

OTN/MEOPAR/DFO Glider Operations in Canadian Waters

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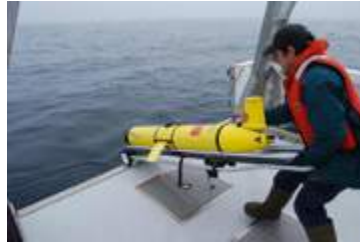
The Genesis of the OTN/MEOPAR/DFO Glider Program

- Identified strong need to monitor ocean conditions
 - Expand coastal monitoring for climate change studies
 - Provide environmental context for marine animal movements
 - Provide validation data for ocean models
- Add mobile acoustic receiver capability
- Offload data from bottom-mounted acoustic receivers
- Respond to extreme events
- Track marine mammals to reduce ship strikes

Description of Gliders

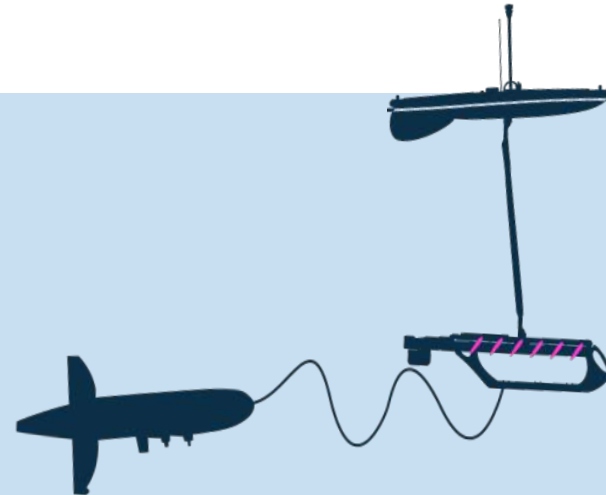
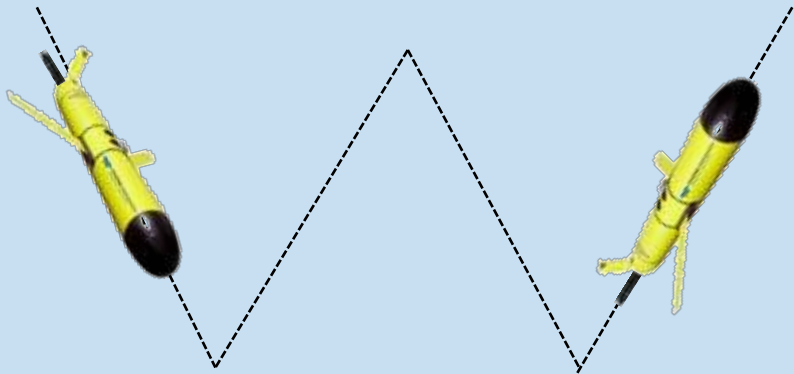
Teledyne Webb Slocum Electric Glider

- Buoyancy driven & battery powered
- Mission length: 4 weeks to 4 months
- Speed over ground: $\sim 1 \text{ km hr}^{-1}$
- Operate in sawtooth pattern down to 200 m

