Measuring Ocean Dispersion and Tracking Oil in Arctic Waters

or

How to utilize autonomous technology to map the faith of oil in water

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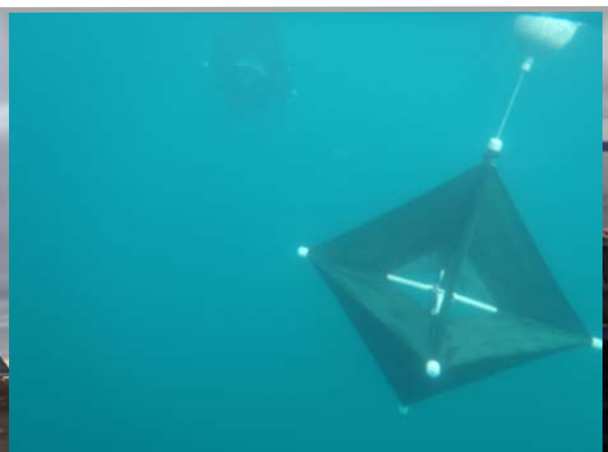
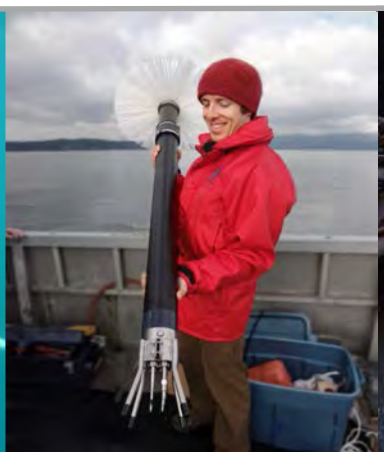
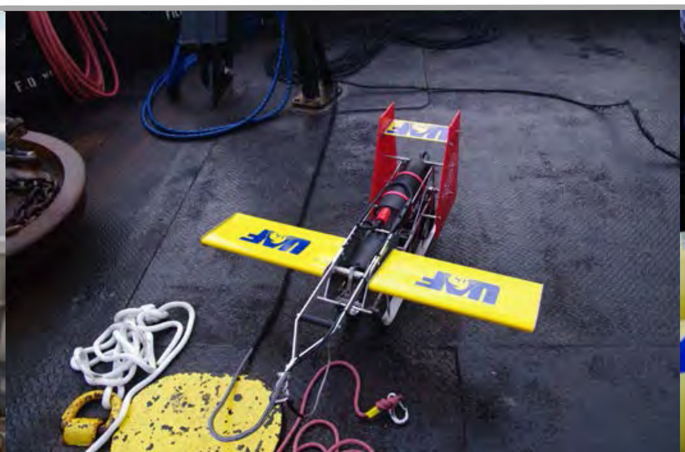






BOEM Bureau of Ocean Energy Management
AOOS Alaska Ocean Observing System
ConocoPhillips
Rutgers University
UAF University of Alaska Fairbanks
NOAA

Critical for proper response to an oil spill is **real time data** from the field and models for predicting the evolution over time and space

→ Example of observational and model capabilities
→ How to measure dispersion and its importance
→ Small-scale physical oceanographic processes

Case study:

ARCTREX: Applications for Mapping Spilled Oil in Arctic Waters

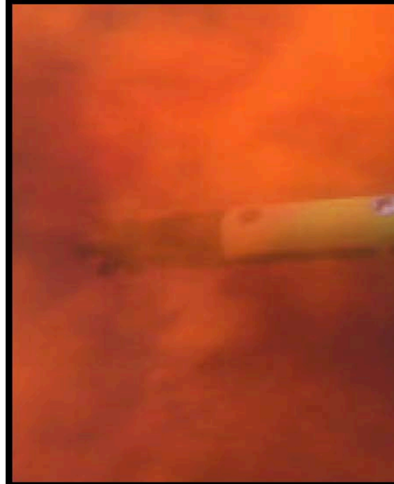
- 2014-2015 dye releases in the Northeastern Chukchi Sea
- **Test available observational technology**, capability to map a dye plume in time and space, simulating an oil spill, and provide real time data to response agencies.

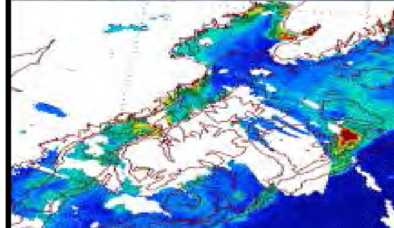
map>

Technology for observing and monitoring the ocean environment in *real time* at small spatial scales and long temporal scales

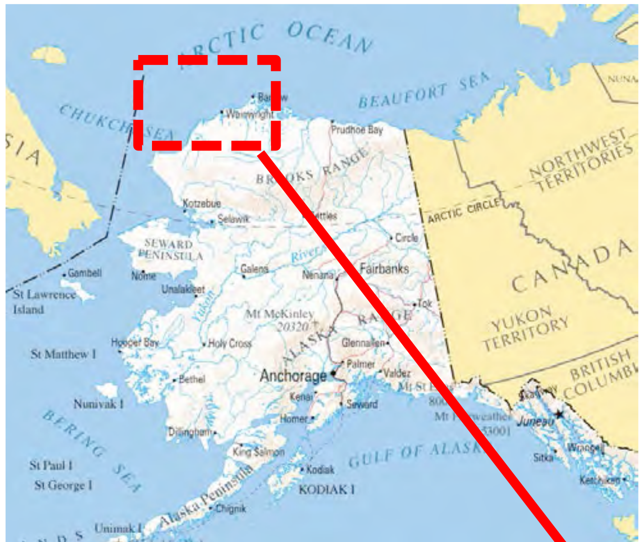
HF Radar: Real-time surface current and ocean environment mapping in two-dimensions. Enables real time currents for science, monitoring oil spill response, search and rescue, and Arctic domain awareness (ship tracking). UAF has developed unique high-latitude experience and remote operational capability. **Hank Statscewich – next talk!**

Autonomous Underwater Vehicles (AUVs): enable real time ocean data, adaptive sampling, including e.g. real-time passive acoustic monitoring, detection and identification. Can operate dormant, or actively for ~4 months. Arctic domain awareness application with continuous presence at high latitudes.



