ASL Environmental Sciences

Solutions Newsletter

Winter 2017

February 2017 ASL Newsletter this issue:

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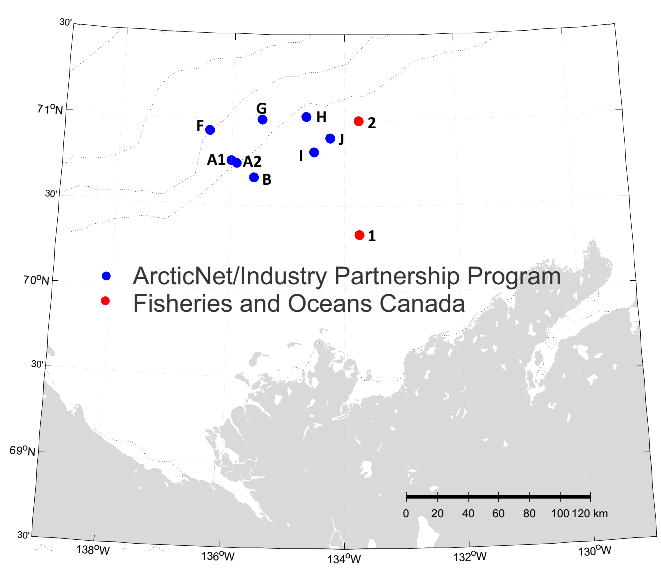
- ASL's Ice Profilers Survive Collision with Ice Island and Continue Sampling for Two More Years

ASL at the ArcticNet Annual Science Meeting, Dec. 2016, Winnipeg MB

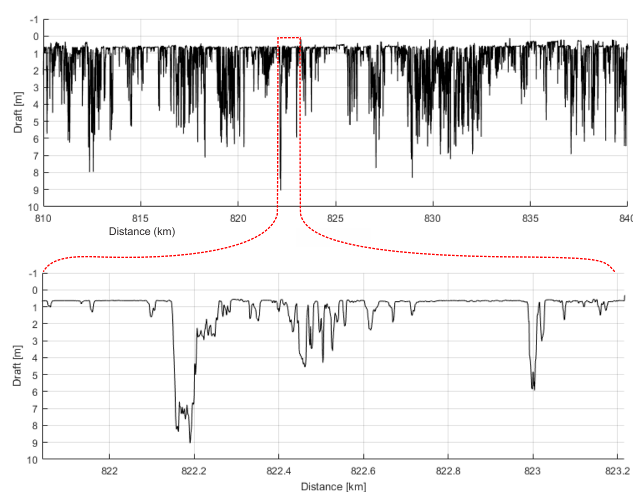
Ed Ross and David Fissel of ASL attended the 2016 ArcticNet Annual Science Meeting and presented a paper titled: "Spatial Variability of Sea Ice Drafts in the Continental Margin of the Canadian Beaufort Sea from a Dense Array of Moored Upward Looking Sonar Instruments" (presentation link). Dr. Humfrey Melling of the Institute of Ocean Sciences (DFO) was a co-author and continues to work closely with ASL in this field.

An array of year-long moorings, designed by ASL for ArcticNet, incorporated ASL's Ice Profiling Sonar (IPS) instruments. These were operated at eight sites in the Beaufort Sea for a two year period from 2009 to 2011. The analysis included two other moorings operated by DFO over the same period, also including ASL's IPS instruments.

The ArcticNet ASM Conference also featured two other papers co-authored by ASL scientists. These papers addressed: sea ice drift in response to wind and ocean current forcing (Asplin et al., 2016a); and the propagation of ocean waves into the Arctic ice pack (Asplin et al., 2016b).



Locations of the ten ULS moorings operated in the Canadian Beaufort Sea from 2009-2011.



A spatial-series of ice draft is shown in the top plot. Below this plot is a zoomed-in segment of the spatial series showing the highly detailed ice features including deep ice keels and undeformed first-year ice.