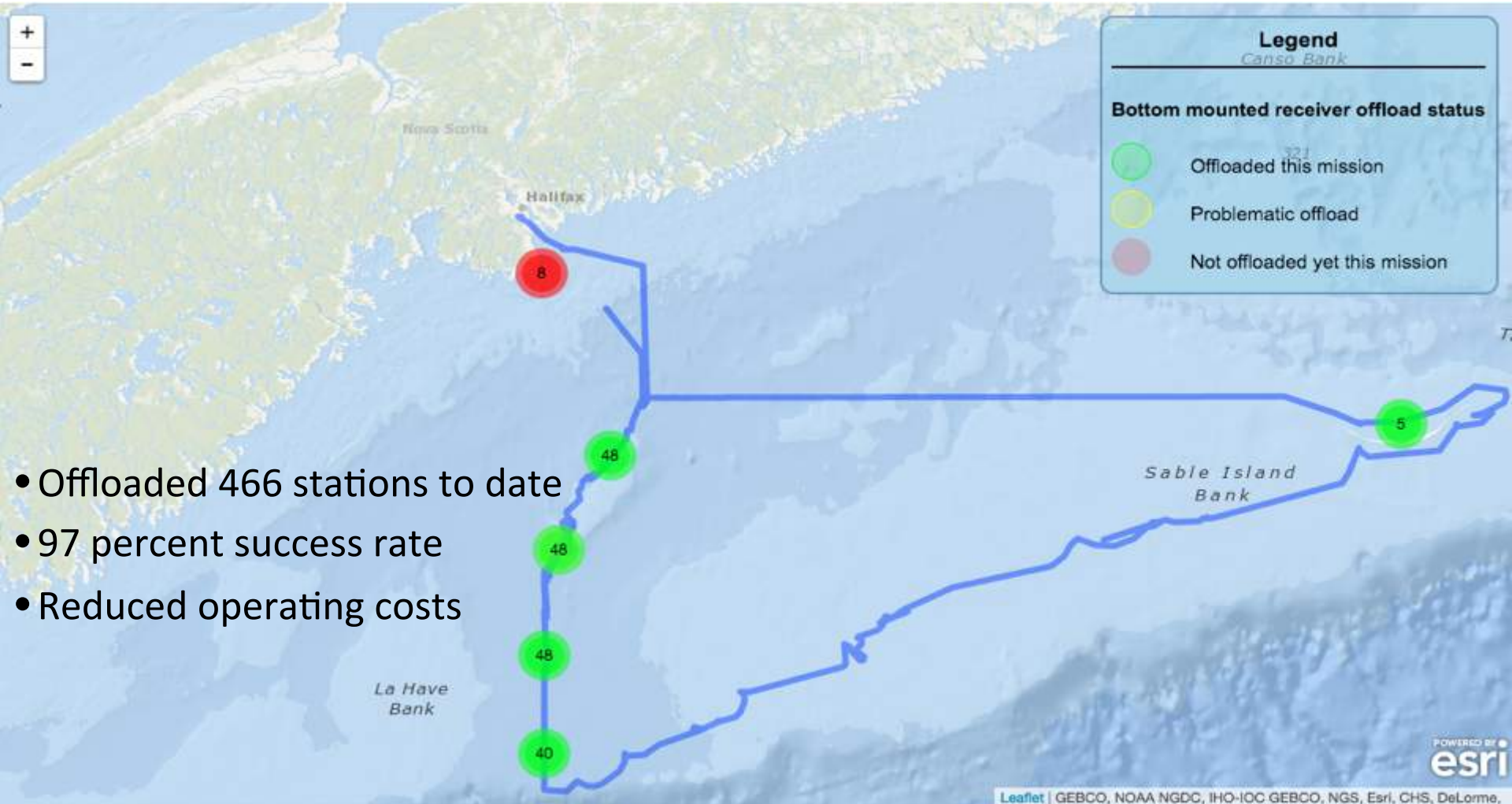


Liquid Robotics Wave Glider

- Wave driven & solar powered
- Can be at sea for a year at a time
- Speed over ground: $\sim 2.5 \text{ km hr}^{-1}$
- Survived waves of $> 10 \text{ m}$ and winds of $> 50 \text{ kts}$

