Observing the Arctic Ocean under melting ice - the UNDER-ICE project

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http://under-ice.nersc.no

Introduction

The reduction in Arctic sea ice observed in recent decades is believed to have significant impact on ocean circulation and water mass distribution, fluxes, mixing processes, and biological productivity in the Arctic Ocean. Our new project, **Arctic Ocean under Melting Ice (UNDER-ICE)** aims to improve understanding of these ocean and sea ice processes in ice-covered areas and the marginal ice zone in an area covering the **Fram Strait** and stretching northward towards Gakkel Ridge.

The project runs from **2014 to 2017** and will bring together **acoustical** and **physical oceanography**, **marine biology**, and **sea ice research**. Direct observations will be combined with remote sensing data and numerical modelling to investigate the changes in the Arctic Ocean in conditions of diminishing ice cover, and study the possible feedback mechanisms between the ocean and sea ice.

Planned work

To resolve mesoscale variability and estimate the recirculation transport, an integrated observation and model system is being developed as part of the UNDER-ICE project. The observational programme, starting in Sep. 2014, consists of acoustic tomography and underwater glider measurements in the deep water areas, oceanographic moorings on the continental slope, and repeated hydrographic sections. The results will be combined with ice-ocean modelling through data assimilation.

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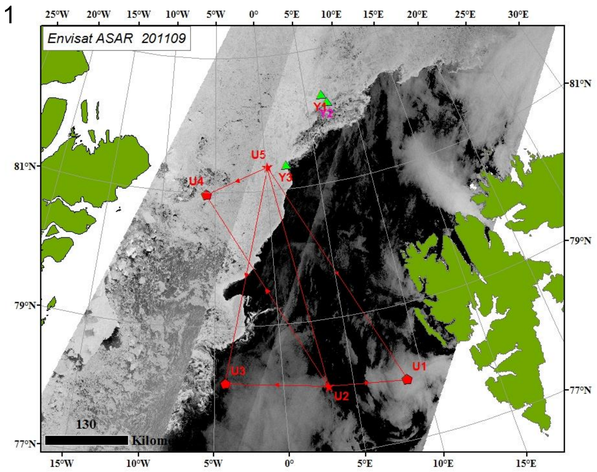


ENVISAT ASR images from 9-10 September 2011. Acoustic moorings are demarcated as red pentagons (receivers) and red stars (sources). Oceanographic moorings: green triangles.

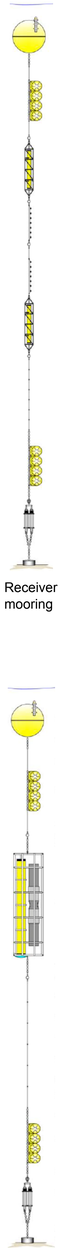
UNDER-ICE project themes

Water masses and fluxes in the Fram Strait
Aim: Provide observations and integrate them with models to improve the estimated transports of heat, mass, and freshwater between the North Atlantic and the Arctic Ocean.

Dynamic processes in the Fram Strait marginal ice zone
Aim: Qualitatively and quantitatively describe the dynamic processes across the marginal ice zone, with focus on internal waves, mesoscale eddies, and front instabilities, using observations and models.

Synthesis and integration of observational data and model simulations
Aim: Integrate results of data analysis and model simulations and quantify ocean water processes under the ice and in the MIZ. Assess the overall role of the Arctic Ocean in the climate system.

Arctic data portal - data management
Aim: Develop an open standards compliant web portal offering open access to metadata and acoustical and met-ocean observational and model products to support studies of climate change in the Arctic.



Water masses and fluxes in the Fram Strait

Acoustic thermometry in the Fram Strait

A multipurpose acoustic system for acoustic thermometry, low frequency passive acoustics and glider navigation was developed and implemented for a two-year operation within the EU project ACOBAR (2008-2013), http://acobar.nersc.no. The acoustic transceivers transmitted broadband signals for thermometry and narrowband signals to assist glider navigation (Sagen et al. 2011, Mikhalevsky et al. 2013).

UNDER-ICE continues and extends the ACOBAR thermometry experiment with **five ocean acoustic moorings** and **three oceanographic moorings** (Figure 1). The thermometry moorings will include hydrographic instrumentation. The receiver technology is upgraded from 4 to 10 hydrophones per mooring, allowing better signal processing capability, including beam forming, and will provide travel times and arrival angle information. This improves our capability to identify and track the acoustic arrival, leading to better data for inversions to ocean temperature and assimilation into models. Data will be available for analysis within UNDER-ICE after recovery in 2016.

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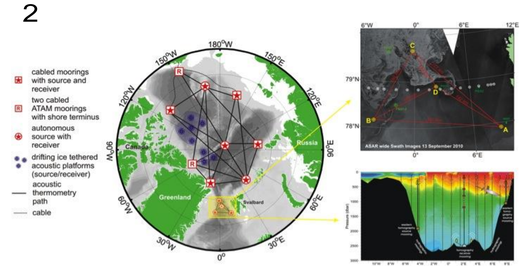
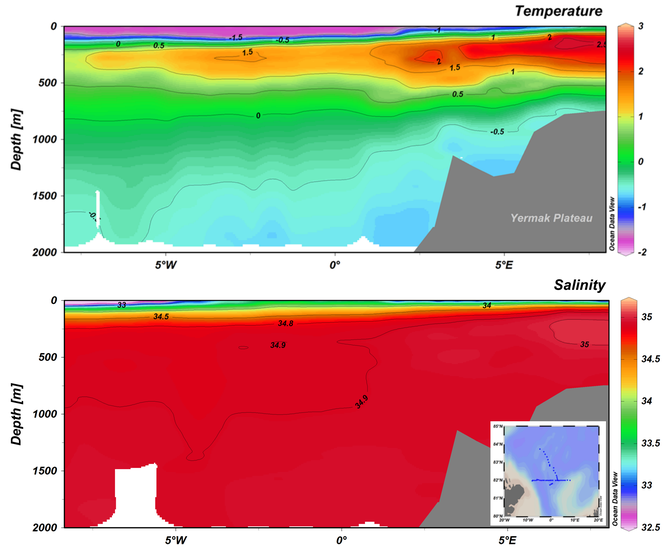


