Marine Mammal Species Diversity on Canada's East Coast

Bruce Martin[1,2], **Julien Delarue[1]**, Katie Kowarski[1,3], Emily Maxner[1] , Jeff MacDonnell[1,4], Briand Gaudet[1], Eric Lumsden[1], Steve Fenton[1], Eric McCorquodale[1], David Smart[1], Carmen Lawrence[1], Craig Evans[1], Ash Hill[1], Trent Johnson[1], Karen Hiltz[1], John Moloney[1], Brad Stevens[1]

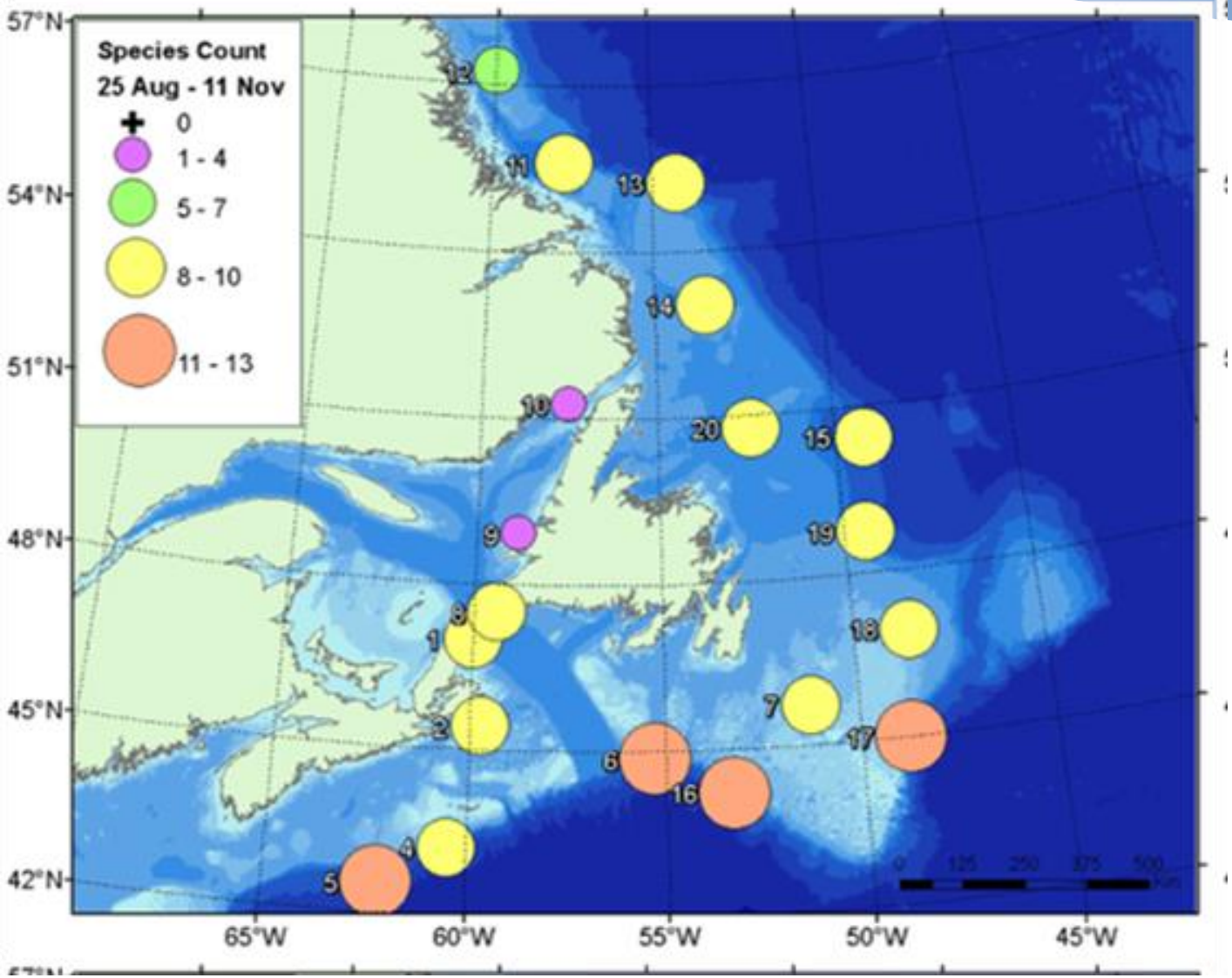
[1]JASCO Applied Sciences, Halifax NS, Canada

