4.10. Fish and marine mammal interactions in the high Arctic

Silviya Ivanova[1], Steven T. Kessel[1], Svein Vagle[3], Mario Espinoza[2],

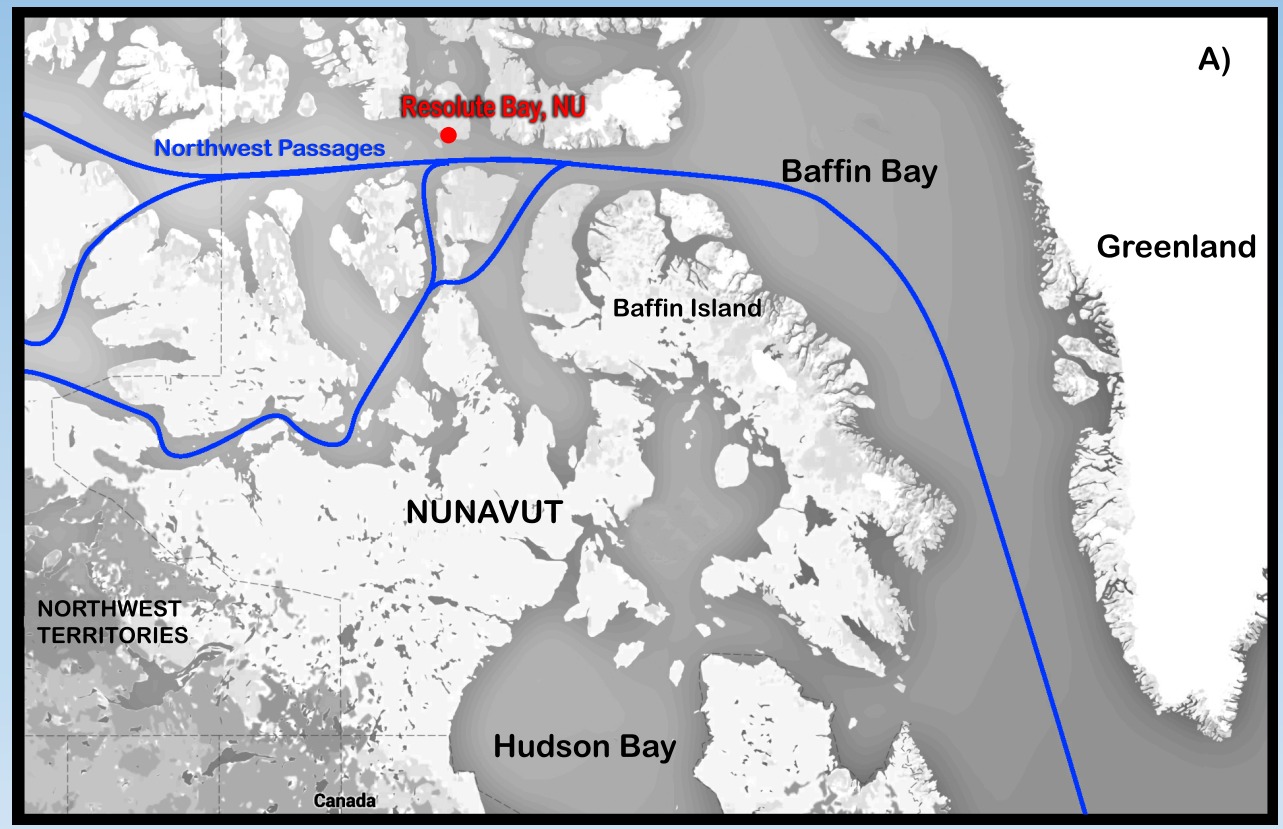
Montana McLean[5], Caitlin O'Neill[4], Justin Landry[1], Nigel E. Hussey[1], David Yurkowski[1], Aaron T. Fisk[1].

[1]Great Lakes Institute for Environmental Research, University of Windsor. [2] University of Costa Rica [3] Institute of Ocean Sciences, Fisheries and Oceans Canada. [4] School of Earth and Ocean Sciences, University of Victoria [5] Biology Department, Dalhousie University

Objectives

- Gain understanding of the high Arctic marine ecosystem
  - Movement of fishes
  - Anthropogenic disturbance
  - Movement of marine mammals
  - Oceanography variables

- Study site
  - Resolute, Nunavut



Species

- Arctic cod (*Boreagadus Saida*)
- Shorthorn Sculpin (*Myoxocephalus scorpius*)
- Ringed seals (*Pusa hispida*)

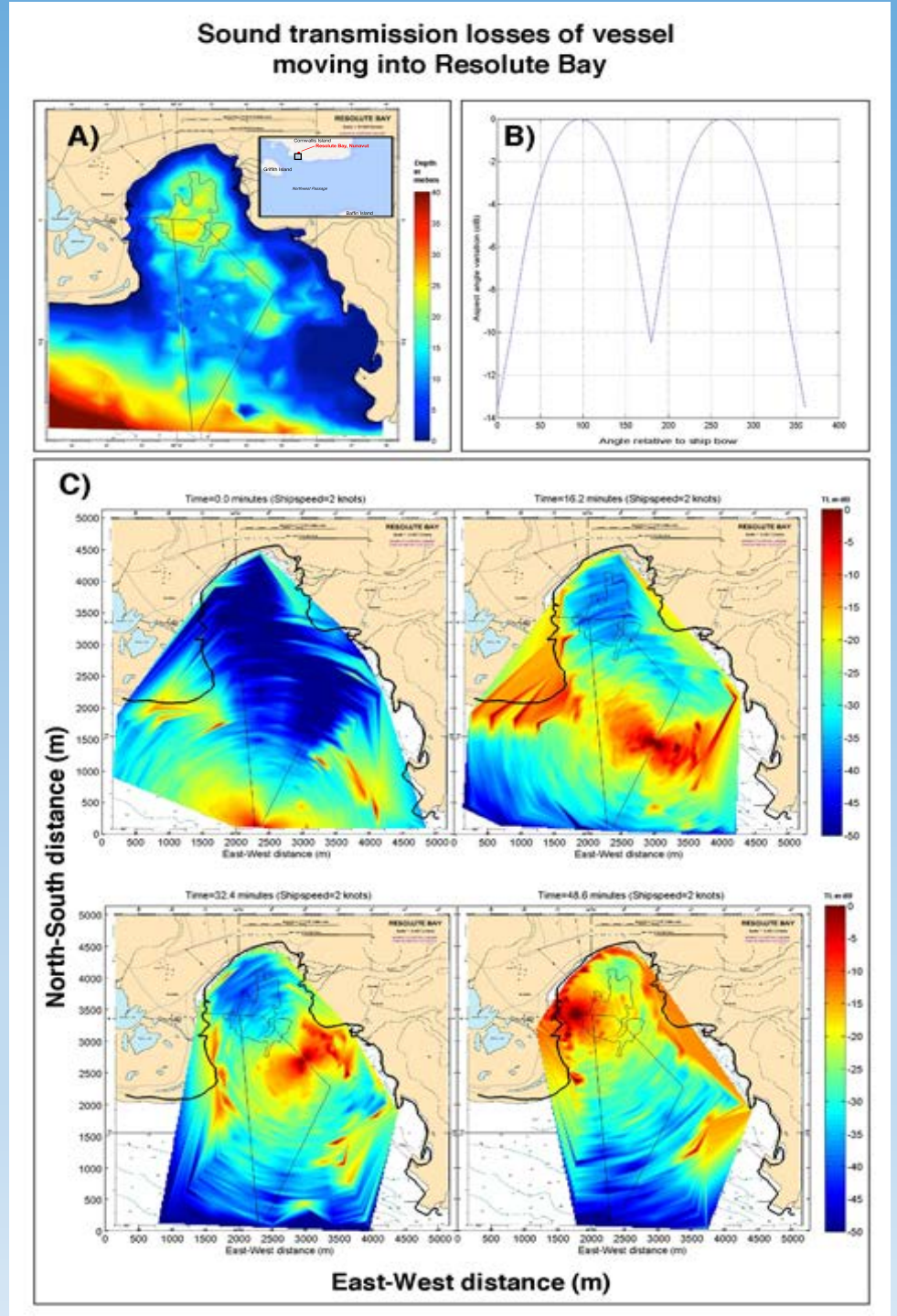
Sources: http://www.arcodiv.org/Fish/Boreogadussaida.html,

http://rybalka.ru/riba/kerchak-evropeiskii

http://cetus.ucsd.edu/voicesinthesea_org/species/pinnipeds/ringedSeal.html

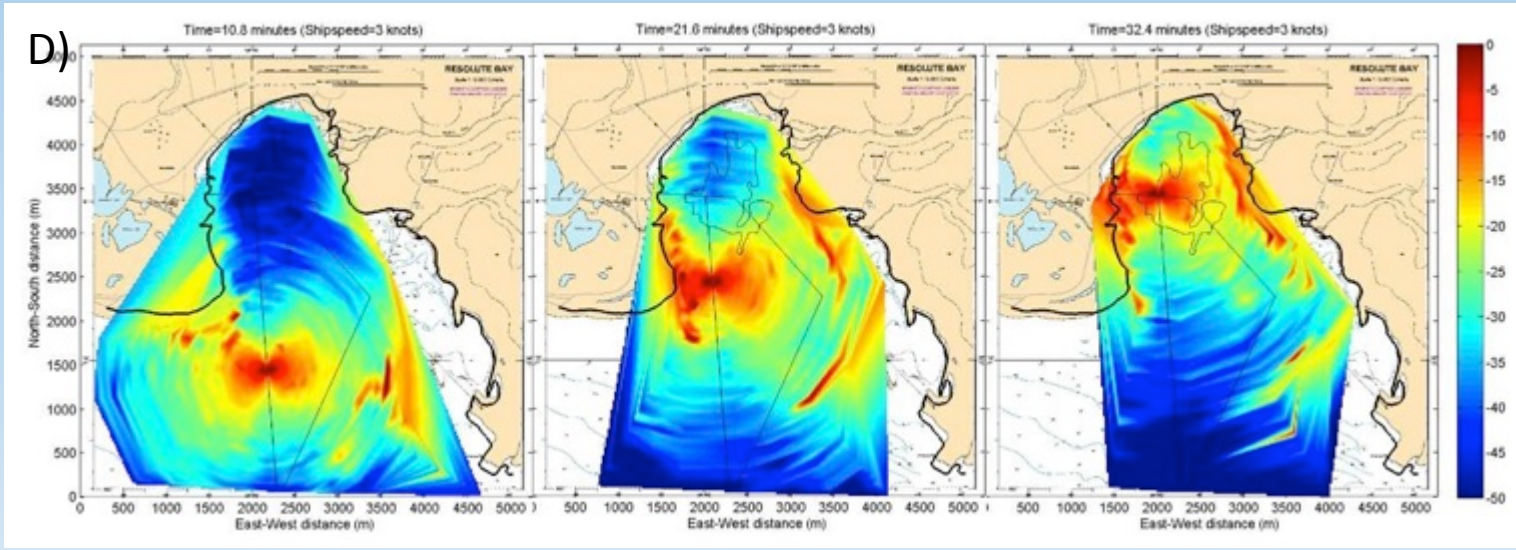
Sub-project 1:
Anthropogenic disturbance & Arctic cod

Silviya Ivanova



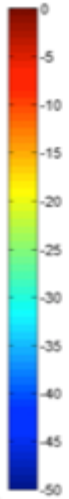
1: Sound transmission losses

- A) Bathymetry of Resolute bay
- B) Noise-field directionality around a ship (bow - 0 and 360 degrees; behind - 180)
- C) Sound Transmission Losses (TL) along the eastern lane (cargo and fuel vessels)
- D) Sound TL along the western lane (passenger vessels)