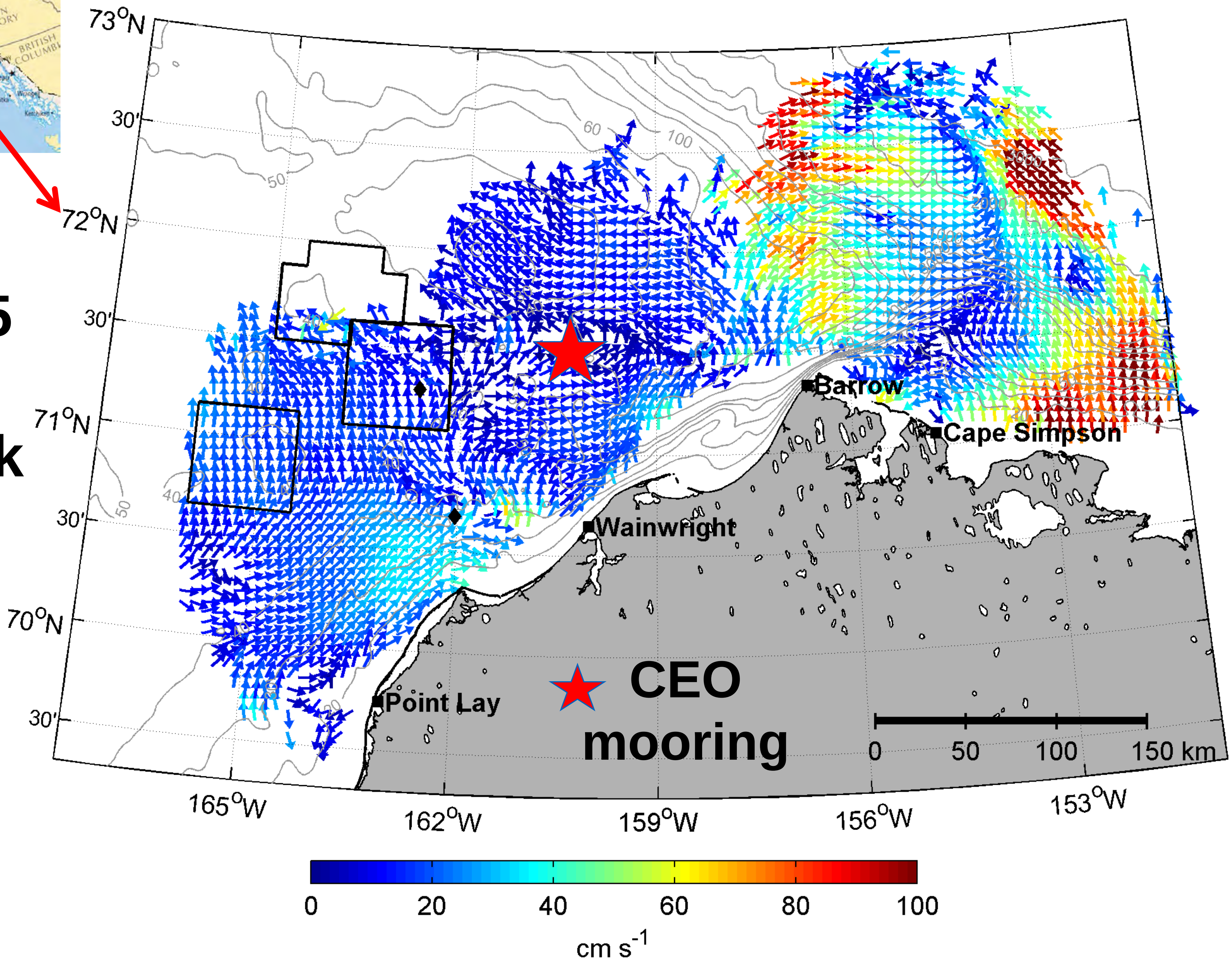


Chukchi Sea surface currents
Daily average 9-15-2014



HF Radar: Land-based 5 MHz long-range network

6-km grid covering 80,000 km²



Chukchi Ecosystem Observatory (CEO)

http://www.ChukchiEcosystemObservatory.org

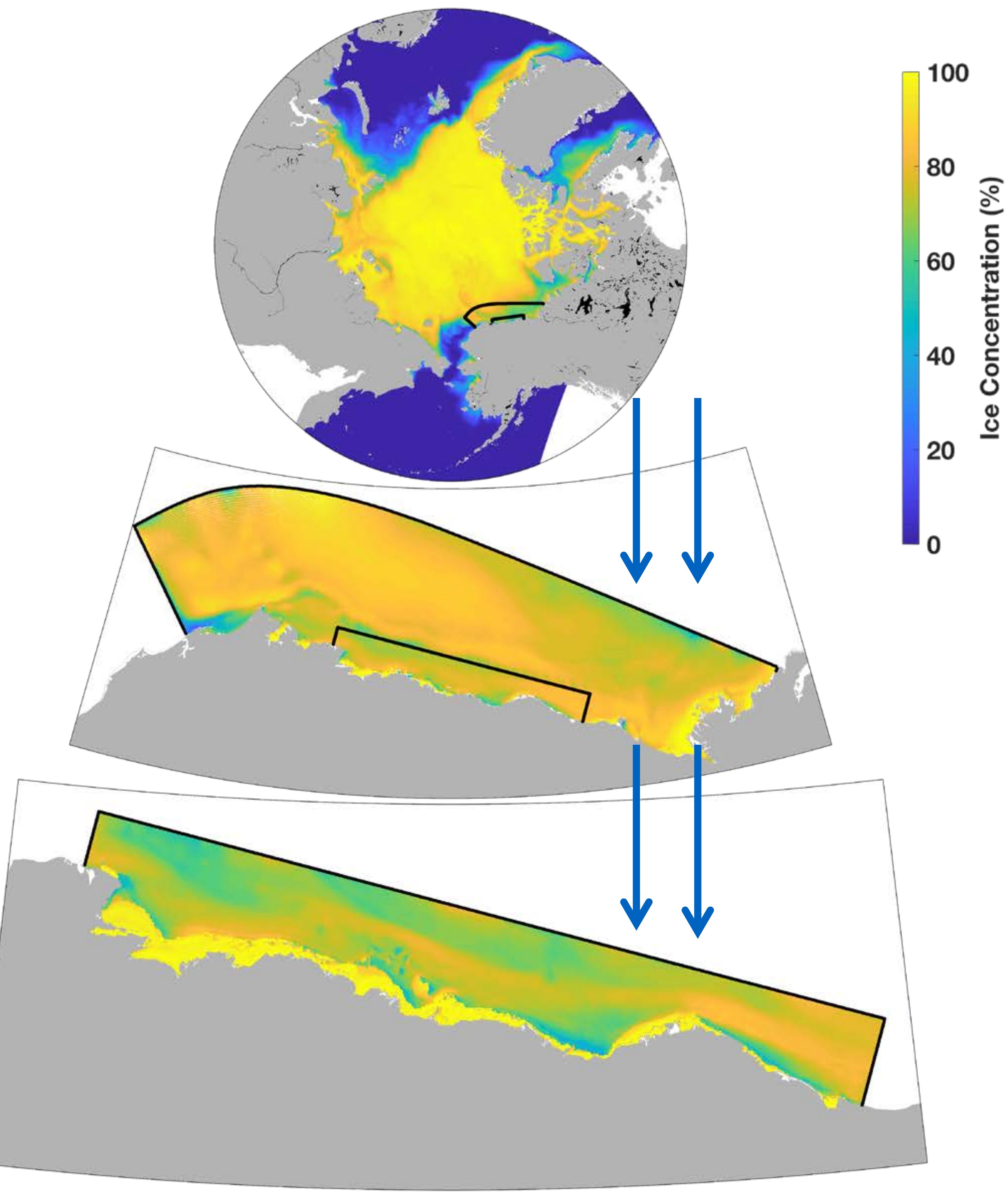
- Monitor the Chukchi-Hanna Shoal ecosystem year-round from the vantage of multiple disciplines, across multiple trophic levels, and with high temporal resolution.
- Relate timing and magnitude of fluctuations of nutrient and carbonate chemistry, particles, phytoplankton, zooplankton, fish and marine mammals to variations in each other and the currents, waves, wind, light, and ice.
- Provide reference observations for evaluating and improving regional and global-scale biogeochemical, ice-ocean circulation, ecosystem, stock-assessment**, and oil spill response models**

Numerical Model Development & Applications

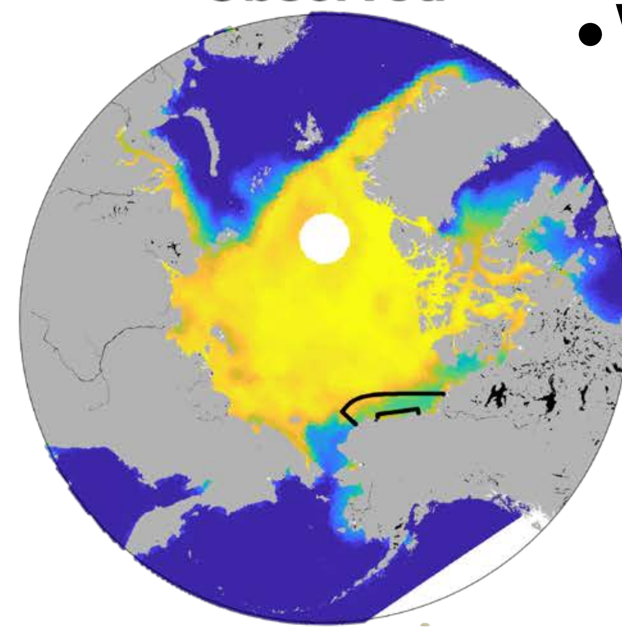
Hydrological – Ice – Oil – Ocean Circulation Modeling