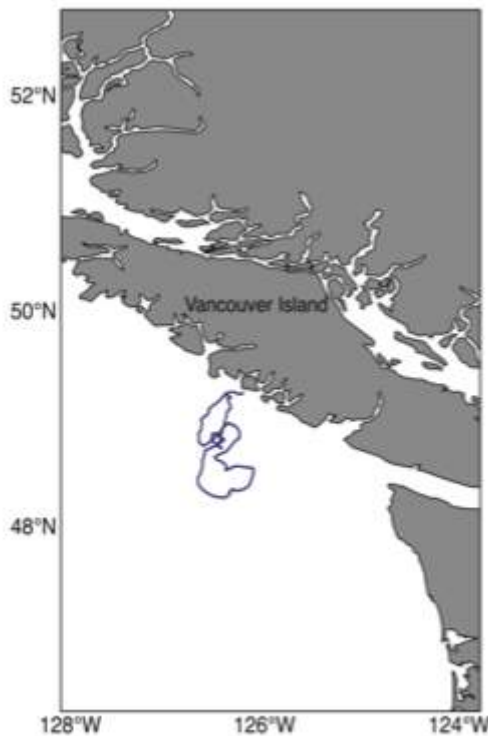


Acoustic Receiver Offloads for Animal Tracking

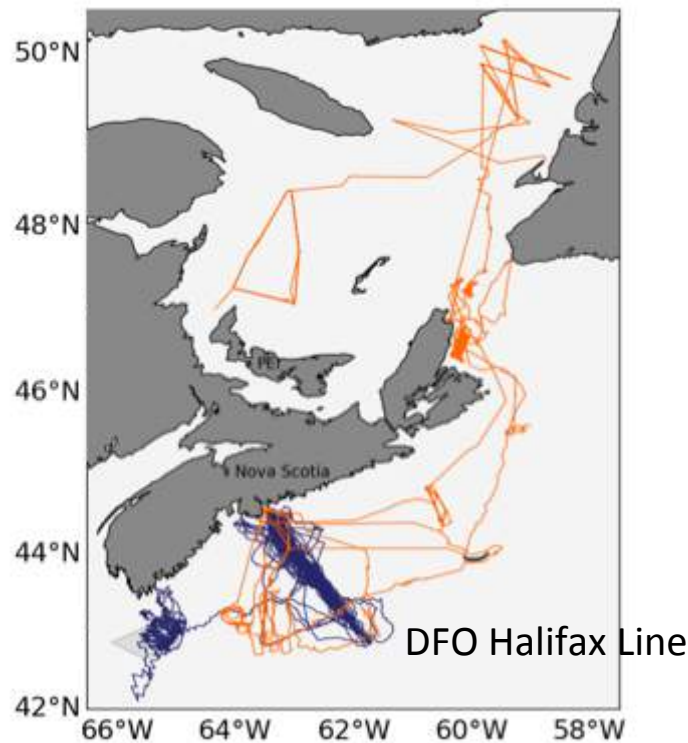


Five Years of Bi-Coastal Operations

West Coast: 2016

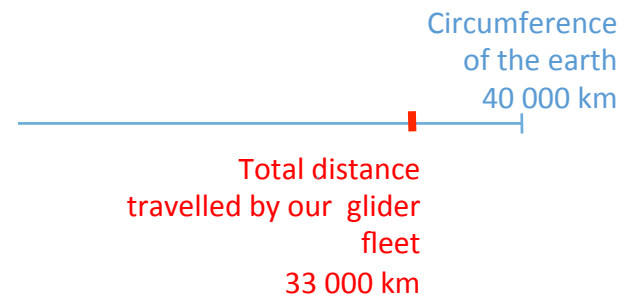


East Coast: 2011 – 2016



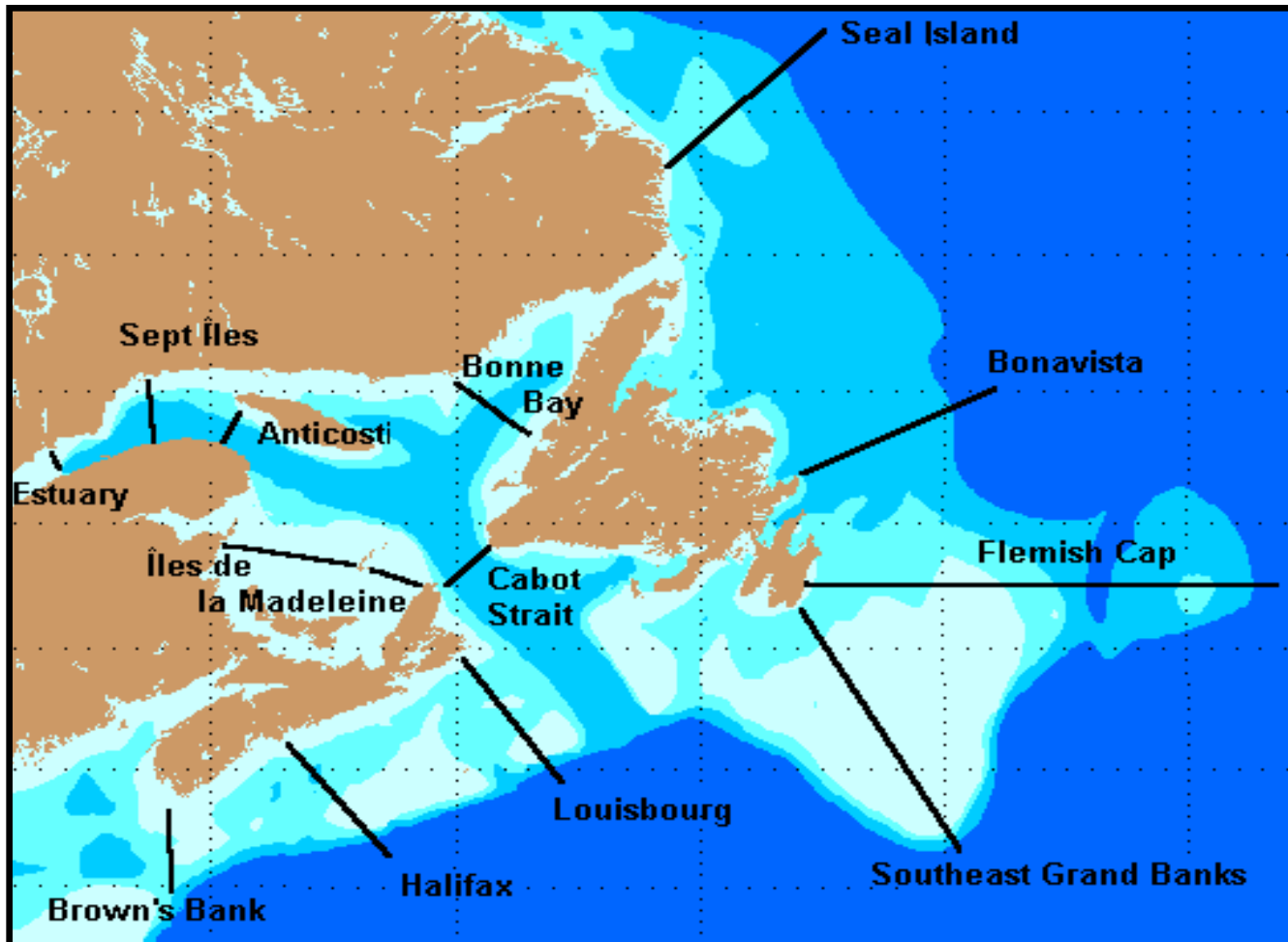
- Slocum Glider
- Wave Glider

By the numbers ...
>60 missions completed
>33,000 kms traveled
>1300 days at sea
>2B data points collected

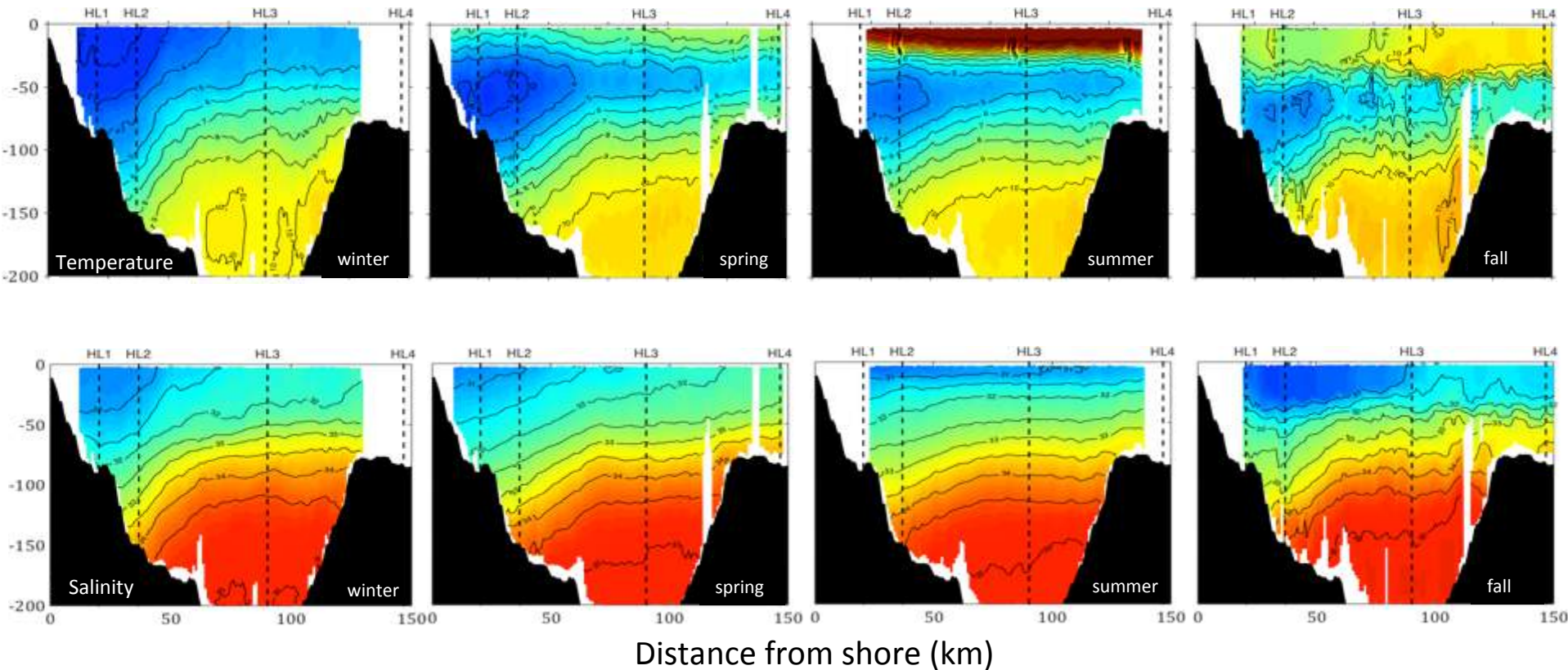


Atlantic Zone Monitoring Program (AZMP) Halifax Line

Monitor physics, chemistry and biology along key biogeographic lines with spring and fall cruises