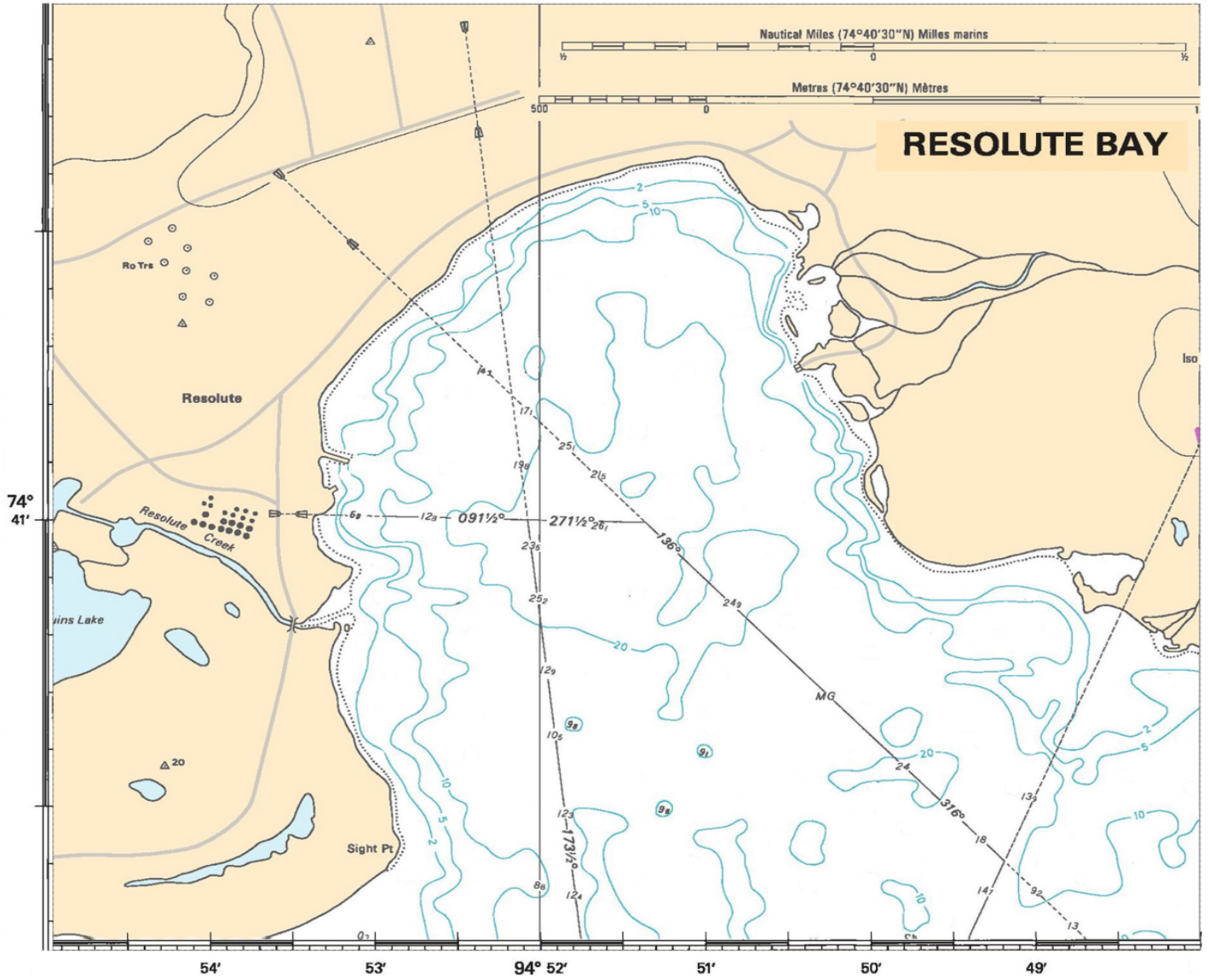


1: Arctic cod Population Home Ranges

Noise level scale (in dB):



Note: levels below -18dB were removed



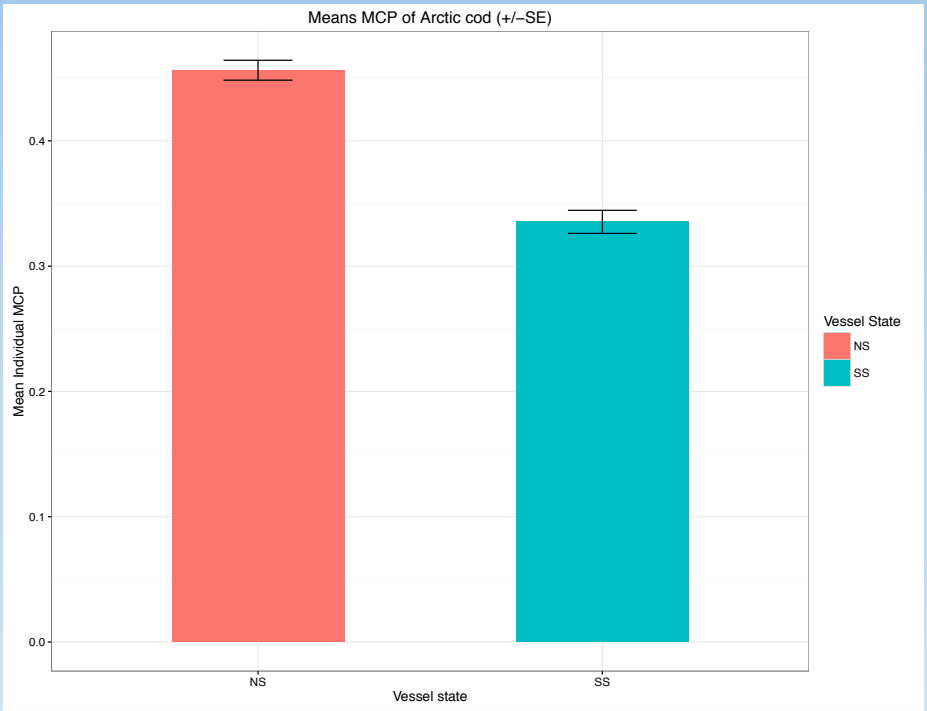
Hurlbert's index of overlap (0=no overlap; 1=complete overlap):

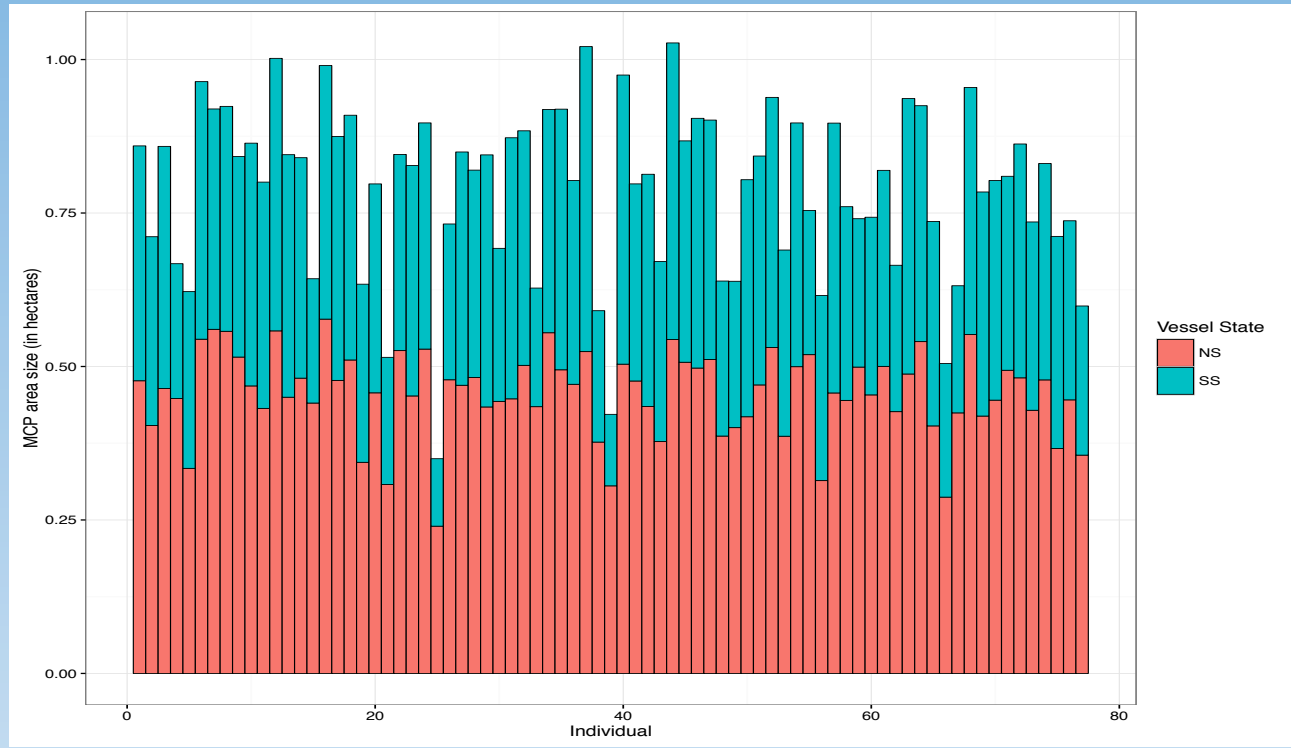
- No vessels (NS) vs Vessels present (SS)
  – 0.31 as population
  -- 0.24 mean for individuals

- No vessels (NS) vs Vessels moving (SM)
  – 0.48 as population
  -- 0.04 for individual # 821

1: Minimum convex polygon (MCP)

- Individual MCP
- Mean MCP



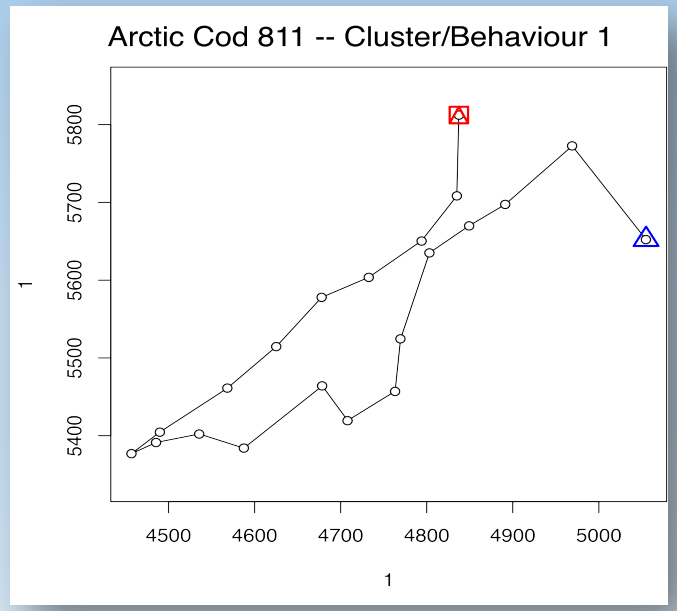


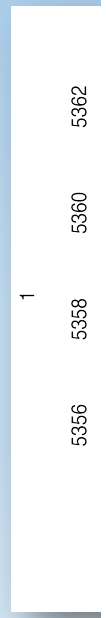
Vessels Absent (NS)

