TIME-DEPENDENT HYDRAULIC FLOW AND ENHANCED MIXING

Sill dynamics in the central Canadian Arctic Archipelago

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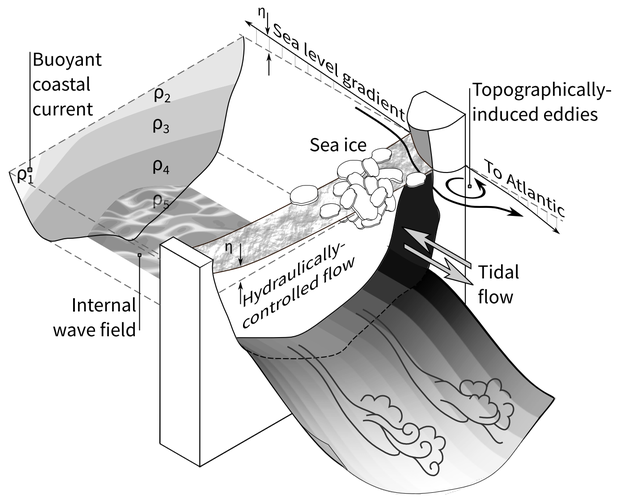
An abrupt transition in water mass properties north and south of shallow sills in the central Canadian Arctic Archipelago is observed in high-spatial resolution transects. An internal hydraulic transition occurs where waters meet. This transition is characterized as a decelerating jet and manifests as a 50 m drop in isopycnal depth during strong tidal flow. An idealized two-dimensional simulation captures many facets of this transition.

INTRODUCTION

- Volume and freshwater fluxes through the Archipelago have a
  - Possible downstream influence in the Labrador Sea
  - A role in the global hydrological cycle (Carmack et al., 2016)
- Fluxes are mediated by small-scale processes as shown
- These processes induce drag much larger than boundary layer friction.



Relevant phenomena within channels of the Archipelago

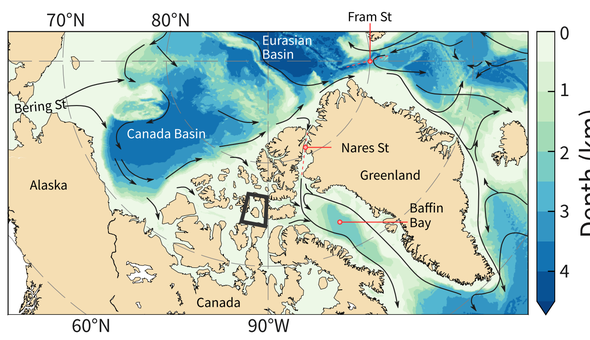
SURVEY

Aims Map turbulent structures
Quantify mixing
Elucidate tidal dynamics

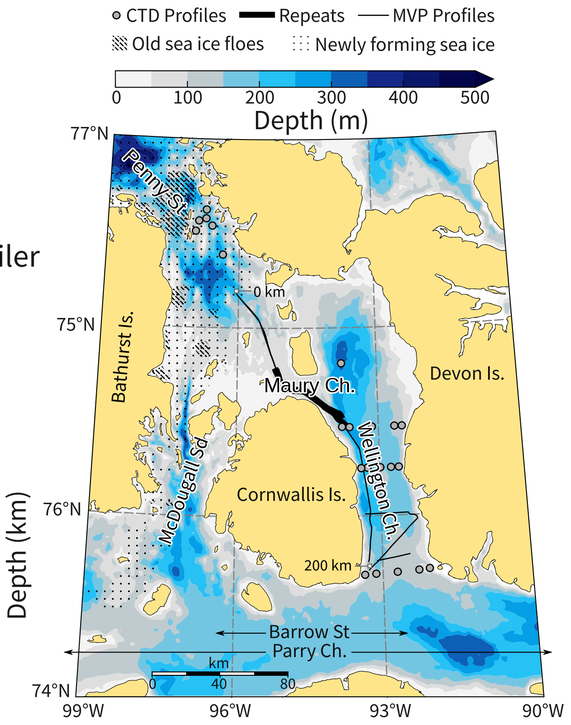
Timing Late September 2015
End of open water season

