8. Near-Shore Acoustical Survey Near Cape Shirreff, Livingston Island; submitted by Joseph D. Warren (Leg II), Adam D. Jenkins (Leg II), and David A. Demer (Leg II).

8.1 Objectives: The near-shore area around Cape Shirreff serves as the main feeding ground for the seasonally resident fur seal and penguin populations at Cape Shirreff. These animals feed primarily on Antarctic krill, which aggregates in large swarms and layers in the waters just offshore of the island. Shallow and highly variable bathymetry makes this area unsuitable for study from large ships. Using a specially modified 19-ft zodiac (R/V *Ernest*), the near-shore region was surveyed, collecting acoustical backscatter and meteorological data. During this time, the R/V *Yuzhmorgeologiya* conducted a complementary offshore survey of the area (Figure 8.1). This survey overlapped coverage with that of *Ernest* and at the same time collected physical oceanographic, meteorological, and net tow data. All of these data sets were analyzed to study the relationships between the oceanography and biology of the area. Additionally, both ships collected bathymetric data for this region to investigate the presence and effect of two large submarine canyons that flank Cape Shirreff.

8.2 Methods and Accomplishments: Approximately 150 n.mi. were surveyed using *Ernest* from 17 to 23 February 2002 (Figure 8.1). *Ernest* is a Mark V 19-ft zodiac powered by two outboard engines: a 9.9-hp Yamaha and a 55-hp Johnson (Figure 8.2). The boat was equipped with radar, multiple GPS, EPIRB, VHF radio, a WeatherPak 2000 meteorological station (measuring temperature, humidity, barometric pressure, bearing and apparent and true wind speed and direction), and a 120kHz Simrad EY500 echosounder. A graphical user interface and logging program was written in Matlab by Joseph D. Warren to log and display all of the environmental parameters and chart *Ernest's* position in real-time (ErnieView). The split-beam echosounder transducer was deployed from the port side on a moveable arm. The system can be raised out of the water for quicker transit or rough sea state. There is also a downrigger that can be used to deploy additional instrumentation such as a small CTD or video camera system. *Ernest* runs from a bank of four gel cell batteries that can provide up to 20 hours of continuous power, providing 120-VAC power for data logging computers and instrumentation. The boat was also equipped with a survival and tool kits, manual and automatic bilge pumps, three survival suits, four fuel tanks, binoculars, and anchorage equipment.

Ernest was deployed from *Yuzhmorgeologiya* on 17 February 2002. First, the acoustical system was calibrated in approximately 30m of water near Cape Shirreff using a 38.1mm diameter tungsten carbide sphere. That afternoon and evening, *Ernest* was used to conduct a small-area survey of the eastern submarine canyon to locate a suitable mooring location for the multi-instrumented-buoy. Subsequent operations were based from the field camp on Cape Shirreff. The planned survey grid extended 10 n.mi. offshore from Cape Shirreff. Weather conditions were good during much of the survey period, allowing good (>60%) coverage of the grid. Strong winds (20-25-kts from the NW) and rough sea condition limited much of the survey west of Cape Shirreff. Typical survey speeds were 5-kts and an average of 6 hours per day were spent on the water. During *Ernest's* survey work, *Yuzhmorgeologiya* conducted a complementary survey grid, further offshore, but staying near *Ernest* in case of emergency. Once *Ernest* returned to shore at Cape Shirreff each afternoon, *Yuzhmorgeologiya* proceeded to conduct an offshore acoustical survey, collecting CTD and IKMT zooplankton samples during the return trip to Cape Shirreff the following morning (Figure 8.1). *Ernest* was brought aboard *Yuzhmorgeologiya* on the afternoon of 23 February 2002.

8.3 Results and Tentative Conclusions: Volume backscattering coefficient at 120kHz were integrated over the upper 100m of the water column and averaged over 0.1-n.mi. of survey distance (Sa). These Sa are believed to be proportional to the density of krill (Figure 8.3). As was seen in the 1999/00 survey effort, the highest concentrations of krill were found in the near-shore region southeast of Cape Shirreff. However, this year's survey also found high densities of krill in the near-shore region southwest of the Cape. Weather conditions and equipment malfunction prevented successful deployment of the video camera system, so the backscattering aggregations thought to be krill were not visually identified. However, based on the 1999/00 near-shore survey and the 2001/02 net tow data from *Yuzhmorgeologiya*, the acoustical targets are believed to be euphausiids *Thysanoessa macrura* and *Euphausia superba*. During the survey, penguins and seals were often seen foraging in areas with high acoustic backscatter.

