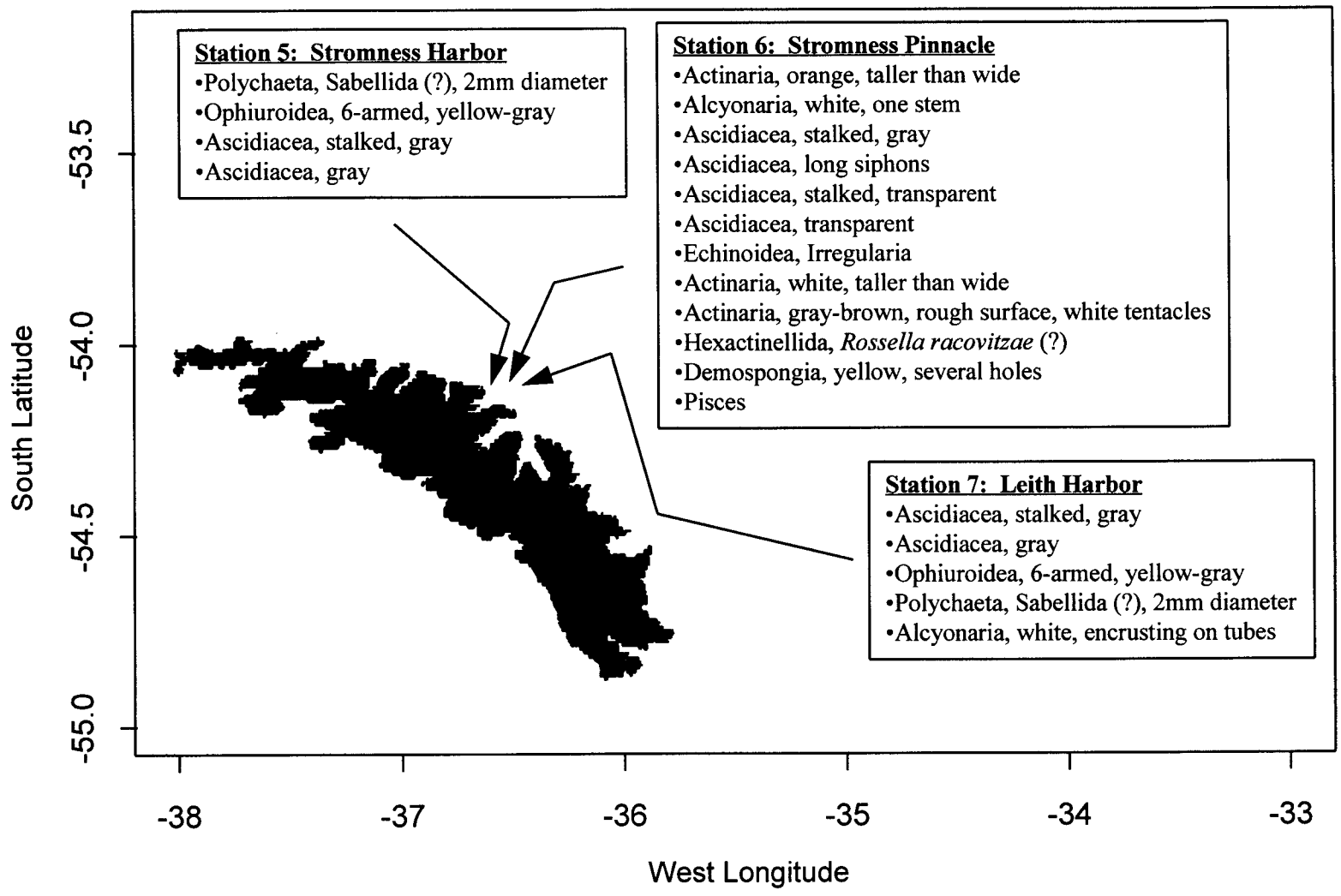

Figure 9.5 BAFs survey stations 5, 6, and 7. Listed animal types are the most abundant animals identified at these stations (see Table 9.3). These stations are considered to be inshore.