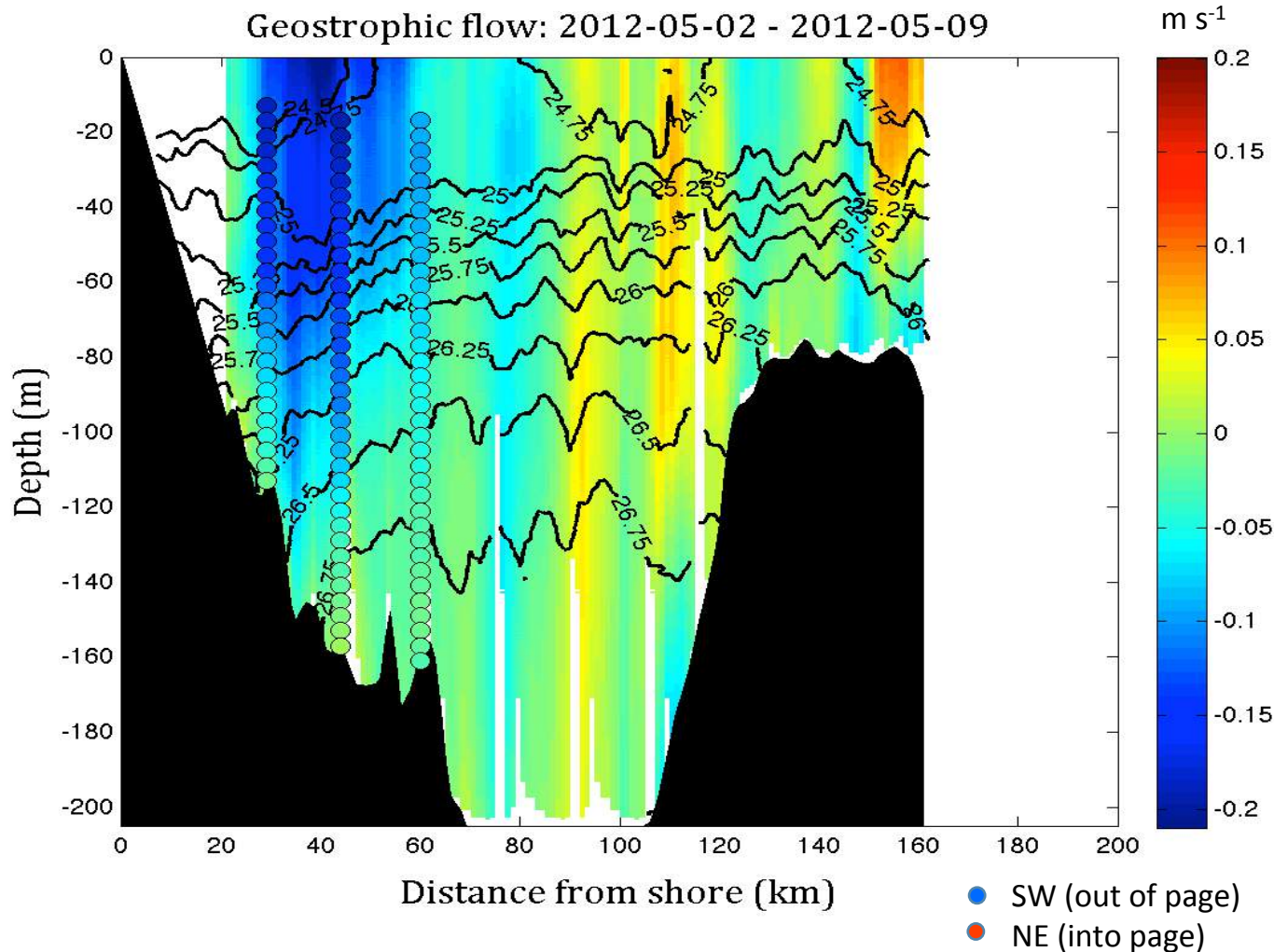
AZMP Halifax Glider Transects: High Resolution Hydrography



- Cold and fresh water inshore associated with the Gulf of St. Lawrence water is visible
- Cold Intermediate Layer spatial coverage documented

Dever M., Hebert D., Greenan B.J., Sheng J. and Smith P.C. (in press). Hydrography and coastal circulation along the Halifax Line and the connections with the Gulf of St Lawrence. *Atmosphere-Ocean*

