Proposed observations of the growth of land-fast sea ice in M^{c}Murdo Sound, Antarctica during the winter of 2003

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Abstract

We present some preliminary oceanographic and ice structure measurements taken in M^{c}Murdo Sound during September 2002 and describe proposed measurements to be undertaken during the Antarctic winter of 2003. The purpose of these measurements is to quantitatively describe the formation of the land-fast sea ice in M^{c}Murdo Sound and determine the link between this formation and the underlying oceanographic conditions. Specifically we are concerned with determing the relationship between the underlying oceanographic conditions and the formation of a type of ice termed *platelet ice*, as well as investigating the cause of horizontal layering which has been observed in M^{c}Murdo Sound. Almost all that is known about sea ice growing attached to the Antarctic landmass has been measured in the spring when the sea ice has grown to over one meter thick. Here we intend to measure the physical conditions of the thin sea ice that prevails in Antarctic winter conditions.

1 Introduction

The prevalent form of sea ice in M^{c}Murdo Sound (See Fig. 1 for a map of M^{c}Murdo Sound), *columnar ice*, is a matrix of pure ice crystals, interleaved with brine-filled inclusions. This trapped brine causes the ice to be saline. Horizontal layering, or *banding*, is a common feature of the ice, with over 30 horizontal layers being identified in the top meter of some cores. Whether these bands are due to variations in growth velocity, or related to gas production is still a matter of some conjecture. The crystals of columnar sea ice can be strongly aligned with the c-axes in the direction of the predominant oceanic current. This ordering is often disrupted at the base of the columnar sheet, where an open-textured, random array of dendrictic crystals is sometimes found. Termed *platelet ice*, this ice type was recognised during the British Antarctic Expedition 1910-1913 but has since eluded attempts to understand the details of its formation. It is known to first appear at the ice-water interface between July and mid September and that its appearance is related to the heat content of the water mass of M^{c}Murdo Sound.

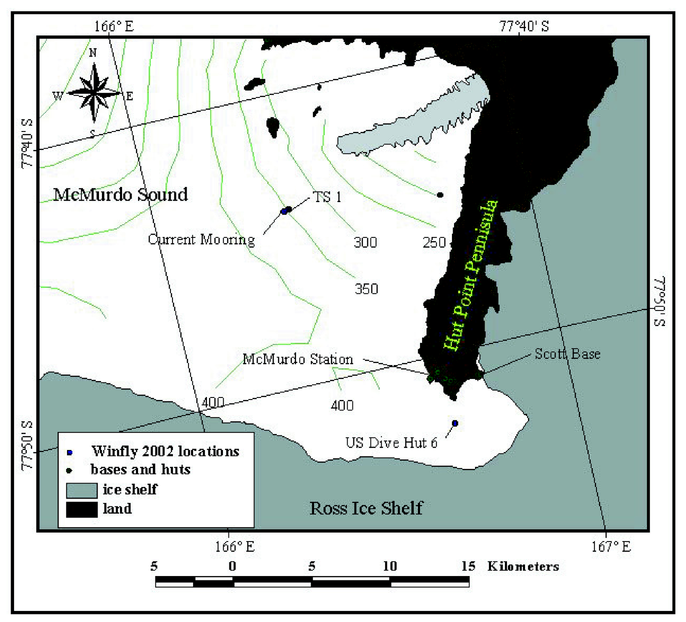

Figure 1 Map of M^{c}Murdo Sound showing sites where measurements were undertaken during Winfly 2002.

The measurements proposed here will consist of both oceanographic circumstances and sea ice aspect. The oceanographic measurements will include CTD casts to determine the properties of the underlying water column, CT deployments at the ice-water interface to accurately measure the degree of supercooling, and ADCP current profiles to observe the currents beneath the ice. The sea ice measurements will include utilising thermistor buoys to record the growth rate of thin sea ice, ice coring to determine both physical structure and salinity, and oxygen isotope analysis to determine the origin of the ice. Some preliminary measurements were undertaken during August and September of this year and are presented in the following section.

2 Winfly 2002 Measurements

Fig. 2 presents the east-west and north-south currents measured by a current mooring that was deployed 200 m below the ice surface on 1 September 2002 (See Fig. 1 for location of current mooring). Fig. 3 displays the power spectrum magnitude of these currents.

