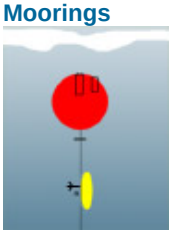
Print

Beaufort Gyre Exploration Project: Methods

Instruments

The major objective of the observational program is to determine freshwater content and freshwater fluxes in the BG during a complete seasonal cycle. Beginning in August 2003, we began to acquire time series measurements of temperature, salinity, currents, geochemical tracers, sea ice draft, and sea level using moorings, drifting buoys, shipboard, and remote sensing measurements. The moorings precisely measure the variations of the vertical distribution of freshwater content and sea ice draft at representative locations. The hydrographic sections examine the horizontal distribution of fresh water in the BG region. The remote sensing program helps to characterize the variability of the sea ice thickness (SIT) and horizontal structure of the sea surface height (SSH).

Moorings



Moorings provide time series of temperature, salinity, currents, sea ice draft, and bottom pressure (sea surface heights). A McLane Moored Profiler (MMP, colored yellow in mooring diagram) is used to sample currents and hydrographic data from 50 to 2050 m with a 17 hour time interval. In addition, an upward-looking sonar (ULS) provides information about sea ice draft, and a bottom pressure recorder (BPR) measures sea level height variability and near bottom temperature and salinity. Each mooring consists of a surface flotation package at 50 m depth housing an ULS, a mooring cable containing the MMP, dual acoustic releases and tether to BPR attached to the anchor.

McLane Moored Profiler (MMP)

The MMP is an autonomous, instrumented platform on a conventional mooring tether, which repeatedly traverses that line based on a user defined operation program, acquiring in situ profiles of temperature, salinity and velocity. The maximum depth rating is 6000 m, and design endurance is over one million meters per deployment. The system software gives the operator great flexibility in defining the sampling schedule, allowing profiles to be interspersed with extended measurements at fixed levels. The CTD and current measurement instruments presently employed on the MMP are products of Falmouth Scientific, Inc.

Acoustic Doppler Current Profiler (ADCP)

In addition to the current measurements that the McLane Moored Profilers provide, one of the subsurface moorings (D) is also outfitted with an Acoustic Doppler Current Profilers (ADCP). Similar to a sonar device, these instruments transmit acoustic (sound) signals at a fixed frequency. The signals reflect off of particles in the water, such as plankton, which flow through the water with the current. The shift in frequency of the return signals is proportional to the velocity of the water (this is the Doppler effect). The ADCP receives the return echos at precise time intervals which correspond to different depths in the water column. This way we obtain a high-resolution vertical profile of the absolute horizontal velocity over a given depth range. Currently only one of the subsurface moorings, Mooring D, has an ADCP. The ADCP is installed on the top float, and thus will be measuring currents from the top of the float up to the water surface or underside of the ice.

Upward-Looking Sonar (ULS)

Upward looking sonar IPS4, manufactured by ASL Environmental Sciences, is mounted in the uppermost mooring flotation (colored red in mooring diagram) to sample the ice draft with a precision of +/- 0.3m in ice thickness. The systems determine the return travel time of an acoustic pulse reflected from the sea ice or water surface. A pressure sensor is incorporated to measure the sea level changes due to winds and tides, and the vertical changes in the mooring length due to current drag. Ice thickness is computed from the difference between the instrument depth and the range to the underside of the sea ice. The range is corrected for instrument tilt and speed of sound differences (which may be estimated from the uppermost MMP data and open water events).

Bottom Pressure Recorder (BPR)

Precise bottom pressure measurements will be made using Sea-Bird Electronics SBE-16plus temperature and salinity recorders, with precision Paroscientific Digiquartz (6000 psia) pressure sensors. Integrating the pressure measurements increases the resolution of the pressure measurement, although this may be limited somewhat by sensor drift and background noise. The resolution of the pressure measurement depends on the sensitivity of the sensor and the resolution of the counter. For the transducer applicable to our application, a measurement integration of 30 seconds will resolve 1.5mm. Lithium batteries will provide sufficient power for a full year of measurements.

Ice-Tethered Profiler (ITP)

The Ice-Tethered Profiler (ITP) consists of a small yellow surface capsule, an 800 meter line, a specially modified moored profiler, and small anchor. The profiler has been modified so that it can fit through a 10" hole that is cut into an ice floe using an auger. The moored profiler makes daily measurements of the water pressure, temperature, and salinity and downloads these measurements (as well as its GPS location) to a controller inside the yellow float. The controller then uses a modem and satellite phone connection to send the data back to computers at WHOI. The ITP has enough battery power to last for three years in the ice, provided that its host floe remains intact.

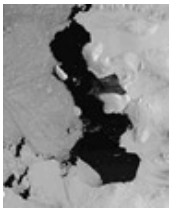
Ice Beacons

The moorings (A, B, C, and D) terminate at a depth of 50m in order to avoid interactions with the submerged portions of ice islands or deep pressure ridges. Thus, several economical ice-tethered drifters were deployed in 2003 to provide concurrent temperature and salinity data at several discrete depths in the uppermost 50 m. METOCEAN expendable ice beacons, which will suspend 3 or 4 SeaBird MicroCats down to 40 or 50 m depth (the deepest MicroCat will also have a pressure sensor to determine depth), interrogate each sensor several times per day, and broadcast the data via Argos, which will also provide the drifter location. The ice beacons have power to obtain measurements for over 1 year, but have no flotation so will eventually melt through the ice and sink. They take minutes to deploy (from the ship or by helicopter), requiring only that a hole be augered through a multiyear ice floe.

CTDs

CTD is an acronym for the parameters that this device measures: "Conductivity, Temperature, and Depth." The CTD itself is a set of small probes attached to a large metal rosette wheel (see image). The rosette is lowered on a cable down to the seafloor, and scientists observe the water properties in real time via a conducting cable connecting the CTD to a computer on the ship. The water temperature and salt content, or salinity (which is computed from the conductivity), is important to oceanographers because it tells us about the types of water masses present, and how they are moving in the ocean. There can also be a host of other acessories and instruments attached to the CTD package. These include Niskin bottles (shown in image) which collect water samples at discrete depths for measuring chemical properties, Acoustic Doppler Current Profilers that measure the horizontal velocity, and oxygen sensors that measure the dissolved oxygen content of the water.

Remote Sensing



To assess freshwater content variability in the sea ice we utilize remote sensing technology. Sea ice thickness (SIT) is measured from satellites using technology developed by Seymour Laxon, University College London, United Kingdom. Dr. Laxon provides altimetry and sea ice thickness data for the periods of cruises and mooring work. Seasonal variability of the freshwater content in the sea ice and seasonal fluxes of freshwater are calculated based on these data and compared with 3-4 pressure gauges and data from upward-looking sonars. Sea ice thickness data from satellites is calibrated using ULS data from moorings, and numerical models will be calibrated and validated using SIT from moorings and satellites. We will correlate SIT variability from moorings with its large-scale dynamics from satellites, sea ice drift from IABP, atmospheric pressure variability, and structure of T-S fields. SSH data from satellites will be calibrated using sea level measurements from moorings. Numerical models will be calibrated and validated using SSH from moorings, coastal stations and satellites. We will also correlate sea level variability in the BG with its large-scale dynamics, sea ice drift, atmospheric pressure variability, and structure of T-S fields. This will be used to investigate correlation between sea level seasonal variability in the BG and along Alaskan, Siberian, and Canadian coastline using coastal and island tide gauge data. We will attempt to reconstruct the dynamics of the BG based on sea level observations along the coastline using long-term observations of sea level from coastal stations.

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