Pan-Arctic ROMS

Modeled



Observed



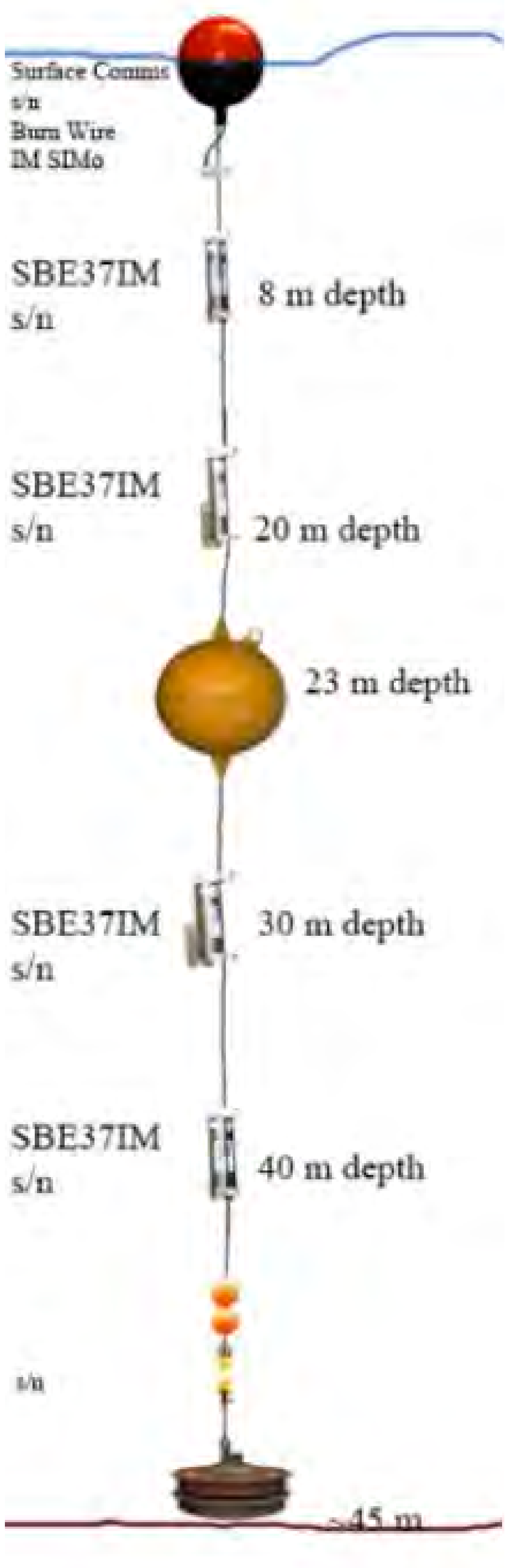
Recent Improvements

- Wetting & Drying: better tides
- Coastal river discharges: FW & heat
- Multiple ice model options
- Nested ice-ocean models
- Landfast ice parameterization

Seth Danielson and Kate Hedstrom, UAF

BOEM Bureau of Ocean Energy Management

Ice detection buoy: A Real-time Sensor System for Detecting Freeze-up on Arctic Shelves



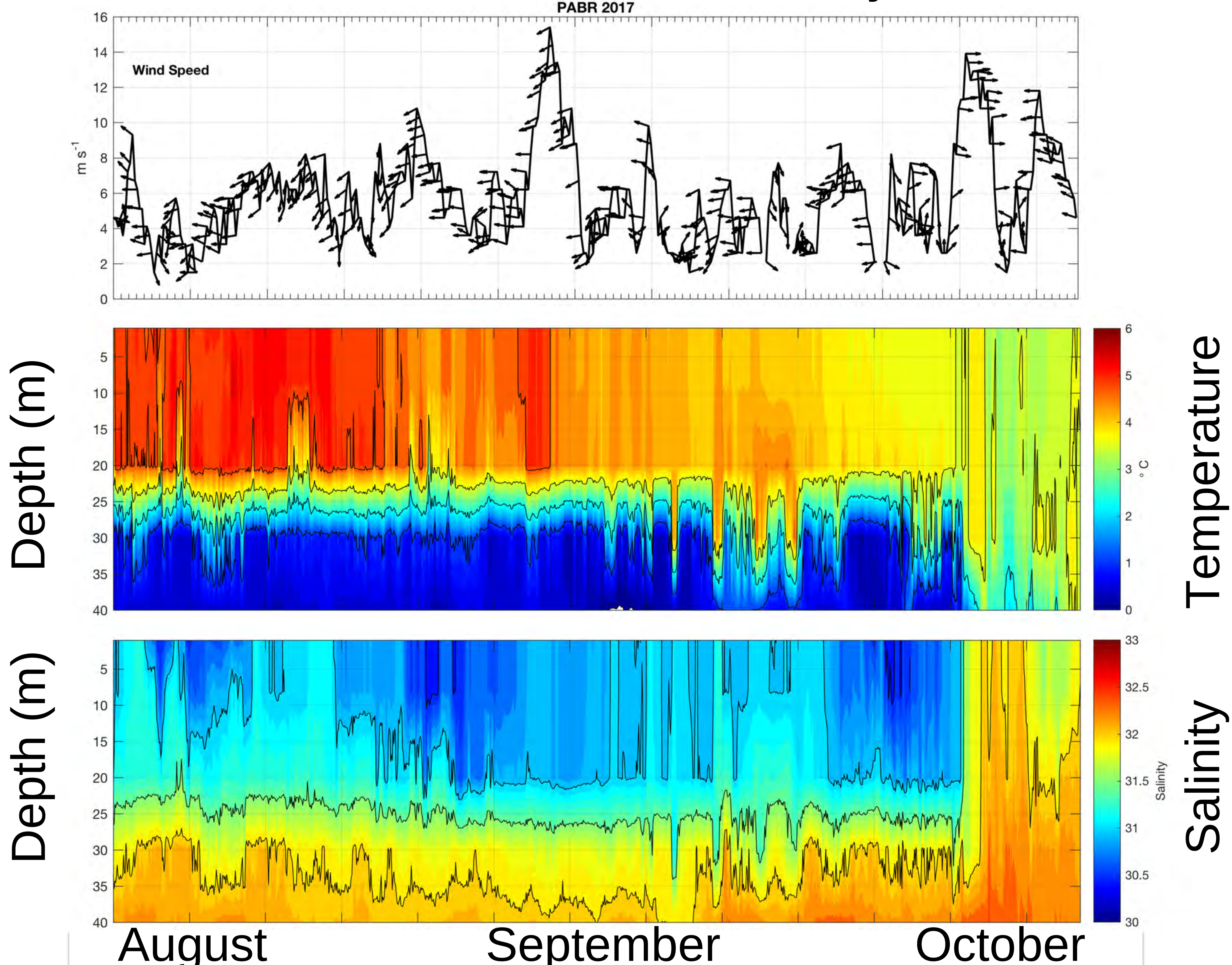
→Provides **real-time data on the vertical temperature and salinity structure of** the ocean so that agency permitting agencies, and stakeholders, including the oil and gas industry and subsistence users, will know when offshore sea ice formation begins.

→ Data can be used to evaluate and refine NOAA and NWS sea ice forecast models (both existing models and those under development), which depend upon accurately predicting the seasonal evolution of the thermohaline structure of the ocean.

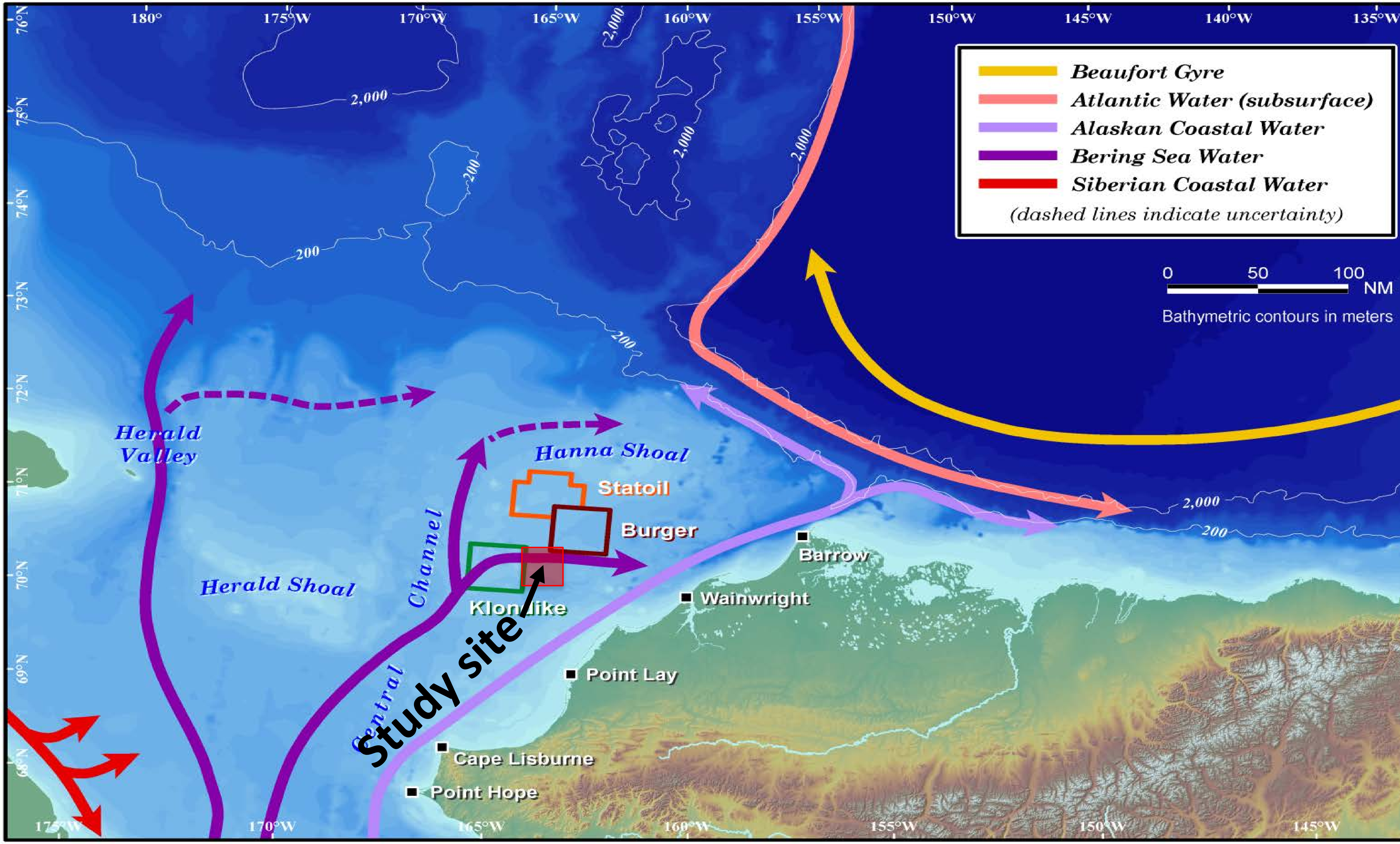
→ Useful in guiding remote sensing algorithms for frazil ice detection, a notoriously difficult process for remote sensing platforms.

