

# Using Slocum gliders to characterize baleen whale habitat

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# Why study whale habitat?

To prevent this...



...we need to know where whales are

**Find the habitat, find the whales**

# The concept, and challenge

Baleen whales feed at low trophic levels

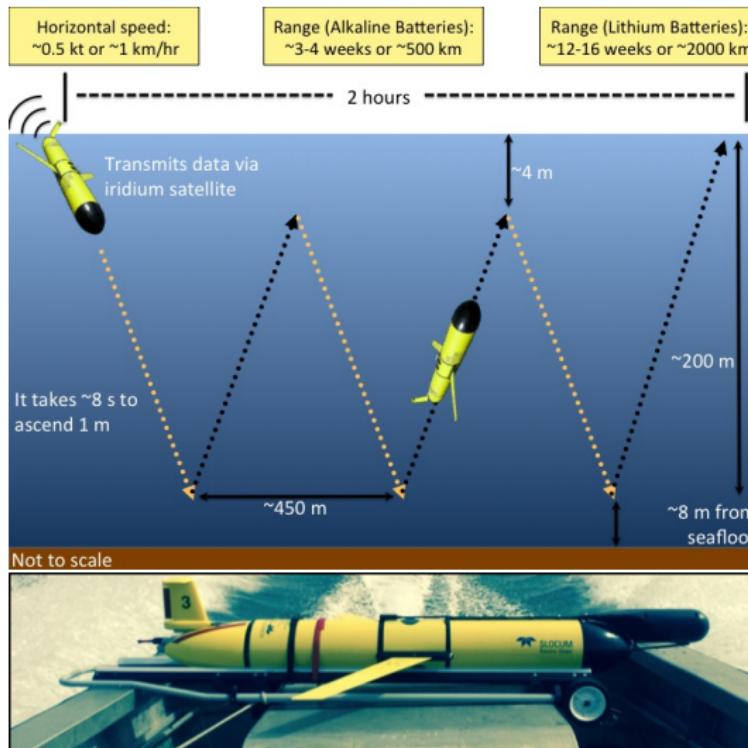
Prey is coupled to oceanographic processes

Baleen whales \*should\* be linked to variation in these processes

**BUT**

Difficult to quantify, mainly due to lack of sufficient **spatially** and **temporally** coincident measurements of whales and oceanographic data

