Thin-ice Arctic Acoustic Window (THAAW)

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LONG-TERM GOALS

The Arctic Ocean is currently undergoing dramatic changes, including reductions in the extent and thickness of the ice cover and extensive warming of the intermediate layers (Fig. 1). The multiyear ice is melting. Ice keels are getting smaller. With more open water, the internal wave energy level and therefore acoustic volume scattering are likely increasing, at least during summer. What was learned about acoustic propagation and ambient noise in the Arctic during the Cold War is now obsolete.

The long-term objectives of this research program are to understand the effects of changing Arctic conditions on low-frequency, deep-water propagation and on the low-frequency ambient noise field. The goal is to determine the fundamental limits to signal processing in the Arctic imposed by ocean and ice processes. The hope is that these first few new steps will lead to a larger, permanent acoustic monitoring, communications, and navigation network in the Arctic Ocean.

This research effort was funded as an expansion of ONR Grant N00014-12-1-0226, entitled "North Pacific Acoustic Laboratory: Deep Water Acoustic Propagation in the Philippine Sea." This annual report is in addition to the annual report for ONR Grant N00014-12-1-0226 that describes the research effort in the Philippine Sea.

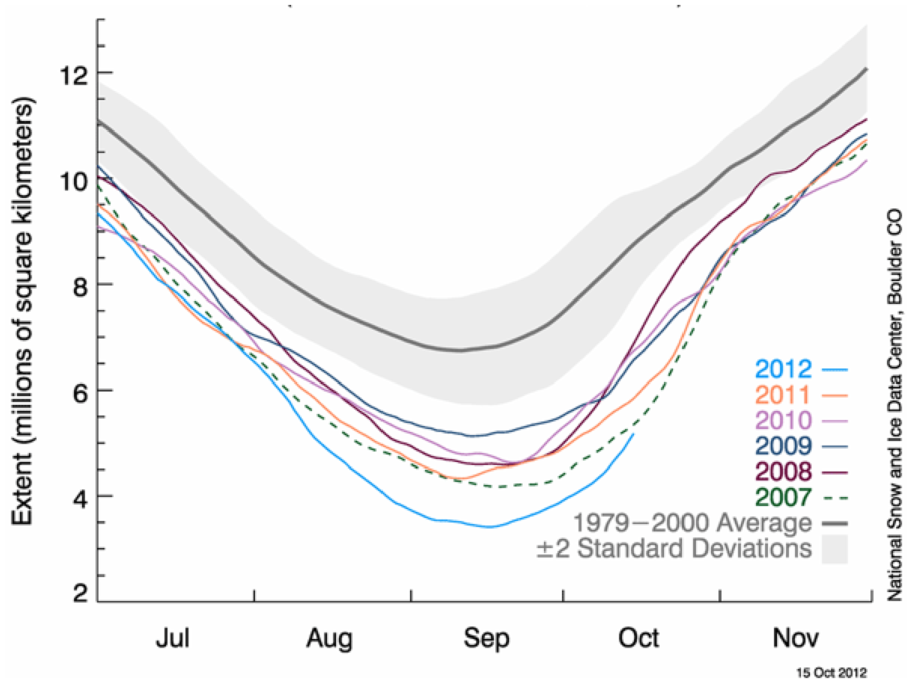

Figure 1. Arctic sea ice extents (area of ocean with at least 15% sea ice) for July through November 2007–2012 compared to the 1979 to 2000 average. Credit: National Snow and Ice Data Center.

OBJECTIVES

The THAAW project is a preliminary experiment to make acoustic propagation measurements in what P. Mikhalevsky (SAIC) refers to as the new thin-ice Arctic regime. The hypothesis is that three factors will contribute to the THin-ice Arctic Acoustic Window (THAAW):

(1) The thinning ice in the Arctic is now dominated by one and two-year ice, with greatly reduced multi-year ice and consequently greatly reduced pressure ridging. The reduction in pressure ridging will result in reduced transmission loss compared to that previously observed. Operation at higher acoustic frequencies than in the past may therefore be possible, making off-the-shelf sources feasible for long-range propagation in the Arctic and obviating the need for the large, expensive, custom sources used in the 1990s for the TAP (Mikhalevsky *et al*., 1999) and ACOUS experiments (Gavrilov and Mikhalevsky, 2002, 2006).

(2) There is still ice cover, however, albeit thin and with reduced areal extent, throughout much of the year that will continue to largely insulate the Arctic ocean from wind and solar forcing, preserving the stable Arctic acoustic channel. Long temporal processing and near optimal pulse compression gains should therefore still be possible.

(3) It has been known for some time that ambient noise in the Arctic is highly variable, with periods of high noise associated with pressure ridging and periods of low noise when the wind is low and the ice is stable. Because there is no significant shipping in the Arctic (yet), the shipping contribution to low-frequency ambient noise, which dominates in much of the world ocean, is absent. Consequently, in this thin-ice regime with much reduced ridging, there should be longer and more frequent periods of low noise conditions than experienced in the past.

