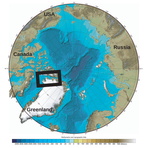
The Ellesmere Island Coastal Currents: Spatial Scales of Freshwater Fluxes in Nares Strait



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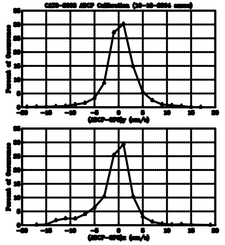
Introduction:

Canadian Archipelago Throughflow Study

This 5-year study contributes to the U.S. Global Change Program. Our approach combines a moored array with intense ocean surveys, satellite remote sensing, bivalve chemical analyses, and atmospheric modeling. It will uncover how freshwater fluxes through the Canadian Archipelago compare to those between Greenland, Iceland, and Norway.

The 2003 expedition of the USCGC Healy to Nares Strait between northern Greenland and Ellesmere Islands contributes to the first-ever, simultaneous tracking of the major freshwater fluxes out of the Arctic Ocean. This freshwater flux into the North-Atlantic constitutes a key process that impacts the thermohaline circulation and global climate.



Calibration data: Histogram of the difference between the ship's motion vector determined from the ADCP and navigational GPS data. These errors include heading errors as we show true vector components.

Methods:

The USCGC Healy contains a hull-mounted 75 kHz Ocean Surveyor (OS75) acoustic Doppler current profiler manufactured by RD Instruments, Inc. The phased-array is mounted in its own well and is separated from the water by an acoustically transparent window. Trimble Inc. Centurio P-code and Ashtech Inc. attitude global positioning systems provide U.S. military-grade navigational and heading information to transform single ping data from beam to averaged earth referenced velocity estimates.

We greatfully acknowledge professional, cheerful, and highly dedicated support from officers and crew of the USCGC Healy commanded by CAPT Daniel Oliver. This work is funded by the NSF via OPP0230236.

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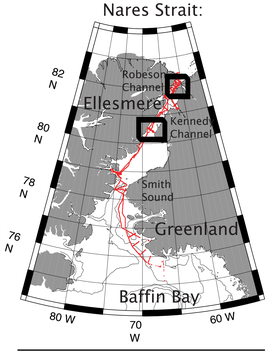


Context:

Nares Strait in the Canadian Archipelago constitutes one major pathway of freshwater from the Arctic Ocean into the North-Atlantic. The freshwater flux impacts stratification in the ocean and thus density-driven (thermohaline) flows. ***The exchange of fresher strait or shelf waters with adjacent deep oceans involve several physical processes, many of which are poorly understood and most of which are ignored in the Arctic System Science context.*** Synthesis requires integrations over large spatial and temporal domains, but synthesis can not succeed without incorporating key processes of across-shelf exchange:

What are the physics that transform 0.0 psu salinity (fresh) water to the so-called “fresh” 34.9 psu salinity water at 2000-m depth in the Labrador Sea?

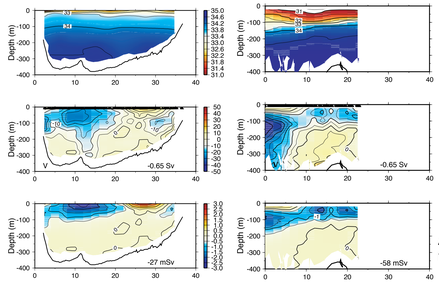
How do fresh waters mix vertically from the surface down and how do they advect horizontally from shallow coastal areas to the deep ocean?

These are non-trivial dynamical questions that require appreciation of geophysical fluid dynamics. The earth’s rotation imposes strong and dominant dynamical constraints that often prevent across-shelf exchange.

The Internal Rossby Radius of Deformation (~5 km) Scales Flows in Nares Strait

Freshwater Flux:

Nares Strait South: Nares Strait North:



Salinity

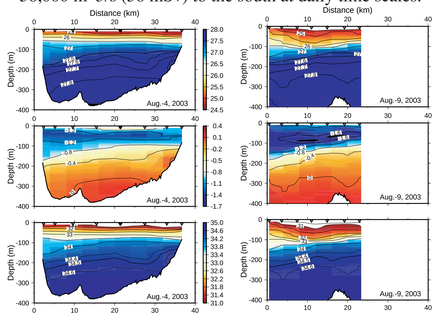
Velocity

Removed tidal currents with 8 constituents of the barotropic model of Padman and Erofeeva (2004).

Freshwater Flux

Along-channel flux of fresh water.

The freshwater flux normal to the section is the integral over the section of velocity weighted by salinity. It thus requires measurements of both salinity and velocity. The freshwater fluxes here are 27,000 m^3/s (27 mSv) and 58,000 m^3/s (58 mSv) to the south at daily time scales.



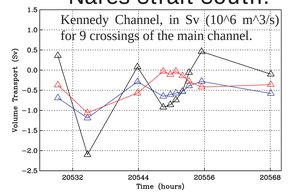
Density

Temperature

Salinity

Volume Flux:

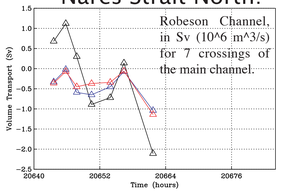
Nares Strait South:



The average flux estimates over all section data are

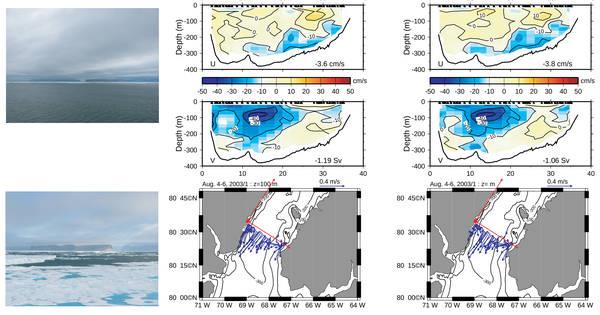
0.5±0.74 Sv (no detiding, black)
0.7±0.31 Sv (model detiding, blue)
0.6±0.31 Sv (LSQ detiding, red)
Thermal wind gives 0.45 Sv.

Nares Strait North:



The average flux estimates over all section data are

0.6±1.02 Sv (no detiding, black)
0.6±0.37 Sv (model detiding, blue)
0.6±0.37 Sv (LSQ detiding, red)
Thermal wind gives 0.45.



North-eastward views from USCGC Healy Aug.-4, 2003 (left panel) during ADCP/CTD surveys (right panels) and mooring deployments (not shown) in Kennedy Channel. Greenland is in the background. to the right in the photos Note the ice advecting into the area during the three hours that separate these pictures.