# A platform for studying whale habitat: Slocum Gliders

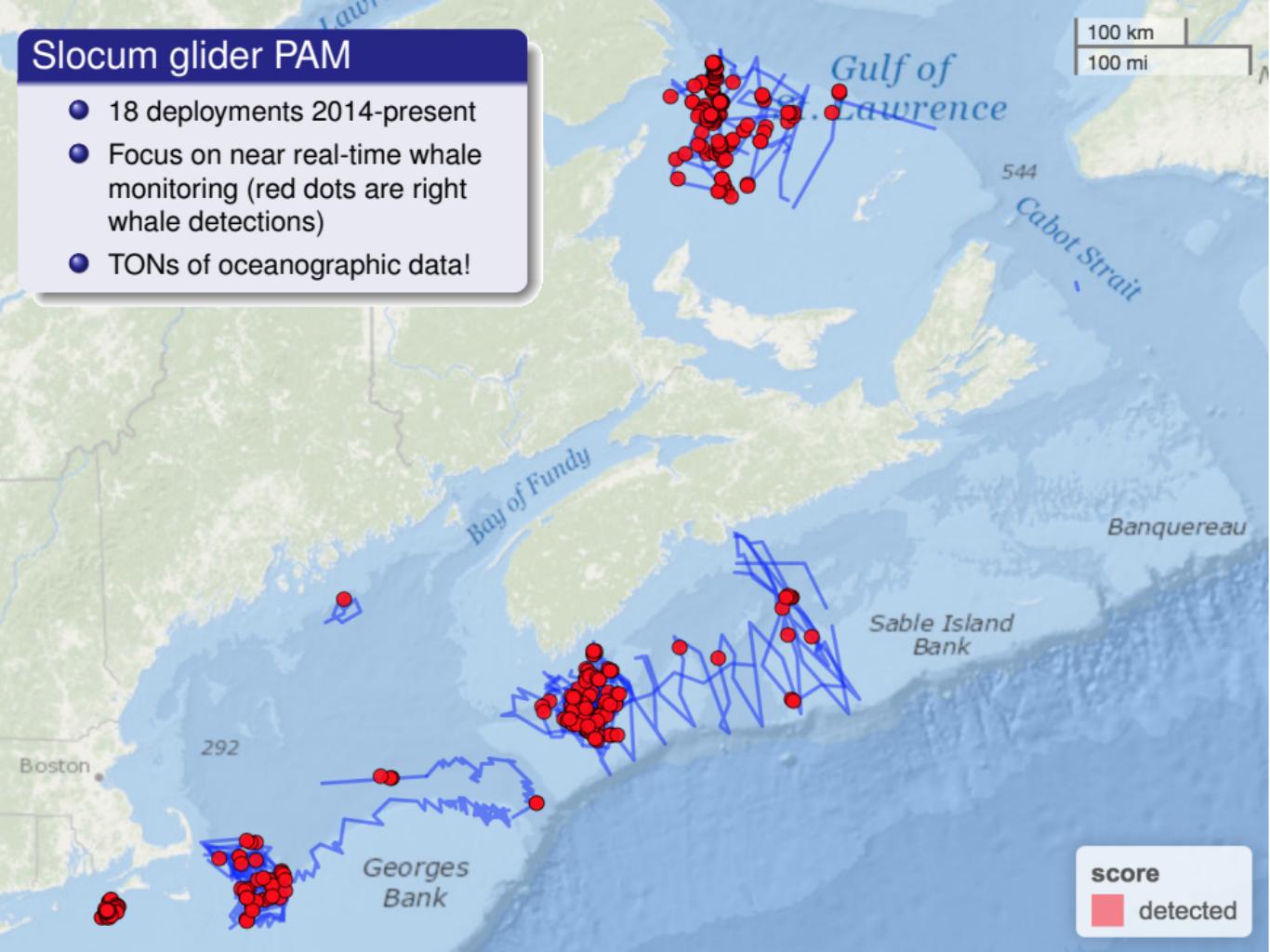


Slocum glider equipped with a DMON (digital acoustic monitoring instrument)

Baumgartner & Mussoline. (2011). A generalized baleen whale call detection and classification system. *The Journal of the Acoustical Society of America*, 129(5), 2889-2902.

## Slocum glider PAM

- 18 deployments 2014-present
- Focus on near real-time whale monitoring (red dots are right whale detections)
- TONS of oceanographic data!



## Questions

A ‘multi-species’, multivariate, exploratory approach to determine if we can use glider data to quantify:

- How do baleen whales (fin, right, sei, and humpback) partition habitat?
- How does this vary over time / space / etc.?



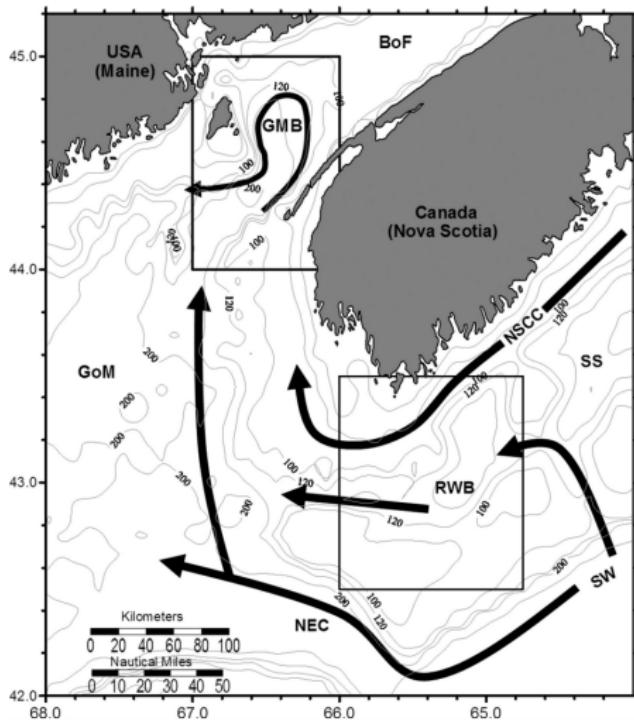
?



