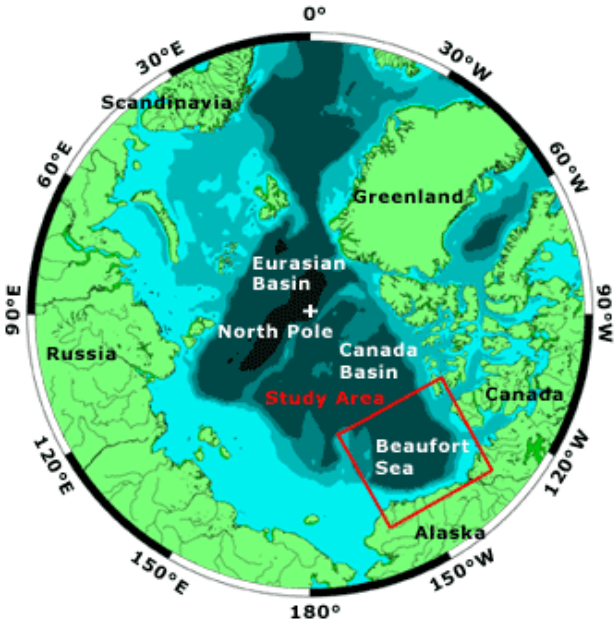
Print

Beaufort Gyre Exploration Project: Background

This program has been supported by four basic projects:

- 1. 2003-2004: "Beaufort Gyre Freshwater Experiment: Study of fresh water accumulation and release mechanism and a role of fresh water in Arctic climate variability" supported by NSF
- 2. 2004: "Beaufort Gyre Freshwater Observing System", supported by Woods Hole Oceanographic Institution
- 3. 2005-2009: "The Beaufort Gyre System: Flywheel of the Arctic Climate?", supported by NSF and
- 4. 2009-2014: "AON: Continuing the Beaufort Gyre Observing System to Document and Enhance Understanding Environmental Change in the Arctic", supported by NSF

Principal Investigator: Andrey Proshutinsky



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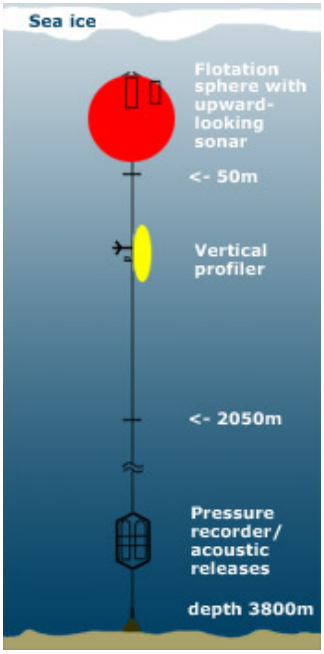
Polar projection map of the Arctic Ocean.



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Sample mooring diagram.

Project Summary

The Canadian Basin with its Beaufort Gyre (BG) contains about 45,000 km^3 of fresh water (Aagaard and Carmack, 1989). This is the major reservoir of fresh water stored in the Arctic Ocean and its volume is 10-15 times larger than the total annual river runoff to the Arctic Ocean, and at least two times larger than the amount of fresh water stored in the sea ice. What is the mechanism of fresh water accumulation in the BG? A release of only 5% of this fresh water is enough to cause a salinity anomaly with the magnitude of the Great Salinity Anomaly of the 1970s. This leads to other questions: What is the seasonal and interannual variability of freshwater content in the BG? and What is the role of the BG in the variability of freshwater export to the North Atlantic? There are no robust answers for these questions because the BG is one of the most hostile and inaccessible areas of the globe, so that most of it has never been measured or observed.

The major goal of this project is to investigate basin-scale mechanisms regulating freshwater content in the Arctic Ocean and particularly in the BG. The major hypothesis of the project is that the BG accumulates a significant amount of fresh water from different sources under anticyclonic (clockwise) wind forcing, and then releases this fresh water when this forcing weakens or changes direction to a cyclonic (counterclockwise) rotation. This accumulation and release mechanism could be responsible for the observed salinity anomalies in the North Atlantic and for a decadal scale variability of the Arctic system as the BG may both filter annual river inputs and pulse freshwater outflows.

In the summer of 2003 we (1) established the BG observational program with Fiona McLaughlin and Eddy Carmack from Fisheries and Oceans Canada at the Institute of Ocean Sciences (click here to see study area and observational system design) to measure freshwater content (in sea ice and in the ocean) and freshwater fluxes in the BG using moorings, drifting buoys, and remote sensing; (2) started analyzing all available historical data for the area using Russian, US and international data archives; and (3) began modeling processes of freshwater accumulation and release using ideal and real-time numerical and laboratory models in collaboration with scientists working in the Arctic Ocean Model Intercomparison Project (AOMIP).

Moorings provide us with time series of temperature, salinity, currents, sea ice draft, and bottom pressure (sea surface heights). Conventional mooring systems containing a McLane Moored Profiler (MMP) used to sample currents and hydrographic data from 50 to 2050 m with a 17 hour time interval. In addition, an ASL Environmental Sciences 420kHz upward-looking sonar (ULS) provides information about sea ice draft, and a high accuracy bottom pressure recorder (BPR) measures sea level height variability and near bottom (3800 m) seawater temperature. Each mooring consists of a surface flotation package at 50 m depth housing a ULS, a mooring cable containing the MMP, and dual acoustic releases and BPR immediately above the anchor.

Several economical expendable ice-tethered beacons produced by the METOCEAN company were deployed in 2003 to provide concurrent temperature and salinity data at several discrete depths in the uppermost 40 m. These instruments suspended 3 SeaBird MicroCat C/T recorders and broadcast the data via Argos, which also provided the drifter location. These beacons worked successfully during 2003-2004. Since 2004, Ice-Tethered Profilers (ITPs) replaced beacons and provide Lagrangian information about water temperature and salinity in the BG region year-round at levels from 8 to 760 meters with high vertical resolution.

Shipboard hydrographic data and water sampling are carried out at about 30 standard sites on each cruise. The scientific objectives of this program include: (1) identification of water mass characteristics, using multiple hydrographic tracers, and computation of freshwater content from different sources; (2) comparison of observed characteristics with historical data from the region; and (3) separation of the components of halocline water according to their origin. Temperature, salinity, oxygen, and nutrients, CFCs, carbon tetrachloride, total alkalinity, dissolved inorganic carbon, Tritium3He and delta18O are measured and analyzed at the locations along each section.

Based on analyses of these direct observations, historical data, and results of specially designed numerical and laboratory experiments, we expect to further our understanding of the Arctic climate system by (1) identifying links among accumulation and release of fresh water in the BG and atmospheric, hydrologic, cryospheric and oceanic processes, (2) quantifying the regional and temporal variability of relevant processes in terms of freshwater fluxes, and (3) determining the relative importance of each factor that influences freshwater content and flux change under global warming conditions.

The observed freshwater content variability in the BG, which acts to integrate the complex contributions from different factors, is expected to be the primary indicator of the ocean's response to climate change (see Results).

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