Tools MVP: Moving Vessel Profiler
ADCP: Shipboard Current Profiler

Dataset 1100 vertical profiles (*T*, *S*)
Continuous velocity profiles



Circulation in and near the Archipelago
Arrows after Beszczynska-Möller et al. (2011)



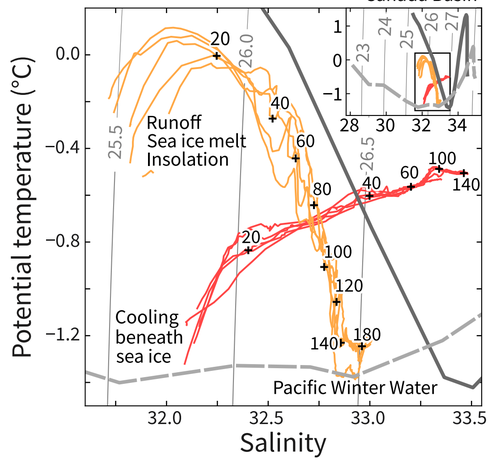
Summary of the observational survey

WATER MASS TRANSITION

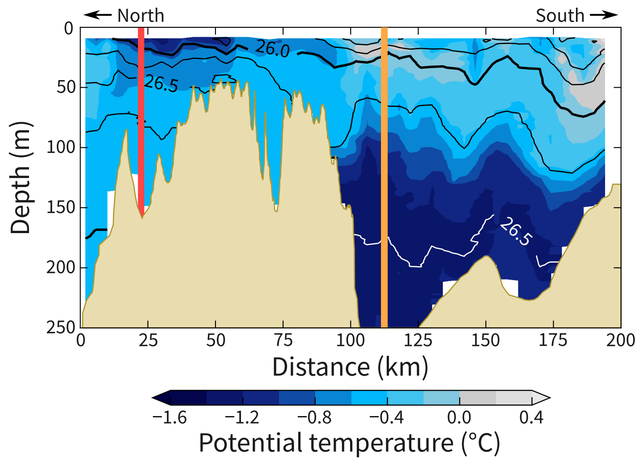
- Two distinct water masses, traceable to origins separated by 1500 km, are observed in within 50 km of each other
- What happens to water traversing the sill from the north?

Northern waters
Warmed, homogenized variant of Canada Basin Water

Southern waters
Cooled variant of Baffin Bay Water



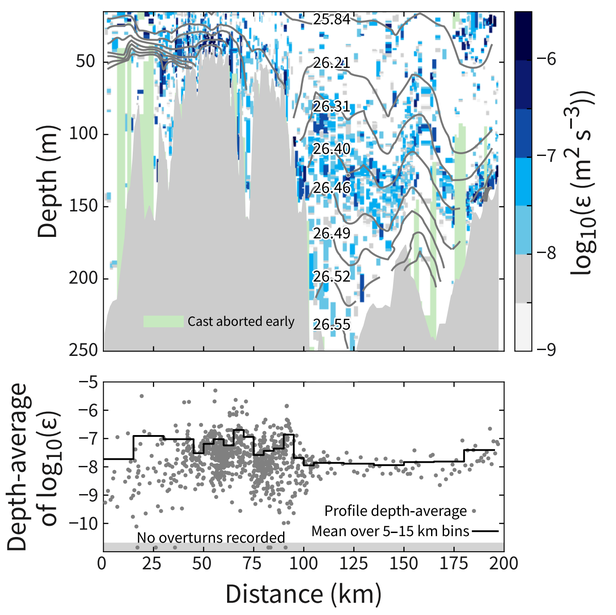
Representative properties either side of the shallow sills