# Start in our ocean lab: Roseway Basin

## Roseway Basin:

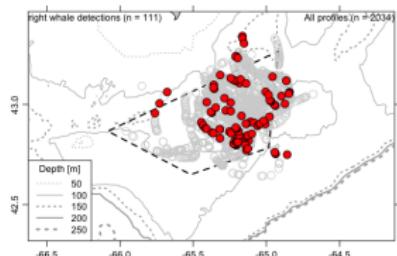
- Shallow (~160m) 40 km off SW Nova Scotia
- Dynamic:  
Nova Scotia Coastal Current (NSCC) and  
Slope Water (SW)
- Right whale critical  
habitat
- Our lab has studied  
since 2007



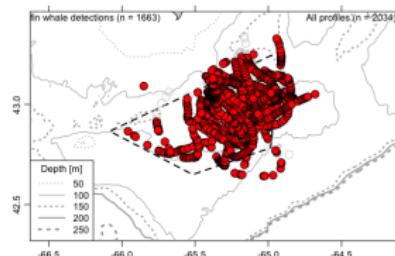
Davies et al (2015). Oceanographic connectivity between right whale critical habitats in Canada and its influence on whale abundance indices during 1987–2009. Journal of Marine Systems, 150, 80-90.

# Glider deployments in Roseway

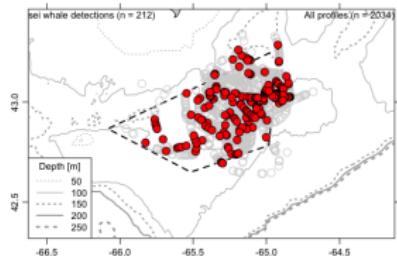
## Acoustic detections from 6 fall deployments, 2014-2016



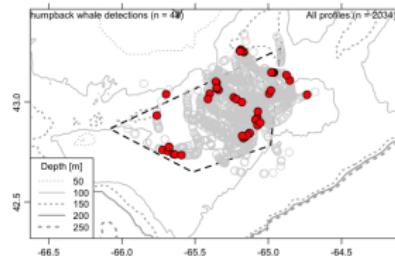
(a) Right (n = 111)



(b) Fin (n = 1663)



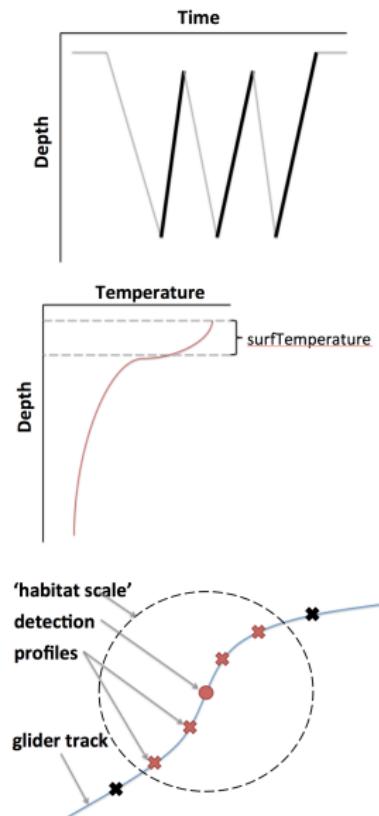
(c) Sei (n = 212)



(d) Humpback (n = 49)