The goal of the THAAW project is to quantify the elements of the sonar equation so that an appropriate basin-scale system for long term acoustic monitoring, communication, and navigation can be designed.

APPROACH

With DARPA funding, SAIC deployed a broadband J15-3 acoustic source and a receiving array in the deep Arctic near the North Pole during April 2013. Both the source and receiver were suspended from the ice and drifted with it. Scripps Institution of Oceanography (SIO), Woods Hole Oceanographic Institution (WHOI), and the Naval Postgraduate School (NPS) augmented the SAIC effort with a bottom-moored Distributed Vertical Line Array (DVLA) receiver (Worcester *et al*., 2009, 2013) deployed close to the Pole. The DVLA consisted of a single 600-m array with the D-STAR controller at the top of the array located approximately 80 m below the surface (to ensure that it would be below any ice keels). The DVLA had 22 Hydrophone Modules. The top 10 Hydrophone Modules were uniformly spaced 14.5 m apart. The spacings between the remaining Hydrophone Modules increased geometrically toward the bottom of the array.

The DVLA receiver was programmed to record without interruption for 108 minutes beginning at 1200 UTC six days per week (Sunday – Friday). It was intended to record receptions at varying ranges from the drifting SAIC source and to characterize the temporal variability and depth dependence of the ambient noise.

The DVLA included 10 Seabird MicroCATs (SBE 37-SM/SMP) (PI: J. Colosi, NPS). The depths of the SBE37 instruments were selected to (i) resolve the halocline in which the salinity changes from 31 psu to 35 psu in the upper 300 m and (ii) to resolve the first few baroclinic displacement modes. This is accomplished by placing sensors near the zero crossings of these modes.

WORK COMPLETED

The SIO-WHOI DVLA was deployed through the ice at Russian ice camp Barneo during 12-15 April 2013 (Fig. 2). The mooring was located at 89º 23.379’N, 062º 35.159’W. The nominal depth of the subsurface float was 80 m in water 4132 m deep. Following deployment of the DVLA, we were informed that the J15-3 source installed by SAIC had been programmed to transmit beginning at 1200 EDT, rather than at 1200 UTC. The satellite communication link with the source that would normally have allowed the transmit time to be corrected had failed, however, making it impossible to synchronize the source transmissions with the DVLA recording schedule. The DVLA therefore did not record at the times of the J15-3 transmissions and instead recorded only ambient noise.

On 3 May 2013 we began receiving ALARM messages from the Xeos Kilo Iridium-GPS beacon located on top of the subsurface float, indicating that the mooring had prematurely surfaced. The reported position at the time of surfacing was 88º 50.30’N, 51º 17.91’W, which is 63.4 km from the position at which the THAAW mooring had been deployed. The implication is that the mooring had failed shortly after deployment, but the subsurface float was trapped beneath the ice preventing the Xeos beacon from obtaining GPS positions and transmitting Iridium messages. The float drifted slowly south toward Fram Strait after surfacing, although there were frequent gaps when no messages were received (Fig. 3).

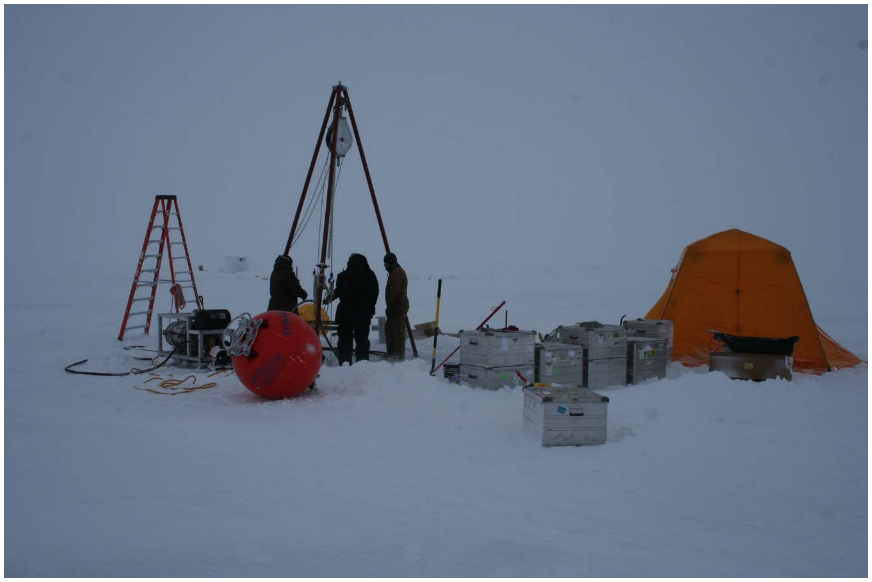

Fig. 2. Deployment of the SIO-WHOI THAAW mooring at ice camp Barneo during 12–15 April 2013. (Photo: P. Worcester)

The mooring was successfully recovered on 20 September 2013 at approximately 84º 02.102'N, 003º 03.497'W, far north of the ice edge (Fig. 4). The last successful position from the Kilo beacon was received on 14 September 2013. The mooring was therefore located by acoustically ranging on the releases, which were located at a depth of approximately 600 m. The recovery was performed using the Norwegian Coast Guard icebreaker KV Svalbard. Dr. Hanne Sagen of the Nansen Environmental and Remote Sensing Center (NERSC) in Bergen, Norway, was Chief Scientist and graciously provided the ship time needed to search for and recover the mooring.