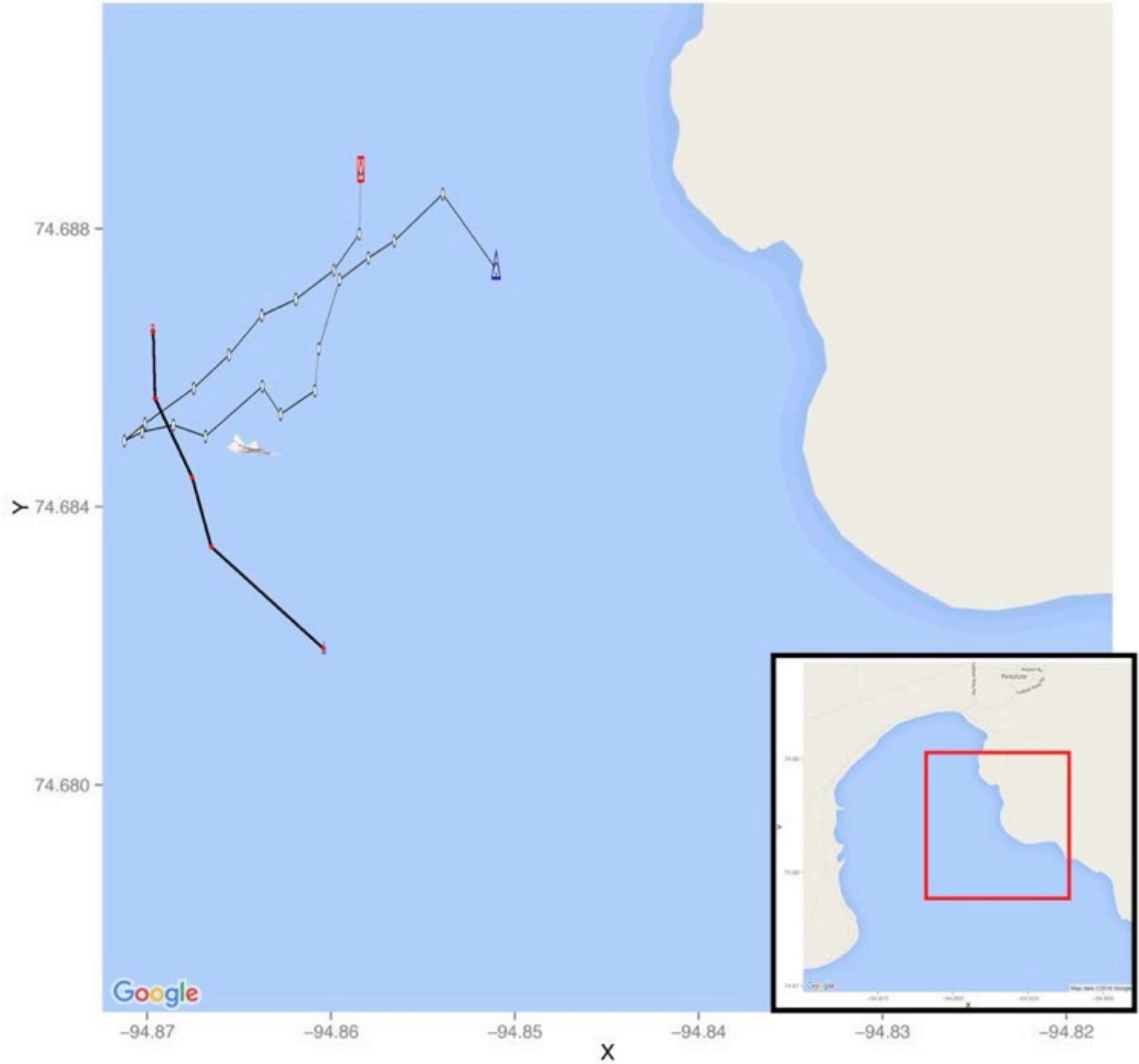
Vessels Present (SM)

1: Cod behaviours

- Three different behaviours
  - Mean Rate of movement (m
  - Mean turn angle
  - Sum of distance
  - Variance of distance

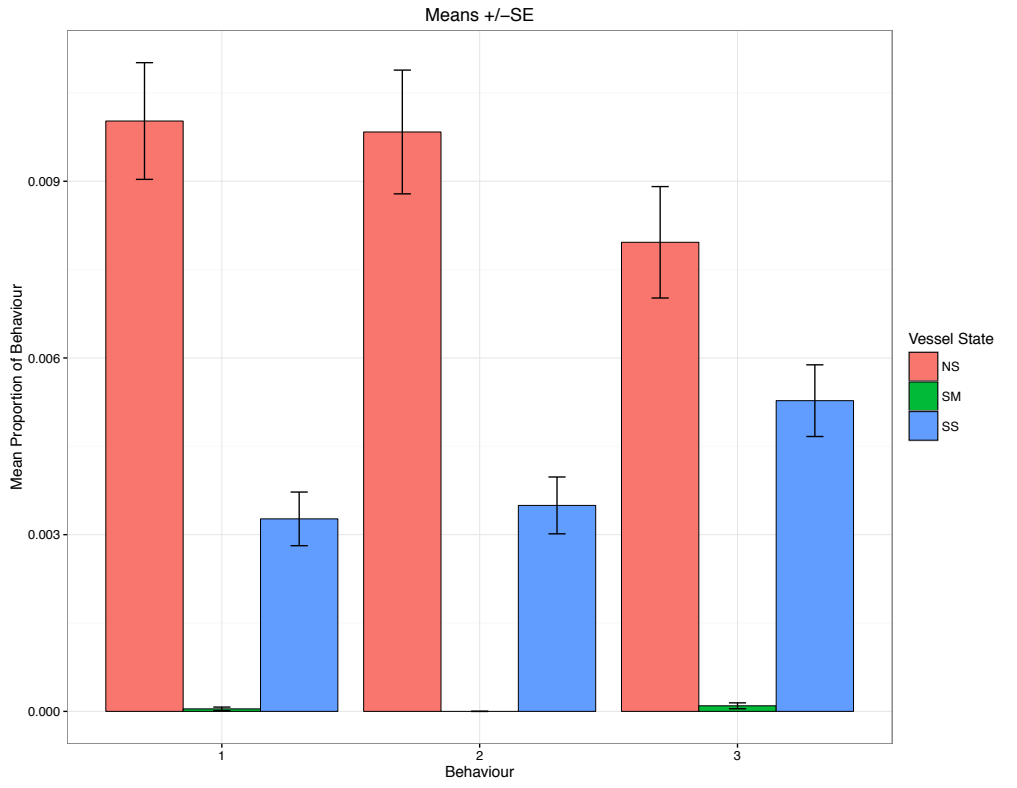




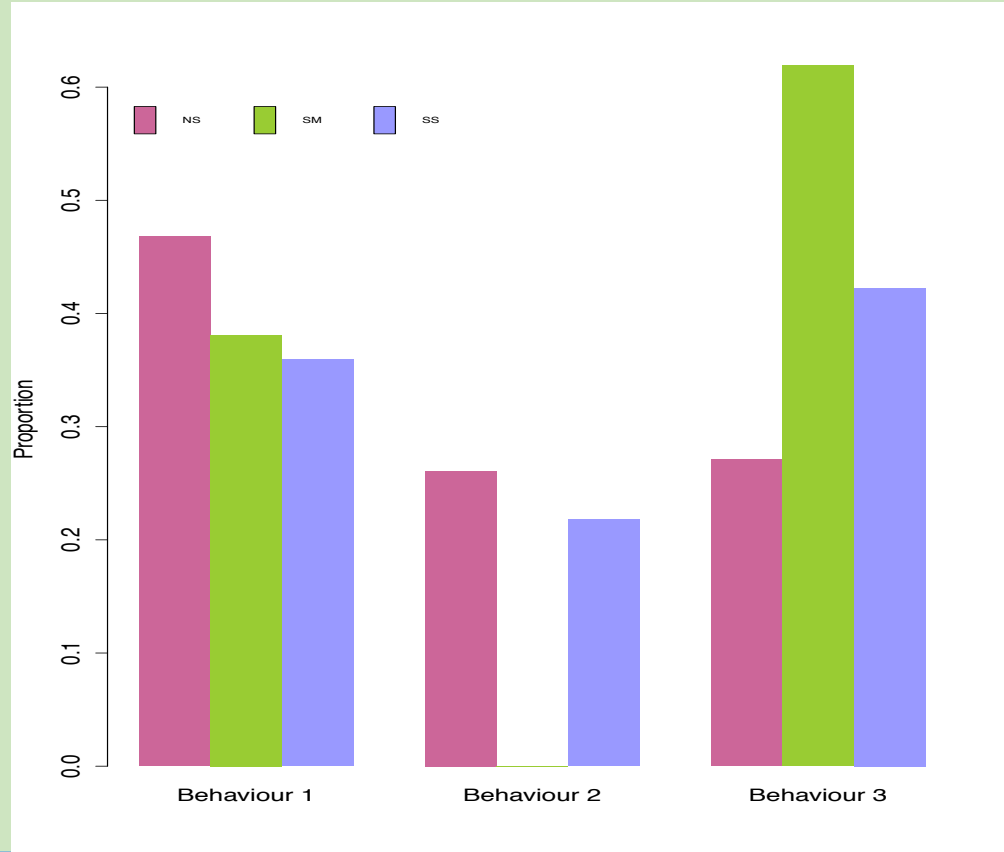


1: Behavior proportions

- Significant change in behavior proportions for all three behaviors in NS vs. SS
  - 1 (p-value<0.0001)
  - 2 (p-value<0.0001)
  - 3 (p-value=0.01831)



- Significant change in population behavior proportions for all three behaviors
  - NS vs SS (p-value<2.2e-16)
  - NS vs SM (p-value=0.0005)

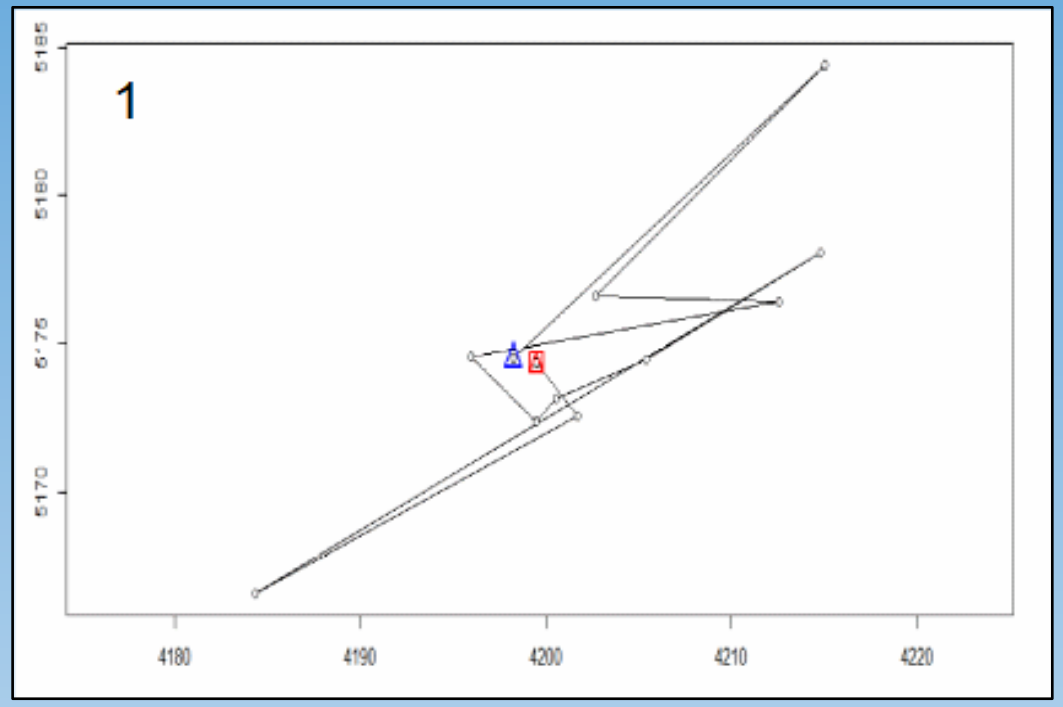


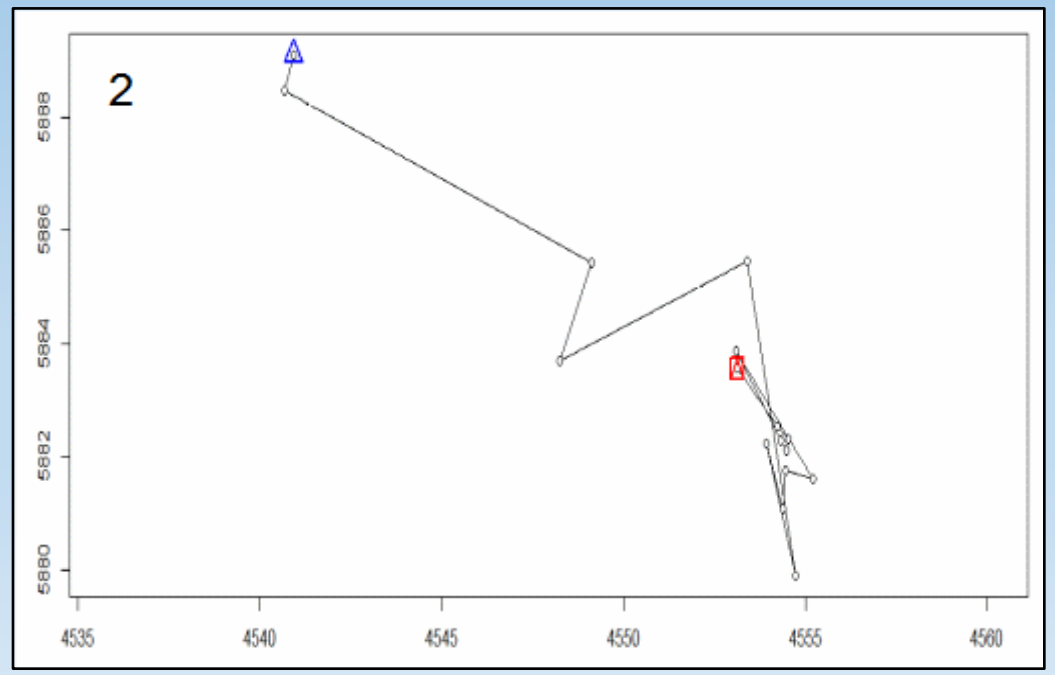
Sub-project 2:
Sculpin movements and trophic ecology