[2]Dalhousie University, Department of Oceanography (Barclay Lab)

[3]Dalhousie University, Department of Biology (Whitehead Lab)

[4]Royal Canadian Navy Acoustic Data Analysis Center

Species Diversity From PAM

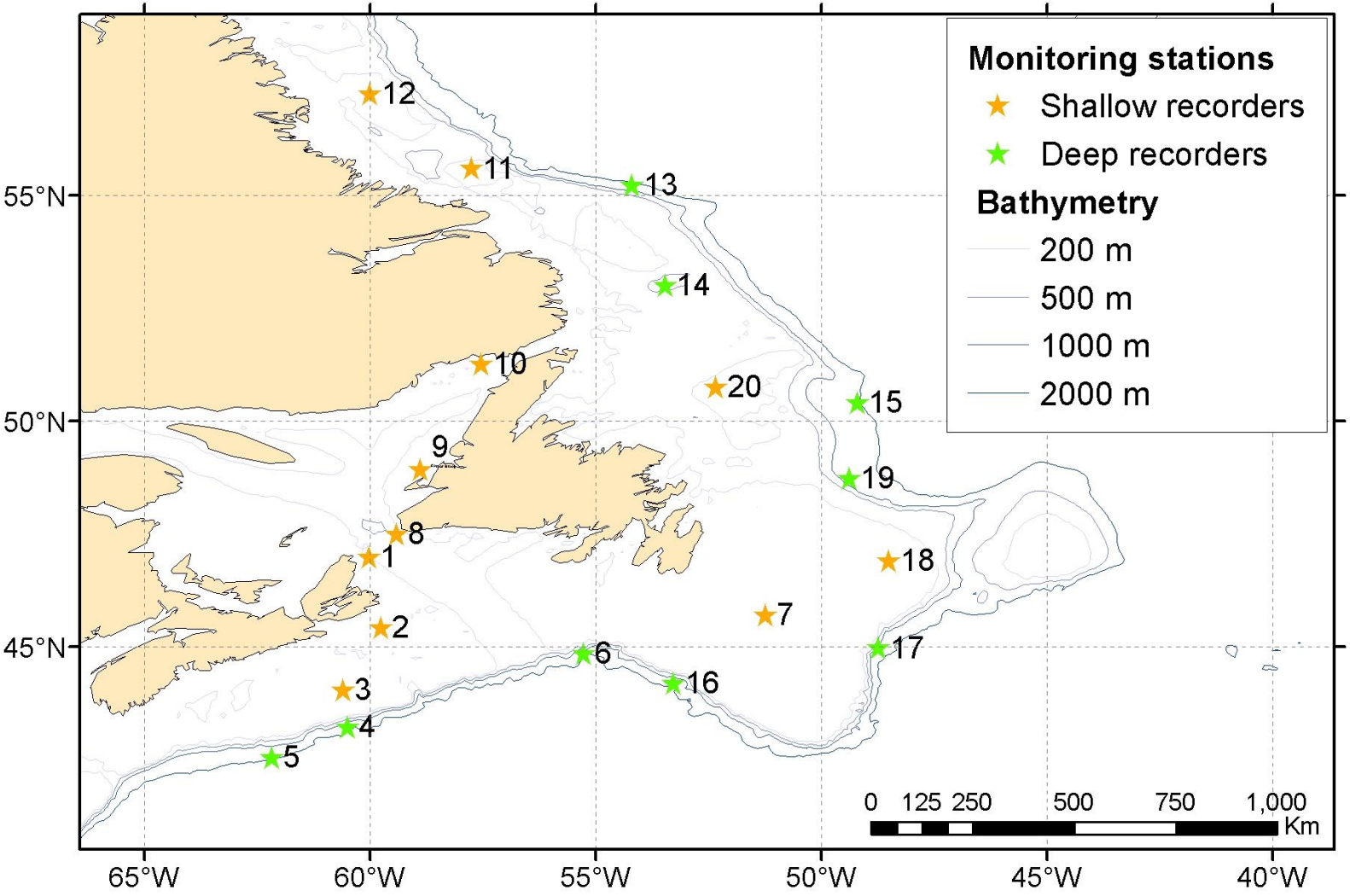


Martin et al, Marine Mammal Species Diversity on Canada's East Coast.