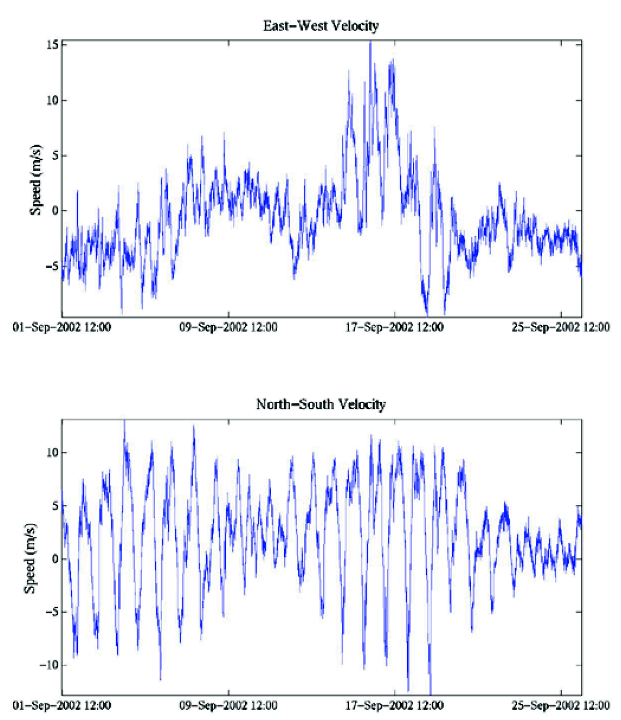

Figure 2 East-west and north-south currents measured by the current mooring.

A quick inspection shows that the north-south current is dominated by a diurnal and semidiurnal component, while the east-west current is dominated by a single diurnal component. Fig. 4 presents the predicted tides at M^{c}Murdo Station using the tidal coefficients presented in [1] for the same time period as the current mooring record. A comparison of Fig. 2 and Fig. 4 clearly shows that the north-south current is mainly tidal driven, while the east-west current is more complex.

Fig. 5 shows a comparison of ADCP measured current speed at site TS 1 and current mooring measured current speed for the same time period. The two signals are well correlated even though they are measuring the current at different depths (7.55 m for ADCP, 200 m for current mooring). Fig. 6 shows a time vs. depth plot of ADCP signal strength and ADCP up-down velocity. The ADCP signal strength is measured in counts and gives an indication of how much of the outgoing acoustic signal is returned to the instrument. The signal strength typically declines with distance from the ADCP, however Fig. 5 shows several instances where the signal strength remains relatively high at intermediate depths. A comparison with the up-down velocities shows that these instances correlate well with episodes of upward velocities. A scenario that could explain this situation is if the ADCP is preferentially picking up objects such as water bubbles or ice crystals rising up through the water column, as such objects would be superior acoustic scatters to the surrounding water column. A longer ADCP record would indicate whether these episodes are correlated with oceanographic events such as the tidal cycle.

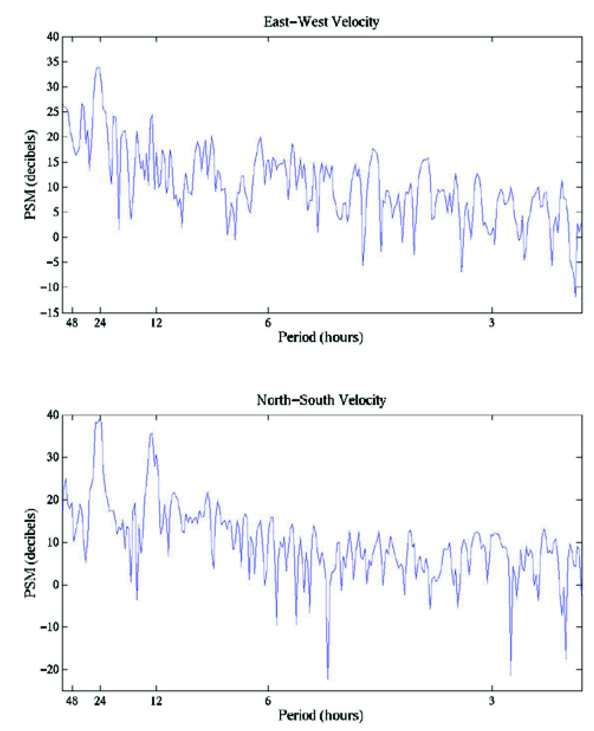

Figure 3 Power spectrum magnitude of east-west and north-south currents measured by current mooring.

