PROJECT SUMMARY REPORT

Project acronym: HY+_HSVA-08_UNI ST ANDREWS
Name of Group Leader: Dr. Magda Carr (University St Andrews)
User-Project Title: Internal wave dynamics in the marginal ice zone
Facility: HSVA ARCTECLAB – Arctic Environmental Test Basin (AETB)

User-Project Objectives (max 250 words):

Oceanic internal waves (IWs) propagate along density interfaces and are ubiquitous in stratified water. Their properties are influenced strongly by the nature and form of the upper and lower bounding surfaces of the containing basin(s) in which they propagate. As the Arctic Ocean evolves to a seasonally more ice-free state, the IW field will be affected by the change. The relationship between IW dynamics and ice is crucial in understanding (i) the general circulation and thermodynamics in the Arctic Ocean and (ii) local mixing processes that supply heat and nutrients from depth into upper layers, especially the photic zone. This, in turn, has important ramifications for sea ice formation processes and the state of local and regional ecosystems. Despite this, the effect of diminishing sea ice cover on the IW field (and vice versa) is not well established. A better understanding of IW dynamics in the Arctic Ocean and, in particular, how the IW field is affected by changes in both ice cover and stratification, is central in understanding how the rapidly changing Arctic will adapt to climate change.

The objective of this study was to generate periodic IWs under different ice types, namely, nilas, grease, and model. The main focus of the experiments was to (i) obtain accurate measurements of the wave induced velocity field under the ice and (ii) get a qualitative understanding of how different ice conditions affect the IW field.

User-Project Achievements and difficulties encountered (max 250 words):

The main difficulty encountered was in the generation of periodic IWs free from surface wave disturbances. The pycnocline (density interface on which the IW propagates) was close to the surface and it was subsequently not possible to generate an IW without a parasitic surface wave. Time was spent on damping the surface wave signal but it was found that the level of damping required resulted in the IW also being damped. As a result, the focus of the experiments had to be changed and internal solitary waves (ISWs) were investigated as opposed to periodic IWs.

ISWs were generated using a sluice gate and the surface condition was varied from (i) nilas or grease ice covering the full length of the tank, to (ii) grease or model ice with an edge such that the surface condition changed from open water to ice cover with the ice cover being free to move. The experiments were original and unprecedented; combining stratified ISW flow with ice. Measurements of wave speed, wave amplitude and wave induced velocity under the ice were obtained in the mid-plane of the tank. Difficulties in visualisation very close to the under side of the ice were encountered due to (i) reflection of the light source off the underside of the ice and (ii) ice at the front of the tank obstructing the field of view.

Highlights important research results (max 250 words):

The experiments showed that the internal wave-induced flow at the surface is capable of transporting ice floes in the horizontal direction at a speed comparable to the wave speed. It is anticipated that the results will allow the transport speed of the ice to be parameterised in terms of the wave induced horizontal velocity, the wave length, the floe thickness, the floe ice type and the floe length respectively.

In thick ice cover cases, in which the thickness of the ice was comparable to the depth of the top layer in the stratification, the ice significantly damped the ISW signal causing the wave to break and even be destroyed in some cases.

The roughness associated with different ice types caused varying degrees of vorticity and turbulence in the wave-induced boundary layer beneath the ice. It is hoped that the velocity data obtained (via PIV) can be used to analyse wave dissipation rates for different wave properties and ice types.