Related talks

- Maxner et al, *Temporal and spatial occurrence of Odontocetes on Canada's east coast.* Friday @09:45, Room D.
- Delarue et al, *Acoustic occurrence and distribution of blue, fin and sei whales of eastern Canada*. Acoustics and Communication Poster Session - Group A.

Atlantic Canada Monitoring Program

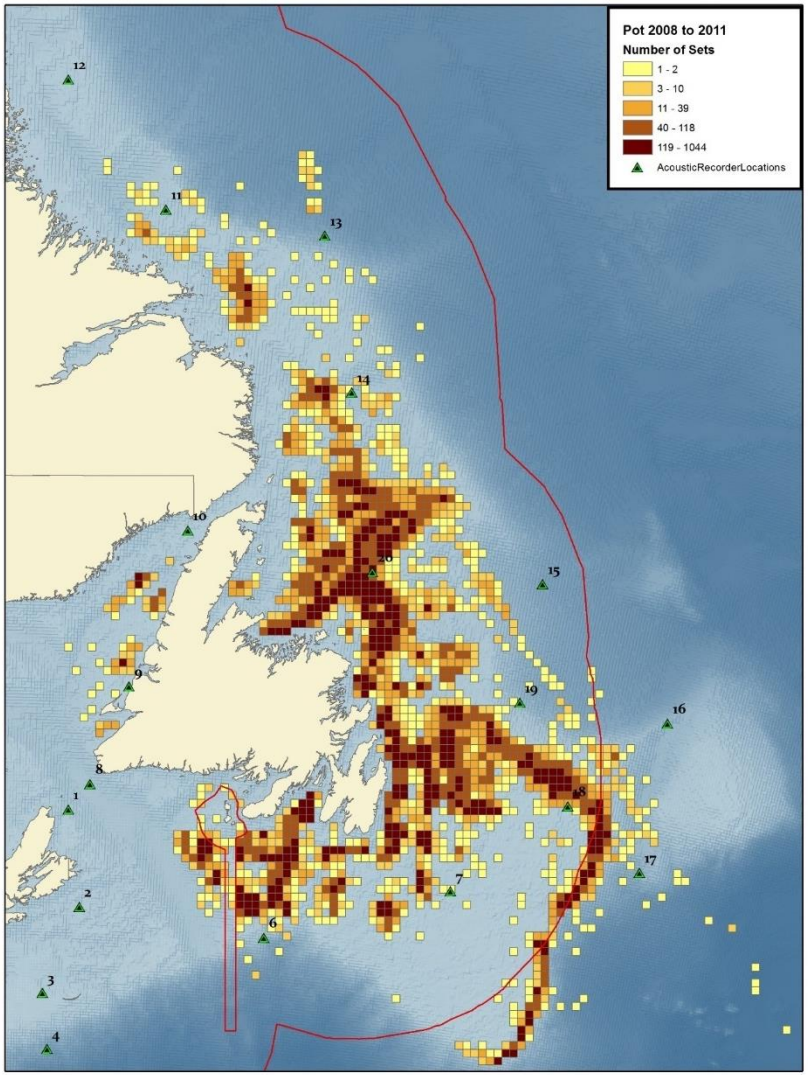


Martin et al, Marine Mammal Species Diversity on Canada's East Coast.