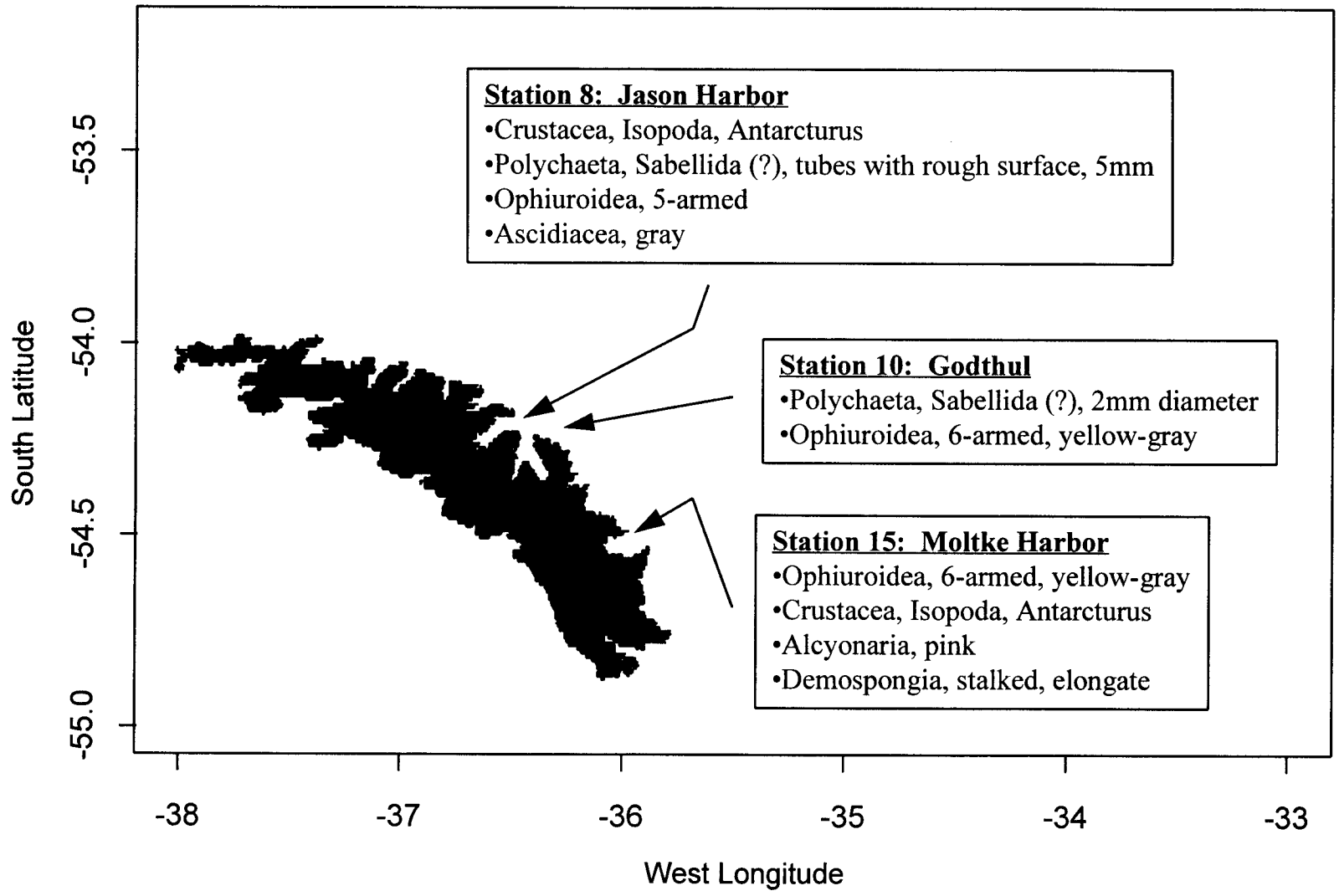

Figure 9.6 BAFs survey stations 8, 10, and 15. Listed animal types are the most abundant animals identified at these stations (see Table 9.3). These stations are considered to be inshore.

