Mooring-based Arctic Ocean observational system

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1. Motivation and Introduction

We propose a coordinated large-scale mooring-based observational experiment in the Eurasian and Canadian basins of the Arctic Ocean. The widely spaced array of moorings (Figure 1) will emphasize the largest-scale modes of variability, including basin-scale shifts of the Arctic Ocean circulation and water mass structure. The overall purpose of the experiment is to provide a quantitative, observationally based assessment of circulation, water mass transformations, biogeochemical fluxes, key mechanisms of variability in the Arctic Ocean, and links to the lower-latitude processes. Coupled with existing oceanographic datasets, the observational data obtained in this experiment will enhance our understanding of Arctic Ocean variability on a broad range of time scales (from hours to years) and space scales (from meters to basin-scales). A number of regional monitoring programs have elucidated local details of the circulation of the Eurasian and Canadian basins, but none has provided the large-scale coverage we propose here (Figure 1). Linked with North Atlantic observations provided by the international ASOF (Arctic/Subarctic Ocean Fluxes), our large-scale oceanographic survey will provide a unique opportunity for coordinated long-term measurements over a vast polar/sub-polar region. We expect that our program will nicely complement related Arctic Ocean field programs (like the proposed IPY CTD survey and Lagrangian drifter program, see Draft of AOSB Observing Plan for example) in a synergistic manner.

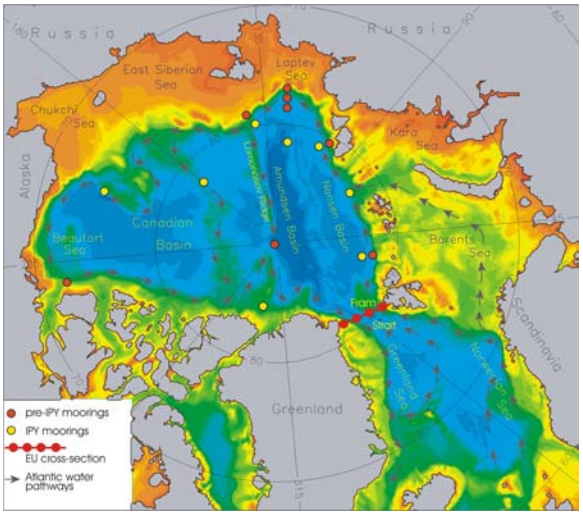

Figure 1. Existing and planned distribution of moorings around the Arctic Ocean.

2. Methodology and design of experiments

The primary monitoring tool of the program will be a series of moorings placed at carefully chosen locations around the Arctic Ocean. Located along the major pathways of water, heat, and salt transport, such moorings should capture climatically important changes in oceanic conditions. Thirteen moorings (some isolated and some deployed in linear arrays continental margins) in the Eurasian Basin and three or four moorings dispersed through the Canadian Basin form basis of the mooring scheme (Figure 1). The locations of moorings are chosen to capture the major near-slope transports within surface, intermediate, and bottom layers, resolve important shelf-basin interaction processes; and document complex interactions between the Fram Strait and Barents Sea branches of the inflowing Atlantic water. The moorings will also provide detailed information pertaining to small-scale processes, particularly heat losses from the warm Atlantic layer, lateral exchange processes, double-diffusive convection, eddies, and thermohaline interleaving. Understanding the exchanges between the Canadian and Eurasian basins will also be among the major targets of the program.

In addition to comprehensive circulation measurements, emphasis on biogeochemical variables will provide unprecedented information on the annual cycle of biological activity and vertical fluxes of carbon and contaminants in the Arctic Ocean. The links between climate, sea-ice and ocean productivity will be explored by correlating the annual biogeochemical cycles recorded by the moored instruments to remotely-sensed sea-ice dynamics (e.g. RADARSAT) and ocean color (e.g. MODIS, SeaWifs). The comparison of fluxes at shelf and deep-basin sites will enable us to assess the sequestration of carbon and contaminants in the deep basins.

Some deployments will continue existing mooring deployments (e.g. NABOS/CABOS, NPEO), providing a valuable opportunity to look at interannual variability. The proposed large-scale array will allow measurement of internal variability, including basin-scale shifts in temperature, salinity, and density surfaces, critical (for example) to our understanding of the Canadian Basin's role as a reservoir for storage of fresh water.