Canada's East Coast

Diverse human activities

Fishing

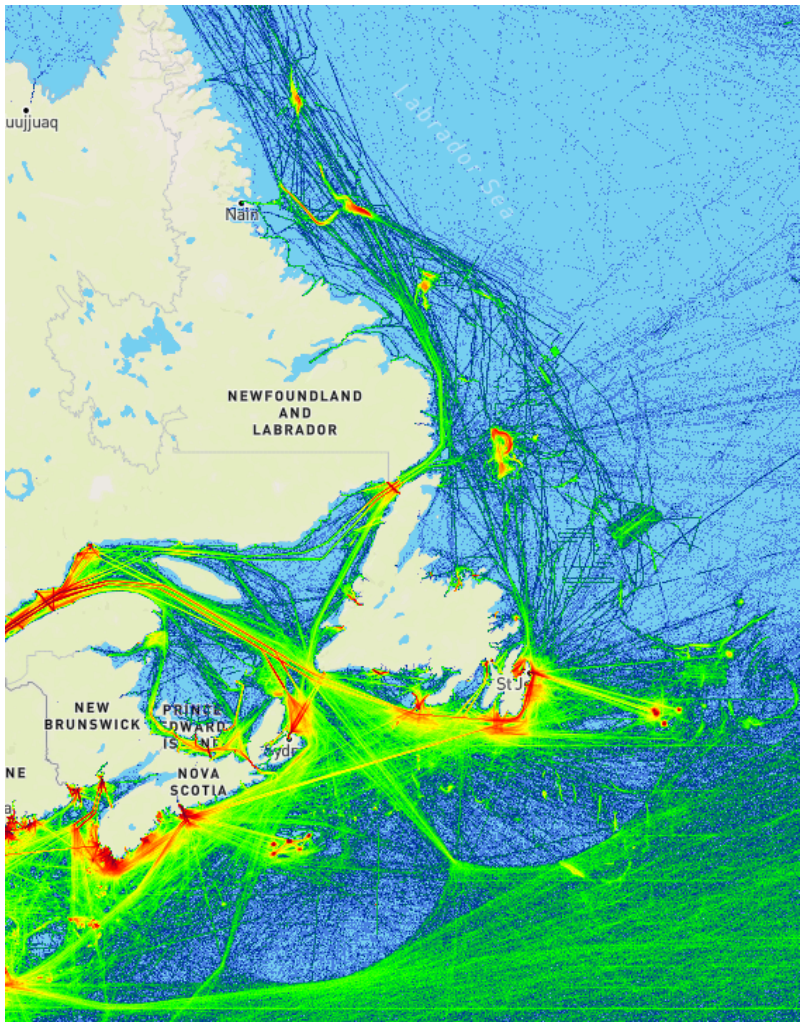


Canada's East Coast

Diverse human activities

Fishing

Shipping



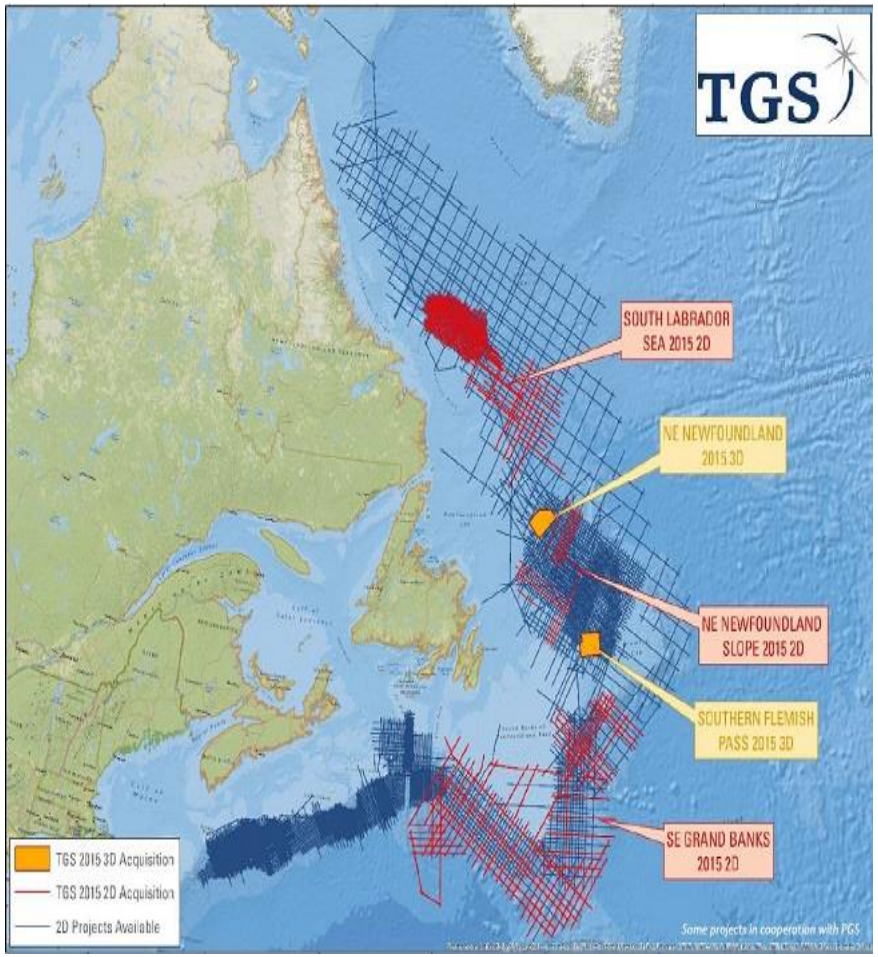