Individual target strengths (TS) were analyzed from the EY500 data. Targets between 10 and 40m depth with along- and athwart-ship angles less than 3 degrees had a bimodal distribution (Figure 8.4a) with a major mode centered at approximately -68dB. This value is consistent with the results from the near-shore survey in 1999/00, and is believed to indicate that the scatterers are large krill (length >5cm). The higher TS values are likely from small fish. The distribution of target strengths versus depth of the scatterer was investigated (Figure 8.4b). Weaker targets were more likely to be found in shallower waters than stronger targets.

The results of the IKMT net samples show that juvenile krill had a higher concentration offshore (water deeper than 500m) while adults were more likely to be found in waters shallower than 500m (See section 3 in this report). The most abundant species at each station varied between juvenile and adult stages of *Euphausia superba*, *Thysanoessa macrura*, and *Euphausia frigida*. Copepods were also abundant and had a similar distribution to that of the krill. The distribution of *Thysanoessa macrura* appeared to follow the bathymetry of the region to some extent with higher densities of these animals found in regions in or near the two submarine canyons that flank Cape Shirreff (Figure 8.5).

The meteorological data collected by the WeatherPak 2000 system aboard *Ernest* shows that wind speeds were generally in excess of 5m/s. Wind direction was variably but most often from the NW (Figure 8.6). True wind speed and direction were calculated from the apparent wind speed and direction and the speed and course of the R/V *Ernest*. The humidity sensor often gave readings >100% and is believed to have a 10-15% offset. Temperature was generally 2°C, ranging from 3°C during brief sunny periods, to just below 0°C when the winds shifted to the south and blew cold air down from the glacier on Livingston Island. Compared to the meteorological data collected by *Yuzhmorgeologiya* (Figure 8.7), the near shore region surveyed by *Ernest* had much more variable wind speed and direction.

An analysis of the CTD and oxygen profiles collected from *Yuzhmorgeologiya* also shows a relationship between the physical oceanography of the region and the bathymetry, particularly the submarine canyons. Alongshore profiles show two elevated regions of temperature and oxygen in the near surface water, which may possibly be from Antarctic Circumpolar Current water that is upwelling through the submarine canyons. This water would provide oxygen to the near-shore region, which would stimulate primary and secondary production. This is a possible explanation for the elevated regions of acoustic scattering that were observed during this survey and why these particular near-shore regions are the primary foraging grounds for the penguin and seal populations of Cape Shirreff.

8.4 Disposition of Data: Data are available from David A. Demer, Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA; phone/fax: +1 (858) 546-5603/5608; email: David.Demer@noaa.gov

8.5 Acknowledgments: We are indebted to the scientists and crew aboard R/V *Yuzhmorgeologiya* for keeping a watchful eye over R/V *Ernest* and crew, and for collecting CTD, acoustical, and net tow data during the survey. We would also like to thank the personnel of the Cape Shirreff field camp for their hospitality during our stay at their home. Under contract from the Advanced Survey Technologies Program at SWFSC, R/V *Ernest* was cleverly designed and solidly built by Leif Knutsen of Port Townsend Shipwrights, Inc. Joseph D. Warren was supported by Office of Naval Research grant #N00014-01-1-0166.