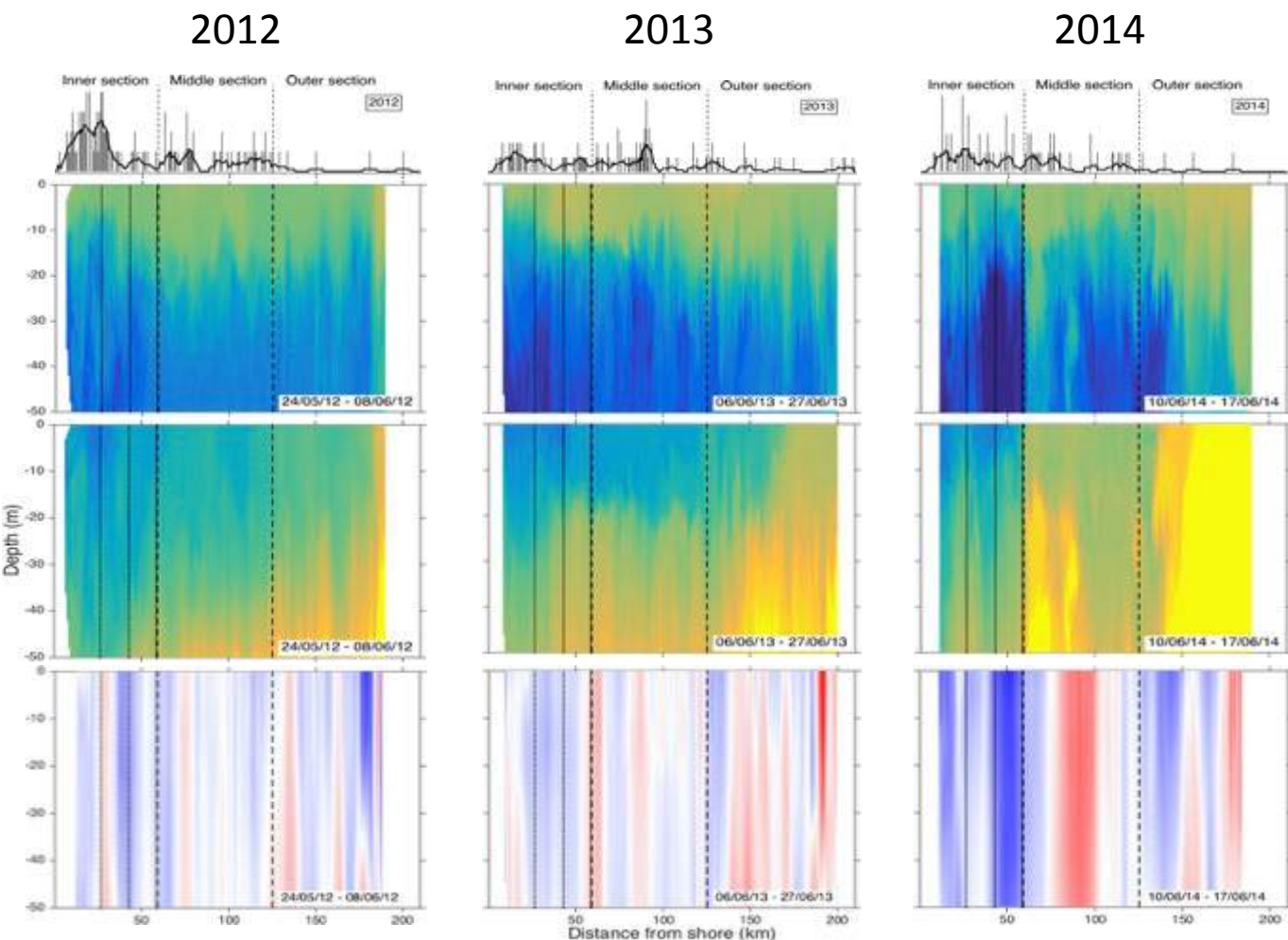
Calculating Ocean Currents from Gliders



- Glider-derived density (black isolines) combined with glider drift allows the calculation of cross-track geostrophic currents (colour shading).
- Estimated currents across the Halifax Line were compared to *in situ* ADCP measurements (coloured circles)

Dever M., Skagseth Ø., Drinkwater K. and Hebert D. (submitted). Improved method to characterize coastally-trapped, buoyancy-driven currents: A comparison between the Nova Scotia Current and the Norwegian Coastal Current. *Journal of Geophysical Research: Oceans*

Salmon Migration along the Scotian Shelf



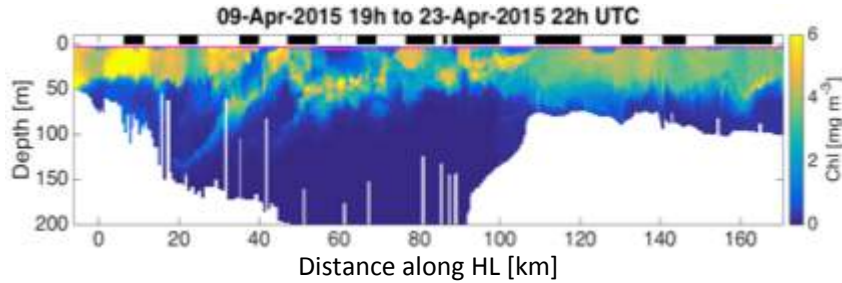
Detections
Temperature
Salinity
Current velocity

- Multiple linear regression revealed Atlantic salmon postsmolts prefer colder and fresher water, with no preference for current strength or direction
- Glider data improves our understanding of salmon migratory behavior, key to the management of the species

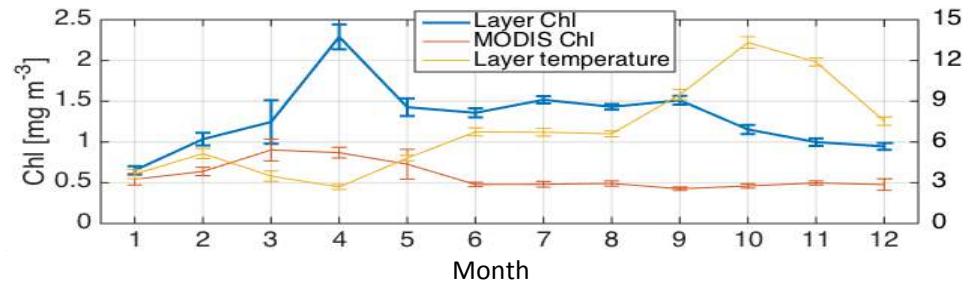
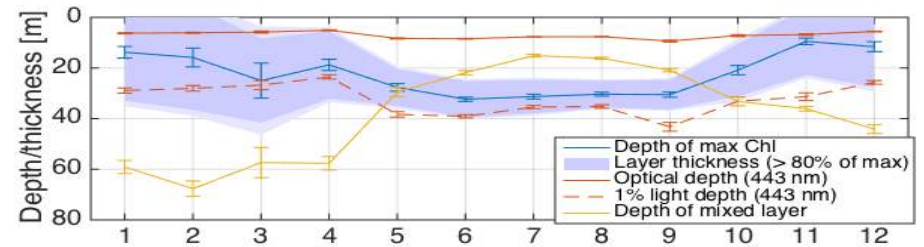
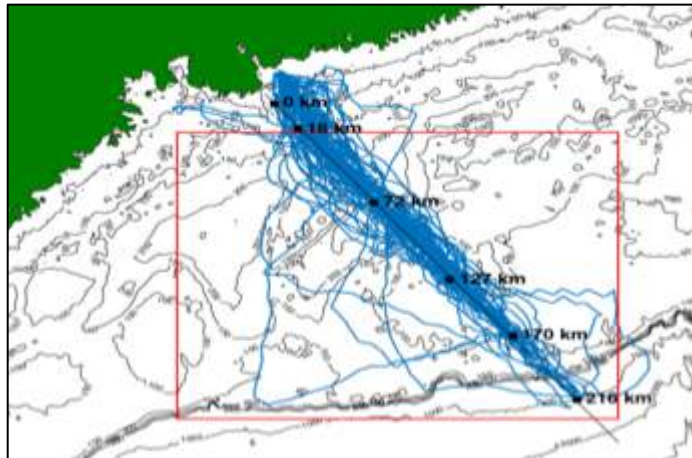
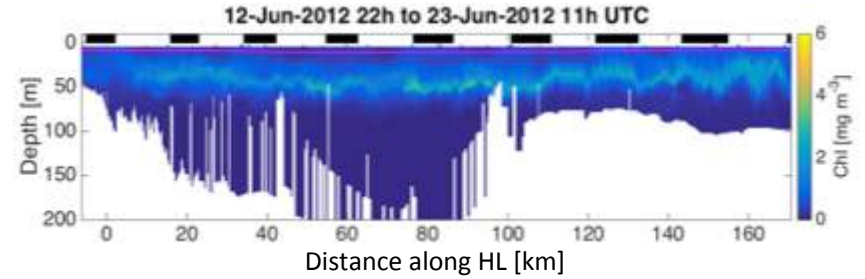
Dever M., Kocik J., Hebert D., Zydlewski J., Hawkes J., Stich D. (in prep.). Linkage Between Coastal Conditions, Detection Patterns and Migratory Behavior of Atlantic Salmon Smolts (*Salmo salar*) Along the Halifax Line.