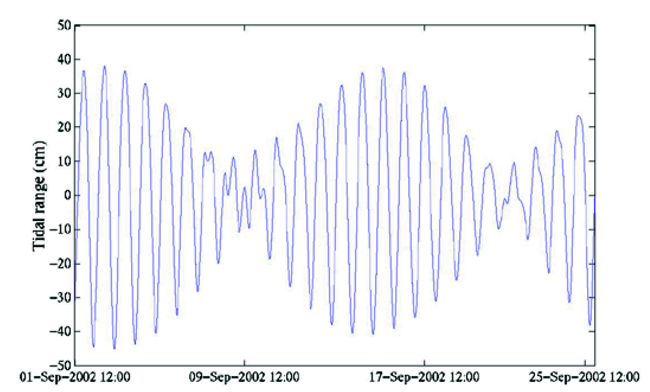

Figure 4 Predicted tides at M^{c}Murdo Station.

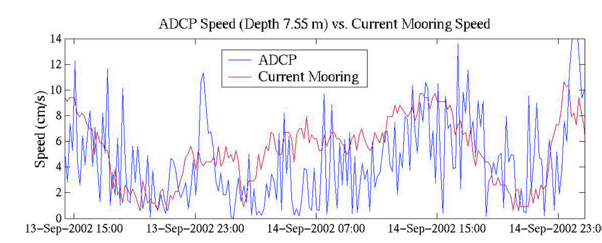

Figure 5 ADCP speed at site TS 1 vs. current mooring speed.

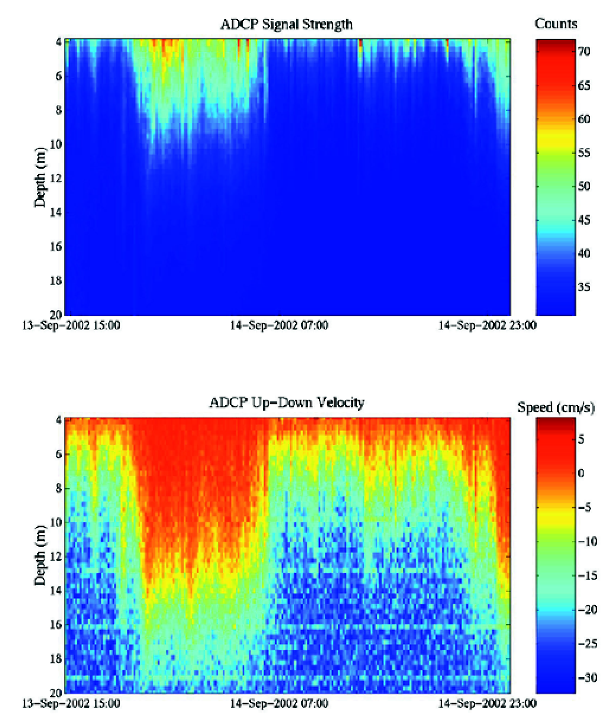

Figure 6 ADCP signal strength and up-down velocity at site TS 1.

Fig. 7 shows the potential temperature, salinity, and poteniitial density profiles from two CTD casts; the first at TS 1, 11:28 6 Sept. (indicated by a green line), and the second at US Dive Hut 6, 19:43 23 Sept. (indicated by a blue line). Both casts show a the potential density linearly increasing with depth while the potential temperature and salinity profiles show both some piecewise linear structure and some variance between the two casts.

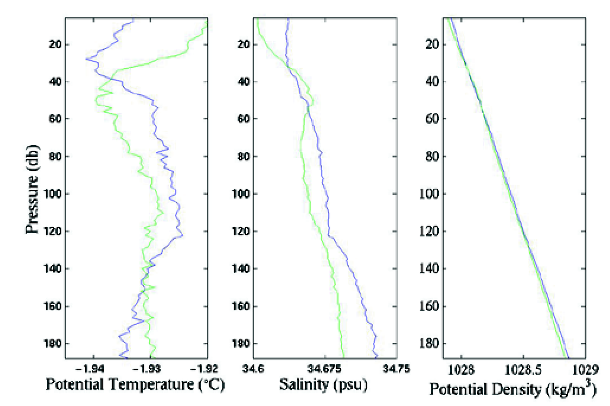

Figure 7 Potential temperature, salinity, and potential density calculated from CTD Casts 5 (TS 1, green line) and 92 (US Dive Hut 6, blue line).