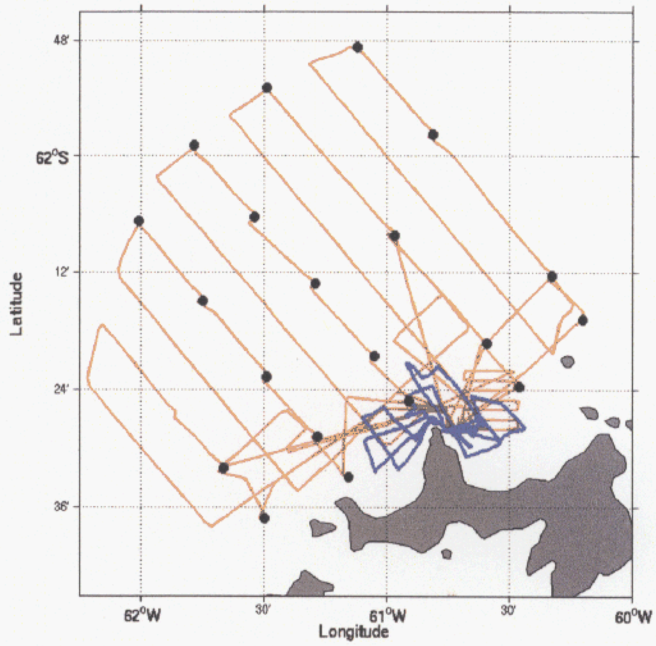


Figure 8.1. Completed tracklines of the R/V *Yuzhmorgeologiya* (red) and R/V *Ernest* (blue) during the 2002 AMLR near-shore survey of Cape Shirreff. Black dots indicate the locations of CTD and IKMT stations.

Figure 8.2. R/V *Ernest* moored at the protected beach immediately north of the Cape Shirreff field camp with the R/V *Yuzhmorgeologiya* in the background.

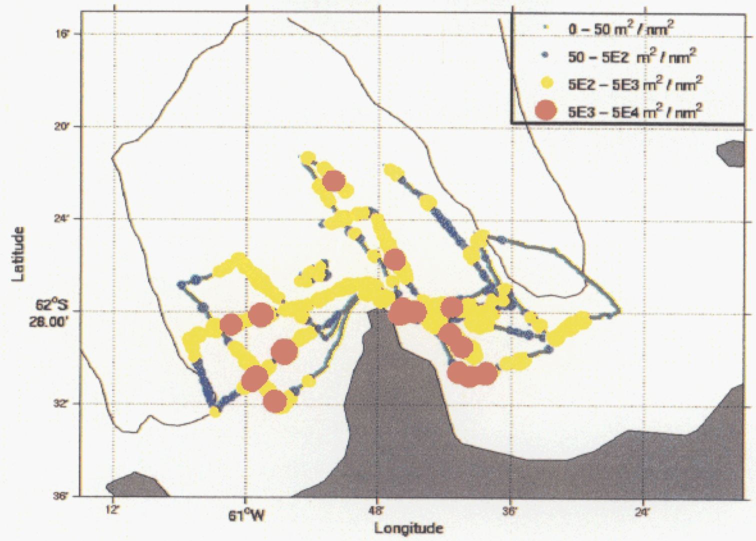
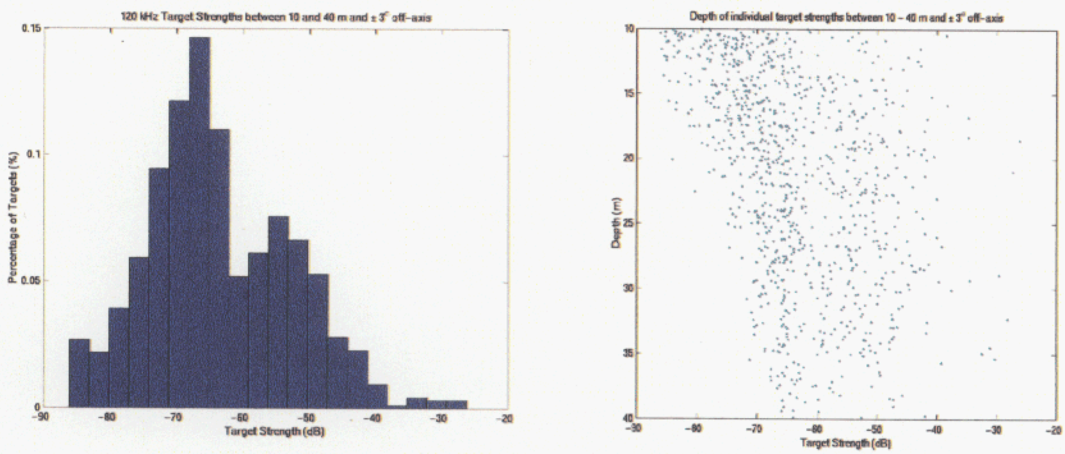


Figure 8.3. Volume backscattering coefficients at 120kHz integrated over the upper 100m of the water column and averaged over 0.1 n.mi. bins (Sa). Overall values of Sa are slightly lower than during the 1999/00 near-shore survey, however the highest Sa values of both years are very similar. Elevated backscatter (indicative of the presence of krill) occurred in the areas immediately east and southeast of Cape Shirreff and slightly further west of the Cape. The 200m isobath is shown in black showing the regions of highest scattering occurred near the heads of these two submarine canyons.