# Data processing

- ① Isolate glider CTD profiles ( $n \sim 7000$ )
- ② Calculate hydrographic variables to capture variation in:
  - Temperature
  - Salinity
  - Density
  - Stratification
  - Bathymetry
  - ...
- ③ Associate whale detections with profile variables collected over a given 'habitat scale'



# Statistical approach

## Linear Discriminate Function Analysis (LDA)

- Multivariate ordination method (like PCA) that seeks to find the linear combination of variables that best separates (or discriminates) between pre-defined groups

### Desirable features:

- Reduces dimensionality of multivariate data
- Can be used for classification/prediction (eventually)
- Presence only (like acoustic detections)
- History of use in ecosystem ecology  
(incl. cetacean habitat modeling)

**Good choice to see how species partition environmental space**

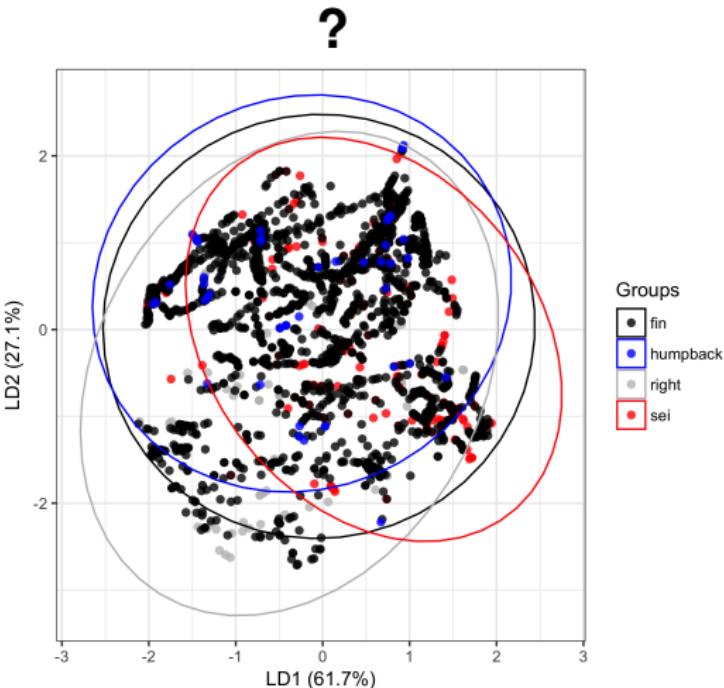
# With all species, it's messy...

## Run details:

- All species
- All years (2014-2016)
- 01 Aug - 31 Dec

## Initial results:

- Poor discrimination of species
- Fin whales are ubiquitous



# Remove fin whales

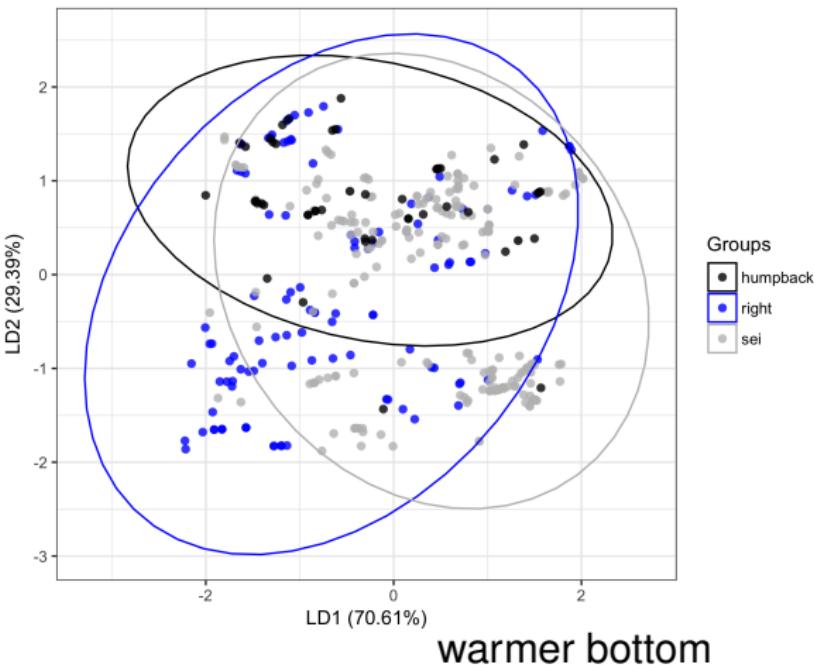
## Run details:

- Same as previous, but without fin whales

## Initial results:

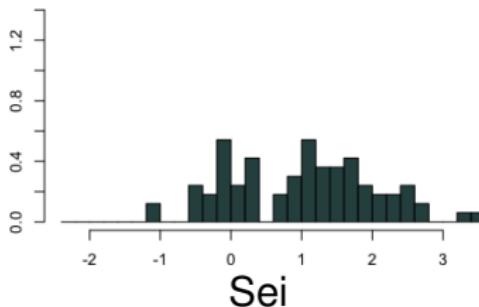
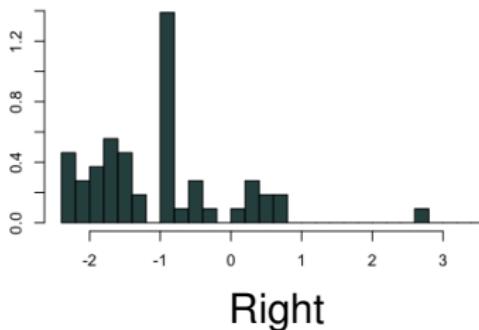
- Right whales and colder bottom temperatures
- Humpbacks in warmer surface water
- Vertical structure matters

warmer surface



# Early fall right-sei distinction

cold, fresh → warm, salty



- Late summer (25 Jul-01 Oct)
- Sei whales associated with warmer, heavier water (SW), while right whales with cold, light water (NSCC)
- Not expected based on knowledge of right whale feeding in Roseway

# Conclusions

## Summary

- Fin whales were ubiquitous
  - Most likely due to acoustic detectability (long propagation range; lots of calling)
- Vertical structure of the water column is important
- Over 3 yrs in the early fall, right whales appear to associate with fresh, cold water (NSCC)
  - Not what we expect for this habitat
- Right and sei whales appear to associate with different oceanographic environments in the early fall, but converge later on in the season
  - Change in foraging behaviour? Vocal behaviour?

## Next steps

- Expand to other areas (GSL, GSC)
- Strengthen connection to physical mechanisms

# Acknowledgements

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Brad Covey  
Jude van der Meer



WHALE  
Whales, Habitat and Listening Experiment



OCEAN  
TRACKING NETWORK



MEOPAR



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Canada  
Pêches et Océans  
Canada



WOODS HOLE OCEANOGRAPHIC INSTITUTION  
1930



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supérieures du Canada  
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OERA  
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Research  
Association