→ Provides a new technology platform for real-time enabled year-round Arctic observations.

2017 Real-time Ice Detection Buoy data

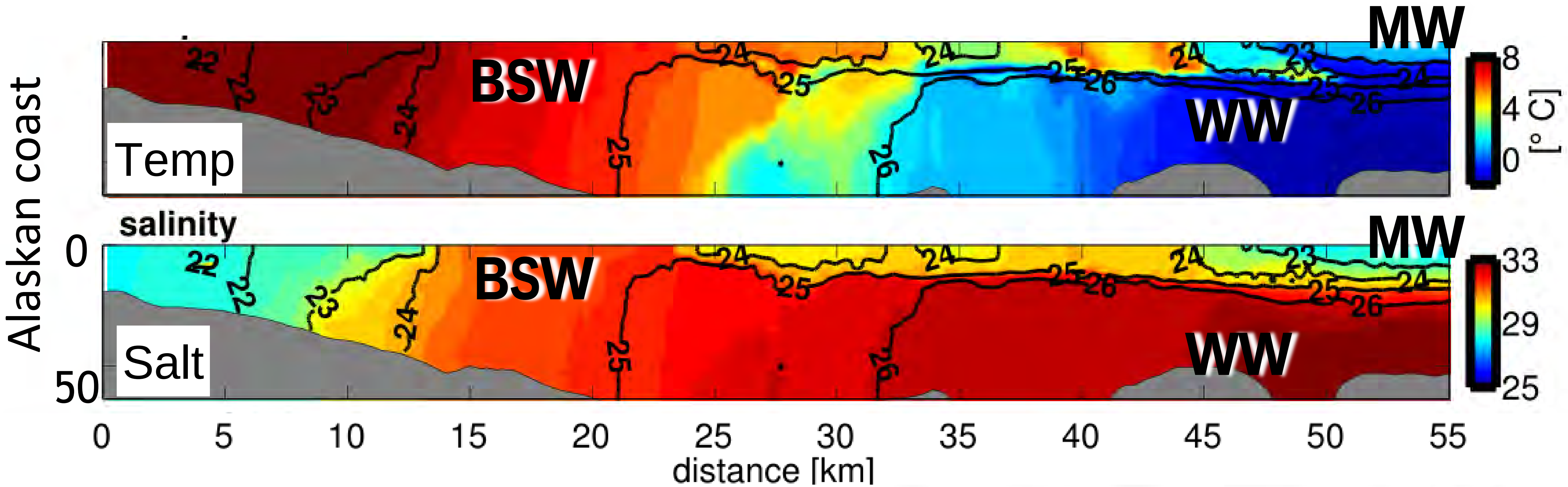


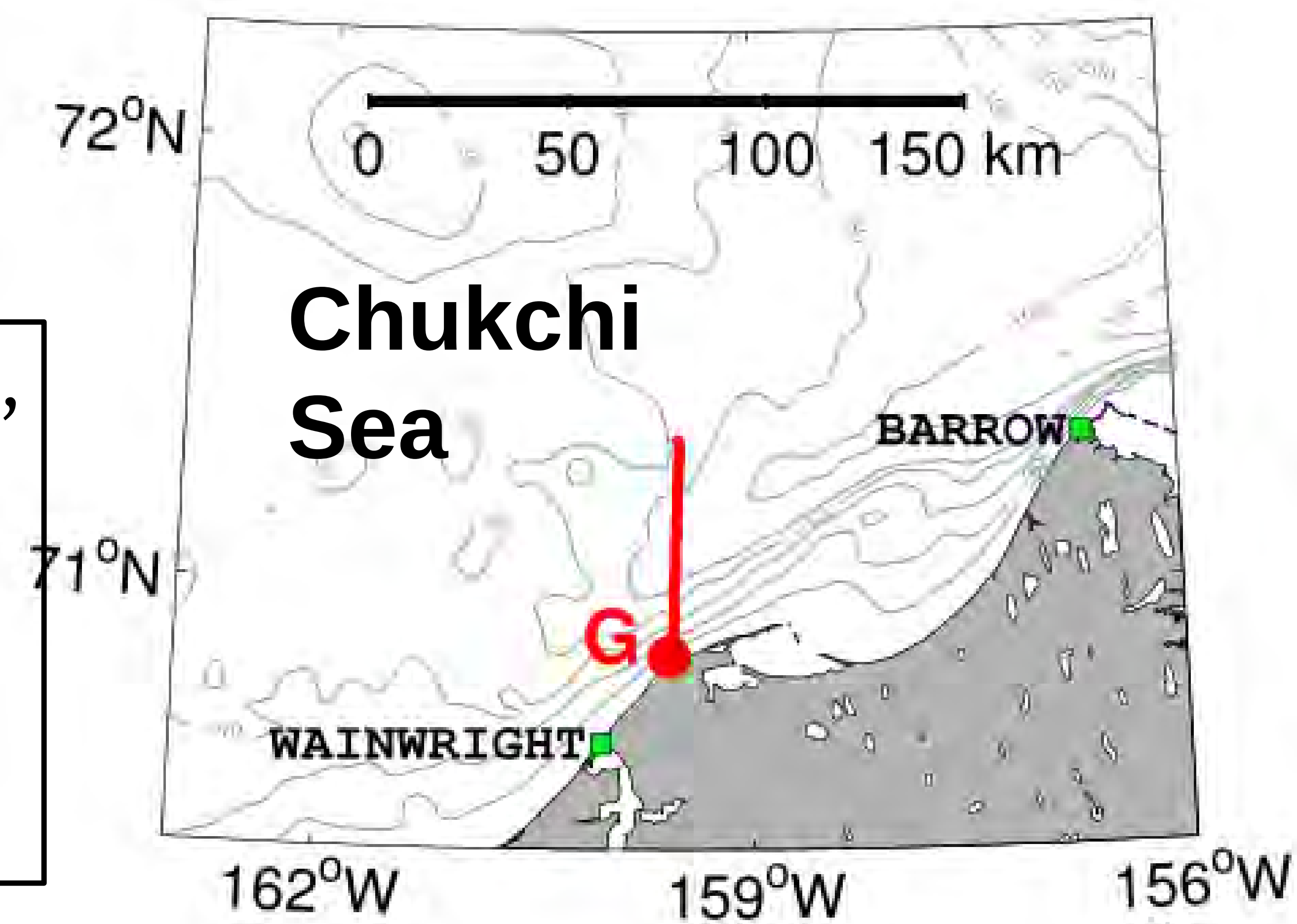
ARCTREX: Applications for Mapping Spilled Oil in Arctic Waters