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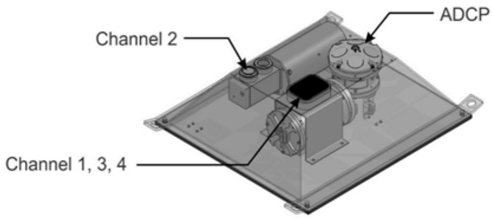
In Situ Anchor, Frazil and River Ice Cover Development: Perspectives from Acoustic Profile Studies

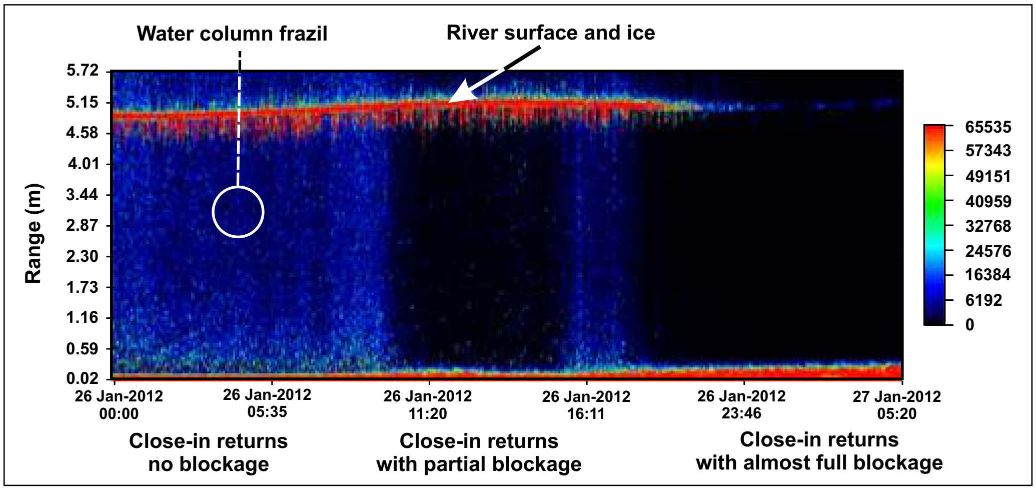
A new ASL Technical Report by John Marko and David Topham of ASL and Martin Jasek of BC Hydro completes a trilogy of research publications on applications of acoustic technology and the ASL Shallow Water Ice Profiler (SWIP) to studies of ice formation in larger rivers. The first part (Marko and Topham, 2013a) verified the SWIP measurement technique by laboratory experiments on suspensions of precision-cut plastic discs. The second part (Marko et al., 2013b) reported actual acoustic data on frazil ice formation and content in the Peace River obtained with a four frequency SWIP unit and a co-deployed ADCP profiler (as shown below).



The deployed instrument package showing the locations of the multifrequency SWIPS and ADCP current profiler including the locations of the SWIPS transducers for channels 1-4.

The third and final part of the research work, available on Research Gate™ as a Technical Report (Marko et al., 2017), interprets a broad body of Peace River acoustic and other data in terms of physical processes active during the initial stages of freeze-up. Interpretations focused on major differences between measured and modelled frazil fractional volumes noted in (Marko et al., 2015). Specifically, anomalously low observed frazil contents were suggested to be evidence of massive anchor ice formation deliberately excluded from model simulations.

This assertion was developed in the new Report through detailed comparisons of simulated and measured ice and river parameters. Wide variations were apparent in model frazil content overestimation as a function of time, with measured values of this parameter varying on temporal scales largely absent from the simulated results. Calculations of thermodynamic balance at frazil initiation and self-consistency dictated that this variability arose from abundant *in situ* anchor ice growth on the riverbed. Independent verifications of this interpretation and estimates of anchor ice growth were obtained from water level changes and acoustic beam blockages produced by anchor ice on SWIPS transducers.



Echogram of the channel 4 (774 kHz) returns in the first blockage event.

A simple "overflow" model was derived for anchor ice layer development on the transducers, which is indicative of the thickness of anchor ice on the adjacent riverbed. This model links anchor ice growth to atmospheric heat losses during supercooling periods. A threshold for blockage onset was established in terms of this ice thickness.