Fig. 8 shows a horizontal and Fig. 9 shows a vertical thin section prepared from an ice core that was taken at a site approximately 2 km east of TS 1 on 26 August 2002. The horizontal thin section is at a depth of 140 cm and the vertical thin section is taken from the range 180-190 cm. Both clearly show the presence of relatively large, randomly oriented platelet ice crystals.

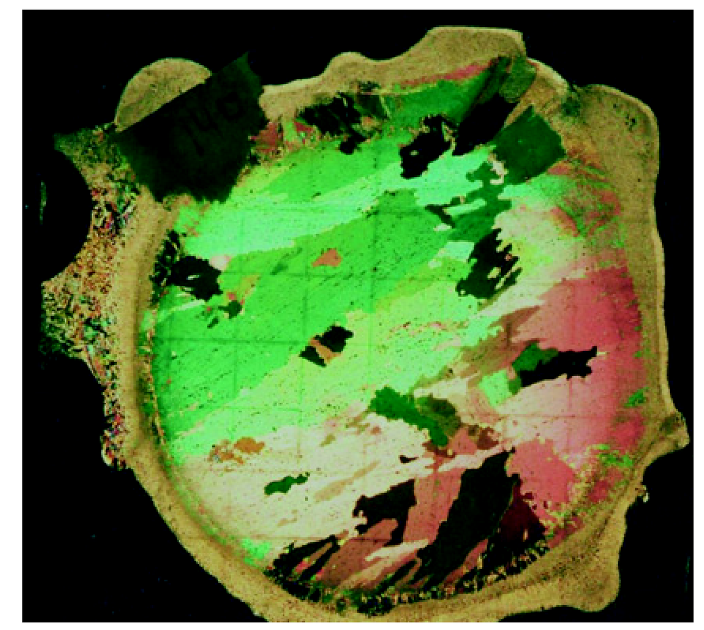

Figure 8 Horizontal thin section, 140 cm.

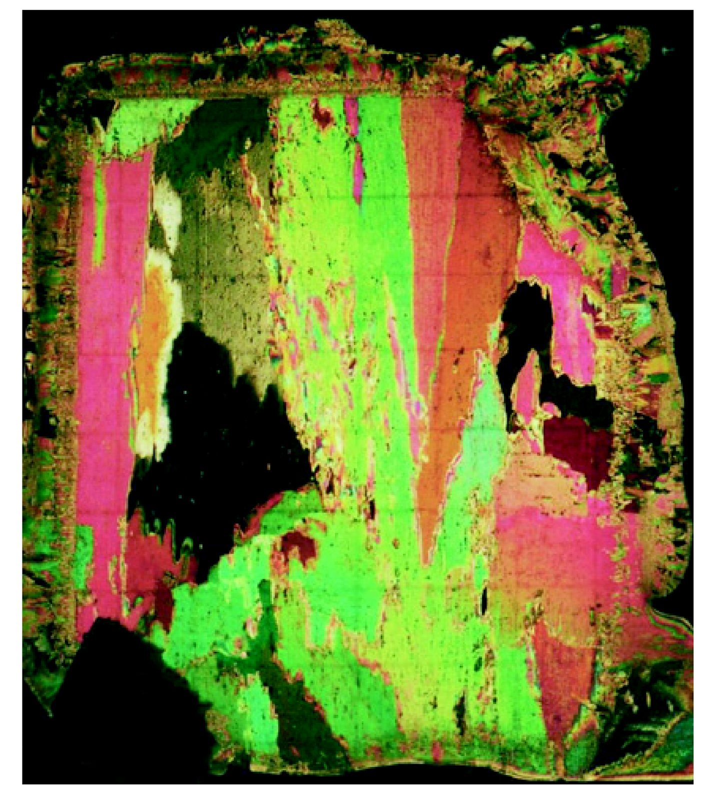

Figure 9 Vertical thin section, 180-190 cm.

3 Summary

Some oceanographic and ice structure measurements from Winfly 2002 are presented. Similar measurements, augmented by a few instruments that were not trialed during Winfly, will be made throughout the Antarctic winter of 2003 in an attempt to quantitatively measure the early season growth of land-fast sea ice in M^{c}Murdo Sound. Of particular interest is the linking of the underlying oceanographic conditions with the growth processes of the ice.

References

[1] E.L. Lewis and R.G. Perkin. The winter oceanography of McMurdo Sound, Antarctica. In *Oceanology of the Antarctic Continental Shelf*, volume 43 of *Antarctic Research Series*, pages 145–165. 1985.

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