Hydrography along the longest transect

TURBULENT DISSIPATION

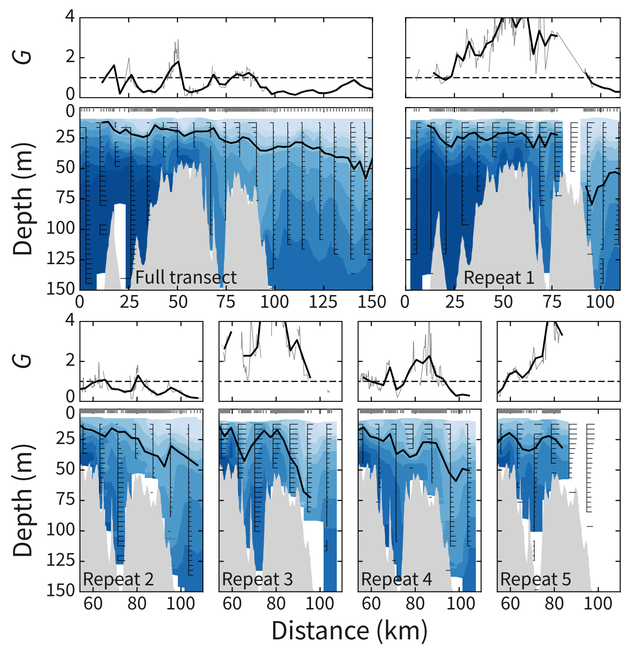
- Total dissipation of turbulent kinetic energy in the channels surrounding Cornwallis Island is 7–20% of the barotropic tidal dissipation
- The remainder is inferred to be due to internal wave and vorticity generation and dissipation in the bottom boundary layer
- Dissipation rates:
  10^{-8}–10^{-7} W kg^{-1}



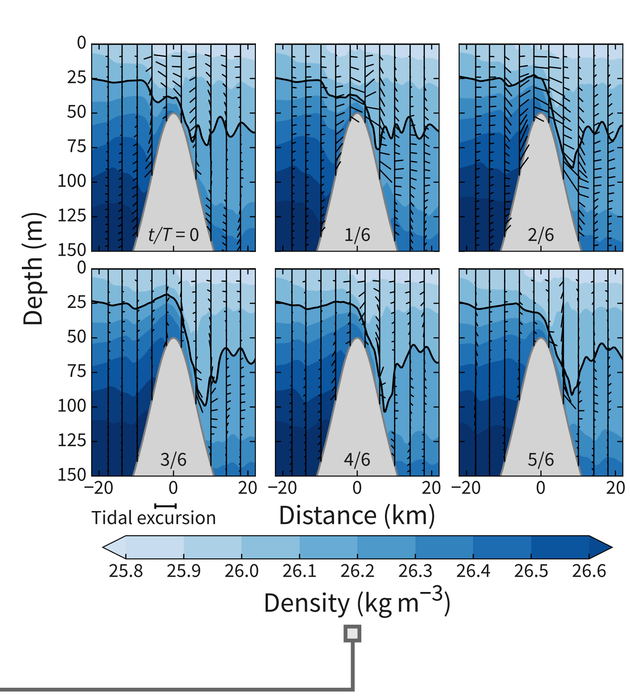
Dissipation in the longest transect and depth-averaged values from all transects

TIME-DEPENDENT HYDRAULIC FLOW

- Transitions from internally supercritical to subcritical occur near the steep slope at the eastern end of Maury Channel and possibly elsewhere
- Mode-1 internal wave speeds through the channel are 0.2 m s^{-1}, but tidal currents reach 0.6 m s^{-1}
- Interpret in the framework of a two-layer, one-dimensional idealization and extend understanding with a numerical simulation



Criticality in along-channel transects
The two-layer, composite Froude number is derived from the observed velocity and density fields shown



A 2D, idealized simulation of flow in Maury Channel without rotation
The model extends to 300 km each side, to 250 m depth, and is forced at the boundaries with both a mean flow and an oscillating component with period *T*

OPEN QUESTIONS

- Planned process-oriented modeling aims to
  - Characterize influence of critical latitude
  - Quantify eddy generation
  - Characterize observed internal Kelvin wave
  - Elucidate flows beyond the constriction

ACKNOWLEDGMENTS

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