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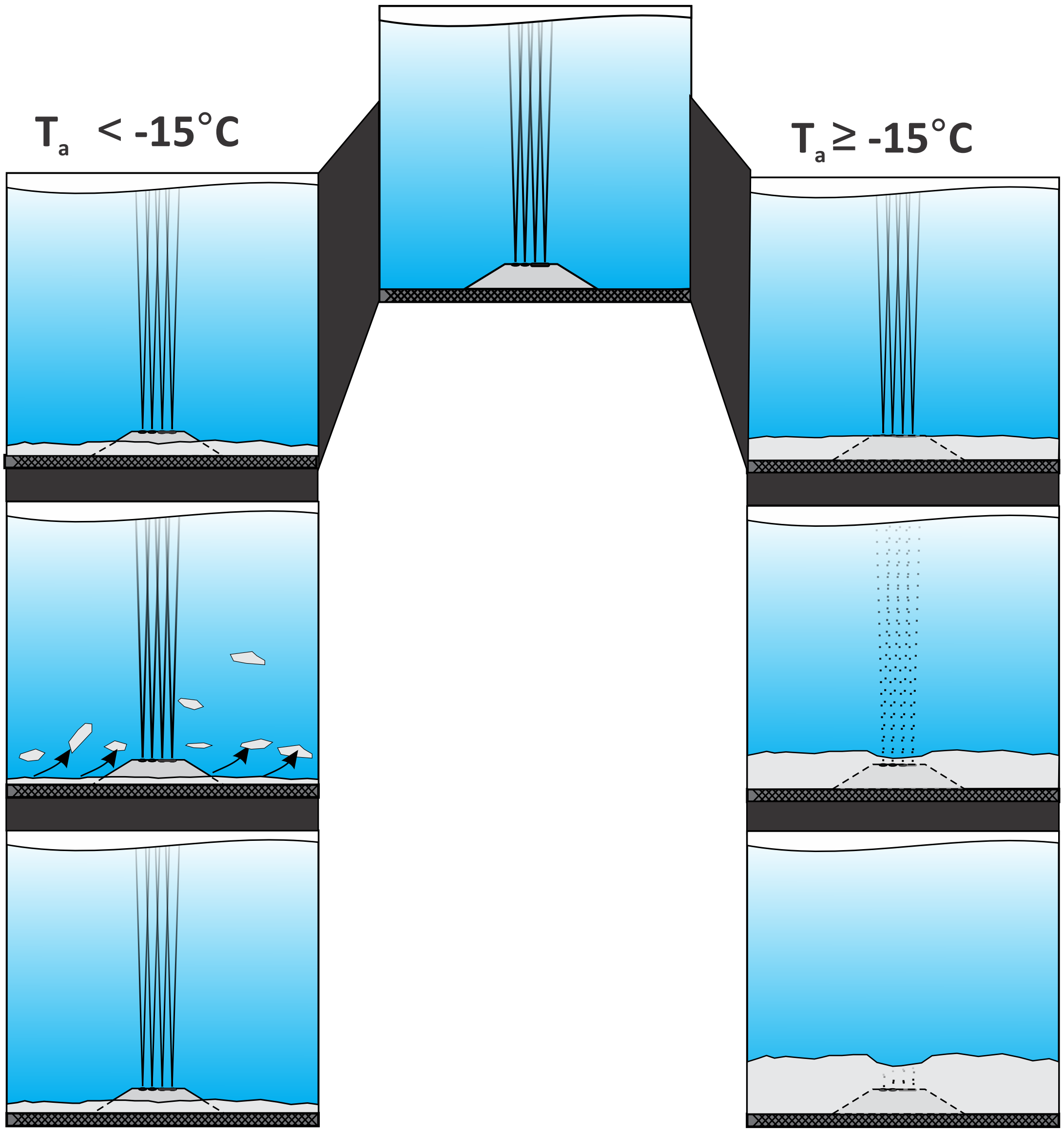
Applications of this threshold to SWIPS frazil data, from intervals not associated with blockages suggested that cooling rates were major determinants of attainable thicknesses of stable anchor ice with, counter-intuitively, greater layer stability coinciding with lower cooling rates. It was concluded that in situ anchor ice growth is the principal direct source of Peace River seasonal ice cover development.