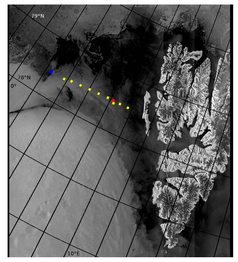
Conceptual sketch of a basin-wide Arctic mooring network for acoustic thermometry, oceanography and a system for underwater navigation and low rate communications for floats, gliders and unmanned undersea vehicles (Mikhalevsky et al., 2013).

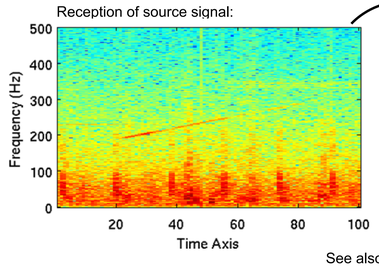
ACOBAR and UNDER-ICE are building blocks towards an proposed acoustic multipurpose network covering the whole Arctic Basin (Figure 2). The acoustic networks in the observing system will provide tomography and thermometry observations; navigation for gliders, floats and UUV's under ice; and passive acoustic listening. In situ observations, together with acoustic and satellite remote sensing, will provide comprehensive oceanographic data for climate and environmental monitoring and ocean-ice-atmosphere modeling for improved predictions of the changing Arctic. By passive listening, the acoustic systems collect long-term data on ice dynamics, basin seismicity, human activities and marine mammals.



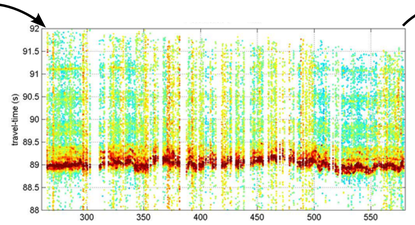
Temperature and salinity section along 82°N from the UNDER-ICE cruise in September 2013 onboard K.V. Svalbard. Note different depth scale.

Acoustic tomography

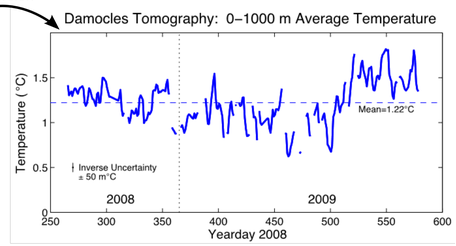




Data processing



Inversion



See also poster n.o EGU2014-**10928** by Sandven, Sagen, Worcester, **Geyer**, Dzieciuch and Dushaw: Acoustic sensing of ocean temperature in the Fram Strait.

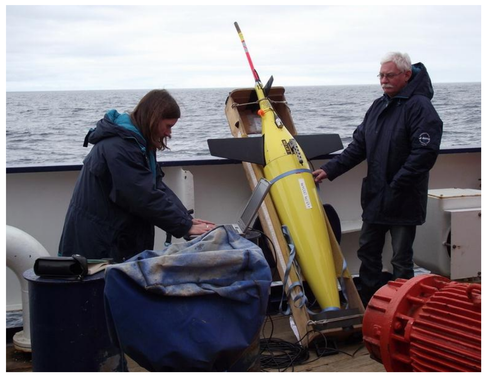
Dynamic processes in the Fram Strait marginal ice zone

Main research questions

- Do internal waves created along the shelf of Yermak Plateau play a significant role in mixing warm water up toward the ice?
- What is the contribution of the mesoscale eddies toward heat and freshwater transports in the Fram Strait, in particular in the recirculation?

Ongoing research activities

- Experiments in using detailed position information from acoustic moorings to deduce current velocity.
- Analysis of Seaglider data to understand sound velocity variability on smaller scales than resolved by moorings



Seaglider ready for deployment. Photo: A. Beszczynska-Möller.

Summary

In the UNDER-ICE project, innovative observing systems based on ocean acoustics, hovercraft and gliders will be used to collect ocean and sea ice data in a series of field campaigns in 2013-2016. New and existing data will be combined with satellite data and numerical models to study processes of importance for the Arctic climate system. The project will contribute to improved understanding of ocean circulation, water mass distribution and mixing, sea ice processes, and primary production in the MIZ. The results will be used to validate climate model simulations from CMIP5 and assess the future evolution of the Arctic and sub-Arctic climate.

Acknowledgements

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Mooring schematics were designed by John Kemp and drawn by Betsey Doherty, WHOI.
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Sagen et al. 2011:The Fram Strait acoustic system for tomography, navigation and passive listening. *Proceedings of Proc. Int. Conf. Underwater Acoustic Measurements: Technologies and Results, Kos.*