THE USE OF AN AUV TO MEASURE ICE THICKNESS DISTRIBUTION AND OCEANIC STRUCTURE IN THE GREENLAND SEA


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Abstract: Deployment of a small Icelandic AUV is proposed in a series of trials during a cruise to the Greenland Sea. The AUV will provide important data in a region of convective activity by simultaneously mapping the T,S structure of small convective plumes and profiling the thickness of overlying pancake ice. This will test models of plume generation by salt rejection and will enable the special capabilities of a small easily-handled AUV to be examined in a polar environment. Understanding the detailed nature of the physics of convection in the Greenland Sea will help us to understand the mechanisms of rapid climate change in northern latitudes.

We propose a scientific mission to measure the sea ice thickness distribution and oceanic structure in a globally important region of the ocean, the central Greenland Sea. The aim is to carry out tests of a small AUV vehicle for sea ice thickness monitoring and to perform systematic simultaneous measurements of possible convective activity initiated by ice formation as well as frontal structure. This offers a significant new advance in single-platform measurements.

The specific objectives of the programme are as follows: To carry out a joint ice profiling and ocean profiling mission in the central Greenland Sea in winter so as to measure the pancake and frazil ice thickness of the ice field and observe convective plumes and frontal structures.

The Icelandic company Hafmynd (www.hafmynd.is) are the designers and developers of a small autonomous underwater vehicle (AUV), called Gavia. This AUV, which has successfully completed a number of trials, is ideally suited for studying small-scale oceanographic processes in the Polar Regions. The Gavia comes equipped with a highly accurate CTD, side-scan-sonar (600 kHz) and a digital camera. An additional digital camcorder can be mounted in the nosecone. The endurance of the Gavia is 24 hours at 3 knots and it can dive to 2000 m depth.

The great virtue of the Gavia AUV is that it is physically very small (approximately 150 cm long and 20 cm in diameter), and thus very easy and quick to deploy and recover. In the open ocean its smallness may cause problems, however the wave-dampened environment of an ice covered sea suggest that this is its natural home. Recent experience of using a large AUV in the Arctic environment by the proposers (Maridan Martin 150, used aboard “Lance” in February 2002 and Autosub used aboard “James Clark Ross” in August 2004) to obtain successful sidescan sonar profiles under ice suggests that there are certain roles in the Arctic ice zone for large long-range AUV and others for a smaller unit. A large vehicle is needed for longrange gridded surveys of ice, ocean or seabed properties Those for which a smaller vehicle is preferable concern the study of mesoscale and small-scale physical
processes where the vehicle forms part of a multi-sensor attack on a particular problem.

DAMTP has developed a salt flux model for the central Greenland Sea in winter which incorporates ice formation, advection and melt, as well as time-dependent brine drainage from frazil-pancake. The model outputs realistic results, when compared with in-situ ice and oceanographic data gathered in the region, and suggests that ice formation and drift play an important role in the preconditioning of surface waters for overturning. Furthermore maximum salt fluxes obtained from the model in the centre of the region corresponds closely to areas of maximum probability of convective overturning and maximum depth of convection as seen in winter cruises.

We believe that the study of sea ice and convection can be fruitfully studied with the Gavia AUV. We expect that these tests will form a natural beginning to a longerterm, more extensive programme of use of an AUV under ice, including longer-range thickness profiling in the Arctic ( extending into the Arctic Ocean) and Antarctic, ocean structure profiling under Antarctic ice shelves, and studies near and under icebergs to determine their draft distributions (to understand iceberg scour and the layered structure associated with iceberg melt).

The systematic, synoptic measurement of ice thickness in the polar seas is recognised as one of the most difficult problems in polar marine science. No satellite technique gives thickness directly, while airborne methods (e.g. electromagnetic eddy current sounding) work only at low level, i.e. must be performed from helicopters and short-range aircraft. Only upward-looking sonar profiling gives accurate information over large areas, and this type of work to date has all been carried out from UK and US military submarines. The problem with such vehicles is that their prime purpose is military operations, so that they cannot easily run systematic grid patterns at selected times and places, nor can their long-term participation in data gathering be guaranteed. The AUV offers the potential of being able to replace the military submarine as the prime vehicle for the collection of under-ice thickness profiles, of vital importance in climate change monitoring.

The first months of the programme will involve in depth planning for the field experiments and test runs of the AUV in an Icelandic Fjord. The main winter mission will be in 2007-2008.