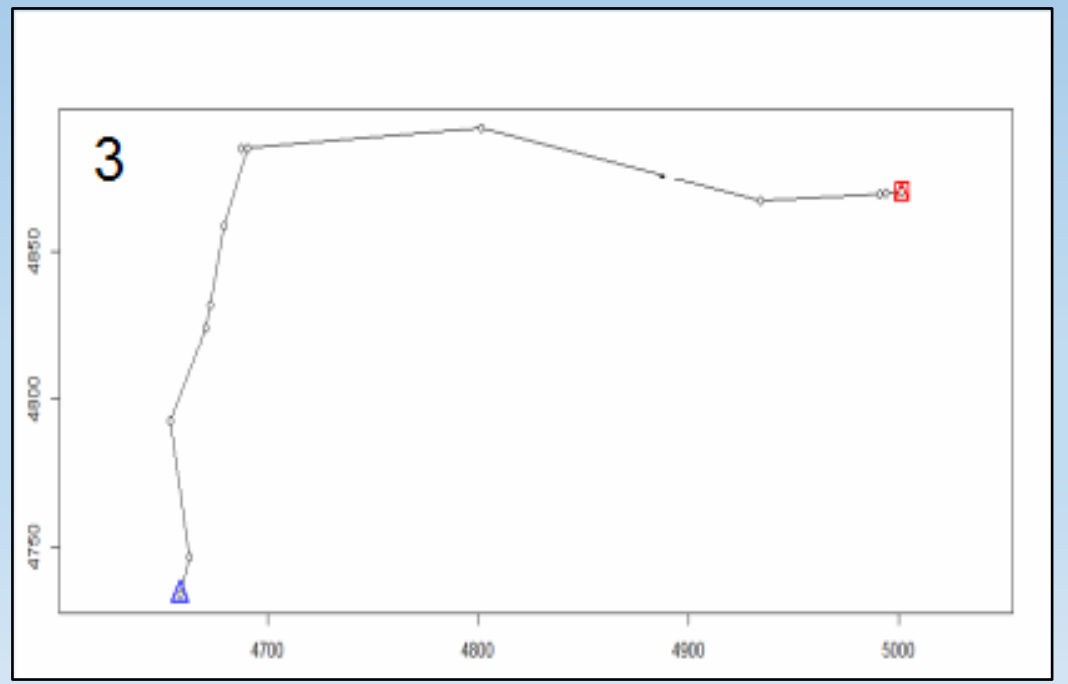
Justin Landry

2: Sculpin: behaviours

- Three different behaviours based on:
  - Mean Rate of Movement (m/s)
  - Mean depth (m)
  - Sum of distance (m)
  - Linearity ratio



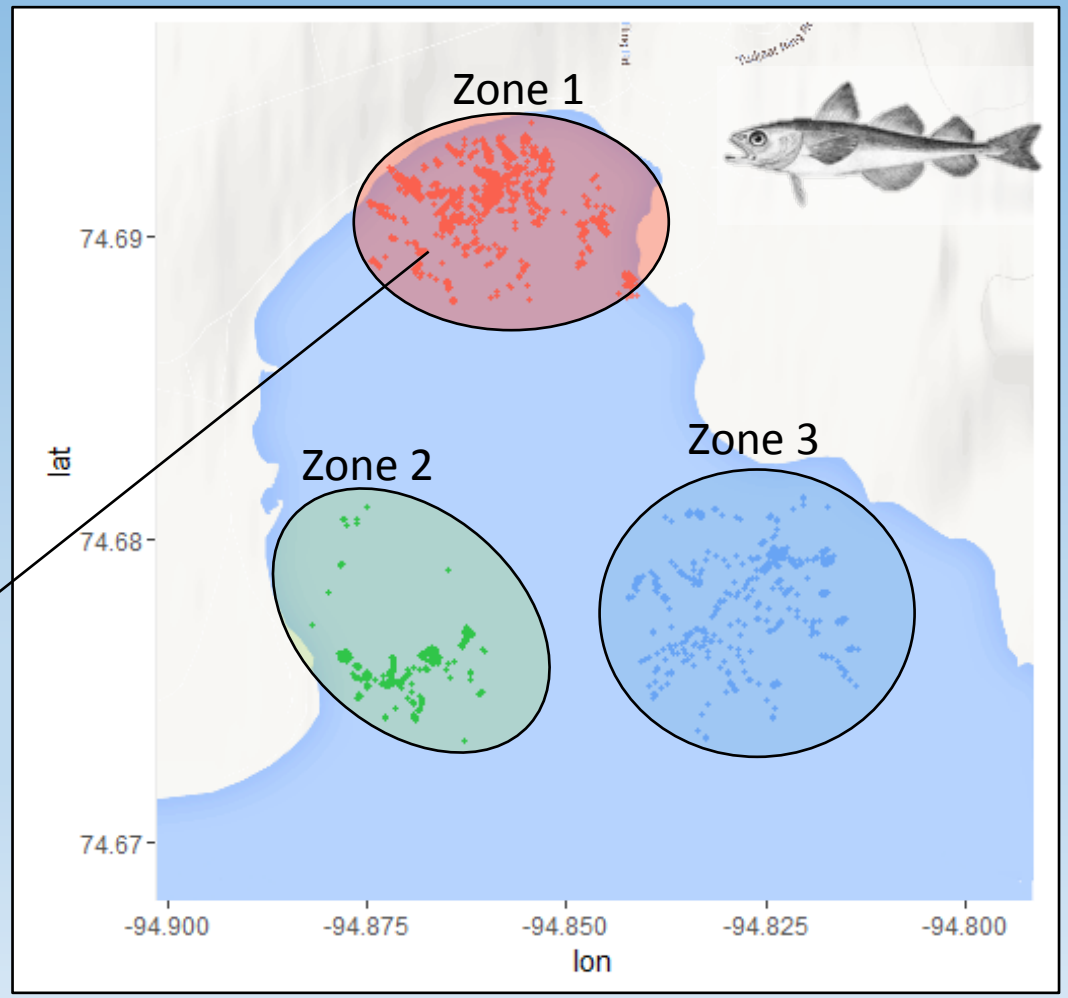




2: Sculpin behaviours & Arctic cod

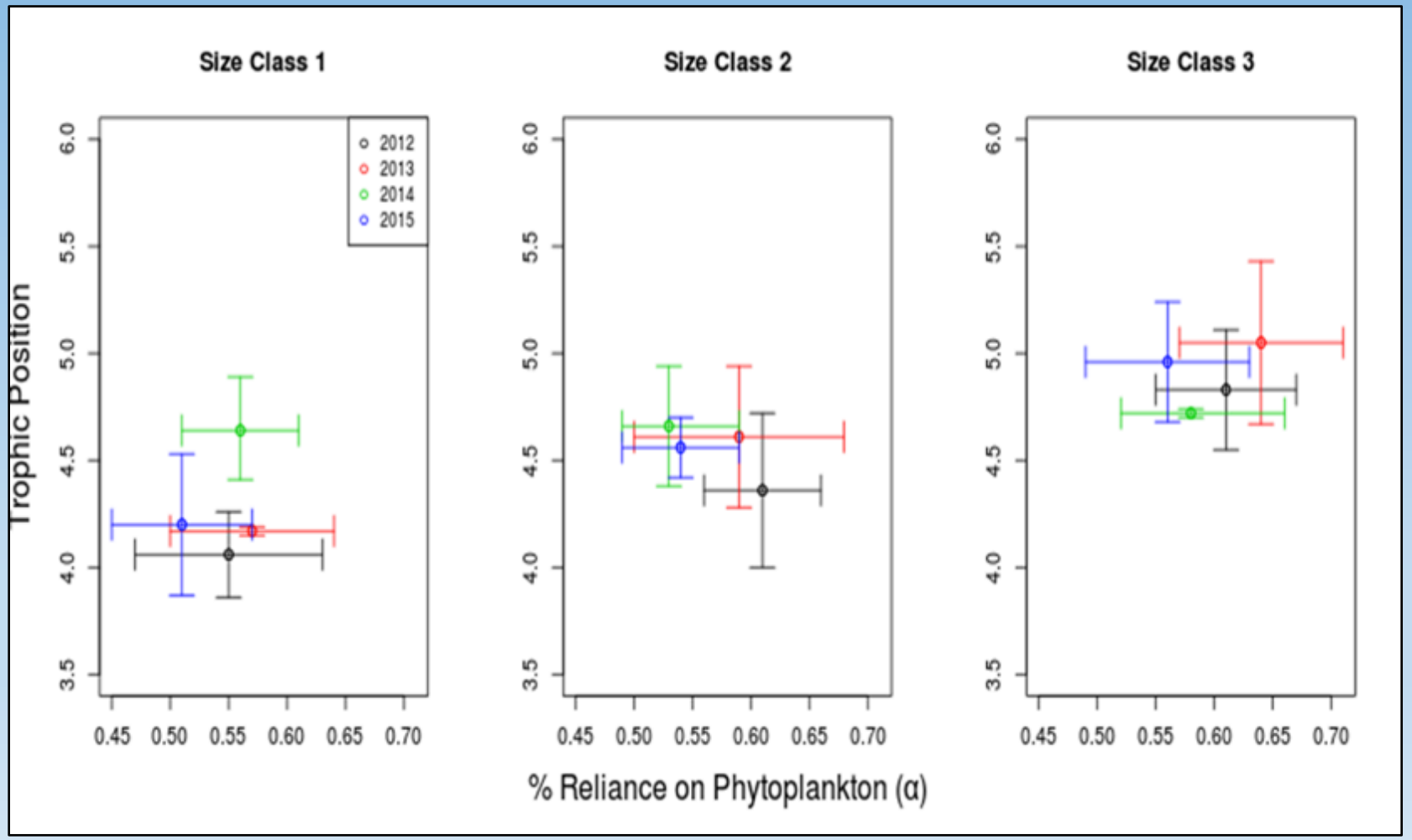
- Movement pattern (MP) 1 decreased significantly with increase in cod abundance & MP 2 increased in Zone 1
  - Explanation 1: feeding on cod
  - Explanation 2: competing with cod for another food resource

