Multipurpose Acoustic Networks in Ocean Observing Systems in Ice-covered Regions

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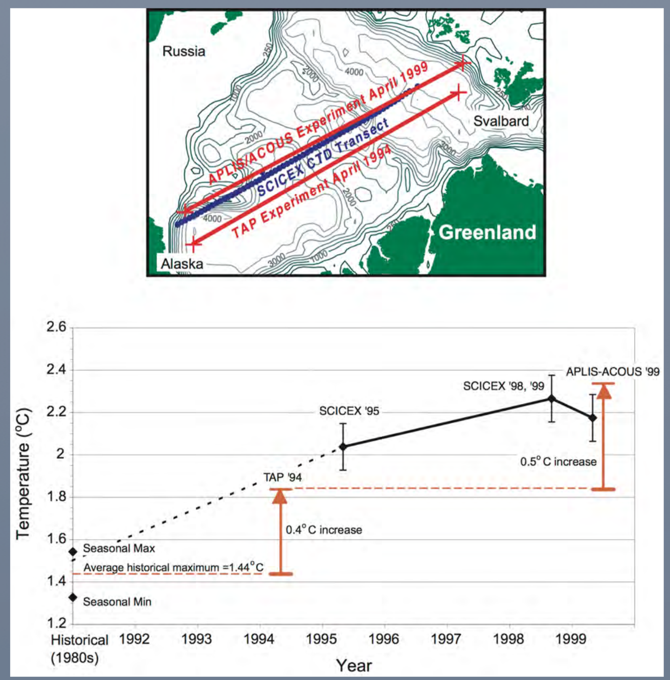
Abstract

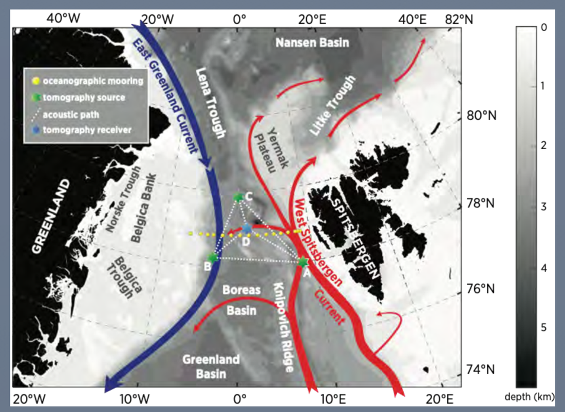
Ice-covered regions are one of the great challenges for ocean observing systems. Monitoring and understanding the rapid changes underway in the Arctic Ocean and in the Southern Ocean surrounding Antarctica are of crucial importance to assessing the role of the ocean in climate variability and change. In addition, as the Arctic converts from a largely perennial ice cover to a seasonal ice cover, oil and gas exploration, fisheries, mineral extraction, marine transportation, and tourism will increase the pressure on the vulnerable Arctic environment, requiring improved ocean-ice-atmosphere data to inform and enable sustainable development while protecting this fragile environment. The international community has previously articulated the need for enhanced under-ice observations in many fora. This is increasingly endorsed by international policy bodies, e.g. the 2nd Arctic Science Ministerial (October 2018).

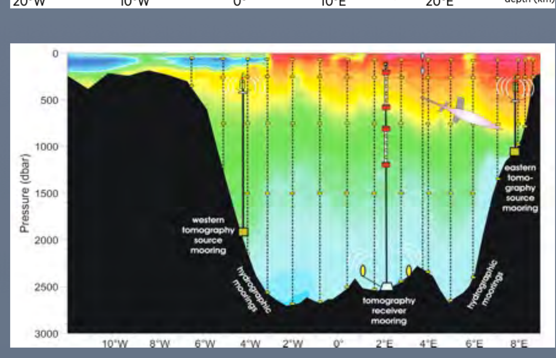
Multipurpose acoustic networks have special roles to play in providing observations year-round in ice-covered regions, supporting and complementing other in situ observations. Acoustic networks provide underwater and under-ice navigation for floats, gliders, and autonomous vehicles, acoustic remote sensing of large-scale temperatures and currents (ocean acoustic tomography and thermometry), and passive acoustic monitoring of both anthropogenic and natural sounds, including those generated by marine life, ice, and seismic events. Moored multipurpose acoustic networks have been implemented on a regional scale in year-long research experiments in Davis Strait, Fram Strait, and the Beaufort Sea. Initiatives for pilot multipurpose low frequency acoustic networks in the interior of the Arctic have begun. Acoustic tracking of floats is already being done in selected regions in the Southern Ocean around Antarctica, and this acoustic tracking system could be expanded to serve multiple purposes.