Rhodamine dye releases in 2014 & 2015

“Typical conditions”: 55-km cross section at the mouth of Barrow Canyon





MW: ice melt water, cool, dilute, T≈0°C, S≈26

BSW: Bering Sea water, warmer and saltier, T≈5°C, S≈30

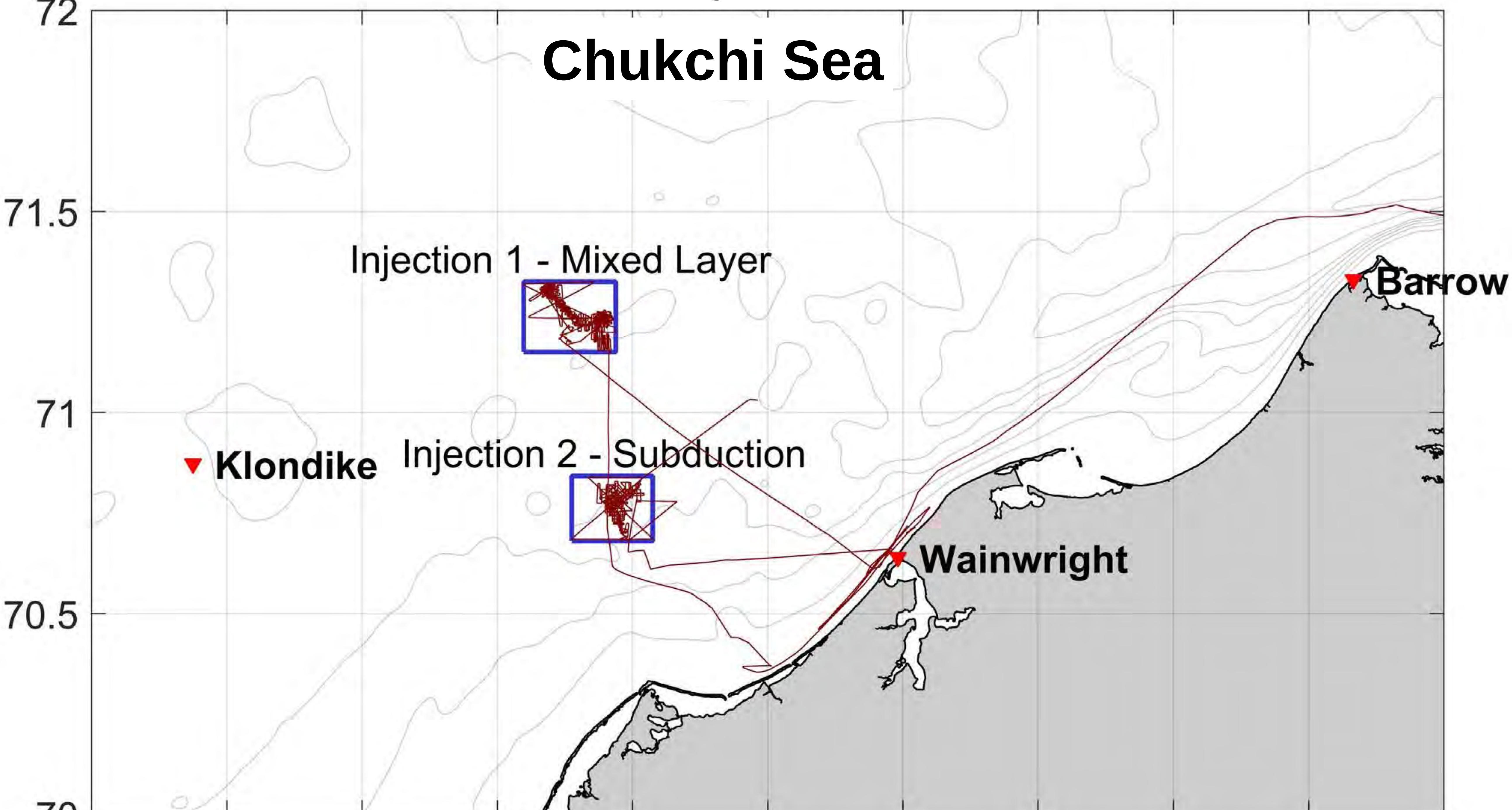
WW: winter water formed by ice formation, near-freezing, saline

site>

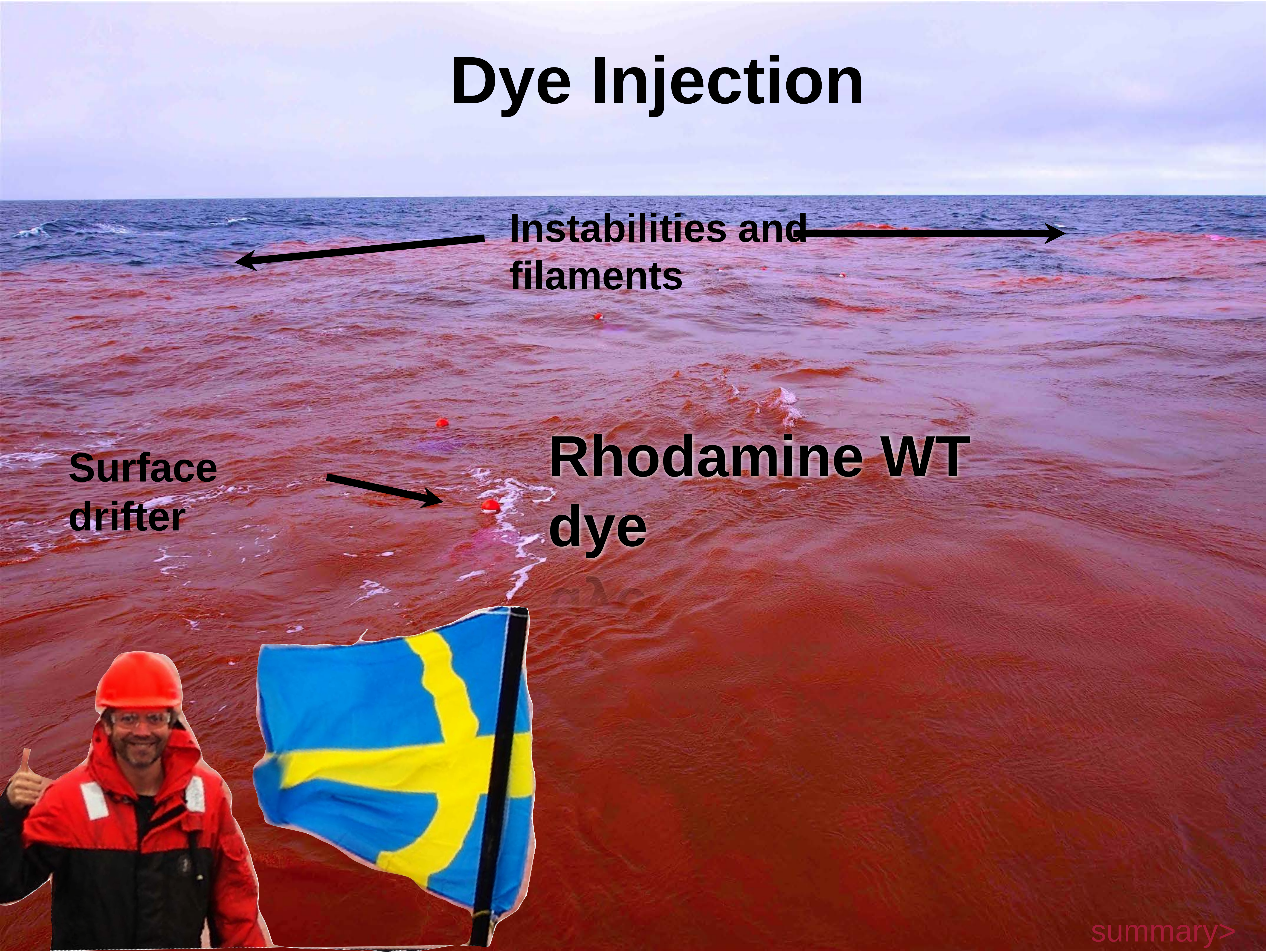
ARCTREX Method: Dye release & mapping

Purposeful injections of a fluorescent dye as a tracer in the summer of 2014 (A second release was performed in 2015)

2014 Injection sites



dye pic>


Dye Injection
Instabilities and filaments
Surface drifter
Rhodamine WT dye
summary>

Injection 1: Surface mixed layer

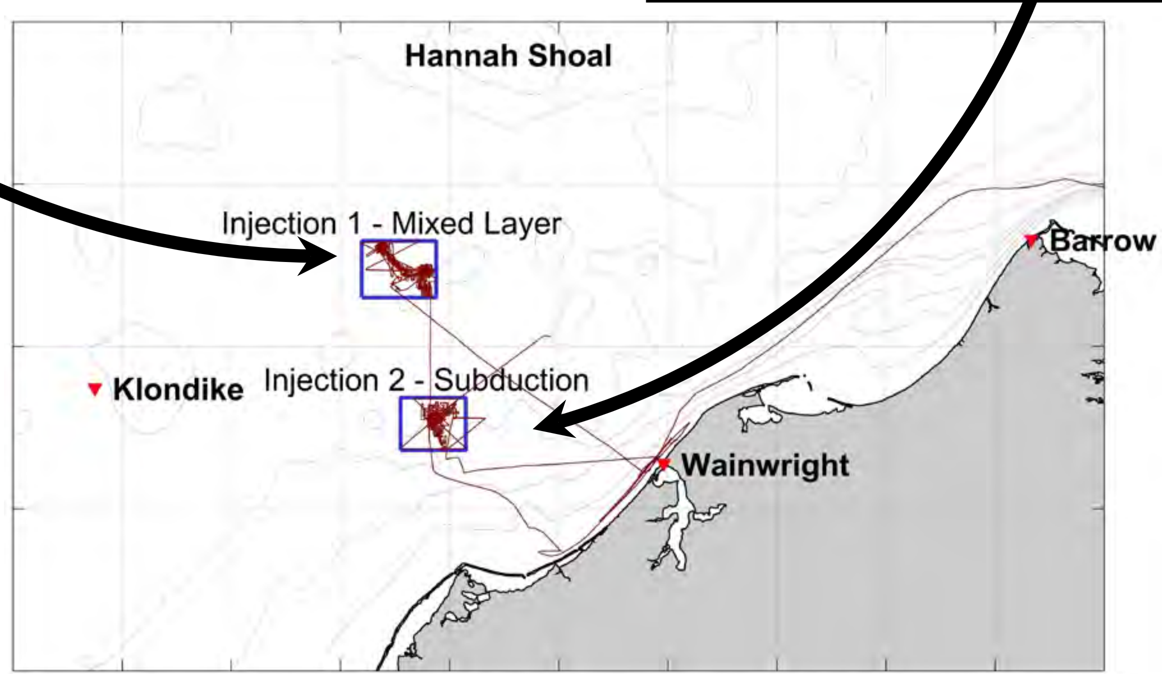
- ~45 kg of dye injected into a well mixed surface layer over a stratified pynocline
- Surveyed over the course of 3 days with 23 realizations of the dye ("patch").
- NW winds 7-8 m/s.