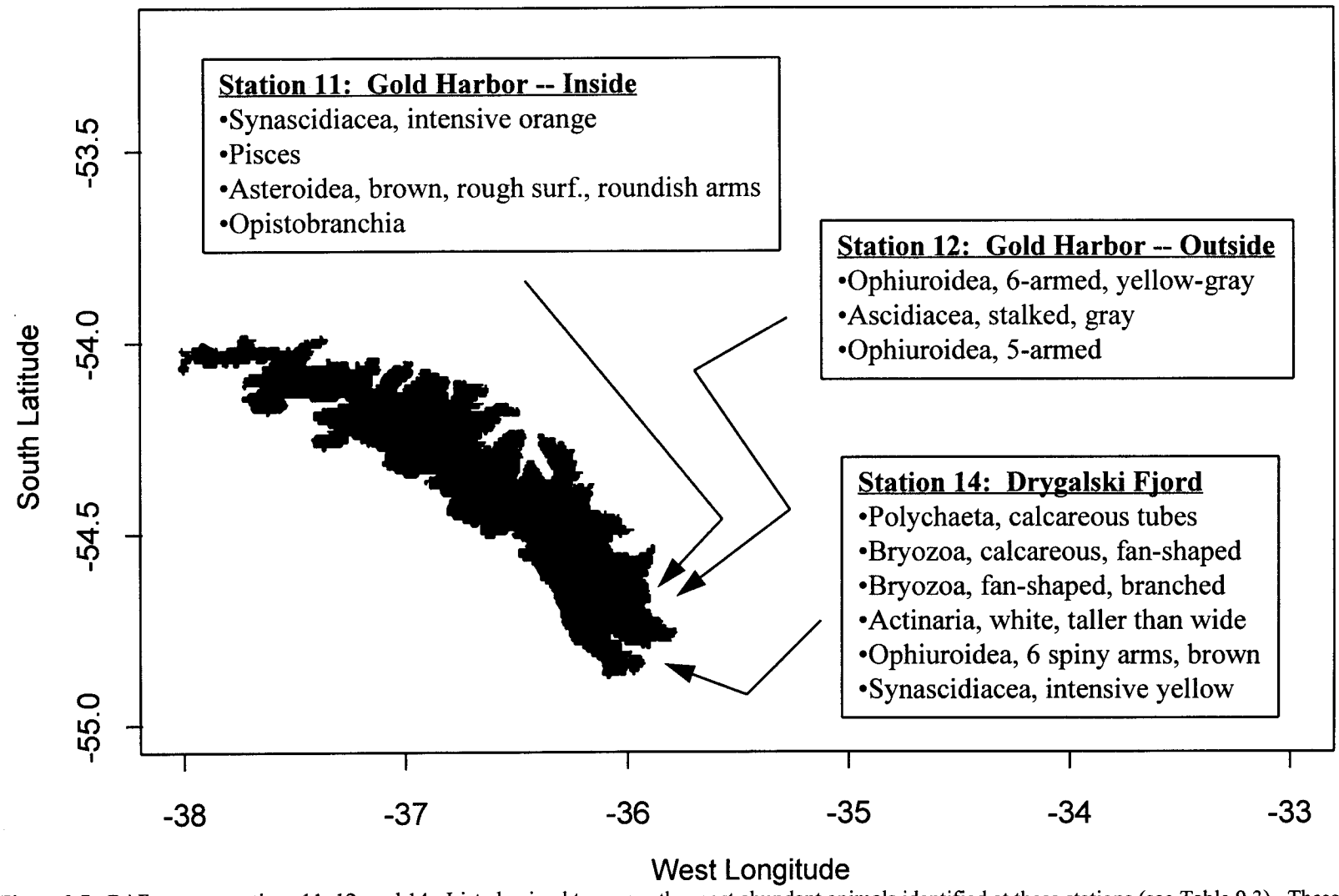

Figure 9.7 BAFs survey stations 11, 12, and 14. Listed animal types are the most abundant animals identified at these stations (see Table 9.3). These stations are considered to be inshore.

10. Seabird research undertaken as part of the NMFS/AMLR ecosystem monitoring program at Palmer Station, 1994/95; submitted by William R. Fraser, Donna L. Patterson, Eric J. Holm, and Karen M. Carney.

10.1 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). Objectives during 1994-1995, the eighth 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 duration of Adelie foraging trips,

6. To band a representative sample (1000 chicks) of the Adelie penguin chick population for future demographic studies, and

7. To determine adult Adelie penguin breeding chronology.

10.2 Accomplishments: Field work at Palmer Station was initiated on 18 October 1994 and terminated on 24 March 1995. The early start date was aided by joint funding from the National Science Foundation's (NSF) Office of Polar Programs. In 1990, NSF selected Palmer Station as a Long Term Ecological Research (LTER) site, and it 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 population size was determined by censusing the number of breeding pairs at 54 sample colonies during the peak egg-laying period (29 November - 2 December, 1994). In 1994, these colonies contained 5591 pairs, a 9.3% decrease in population relative to the 6165 breeding pairs censused in 1993.

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 in 1994/95, creching 1.49 chicks per pair, or 0.11 chicks less than were creched per pair in 1993/94. As in past seasons, two other indices of breeding success were also determined.