MP1: z value = -4.29, $p < 0.001$
MP2: z value = 2.15, $p < 0.05$

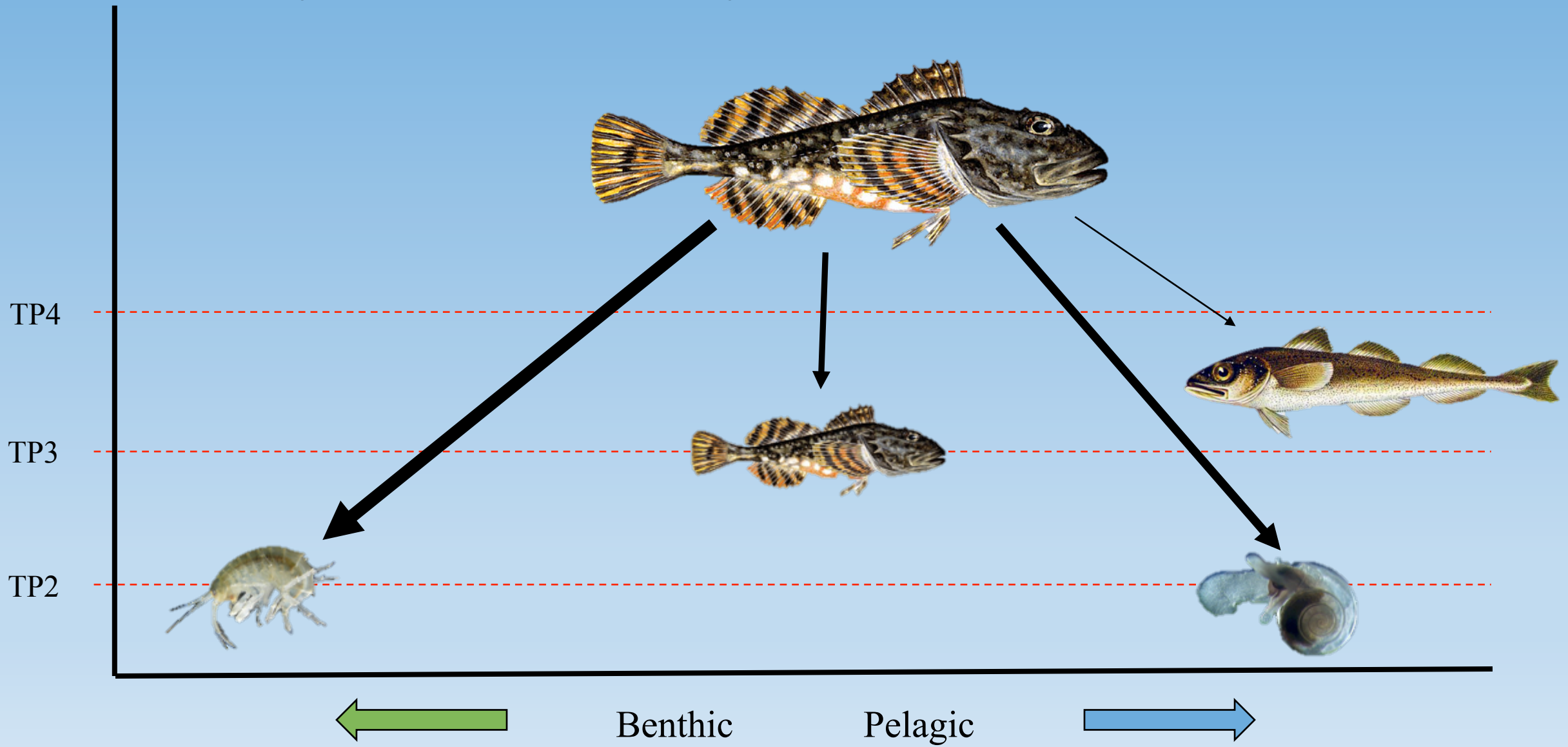


2: Stable Isotope and Stomach Content Analysis of Shorthorn Sculpin

- Trophic position increased significantly with size class, except 2014 (lack of piscivorous prey)
- Energy coupled from both benthic and pelagic sources (>50%)