Following recovery it was found that the synthetic mooring line used between the acoustic releases and the anchor had parted a short distance above the anchor. The cause is unknown.

RESULTS

Preliminary indications are that the 22 Hydrophone Modules in the DVLA and the 10 MicroCATs recorded data. There appear to have been intermittent communication problems between the D-STAR and the Hydrophone Modules, however, resulting in some lost data. Analysis of the ambient noise, temperature, and salinity data collected as the THAAW mooring drifted from the North Pole toward Fram Stait will occur during the coming year.

IMPACT/APPLICATIONS

This research has the potential to affect the design of deep-water acoustic systems in the Arctic, whether for sonar, acoustic communications, acoustic navigation, or acoustic remote sensing of the ocean interior.

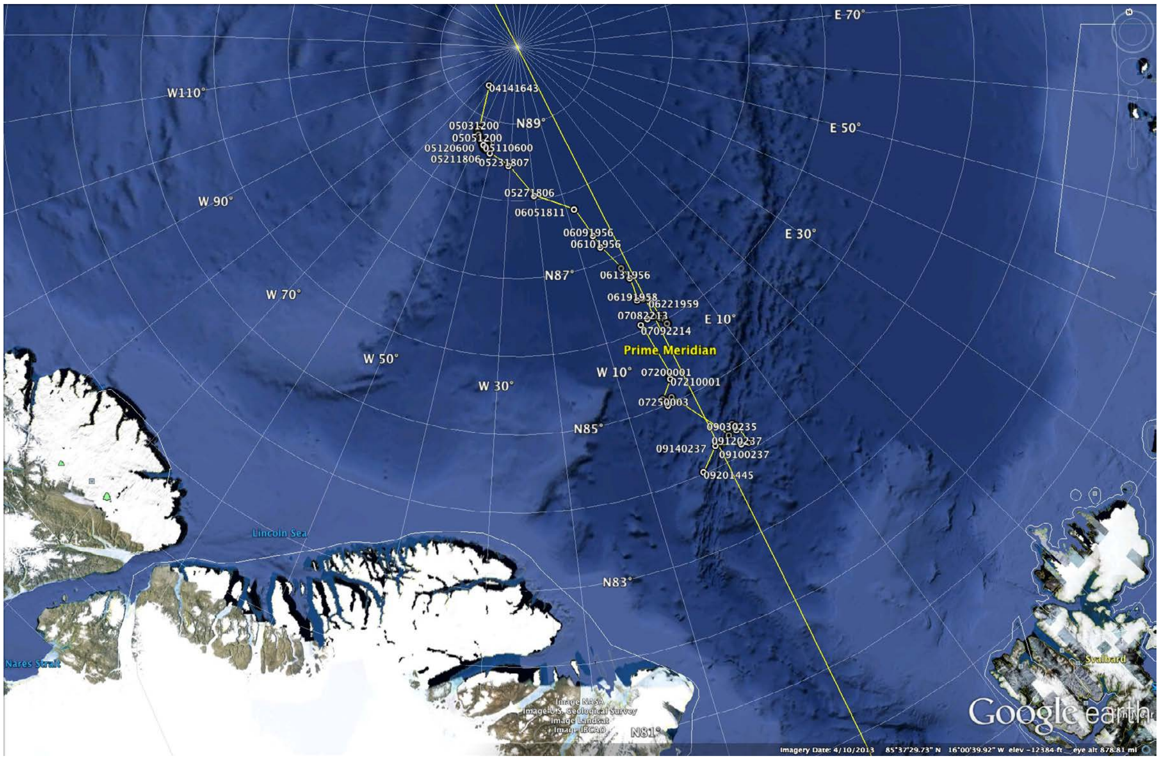

Fig. 3. Drift of the SIO-WHOI THAAW mooring showing the track from deployment at ice camp Barneo on 14 April 2013 until it was sighted on the surface by the KV Svalbard on 20 September 2013. A subset of the GPS positions provided by the GPS-Iridium beacon are labeled in mmddhhmm format.

Fig. 4. Subsurface float when first sighted on the surface by the KV Svalbard on 20 September 2013. (Photo: H. Sagen)

RELATED PROJECTS

This project is a joint effort by SIO (P. Worcester), WHOI (J. Kemp), and NPS (J. Colosi). It was designed to augment the SAIC (P. Mikhalevsky) THin-ice Arctic Acoustic Window (THAAW) project, which is one component of the DARPA Assured Arctic Awareness program.

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PUBLICATIONS

None