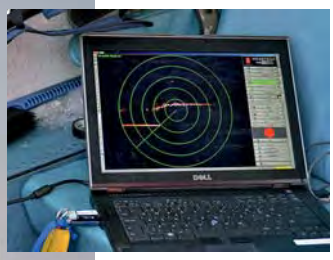
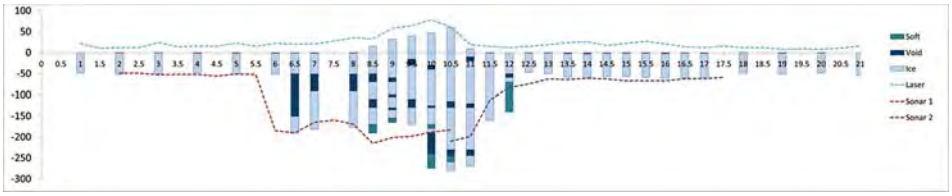
New methods for measuring ice ridges

Sea ice ridges are challenging for winter navigation and offshore activities in ice covered seas since pressure ridges may become ten times thicker than the initial level ice. Traditional measuring methods are time consuming and Aker Arctic has now tried a new faster method together with Meritaito in a project funded by the Winter Navigation Research Board.



Sonar scanner plot gives instant information during the measurement.

Lowering of sonar scanner under the level ice in front of the ice ridge.



Results from drilling (bars), laser (top surface, blue dashed line) and sonar (bottom surface, red and purple dashed line). Profiling of ice ridge no 1.

Ice ridges are formed under high compression due to wind or currents. In the Baltic Sea, the usual thickness is around 10-15 metres, but in the Arctic Ocean, the maximum recorded keel depth is over 45 metres. Usually the cross-section of a pressure ridge keel has a triangular shape with most of the thickness submerged. Therefore a reliable estimate of the thickness and width based on the visible part cannot be made making measurements of the submerged area necessary. Traditionally, measurements are made by drilling holes in the ridge. This method is both arduous and time consuming and thus new quicker methods for profiling and measurements would be beneficial.

Laser and sonar scanning

Aker Arctic has in cooperation with Meritaito carried out a field measurement research project, with the goal being to test and evaluate the applicability of a new method for profiling ice formations and brash ice channels. This new method combines scanning with laser and sonar instruments. Laser scanning is regularly used for measuring the top surface and has shown to give accurate results. Different sonar techniques have previously been used for detecting the underwater portion of the ice cover and for ice ridge measurement, but they have proven time consuming to analyse due to multiple reflections of sound pulses and noise. In this study, a single beam scanning sonar was used and the results were compared with measurements made by traditional drilling in order to evaluate the feasibility of the scanning method.

“All data was collected during a field trip to the Bay of Bothnia last February. One ice ridge was first measured with traditional drilling. It was conducted along the transverse line of the ridge in order to gain a cross-sectional profile," tells Ice Physicist Annu Oikkonen.

"Secondly, the ice ridge was measured by sonar scanning. A hole was drilled in the level ice on both sides of the ridge and the sonar lowered into the water first on one side of the ridge and then on the other side in order to get data of both sides. The sonar scanner plot immediately started to report data and the cross section profile was shown. In the drilling method more drill holes are required, which takes time."

"Another ice ridge was then measured with scanning first and then drilling, after which a comparison of the measurement results from drilling, sonar and laser scanning was made. Overall, the results are fairly compatible. The most prominent difference between drilling and sonar scanning results can be seen in the area where the deepest keel was recorded (figure 3) at the location of 10-11 m in the measurement line. The discrepancy between the two methods may result from the drilling causing changes in the shape of the keel. Another important finding was the ice drilling result at the location 6.5 m. The drilling result was recorded as level ice with a thickness of 50 cm. Later, sonar scanning showed ice at a depth of nearly 2 metres in the same location. Ice drilling results were then checked with a longer drill and the sonar recording was verified. The explanation for this is that drills used for thick ice ridges contain several extensions, which are added one by one as drilling progresses. Ice ridges consist of ice blocks and voids, and the general practice is to stop drilling when water is encountered for more than one metre. Therefore drilling may sometimes lead to an underestimation of the total thickness if an empty space is mistaken for the bottom of the ice formation."

Conclusions

In general, the results from scanning and drilling methods correspond. A clear advantage of the new scanning method is the shorter measurement time and an instant overview of the ice formation. The sonar also captured ice blocks underneath the level ice, which were not observed in ice drilling. Scanning with laser and sonar determines more clearly the location of top and bottom surface of the ice ridge.

The advantage of ice drilling is the information gained about the internal structure of an ice ridge.

"For a research trip it would be beneficial to use both methods in gathering ice data. There is much potential in the new method and further research should be made, especially for measuring brash ice channels. We will continue our cooperation with Meritaito in this area," Ms Oikkonen assures.