The proportion of 1 and 2 chick broods was assessed at 49 sample colonies between 9 January and 12 January (1995). Of the 3078 broods censused, 66.5% (N=2047) contained two chicks, a slight increase over the 62.1% reported in 1994. Chick production was determined by censusing chicks on 22 and 23 January (1995) at 54 sample colonies when approximately 2/3 of them were in the creche stage. Production at these colonies totaled 6685 chicks, an increase of 1.9% over 1994 when 6561 chicks were censused.

Chick fledging weights were obtained between 4-23 February (1995) at beaches near the Humble Island rookery. Peak fledging occurred on 11 February, 5 days earlier than in 1994. Compared to 1993/94, the average fledgling weight of the 370 Adelie penguin chicks sampled decreased by less than 100 g (3.0 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 3 February 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.

Diet studies were initiated on 11 January and terminated on 18 February. During each of the 8 sampling periods, 5 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=40) were subsequently released unharmed. The resulting diet samples were processed at Palmer Station. The early samples taken contained a mix of prey items dominated by the presence of the euphausiids *Thysanoessa macrura* and *Euphausia superba*. Of these, only the krill (*E. superba*) was prevalent in the diets later in the season, with fish becoming a secondary component. An abundance of large krill (*Euphausia superba*) in the size classes 41-45mm and 46-50mm characterized the 1994/95 samples. These were similar to the size classes that predominated in the samples during the 1993/94 season.

Radio receivers and automatic data loggers were deployed at the Humble Island rookery between 7 January and 24 February to monitor presence-absence data on 39 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.

10.3 Tentative Conclusions: The 1994/95 season was characterized by the persistence of heavy winter/spring pack ice until December and a 2-week delay in the timing of the January blooms, conditions that were last present during the 1990/91 season. Although the number of breeding pairs at the 54 censused colonies decreased by 9.3% relative to last season, chick production in these colonies, exhibiting a 1.9% increase, was essentially unchanged. This would argue that the slight decrease in per-pair breeding success shown by Adelie penguins in 1994/95 relative to last season (1.49 vs. 1.60 chicks creched/pair) may be an artifact produced by the 100-nest sample on Humble Island used to determine per-pair productivity. This sample may not be indicative of overall breeding conditions in the 54 colonies used to

measure chick production, suggesting that the number of chicks fledged per colony may in fact be the more significant data for determining year-to-year trends in Adelie penguin breeding success. Increasingly, the long-term data being accumulated at Palmer Station are suggesting that breeding success is colony specific, with year-to-year variability within and between colonies being largely determined by environmental features specifically associated with the terrestrial nesting habitat.

Unlike last season, the predominant components in the diets of Adelie penguins varied from a mixed species assemblage of *T. macrura* and *E. superba* early in the season, to one dominated by *E. superba* later in the season. This change was concurrent with longer and shorter foraging trip durations (on average, 30 hours vs. 8 hours, respectively, based on a partial analysis of the data) and the early absence vs. the late presence of blooms within the penguins' foraging area. Although the causal factors associated with a delayed bloom are not yet clear, the data suggest that the availability of *E. superba* to foraging penguins is at least in part determined by spatial and temporal changes in the availability of phytoplankton within the foraging area. These environmental signals are not reflected as changes in either reproductive success or fledging weights between this season and the 1993/94 data; however, at this point, this should not be interpreted as a "lack of effect." The interactions between these environmental variables, the distribution and availability of prey, and key Adelie penguin reproductive and condition indices are potentially complex, suggesting that longer-term data are needed to begin resolving causal relationships.

10.4 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 AERG.

10.5 Problems, Suggestions and Recommendations: It is becoming more apparent that environmental variables such as sea ice extent and 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 environmental data. It is our opinion that the development of such standards would greatly aid our interpretive potential within and between CEMP monitoring sites.

ACKNOWLEDGMENTS

The scientific party extends its sincere appreciation to the Captain, officers, and crew of the NOAA Ship *Surveyor* for their invaluable contributions to the 1994/95 AMLR field season. The AMLR cruise is very challenging due to numerous and frequently monotonous scientific operations, a very lengthy deployment, and the harsh and unpredictable Antarctic environment. As has always been the case, the ship's officers and crew met each challenge head-on and always performed admirably. Our success was due largely to the stellar performances of all the ship's departments. The 1994/95 season was our last on *Surveyor*. We will certainly miss the ship herself, but much more importantly, we will miss the exceptional people who worked aboard her.