- Dye patch stayed in the surface mixed later.
- Surface mixed layer grew by ~5 m. Dye thickness increased with the increasing surface mixed layer.

Injection 2: Subduction

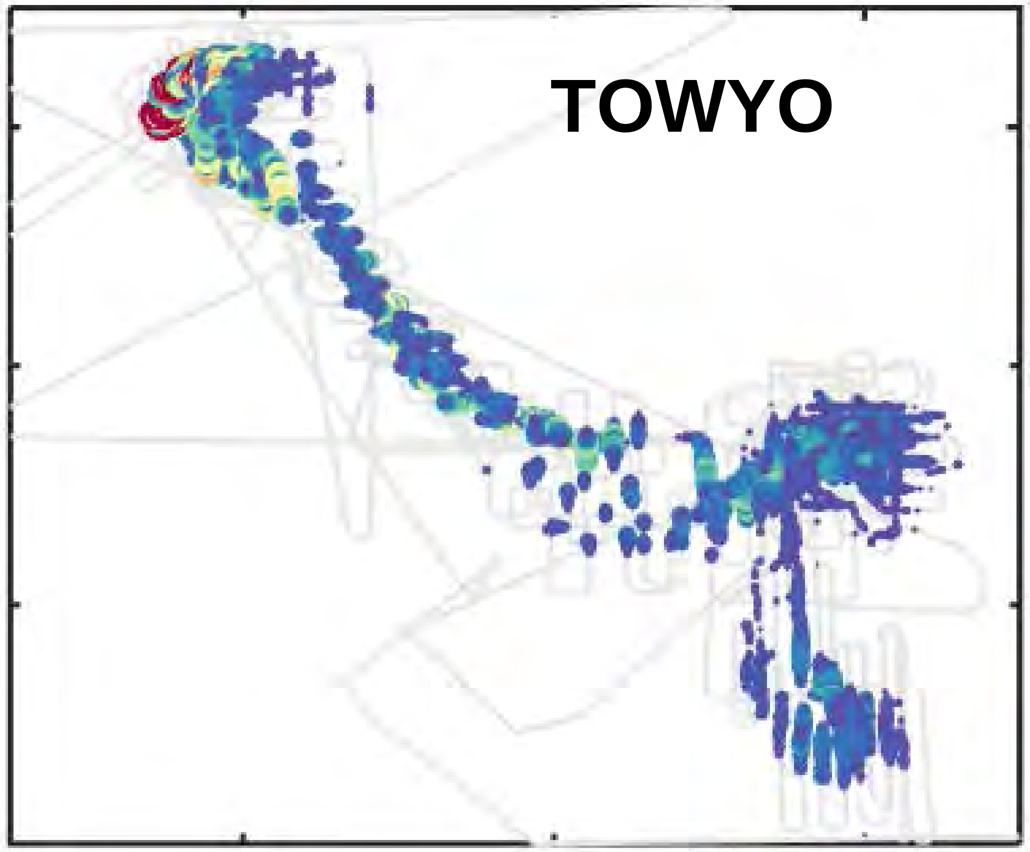
- ~45 kg of dye into a weakly stratified environment
- Surveyed over the course of ~1 day, 11 realizations of the dye ("patch").
- NW or W winds at 10 m/s.

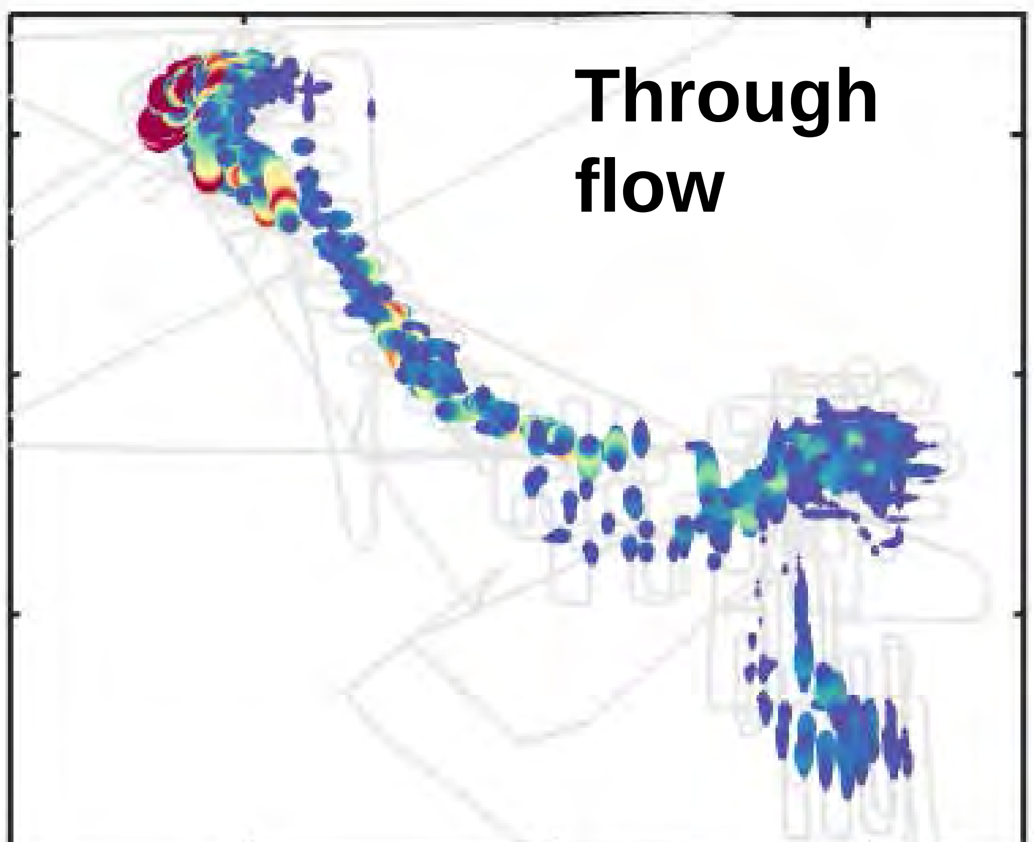
- Dye patch subducted under a fresher body of water to the north of the injection site.
- Initial horizontal dispersion is large compared to Injection 1.
- Upon subduction, mixing into the dense water below and the fresher water above.



