1. INTRODUCTION

The front forms the western boundary of the ACC, and the meridional extent and fronts of the ACC are essentially defined in terms of oceanographic features which are associated with the ACC and its fronts. The ACC and its fronts are important from a biological point of view, and the location of the SACCF has been focused south of the SACCF where Antarctic krill, Euphausia superba, is the dominant zooplankton. The ARSV Laurence M. Gould (LMG) collects underway data on transects of Drake Passage 2-4 times per month in all seasons. This study uses 238 ADCP transects collected over a 10-year period to remotely sense the characteristics of the near-surface scattering layer. We also present preliminary results from the last systematic net sampling effort since the Discovery Expeditions specifically focused on describing the zooplankton species assemblies across Drake Passage.

2. BACKSCATTERING STRENGTH

Backscattering strength was calculated as a function of latitude and depth for each transect. A dominant pattern observed in backscattering strength is deep vertical migration, a known behavior in which zooplankton descend to greater depths to escape predation during daylight hours and ascend to feed at night. Typically the daytime descent is in a distinct layer (aggregation) whereas the nighttime increase is more diffuse (dispersed). Also apparent is a deeper layer in the depth range 200 m to 300 m that is typically present at night.

Backscattering strength from a typical 2-day crossing. The colored line at the top indicates time of day (daytime is denoted by orange; nighttime by black). The red triangle marks the location of the Polar Front. (Adapted from Chereskin and Tarling, 2007.)

3. SPATIO-TEMPORAL PATTERNS

Backscattering strength was averaged over depth, month and geographic region.

5. RELATION TO CLIMATE MODES

A dominant pattern observed in backscattering strength is deep vertical migration, a known behavior in which zooplankton descend to greater depths to escape predation during daylight hours and ascend to feed at night.

4. PERIODICITIES

Periodicities in backscattering strength for the period 1999-2012 were dominated by 3 periods of 1, 7 and 11 years that explained more than 60% of the variance.

7. CONCLUSIONS

We expect that changes in the Southern Ocean due to climate warming are visible in ecosystem dynamics. This study used underway shipboard observations of upper ocean scattering layers as a proxy to observe these changes. The observed interannual variability is consistent with recent observations of decline in krill stocks in the Southern Ocean (e.g., Atkinson et al., 2004). Ideally, with coincident zooplankton samples for calibration and species identification such as collected during LG1410, ADCP backscattering strength will be a useful tool to monitor the Drake Passage ecosystem.

The main conclusions are:

- Temporal variability in backscattering strength for the period 1999-2012 was dominated by 3 periods of 1, 7 and 11 years that explained more than 60% of the variance.
- The annual cycle is consistent with the biological nature of the scatterers. There is a fourfold increase (8 dB) from late winter to spring.
- The spatial distribution shows consistently higher backscattering strength north of the Polar Front. This variation is due at least in part to latitudinal differences in the composition and abundance of zooplankton species.
- There is a long-term trend, with backscattering strength decreasing from 2001 to 2008 in Drake Passage. The decline is most pronounced south of the SACCF, with a decline of about 8 dB over a 7-year period.
- The annual cycle accounts for more than 30% of the variance. Two trends are visible, one with a period of 7 years and another with a period of 11 years.

Acknowledgments

The National Science Foundation Office of Polar Programs sponsored this research through grants PLR-134131 (Chereskin and Sprintall) and PLR-1347911 (Loeb and Santora). The underway ADCP program is carried out in partnership with Eric Firing and Jules Hammon (University of Hawaii). Thanks are also due to Sharon Escher (SOI), the captains and crews of the ARSV Lawrence M. Gould and to Raytheon Polar Services Corporation for excellent logistical and technical support.

References


The annual signal was removed from both the backscattering strength and the SST time series, and the series were less well filtered, in order to examine interannual variability. The Niño 3 and SAM indices were used as shown above, without further modification.

Significant latitudinal differences in the composition and abundance of zooplankton species were found. Both north- and southbound stations included below. Of note in the north is the large amount of Thysanoessa schlegelii in the SACCF. These are very effective acoustic sound scatterers. Euphausia krill species dominate the sound scattering in the Antarctic Zone, especially Euphausia superba and Thysanoessa macrura.

The annual signal was removed from both the backscattering strength and the SST time series, and the series were less well filtered, in order to examine interannual variability. The Niño 3 and SAM indices were used as shown above, without further modification.