Ocean acoustic tomography



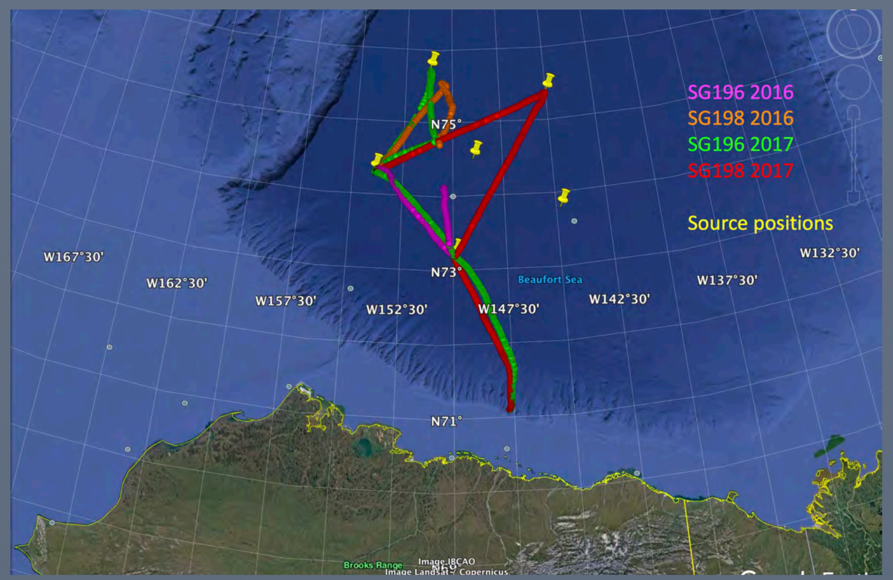
(Top) The TAP, ACOUS, and SCICEX trans-Arctic sections. (Bottom) The maximum absolute temperatures of the Atlantic Layer obtained from historical climatology and the SCICEX 1995, 1998, and 1999 transects that were close to the 1994 TAP and 1999 ACOUS propagation paths. The red arrows indicate the change in maximum temperature inferred from the acoustic mode 2 travel-time changes (Dushaw et al., 2001).





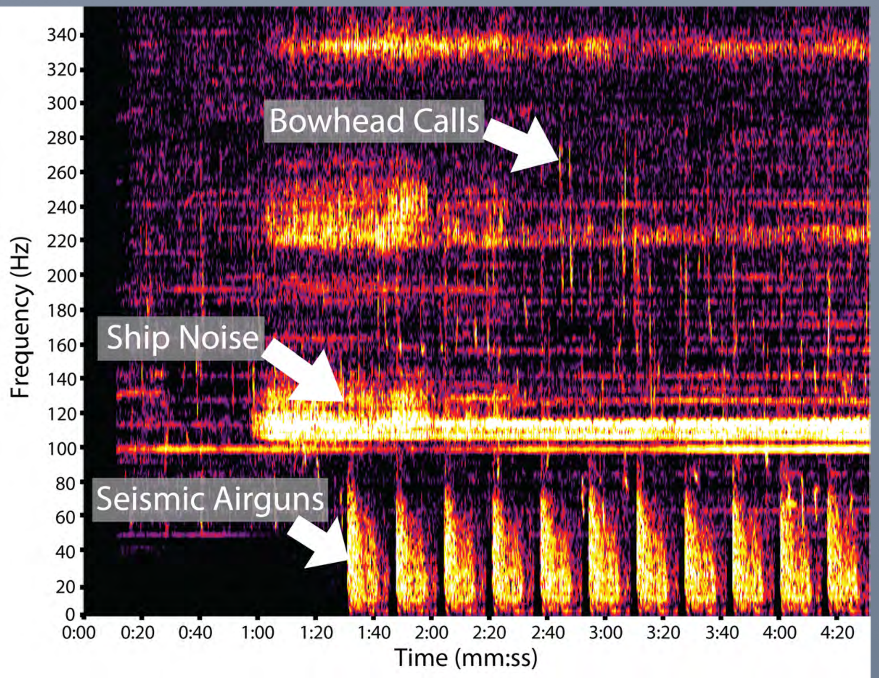
(Top) The Fram Strait multipurpose acoustic system deployed from 2010 to 2012 for tomography, positioning of gliders and floats, and passive acoustics. The system includes three transceiver moorings (A, B, C) and a receiver mooring (D). The array of oceanographic moorings across the Strait at 78°50′ N is shown by yellow dots. (Bottom) The vertical section shows the position of these moorings overlain on the temperature distribution in Fram Strait (red indicates warm Atlantic water and blue depicts cold Arctic waters). (Mikhalevsky et al., 2015).