(a) (b)

Figure 8.4. (a) Histogram of individual target strength (TS) measurements at 120kHz collected by the split-beam EY500 echosounder. The peak value is at approximately -68dB which is similar to that found in the 1999/00 survey and corresponds to large krill. The second mode, centered around -50dB, is likely from small fish, possibly myctophids. (b) Distribution of individual target strengths with depth showing that stronger targets generally occurred in deeper waters. However this may be an artifact of multiple targets incorrectly being resolved as a single target by the echosounder.

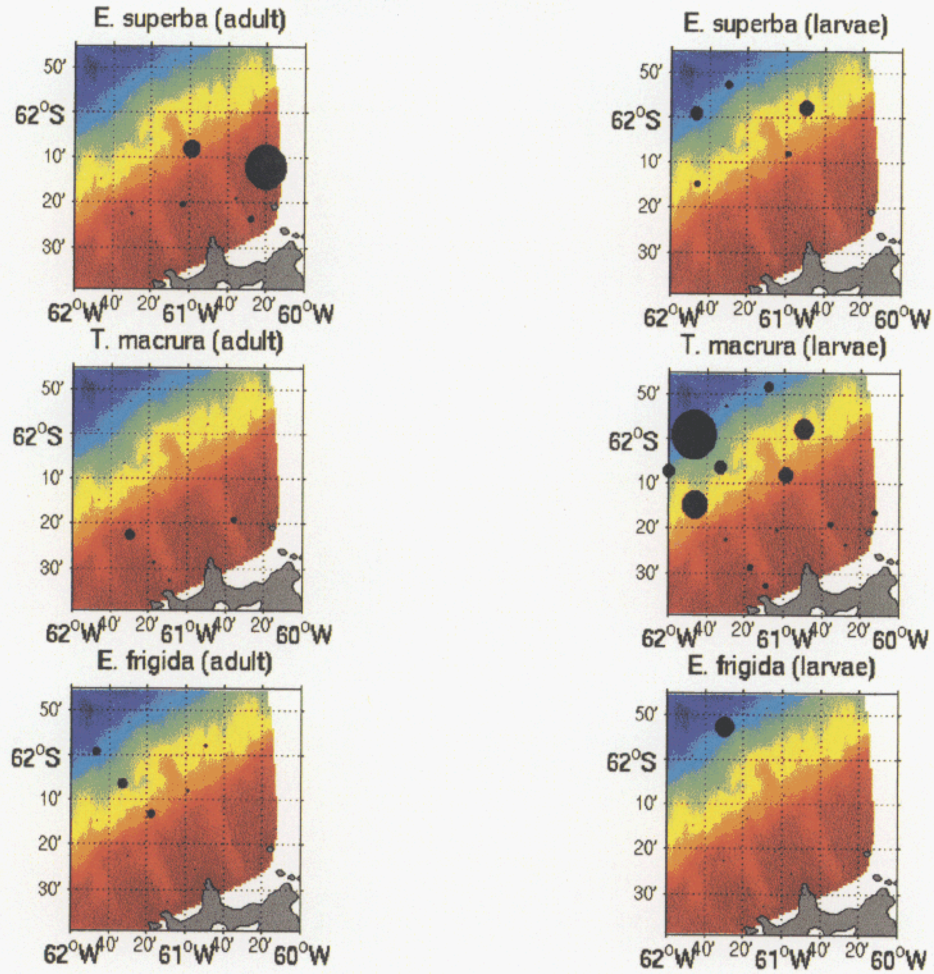


Figure 8.5. Distribution of euphausiids from IKMT new samples collected by the RV *Yuzhmorgeologiya* during the 2001/02 near-shore survey overlaid on a bathymetry map (red = shallow, blue = deep). The largest black circles correspond to numerical densities of 6 animals per m^3. The diameter of the other black circles is linearly proportional to the numerical density. Animals were more abundant off-shore than near-shore, however the distribution of *Thysanoessa macrura* show increased numerical densities on and near the submarine canyons flanking Cape Shirreff.