Lauréats  
KILLAM  
Laureates



CANADIAN  
WHALE  
INSTITUTE



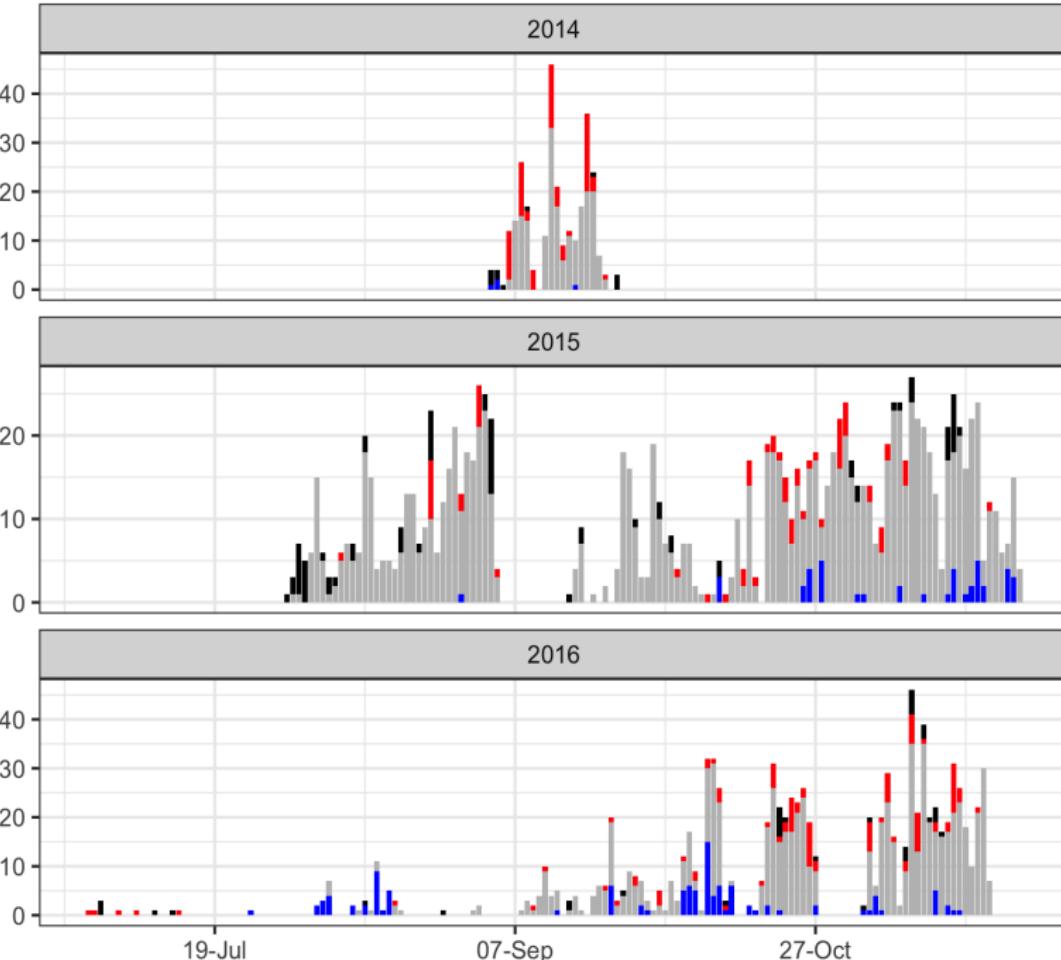
New England  
Aquarium

# Thank you!



# Extra Slides

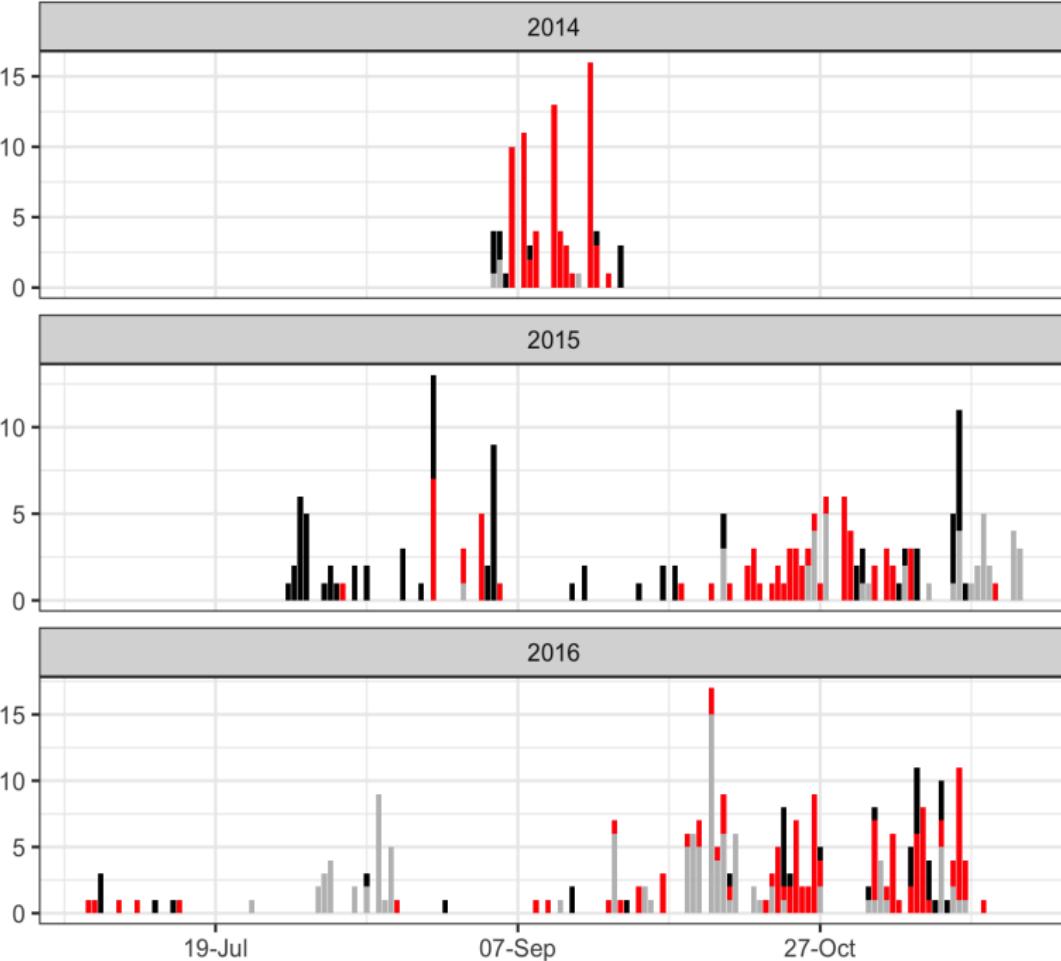
Daily detections of all whales



species

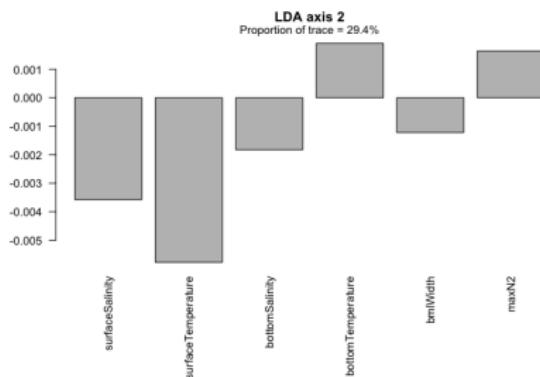
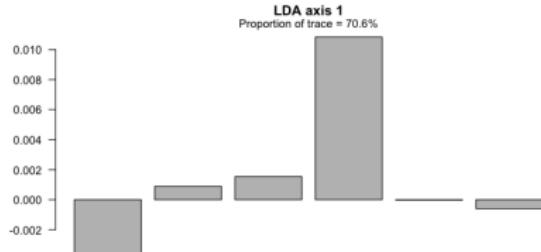
- right
- sei
- fin
- humpback

Daily detections of all whales



species

- right
- sei
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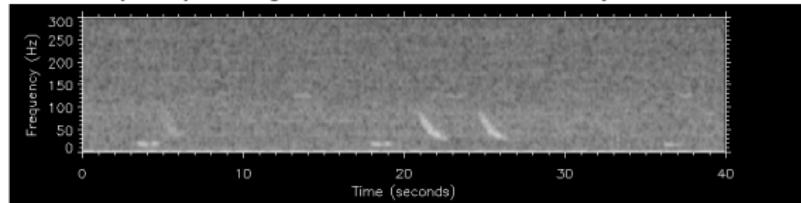


# Real-time acoustic monitoring with the DMON-LFDCS

Slocum glider equipped with a DMON (digital acoustic monitoring instrument)



Sample spectrogram of audio recorded by the DMON



Near real-time output received on shore from the Low Frequency Detection and Classification System (LFDCS)