Schematic illustrations of impacts on SWIPS profiling of proposed anchor ice layer evolution under alternatively soft (Ta ≥ - 15°C) and hard (Ta < - 15°C) supercooling conditions, where Ta is the surface air temperature

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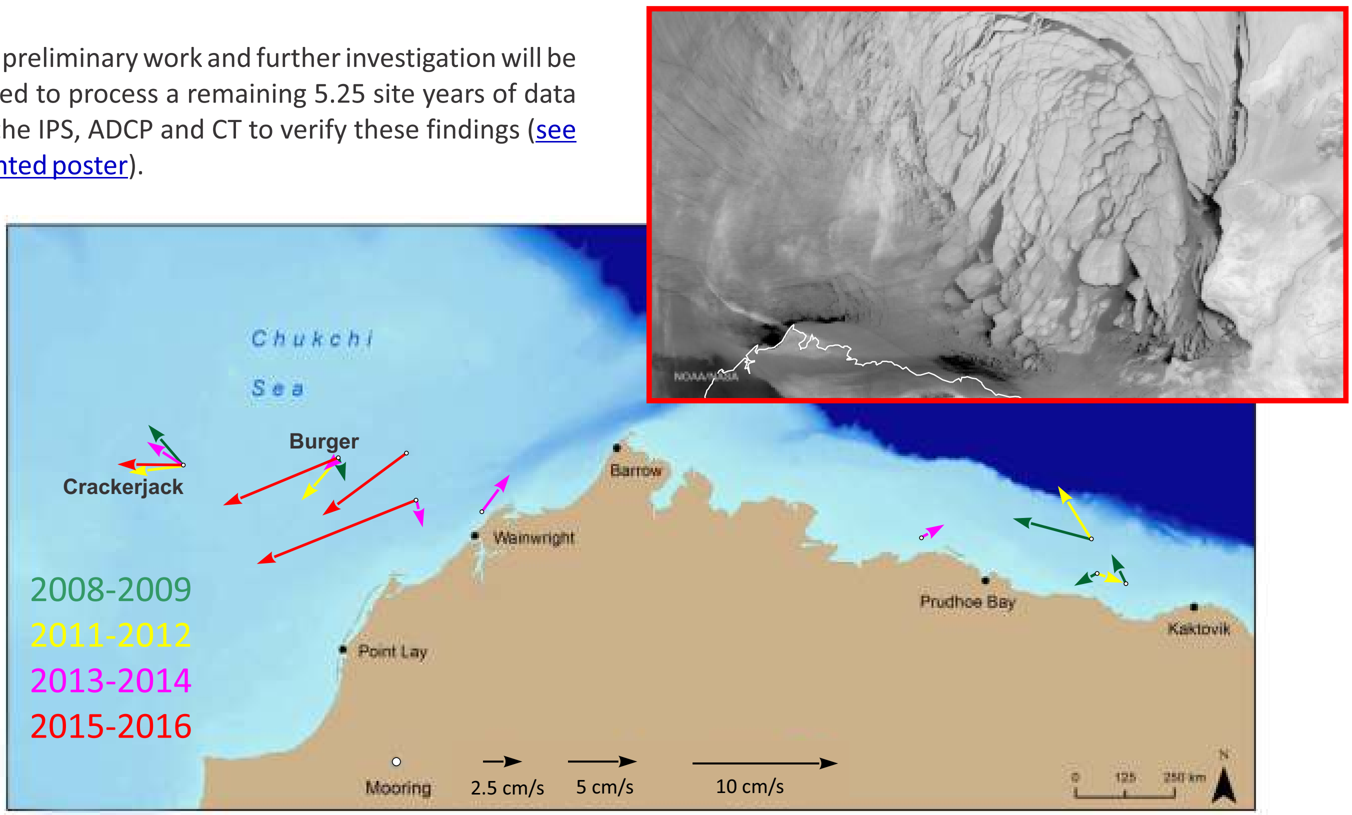
Ice and Physical Oceanographic Observations in the Chukchi Beaufort Seas 2008–2016