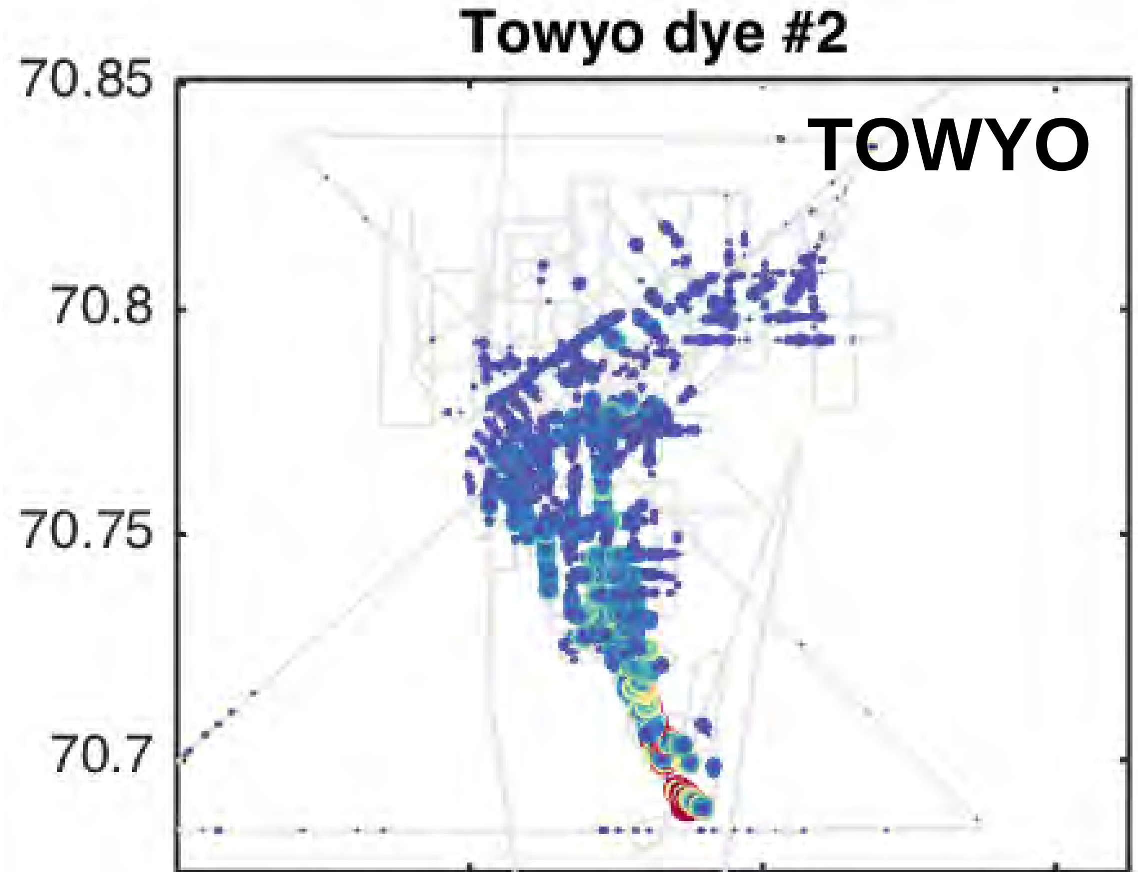
tale of two injections>

Injection 1: Mixed layer

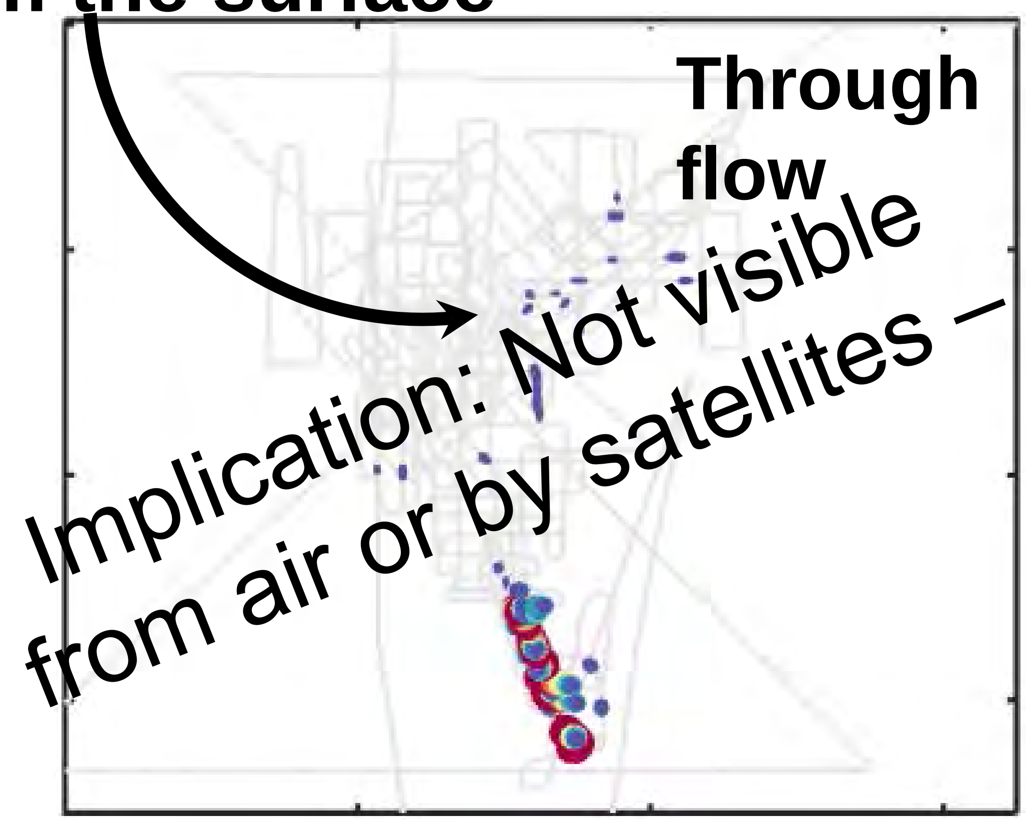




Injection 2: Subduction



Subduction: Dye disappears from the surface

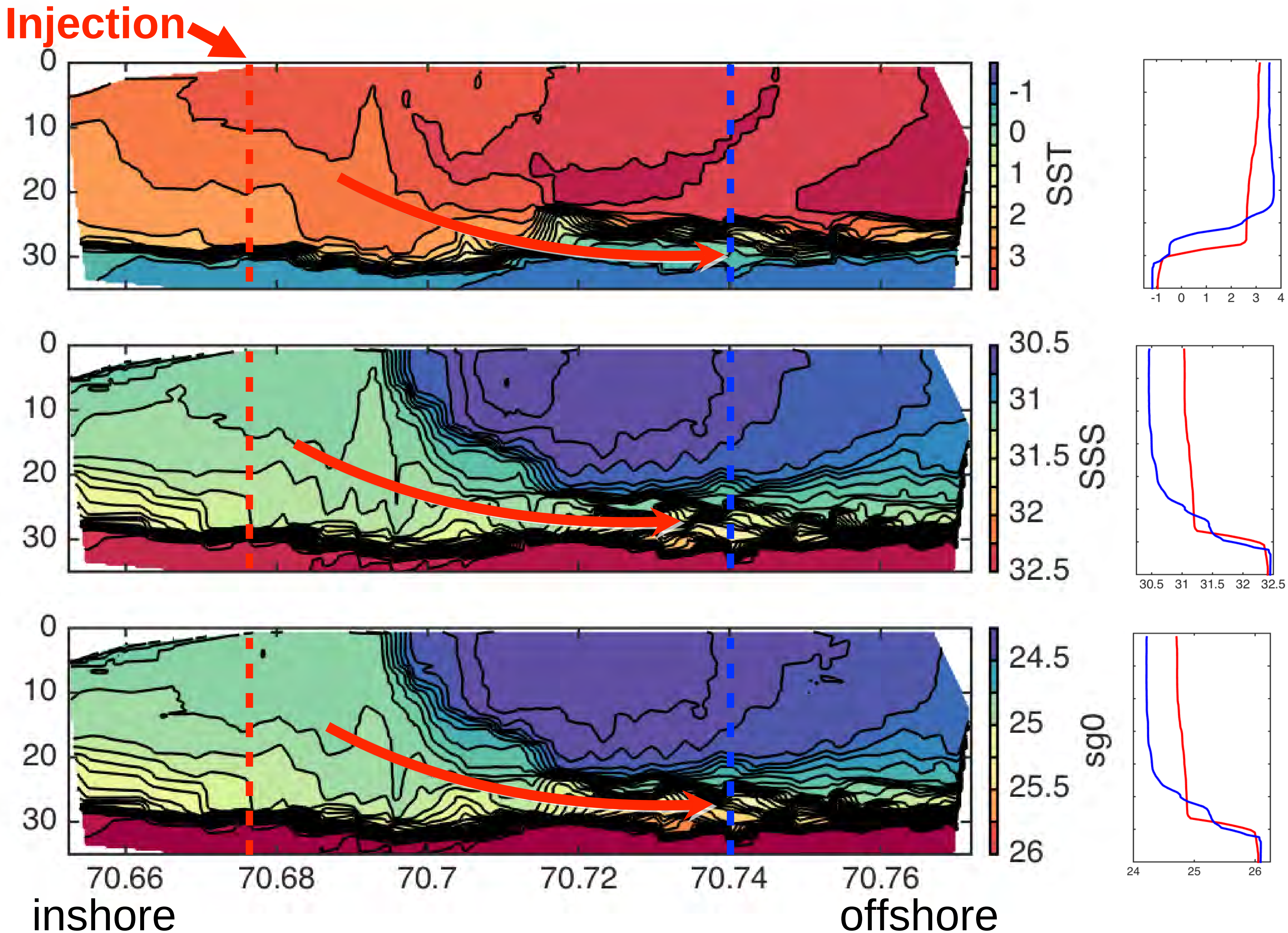


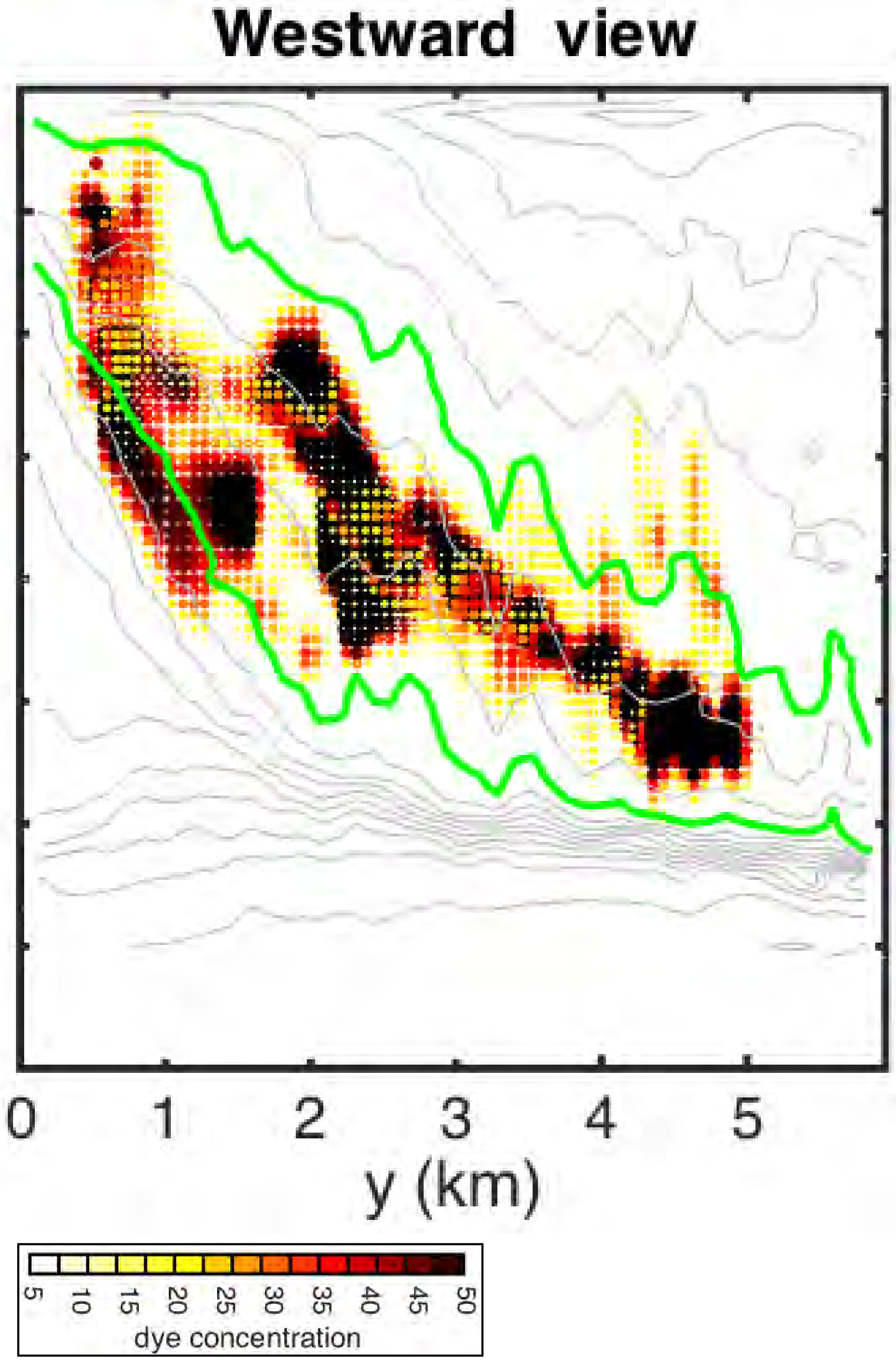
ini 1 map>

Injection 2: Subduction — Dye injected *inshore* of front

Note: Water inshore was ***saltier***, cooler and denser

i.e. ***reverse*** of expected configuration





0 m - surface

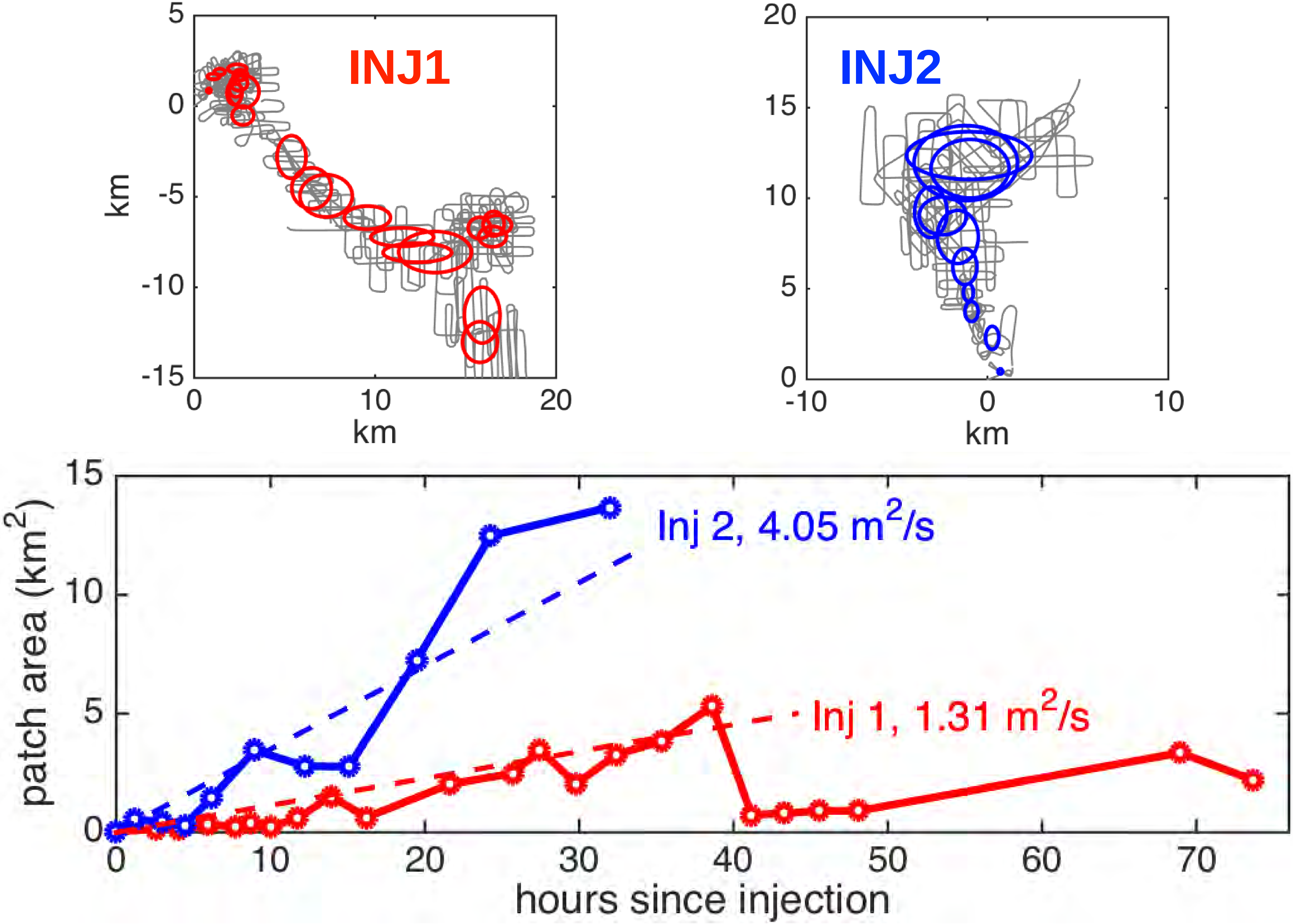
The dye subducted at the front, strained, sheared, and the front advected northward with some vertical mixing and horizontal dispersion

45 m - bottom

Survey 8, 14 Sept 2014 18:10-21:20 UTC

vertical diffusion>

Patch dispersion (horizontal mixing)



Summary

→ We have developed, deployed and operated real-time capable HFR, AUV gliders and moorings for the last 10 years in polar regions (Arctic, Greenland and Antarctica). Only group that operates HFR and gliders consistently in polr regions.

→ Full ecosystem sensor systems + pan-arctic modeling

→ Real-time oceanographic systems enable response agencies and coastguard with updated, best-available information, including supporting logistics and safe response approaches.

→ Next: i) through-ice real-time ocean currents, ii) rapid-deployable remote power modules, iii) nearshore UAV-ASV air-ocean coupled autonomous operations

Thank you ☺

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