Chlorophyll Dynamics on the Scotian Shelf

Spring bloom



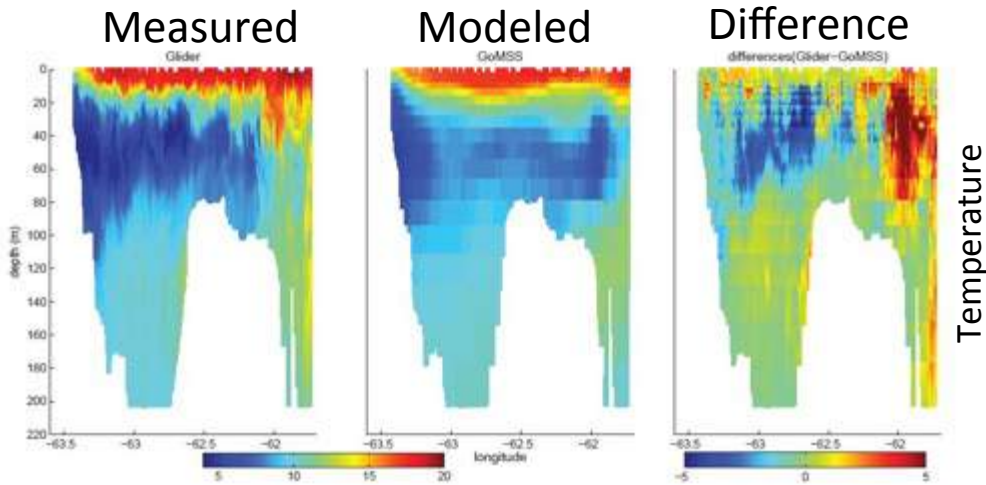
Summer subsurface chlorophyll layer



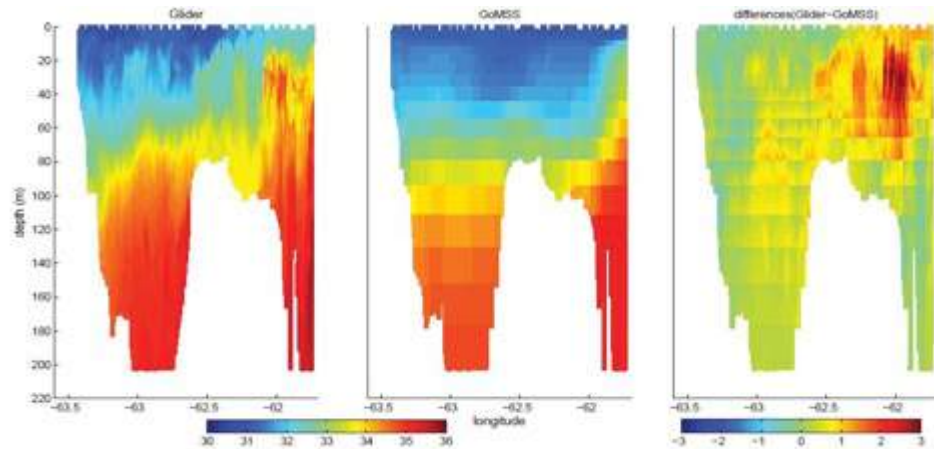
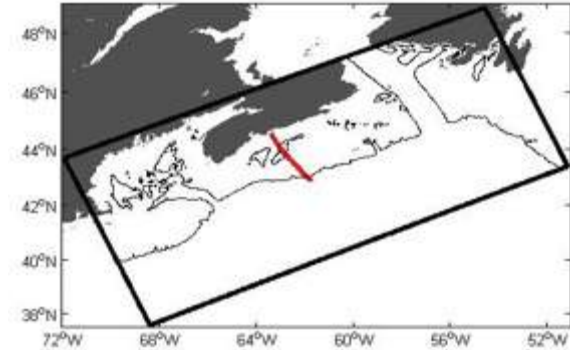
- Summer production not sensed by ocean colour satellites
- Spring bloom dynamics not fully predicted by critical depth hypothesis

Ross, T., S. Craig, A. Comeau, R. Davis, M. Dever, M. Beck. (In prep.) Blooms and subsurface phytoplankton layers on the Scotian Shelf: Insights from profiling gliders.

Validating a Newly Developed Regional Model



Temperature



Salinity

Glider observations were useful for validating GoMSS regional model, particularly:

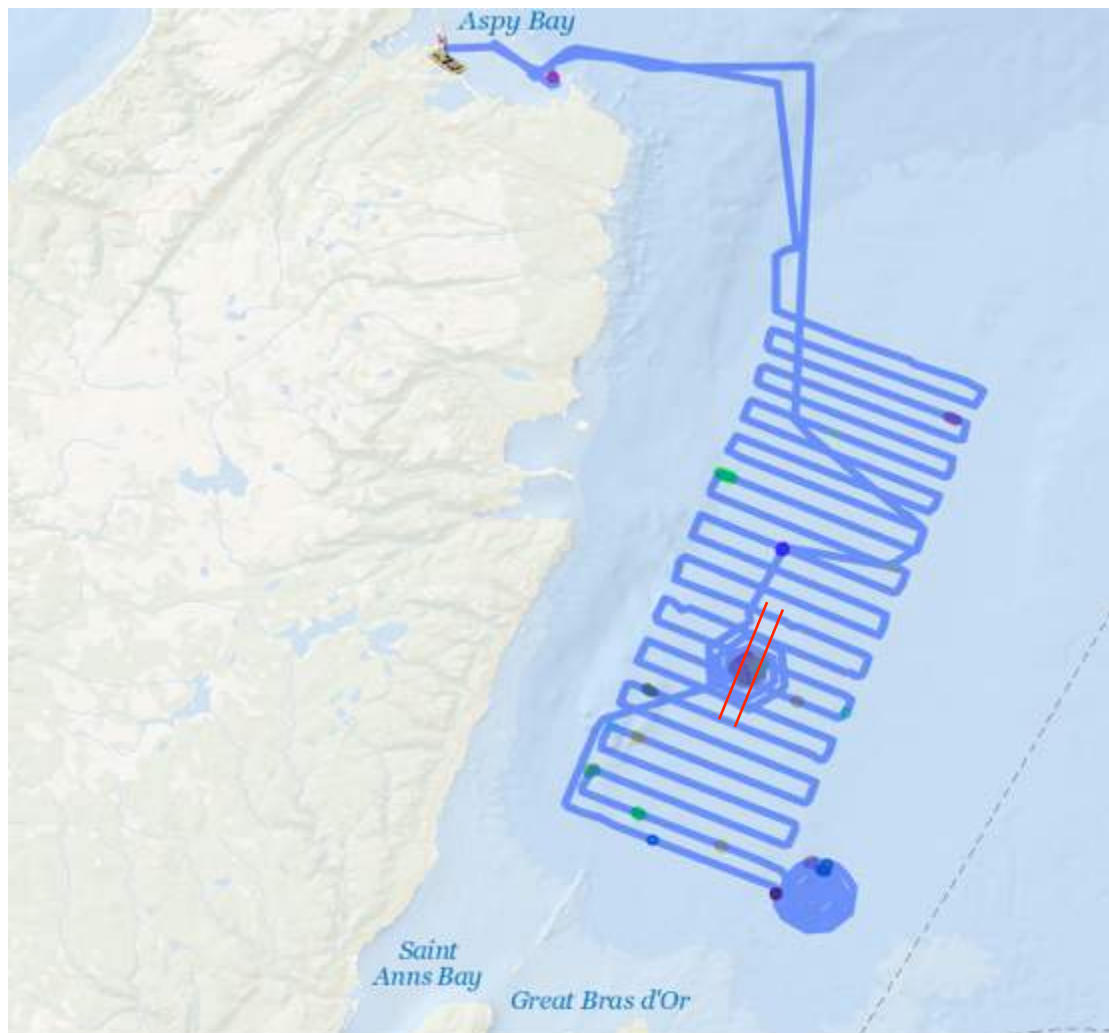
- Intrusion of cold water in intermediate depth
- Depth and structure of the surface mixed layer
- Thermocline depressions
- Position of water front between cold & fresh water on the shelf and warmer & saltier water offshore

Katavouta, A., *Non-linear coupling of scales of ocean variability and implications for downscaling*, Doctoral Thesis, Dalhousie University, 2015.

Katavouta, A., Thompson, K. R., Lu, Y., Loder, J. W., 2016. *Interaction between the tidal and seasonal variability of the Gulf of Maine and Scotian Shelf region*. Accepted to *J. Phys. Ocean.*

Katavouta, A., Thompson, K. R., 2016. *Downscaling ocean conditions with application to the Gulf of Maine, Scotian Shelf and adjacent deep ocean*. Accepted to *Ocean Modelling*.

Emera Maritime Link and Snow Crabs

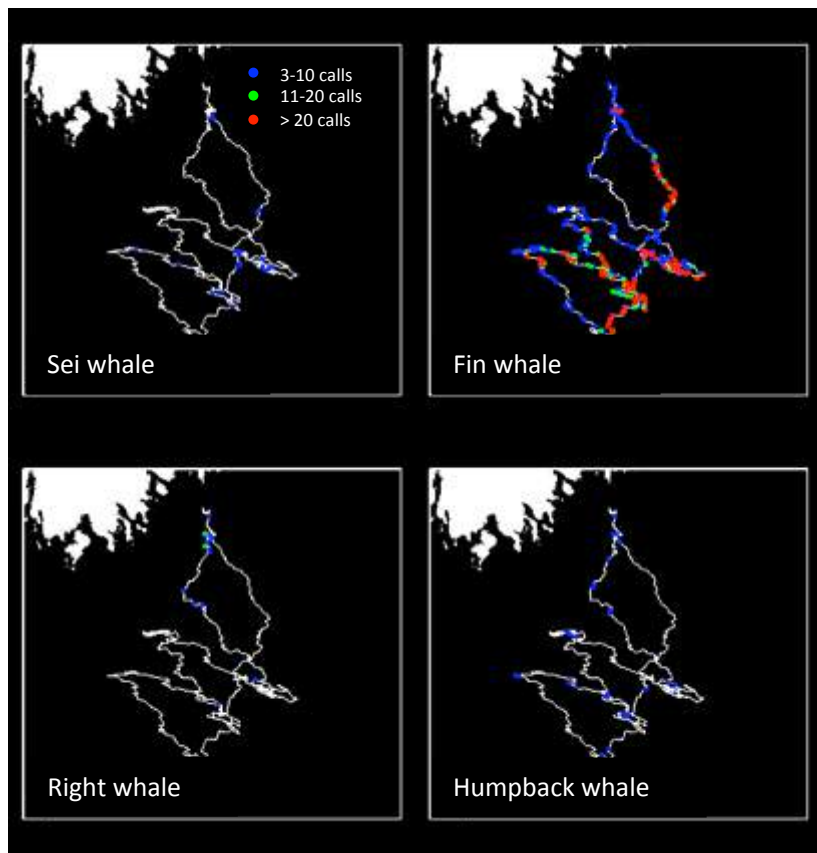


- Maritime Link is a power transmission line between NL and NS
- Emera NL has a monitoring program for snow crab that documents their habitats and behaviour before and after cable installation
- VPS array deployed for fine scale crab movements (shown as red lines)
- Wave glider surveys provide valuable data on medium and long range movements of snow crabs
- At least 15 of 48 animals were detected
- Emera NL intends to maintain a strong working relationship with OTN/MEOPAR