ASL and Olgoonik-Fairweather have worked in collaboration with Shell, collecting ice draft, ice drift, current and physical oceanographic data for eight years at 12 sites in the Chukchi and Beaufort Seas. At each mooring an Ice Profiling Sonar (IPS) is co-located with an Acoustic Doppler Current Profiler (ADCP). These provide current velocity profiles and ice drift velocity measurements over time. The ice draft is calculated using the difference between the pressure and tilt corrected range and the ice drift velocities provide feature horizontal scales. A Conductivity and Temperature (CT) sensor provides information on the physical water properties to complete the picture. Data up to 2014 has been processed and is publicly available from the University of Alaska Fairbanks.

Much of these data are contiguous, enabling detailed studies of ice movement over a prolonged period. Preliminary results show that during 2015 to 2016 the ice drift velocities were among the largest for the entire eight year record. The schematics show the results from 2008 to 2014 and preliminary workings from 2015 to 2016. The visible infrared image acquired on April 13 2016 shows the ice is beginning to break up, with the drift pattern supporting the measured ice drift results.

- 2015–2016 ice drifts (11.6 cm/s)
- 2012–2013 (2015–2016) speeds: Burger 5.5 (8.2) cm/s and Crackerjack 4.9 (4.0) cm/s

This is preliminary work and further investigation will be required to process a remaining 5.25 site years of data from the IPS, ADCP and CT to verify these findings (see presented poster).



Examples of Measured Annual Ice Drift 2008 to 2016: vectors indicating magnitude and direction. Inset shows early ice breakup image (April 13, 2016) taken with a Visible Infrared Imaging Radiometer Suite (VIIRS). Image Credit: Noaa/NASA.

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ASL's Ice Profilers Survive Collision with Ice Island and Continue Sampling for Two More Years

Dr. Andreas Muenchow and his PhD student Pat Ryan from the College of Earth, Ocean and Environment at the University of Delaware were involved in an international collaboration to measure the fresh water flux through Nares Strait from 2003-2012. Nares Strait and Fram Strait are two of the main pathways for fresh water to exit the Arctic. The fresh water flux into the North Atlantic controls the amount of vertical stratification, and in turn the amount of deep water formation. This process has implications for ocean circulation, the transfer of heat from the tropics to the poles via ocean circulation, and in turn global climate.

To measure the fresh water flux due to ice, two IPS4 Ice Profilers were deployed in Nares Strait to obtain near-continuous measurements of ice draft from 2003 to 2012, with small periodic gaps for instrument maintenance. As Nares Strait remains ice infested through the summer, the IPS units had to run through every season. Of particular interest is the encounter these instruments had in 2010 with an ice island calved off of Petermann Glacier. The ice island was initially about 260 km^2. The IPS units which had been nominally deployed at 75 m depth to reduce the risk of ice impact were struck on September 22, 2010, and were pushed down to about 90 m over a three hour interval. The ice island took approximately 11 hours in total to pass overhead of the instruments as it drifted by at an average speed of about 0.3 km/hour. During this passage, the IPS units sampled the range to the underside of the ice at three second intervals, and depth (below the sea surface), pitch and roll at one minute intervals. Besides bent transducer guards, the IPS units (shown in the picture below) survived the encounter, and continue to make ice measurements for this team on other projects (Click here for more references on Ice Profilers).

More can be learned about this project in a paper which Pat is currently submitting to the Journal of Geophysical Research.

The two IPS4 units which were struck by the ice island on September 22, 2010 as seen following recovery in 2012. Besides the bent transducer guards, no significant damage was sustained.