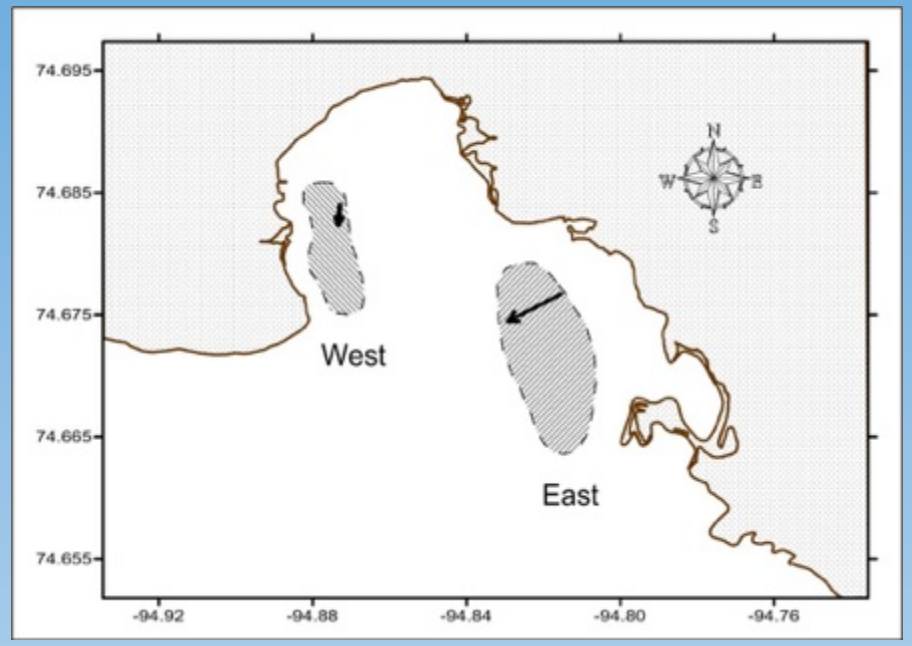


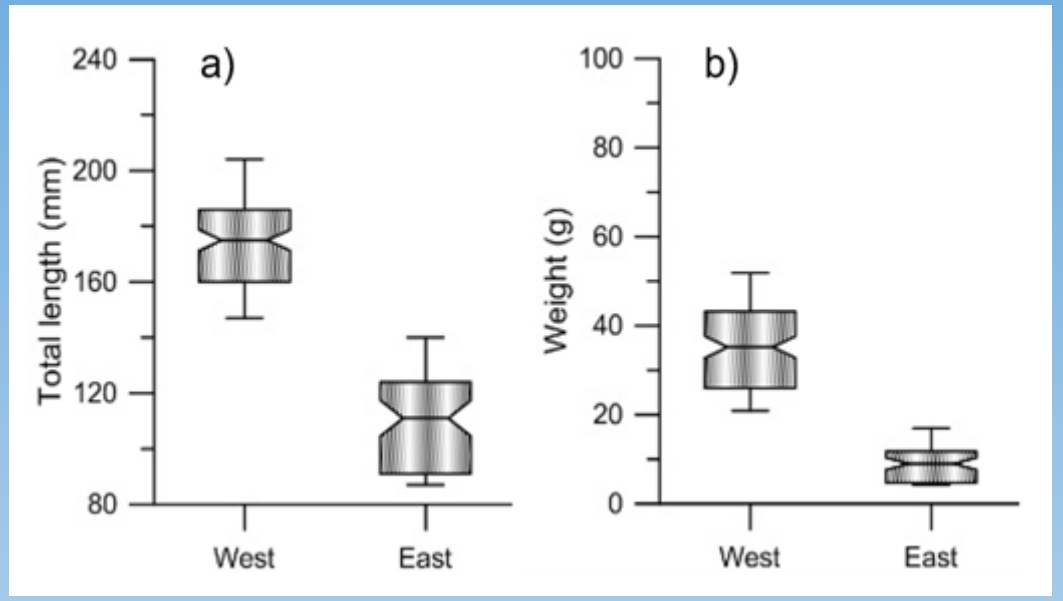
2: Sculpin Diet & simplified food web

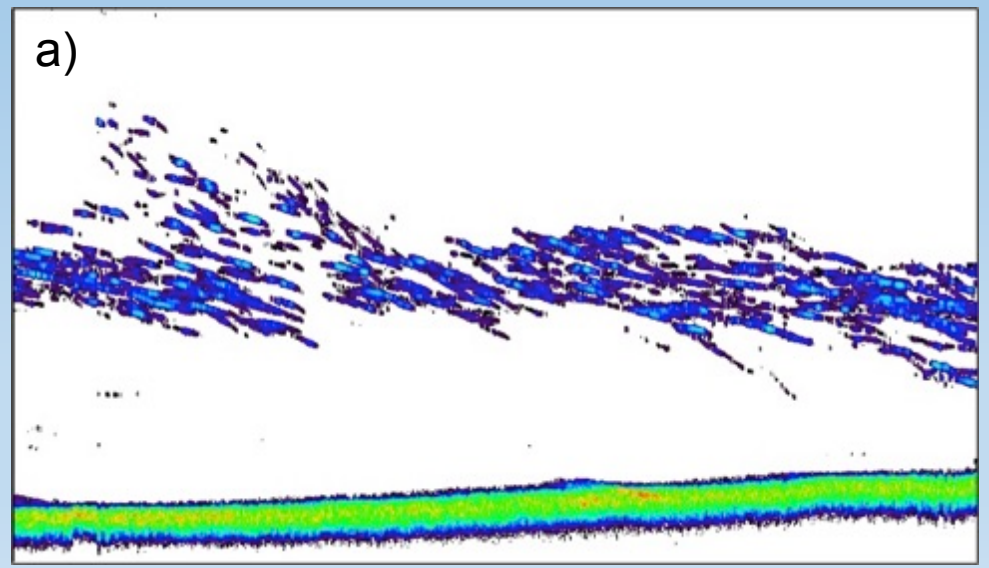


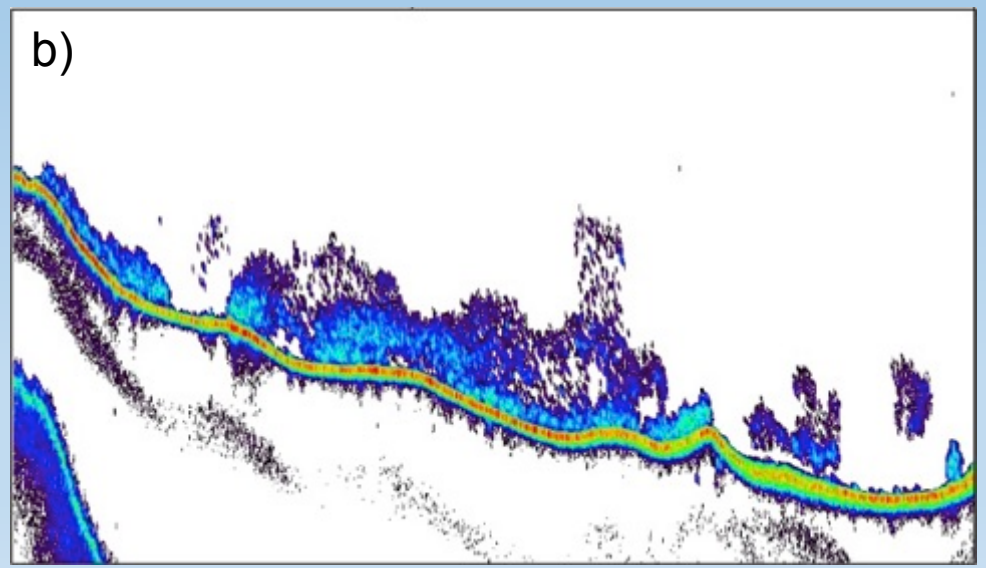
Sub-project 3:
Cod movements

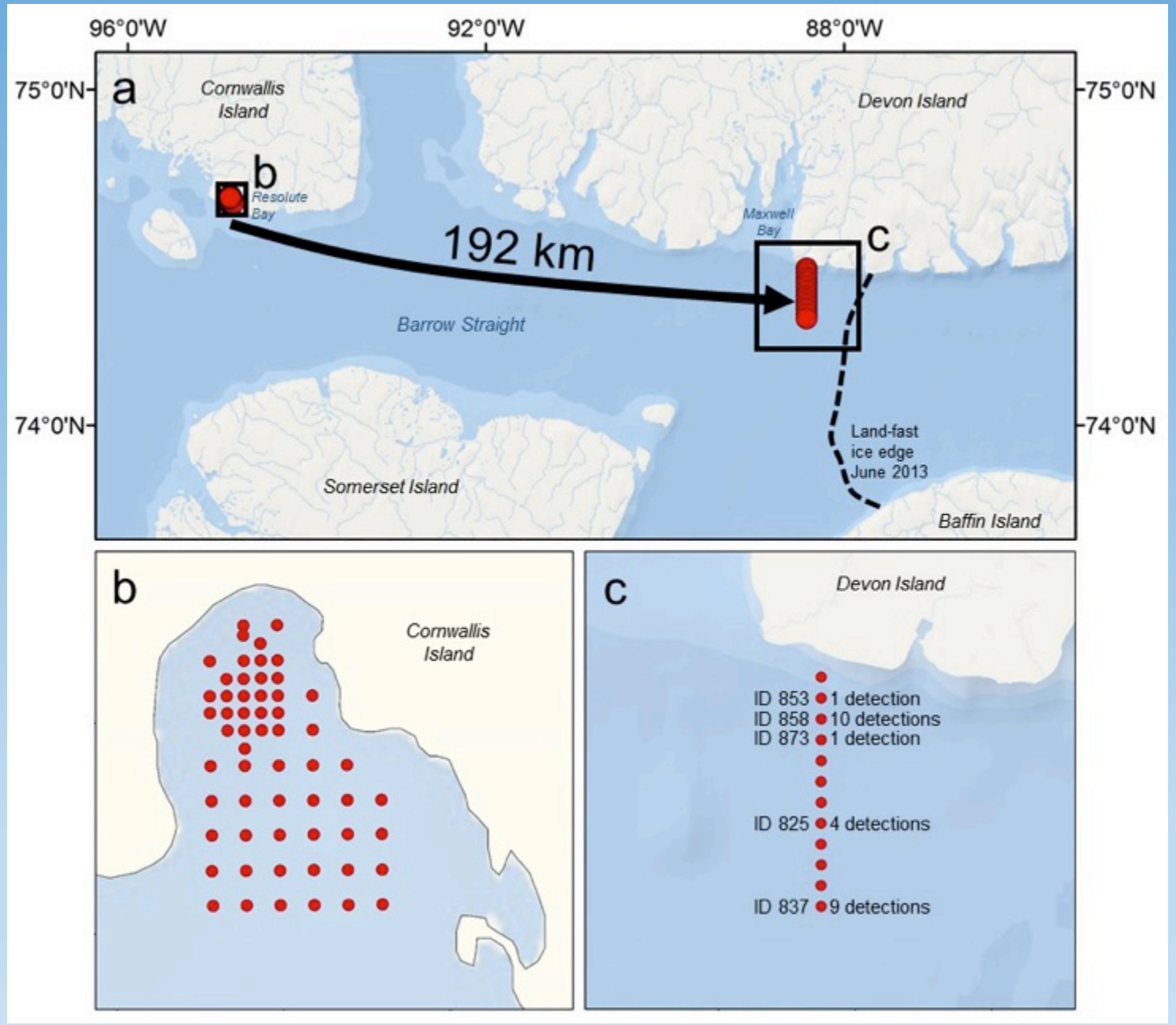
Steven Kessel


74.695
74.685
74.675
74.665
74.655
-94.92
-94.88
-94.84
-94.80
-94.76
West
East
N
W
E
S


a)
b)
Total length (mm)
240
200
160
120
80
Weight (g)
100
80
60
40
20
0
West
East
West
East


a)

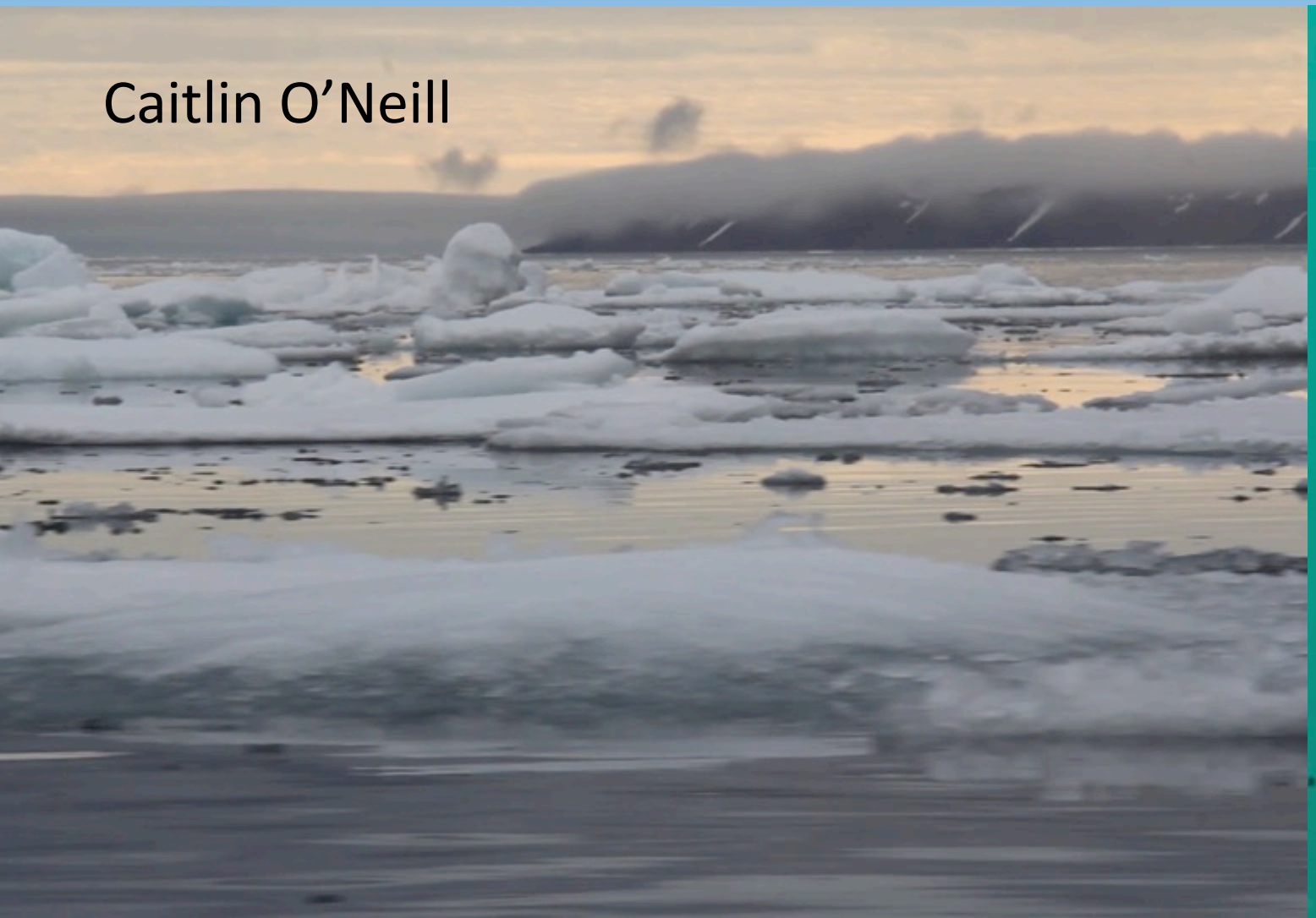

b)

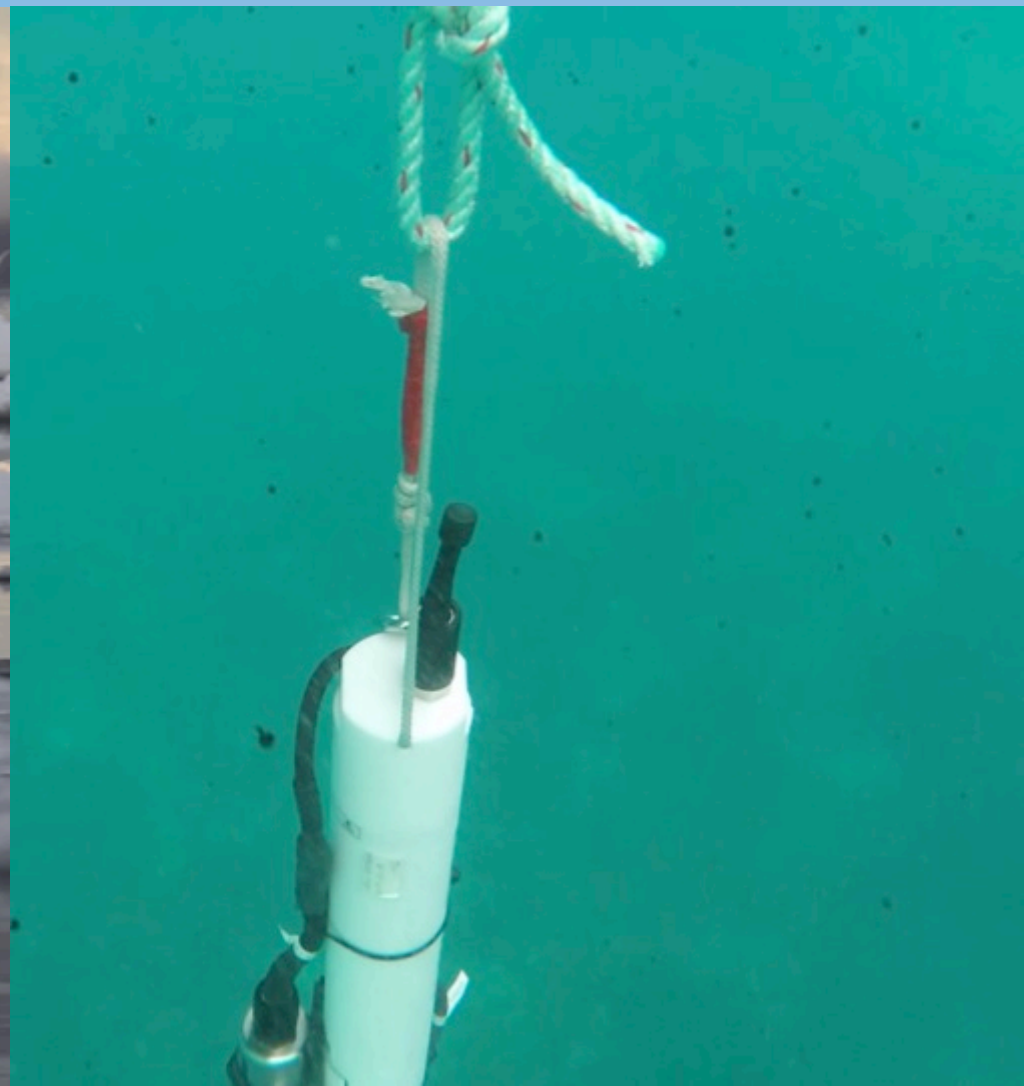


Kessel ST, Hussey NE, Crawford RE, Yurkowski DJ, Webber DM, Dick TA and Fisk AT (In Review) First documented large-scale horizontal movements of individual Arctic cod (*Boreogadus saida*). Canadian Journal of Fisheries and Aquatic Sciences.