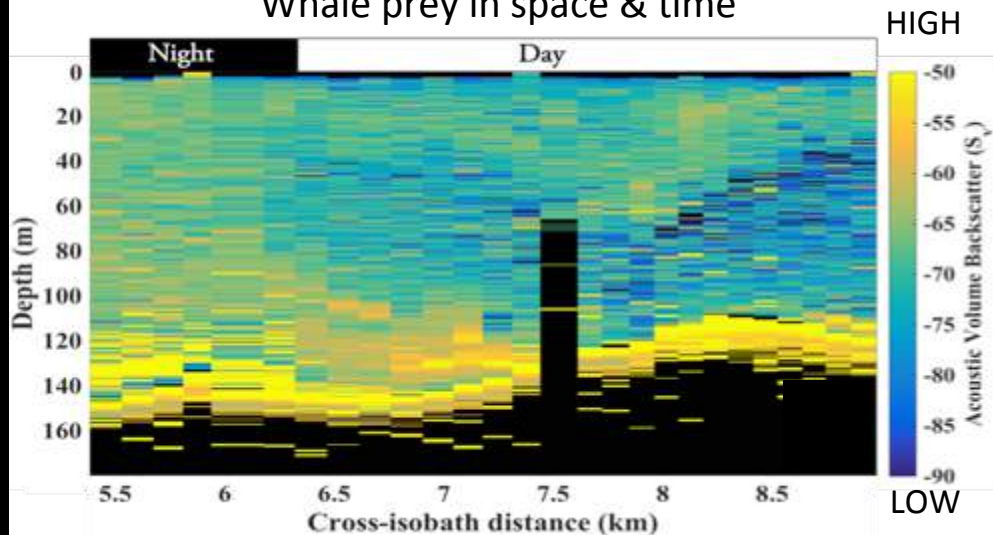
WHaLE: Locating Whales and Critical Habitats

Whales in space & time



- Glider detects whale sounds and prey
- Measure and model whale habitats on east and west coast of Canada

Whale prey in space & time

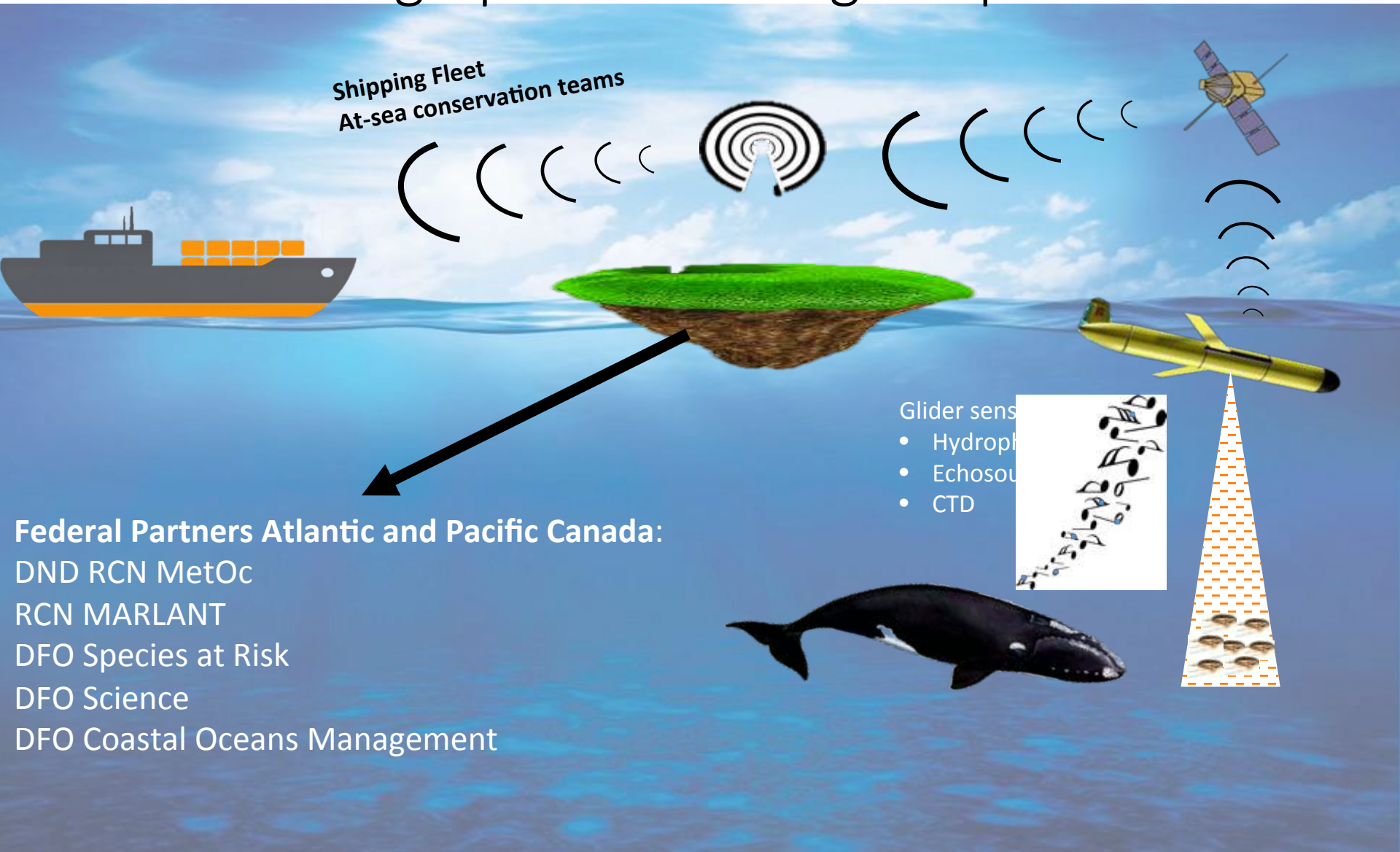


Zooplankton density in Roseway Basin

Whale calls recorded in Roseway Basin
in collaboration with WHOI



Communicating real-time whale locations & oceanographic knowledge to partners



GIII: Gliders International, Industry, and Integration

- International

- Gliderpalooza

- 18 institutions, 36 gliders from Gulf of Mexico to Newfoundland
 - weather forecasting, ocean modeling, hurricane dynamics, animal tracking

- US IOOS Integration

- data management
 - QC of real-time glider data

- Private Industry

- Emera NL

- Hydrophone manufacturers (GTI, Jasco, Ocean Sonics, Turbulent Research)

- Ocean Gliders Canada

- Pan-Canadian Community of Practice to facilitate glider operations

Thank you!!