Some moorings will be equipped with the "McLane Moored Profiler" (MMP). The same tool was used on our pre-IPY mooring deployed in the Arctic Ocean (Figures 2 and 3). This instrument is capable of profiling vertically along the mooring line. The MMP is typically equipped with a CTD sensor and a three-component acoustic velocimeter for current measurements. The up-and-down motion of the profiler is programmable, making it possible

to focus on specific depth ranges and time periods, giving a high degree of flexibility in designing a sampling scheme. Sea level and ice measurements will complement CTD and current observations. We plan to use our moorings as multidisciplinary platforms equipping them with biochemical sensors and other equipment. Sediment traps, transmissometers, fluorometers, nitrate sensors and passive acoustic hydrophones for the detection of marine mammals will provide the necessary measurements and samples to characterize biogeochemical fluxes and the annual cycle of biological activity.

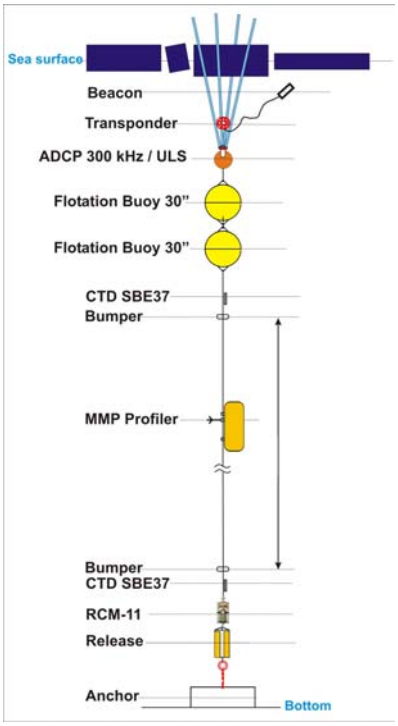

Figure 2. Mooring design and equipment.

New mooring locations are chosen to best complement existing Canadian, Japanese, EU and U.S. moorings, so that international coordination is essential. It is worthy to note that many mooring and CTD locations are within economical zones of various countries. For this and other reasons we consider participation of international scientific partners at every stage of the project to be crucial to its success. We have established strong ties with scientists from other U.S. and international institutions, and invite inquiries from any interested colleagues. Researchers from several countries have already expressed their support to the proposed program. Our plan is for this experiment to be collaboration between institutions and researchers from several countries. Thus far researchers from the International Arctic Research Center (IARC, USA), the Institute of Marine Science (IMS, USA), the University of Washington (UW, USA), the Naval Research Laboratory (NRL, USA), the Arctic and Antarctic Research Institute (AARI, Russia), the Institute of Ocean Sciences (IOS, Canada), the Laval University (LU, Canada), Alfred-Wegener Institute (AWI, Germany), Norwegian Polar Institute (NPI, Norway), and Norwegian Meteorological Office (NMO, Norway) have agreed to conduct this experiment jointly.

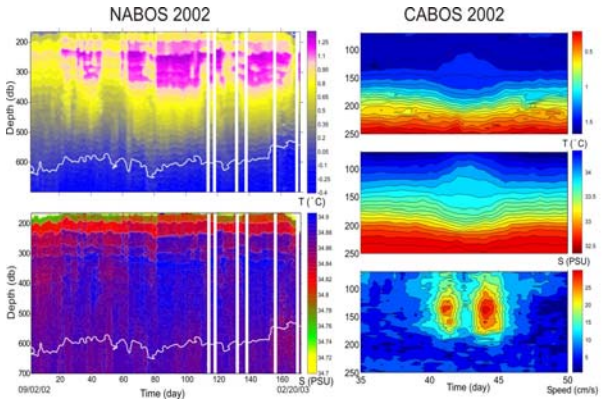

Figure 3. Temperature (^{o}C, upper panel) and salinity (psu, lower panel) from McLane MMP Profiler CTD data. Blank vertical columns represent missing data. Isotherm 0^{o}C (white curve) shows boundaries of the Atlantic Water layer.

4. Summary

Our vision is for this program to evolve into a long-term observational program which, together with other observational programs like the NSF-led SEARCH program, the Canadian-led ArcticNet, the Japan/Canada JWACS (Joint Western Arctic Climate Studies) program, and the European Union observational program in the Fram Strait and the international ASOF (Arctic/Subarctic Ocean Fluxes) program, will provide crucial information for detection of major climatic changes in the Arctic Ocean.

Existing programs like NABOS/CABOS and NPEO have accumulated a great deal of experience deploying and recovering deep-sea oceanographic moorings in the harsh Arctic conditions. Experienced national teams of scientists and technicians were assembled for these programs, and will be crucial to the success of the project. Channels for obtaining national permits for oceanographic work within exclusive economical zones have been established. We already possess a great deal of oceanographic equipment, which can be used for the IPY mooring deployments, but to satisfy the goals of the experiment we need some additional equipment to equip approximately seven new deep-sea moorings, and to add necessary equipment to existing moorings. The cooperative, coordinated approach planned for the experiment makes it extremely cost-effective, scientifically justified, and sound.