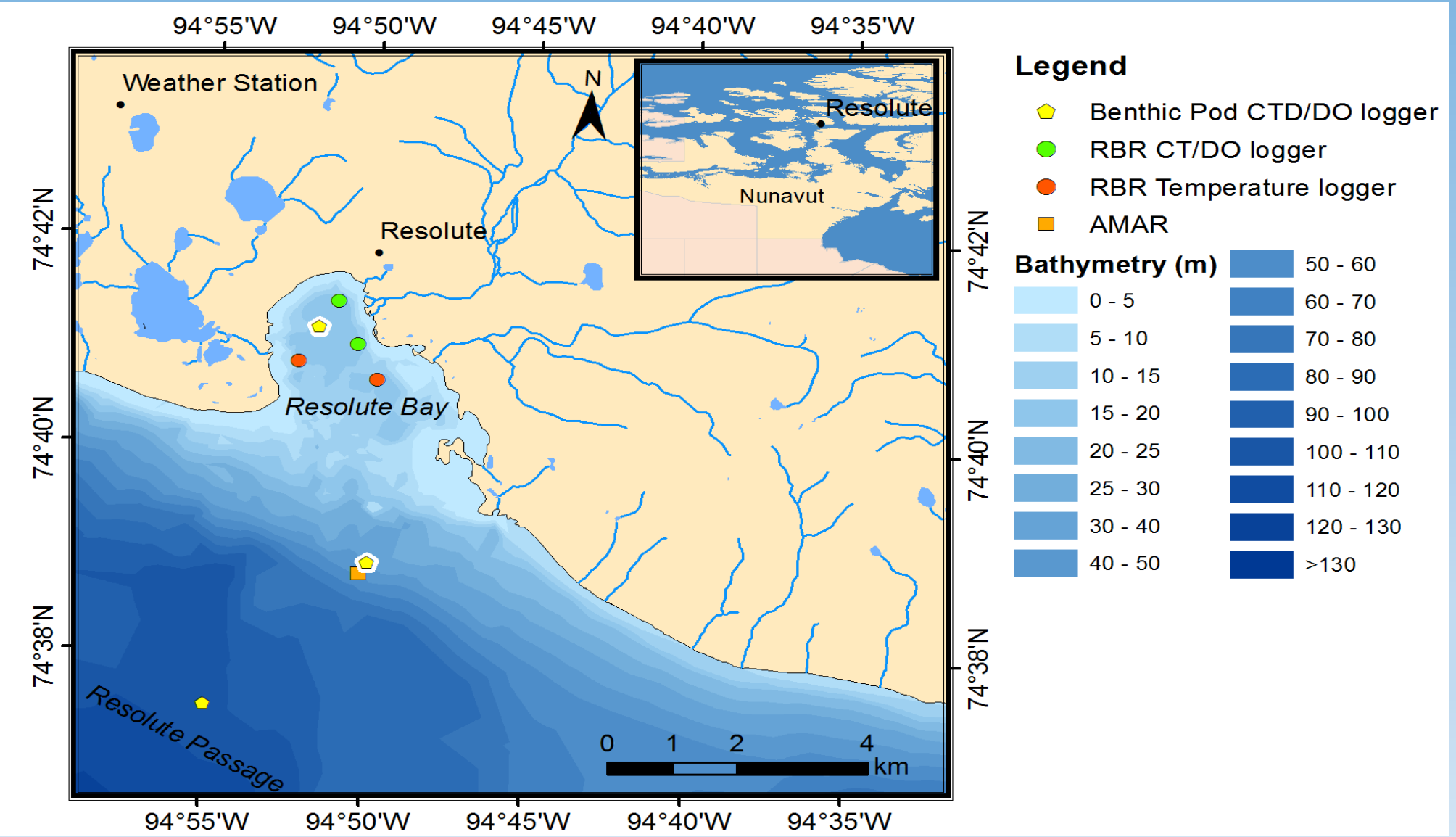
Sub-project 4:
Oceanography variables

Caitlin O’Neill

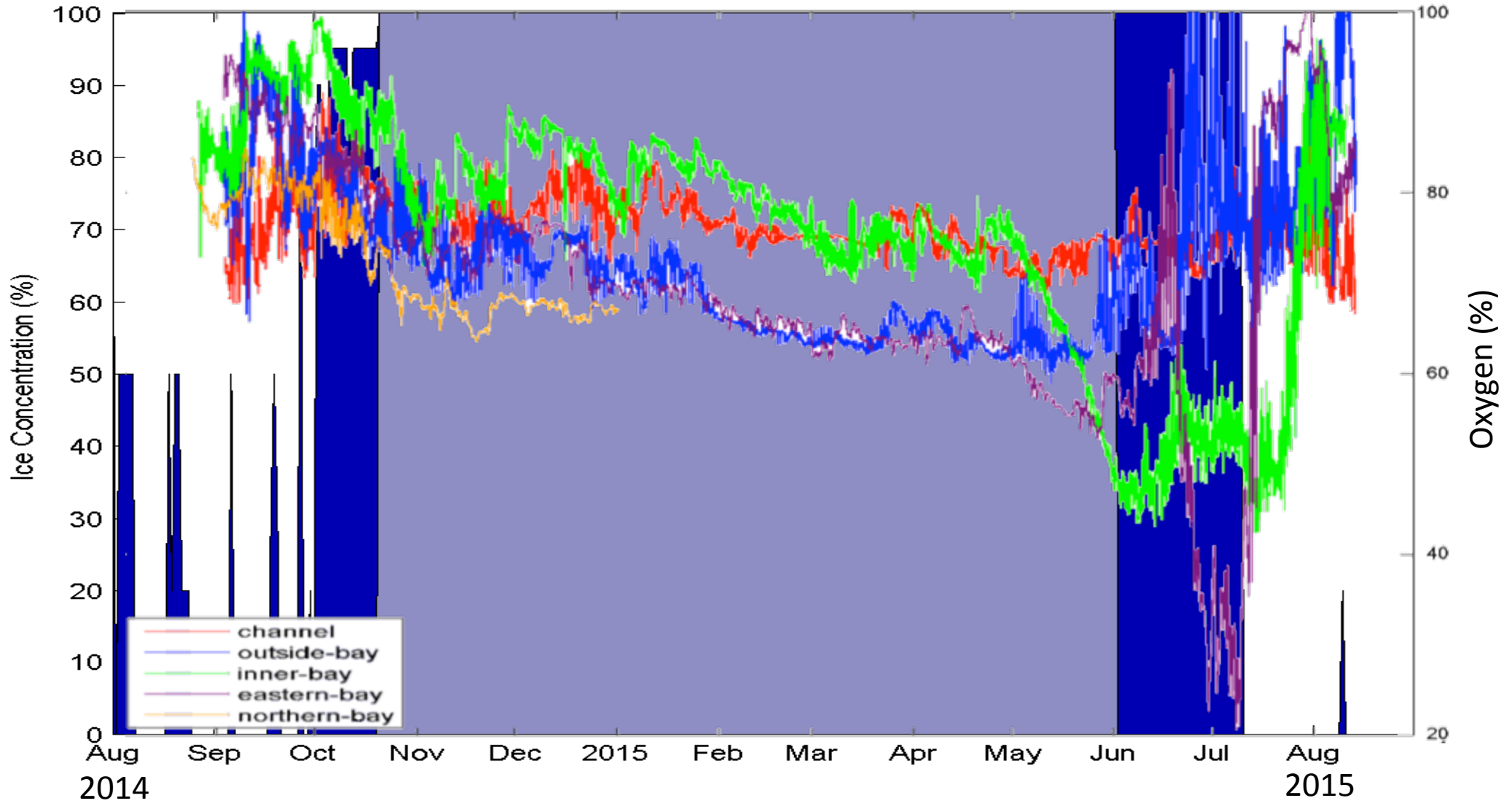




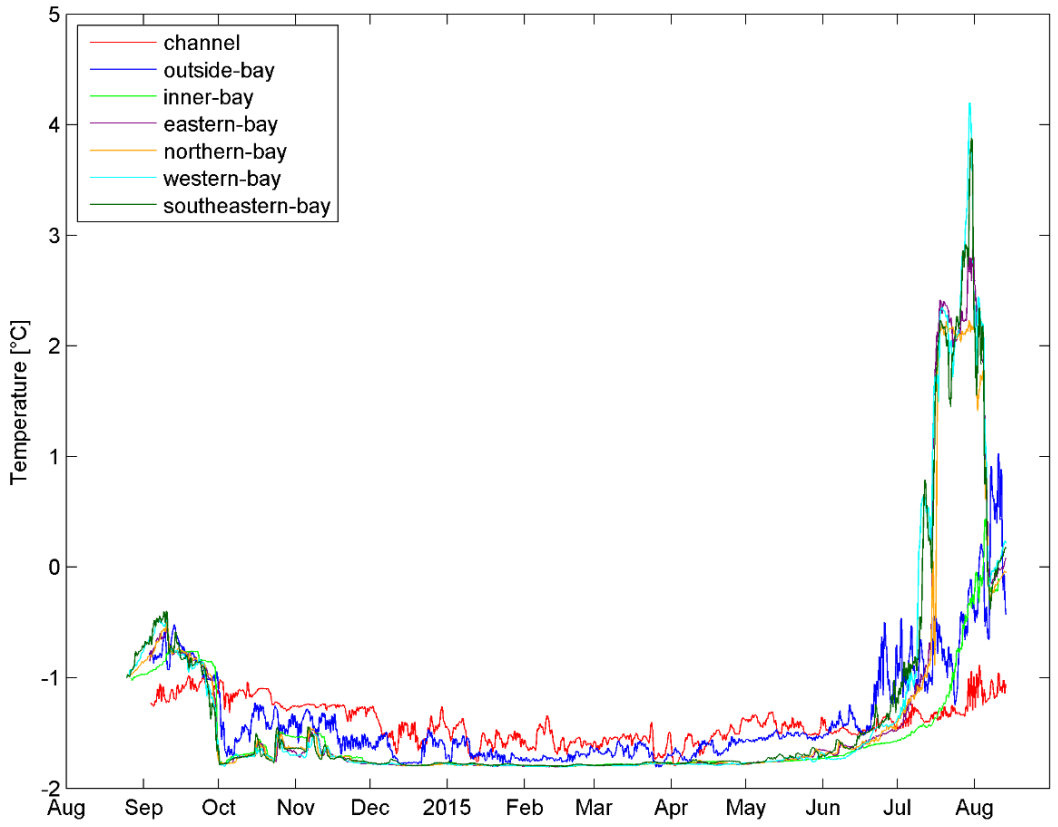
4: Locations of measures

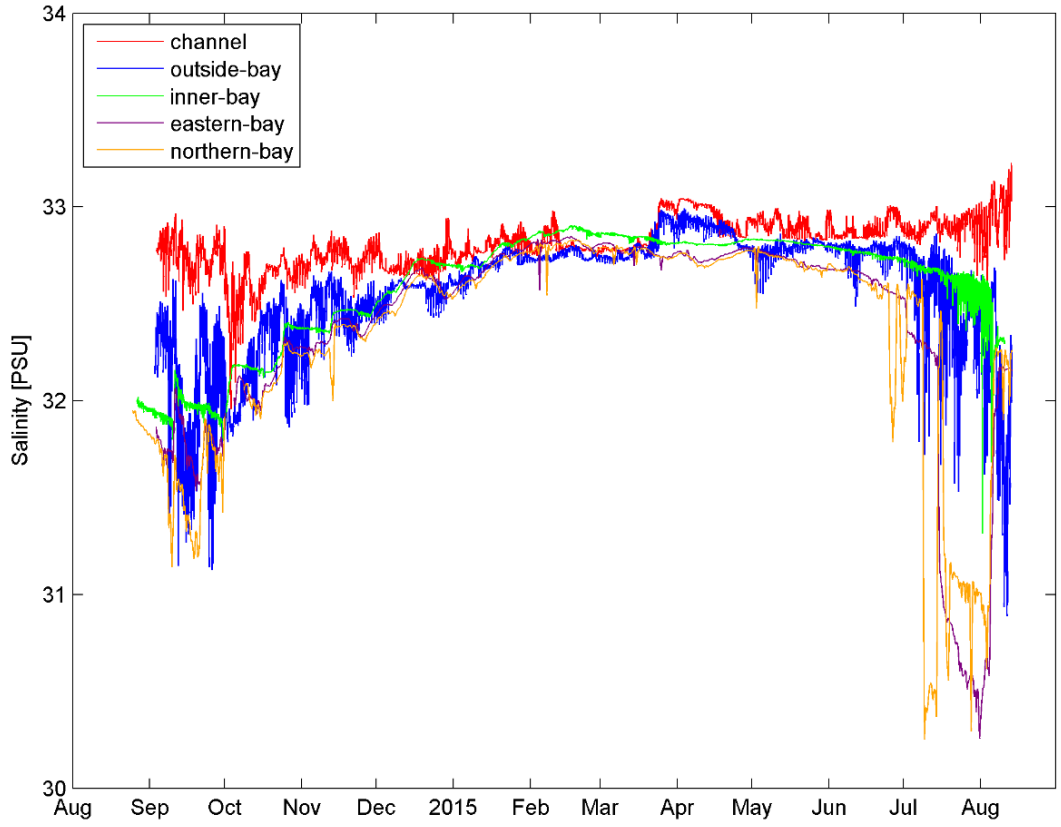


4: Ice Concentration & Dissolved Oxygen Saturation



4: Temperature & Salinity





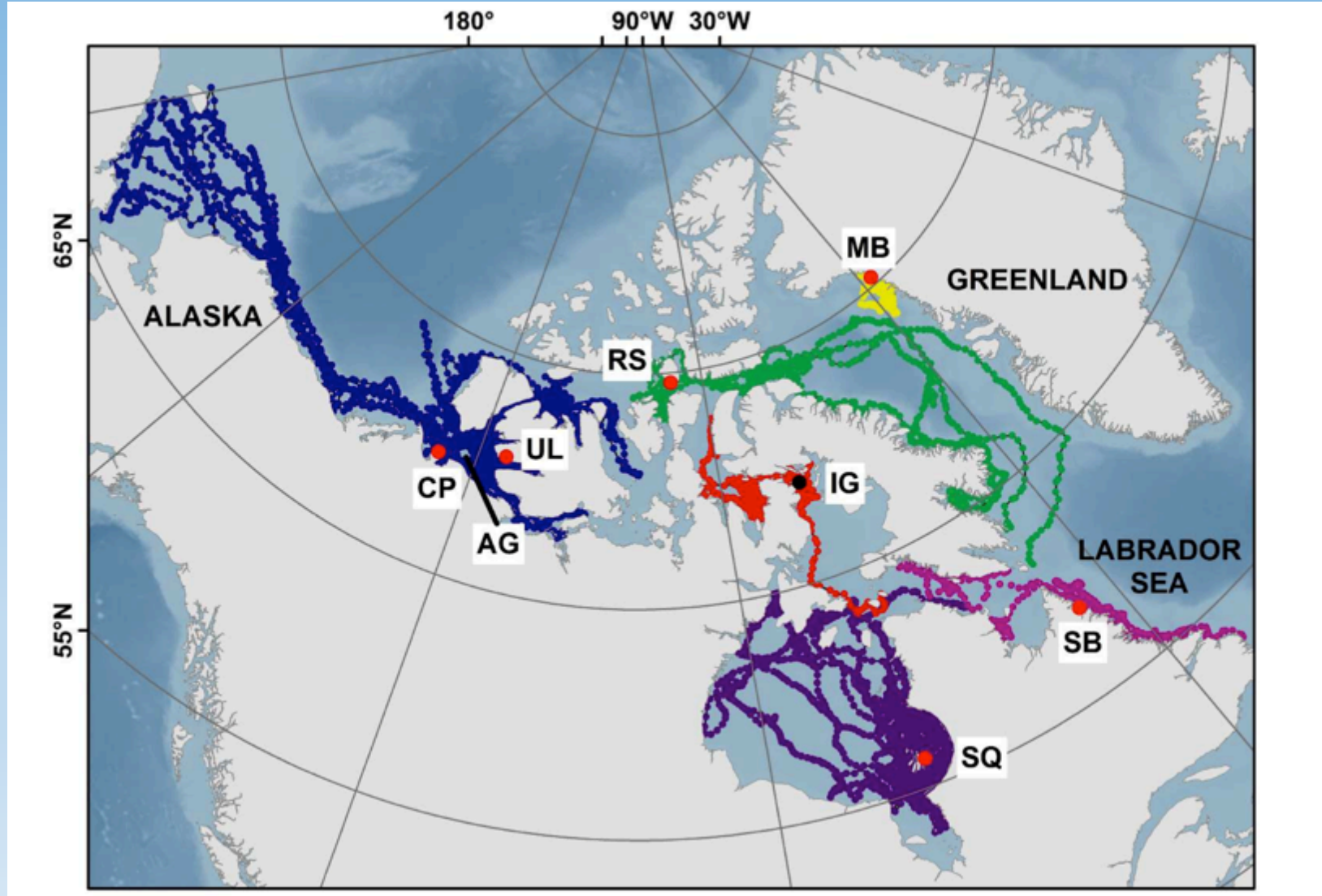
Sub-project 5:
Movement of Ringed seals

Dave Yurkowski

5: Ringed seal movements

- Ice-free periods:
  - Resolute - 102 days
  - Amundsen Gulf - 115 days
  - Saglek Bay – 355 days
  - Sanikiluaq – 190 days

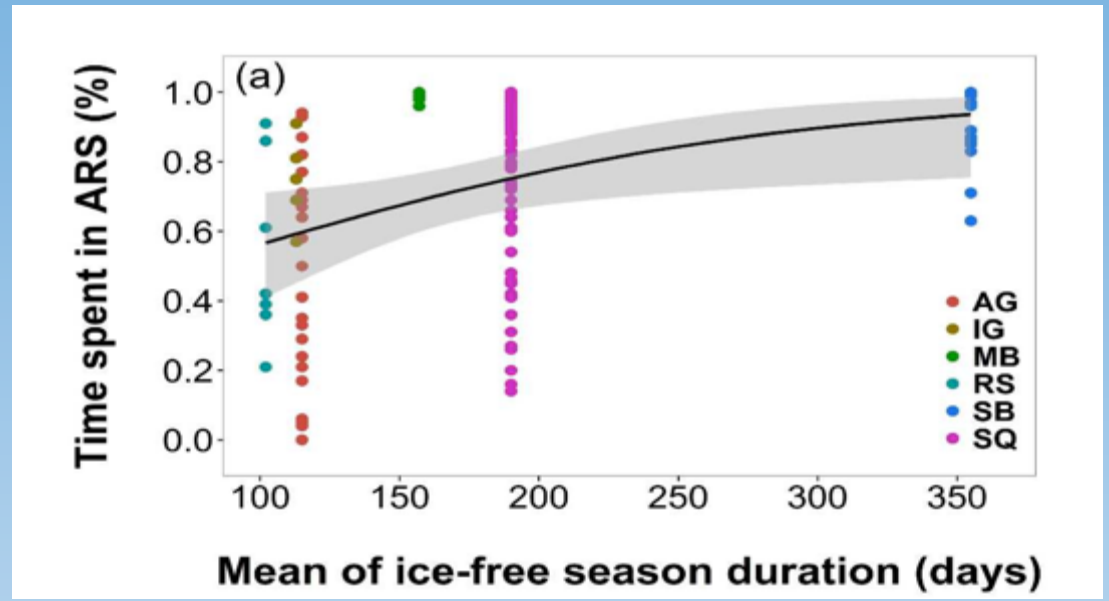
Yellow – Melville bay (MB)
Green – Resolute (RS)
Blue – Amundsen Gulf (AG)
Red – Igloolik (IG)
Purple – Sanikiluag (SQ)
Pink – Saglek Bay (SB)

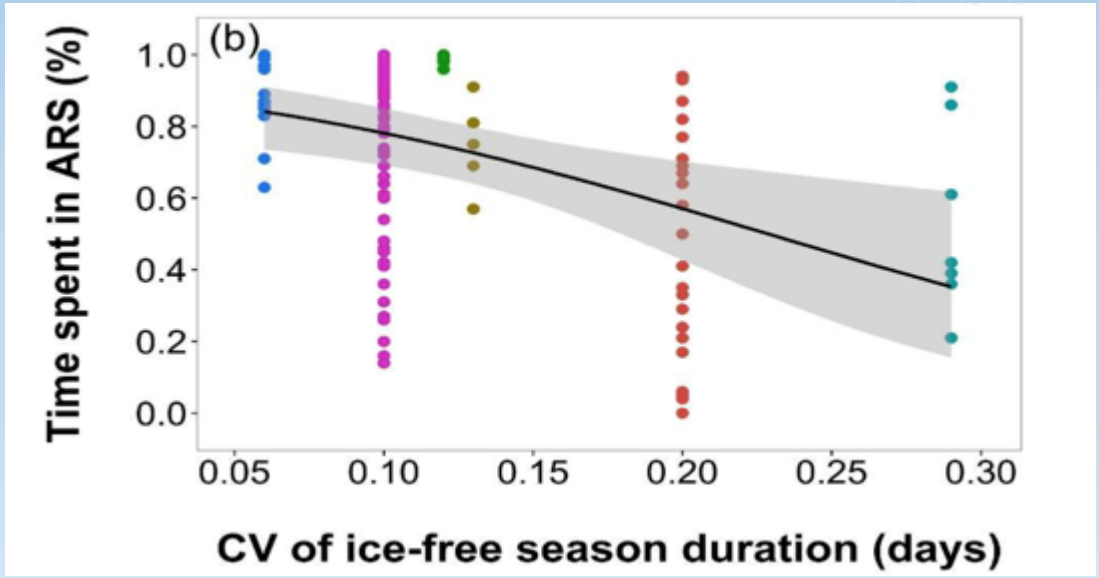


5: Time spent in Area-Restricted Search (ARS)

- ARS behaviour infers slow, tortuous movements thought to occur when encountering patchily distributed prey to increase foraging effort in profitable patches
- A latitudinal gradient - the proportion of time spent in ARS significantly increased with mean ice-free season duration (Fig. a)
- Proportion of time ringed seals spent in ARS was higher in areas where inter-annual sea ice dynamics were more synchronous (Fig. b)

(Karieva and Odell 1987)





Conclusion:

- The results gained from this project:
  - Provide a baseline understanding of the high Arctic marine ecosystem
  - Would help direct future research needs
  - Aid in the prediction of future trends in the Arctic

Publications:

- Kessel, S. T., Hussey, N. E., Crawford, R. E., Yurkowski, D. J., O'Neill, C. V. & Fisk, A. T. (2015). Distinct patterns of Arctic cod (*Boreogadus saida*) presence and absence in a shallow high Arctic embayment, revealed across open-water and ice-covered periods through acoustic telemetry. *Polar Biology*, 1-12.
- Kessel ST, Crawford RE, Hussey NE, Ivanova S and Fisk AT (In Prep) Arctic cod (*Boreogadus saida*) size class segregation in a shallow high Arctic embayment (Intended for Arctic Science)
- Kessel ST, Hussey NE, Crawford RE, Yurkowski DJ, Webber DM, Dick TA and Fisk AT (In Review) First documented large-scale horizontal movements of individual Arctic cod (*Boreogadus saida*). Canadian Journal of Fisheries and Aquatic Sciences.