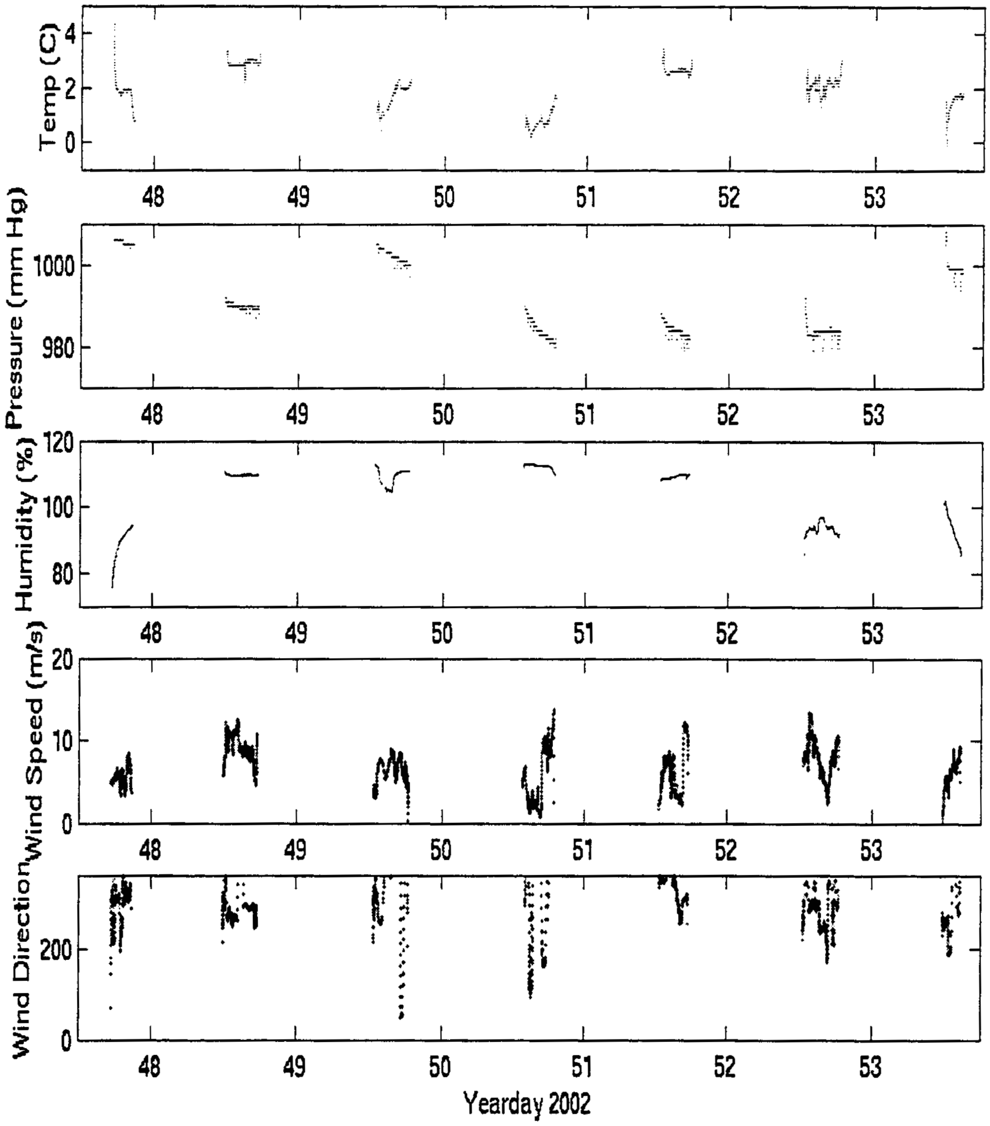


Figure 8.6. Meteorological data from R/V *Ernest* during the near-shore survey. The humidity sensor readings are likely offset 10-15% high. Wind speed was generally higher than 5m/s with a peak gust recorded of 18m/s. Most frequent wind direction was from the NW.