Underwater navigation



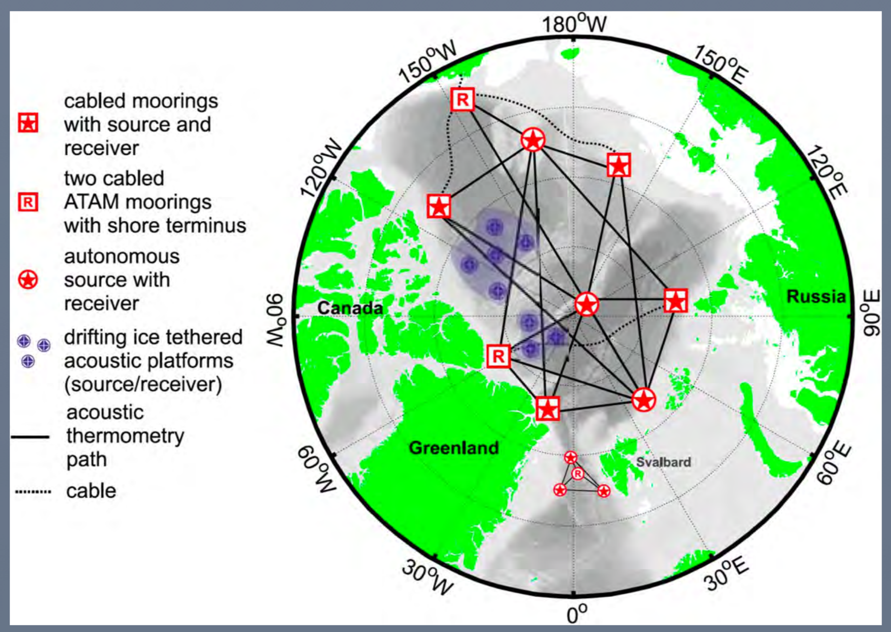
Tracks of acoustic Seagliders (SG196 & SG198) deployed in the Beaufort Sea during the Canada Basin Acoustic Glider Experiment (CABAGE). Receptions from the six moored sources will be used to determine the precision with which the Seagliders can be navigated. (Courtesy of L. Van Uffelen.)

Passive acoustics



Spectrograms showing bowhead calls, a ship transiting, and airgun pulses from seismic surveys (Moore et al., 2012). All three types of signals are ubiquitous in Fram Strait, where bowheads were discovered to sing complex songs in winter (Stafford et al., 2012).

Notional network



A notional basin-wide Arctic mooring network for acoustic tomography, oceanography, and underwater "GPS" system for navigation of and low rate communications with floats, gliders, and UUVs. The Acoustic Thermometry and Multipurpose Mooring (ATAM) applies to all the moorings shown (Mikhalevsky et al., 2015) .

New technology

An ultra-low frequency source (f_0 = 35 Hz, Δf = 4 Hz) developed by GeoSpectrum Technology Inc. The source is on the Norwegian ice breaker KV Svalbard during the 2019–2020 Coordinated Acoustic Thermometry Experiment (CAATEX) conducted jointly by the USA and Norway. The source transducer mounted in the bottom of the frame is approximately 1 m in diameter and 0.2 m thick. Above it are high pressure gas bottles for the pressure-compensation system. (Photo: E. Storheim.)

Recommendations

Recommendation 1: OceanObs'19 recognizes the extreme urgency of observing and monitoring the polar oceans, made difficult by ice cover, and recommends that multipurpose acoustic observing systems, along with other complementary systems including cabled ones, should be brought to operational status.

Recommendation 2: OceanObs'19 recognizes the value of integrating acoustic data with oceanographic and sea ice data and recommends combining spatially integrated measurements from acoustics with point measurements and vertical profiles of physical variables in an integrated Arctic Ocean Observing System.

Further reading

Howe, B. M., J. Miksis-Olds, E. Rehm, H. Sagen, P. F. Worcester, and G. Haralabus (2019), Observing the Oceans Acoustically, *Frontiers of Marine Science*, *6:426*, doi:10.3389/fmars.2019.00426.

Lee, C. M., et al. (2019), A Framework for the Development, Design and Implementation of a Sustained Arctic Ocean Observing System, *Frontiers in Marine Science*, *6:451*, doi:10.3389/fmars.2019.00451.

Mikhalevsky, P. N., et al. (2015), Multipurpose acoustic networks in the Integrated Arctic Ocean Observing System, *Arctic*, *68*(5), 11–27, doi:10.14430/arctic4449.

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