- Matley, J. K., Crawford, R. E. & Dick, T. A. (2012a). Observation of common raven (*Corvus corax*) scavenging Arctic cod (*Boreogadus saida*) from seabirds in the Canadian High Arctic. *Polar Biology* **35**, 1119-1122.
- Matley, J. K., Crawford, R. E. & Dick, T. A. (2012b). Summer foraging behaviour of shallow-diving seabirds and distribution of their prey, Arctic cod (*Boreogadus saida*), in the Canadian Arctic. *Polar Research* **31**.
- Matley, J. K., Fisk, A. T. & Dick, T. A. (2012c). Seabird predation on Arctic cod during summer in the Canadian Arctic. *Marine Ecology Progress Series* **450**, 219-228.
- Matley, J. K., Fisk, A. T. & Dick, T. A. (2013). The foraging ecology of Arctic cod (*Boreogadus saida*) during open water (July-August) in Allen Bay, Arctic Canada. *Marine Biology* **160**, 2993-3004.
- Yurkowski, D.J., C.A.D. Semeniuk, L. Harwood, A. Rosing-Asvid, R. Dietz, T.M. Brown, S. Clackett, A. Grgicak-Mannion, A.T. Fisk & S.H. Ferguson (Submitted). Greater environmental variation and competitive asymmetry increase foraging behaviour variability across a species' range. Oikos.
- Yurkowski, D.J., S.H. Ferguson, E. Choy, L. Loseto, T.M. Brown, D.C.G Muir, C.A.D. Semeniuk, Christina & A.T. Fisk (2016). Latitudinal variation in ecological opportunity and intra-specific competition indicates differences in niche variability and diet specialization of Arctic marine predators. Ecology and Evolution 6:1666-1678.
- Yurkowski, D.J., S.H. Ferguson, C.A.D. Semeniuk, T.M. Brown, D.C.G. Muir & A.T. Fisk (2016). Spatial and temporal variation of an ice-adapted predator's feeding ecology in a changing Arctic marine ecosystem. Oecologia 180:631-644.
- Yurkowski, D.J., N.E. Hussey, C. Semeniuk, S.H. Ferguson & A.T. Fisk (2015). Effects of chemical lipid-extraction and the utility of lipid-normalization models on stable isotope values in arctic marine mammal tissues. Polar Biology. 38:131-143.
- Ivanova, S., S.T. Kessel, S. Vagle, M. Espinoza, M. McLean, C. O'Neill, J. Landry, N.E. Hussey, A.T. Fisk (In Prep). Shipping activity displaces key fish species in the high Arctic. (intended for Nature).

Acknowledgements

- Fisk lab
- Svein Vagle Lab
- Jeff and Mark Amarualik
- Debra Iqaluk
- The residents of Resolute bay
- PCSP
- And all granting agencies

OCEAN TRACKING NETWORK

NSERC CRSNG

University of Windsor

GREAT LAKES INSTITUTE FOR ENVIRONMENTAL RESEARCH

Natural Resources Canada | Ressources naturelles Canada

Polar Continental Shelf Program

Thank you!

Questions…