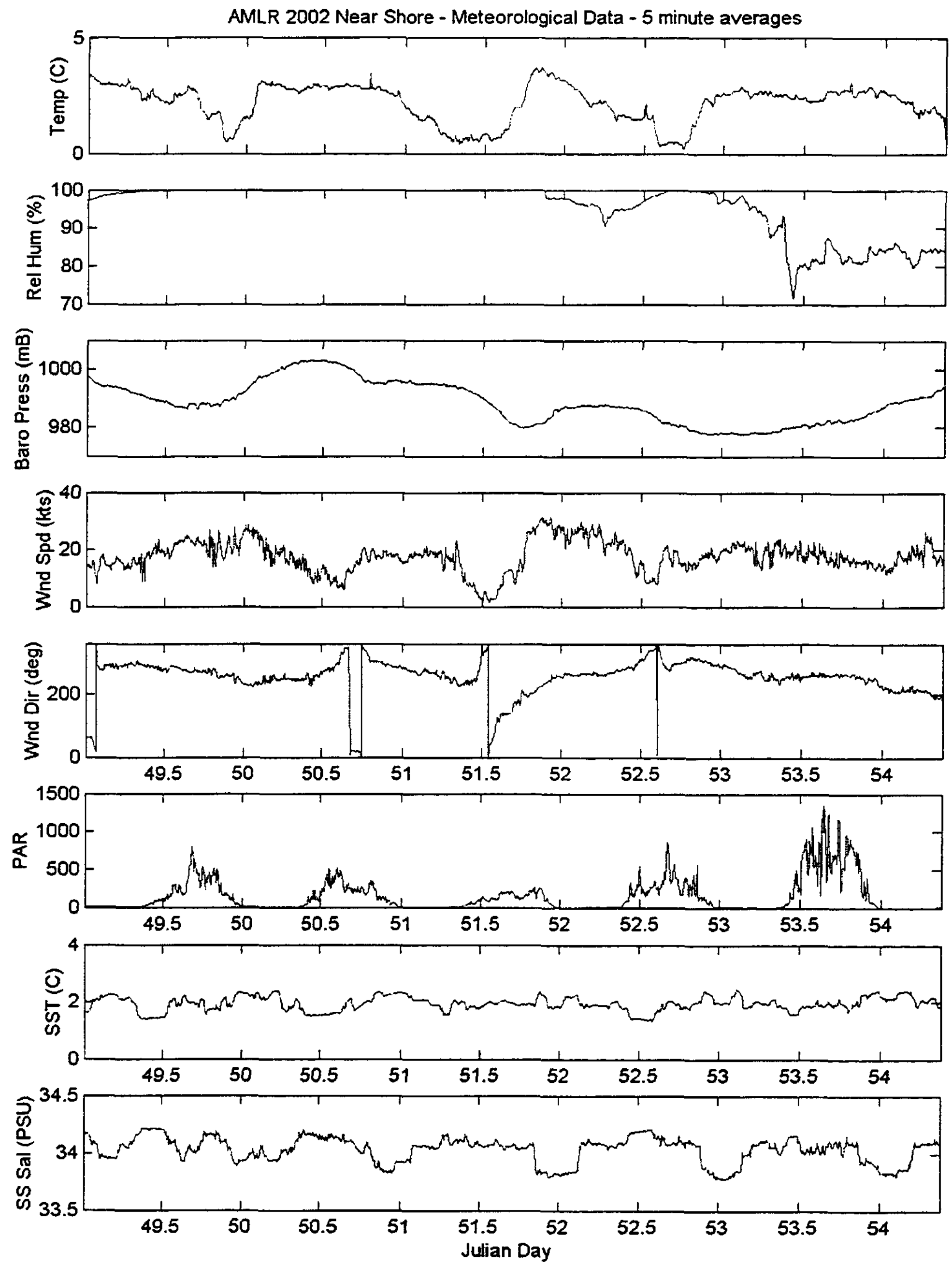


Figure 8.7. Meteorological data from R/V *Yuzhmorgeologiya* during the near-shore survey. PAR is photosynthetically absorbed radiation. SST is sea surface temperature.