Canada's East Coast

Diverse human activities

Fishing

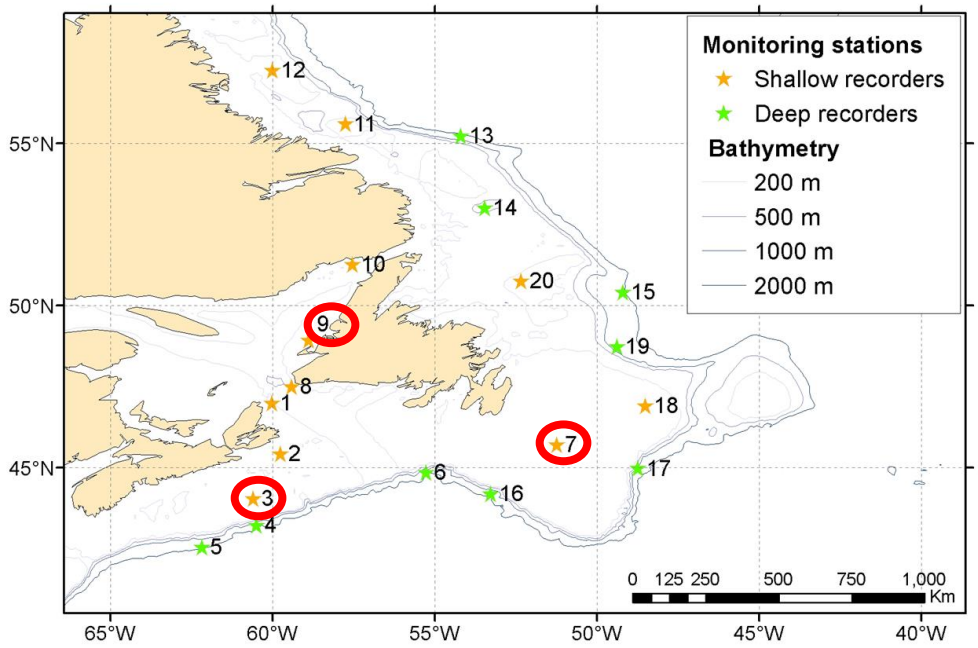
Shipping

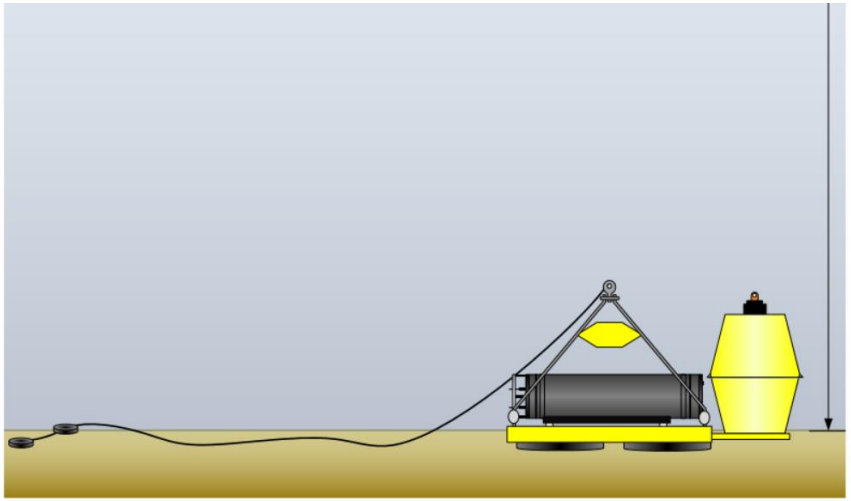
Seismic Surveys



Data Collection

Stations with less than 80 m water



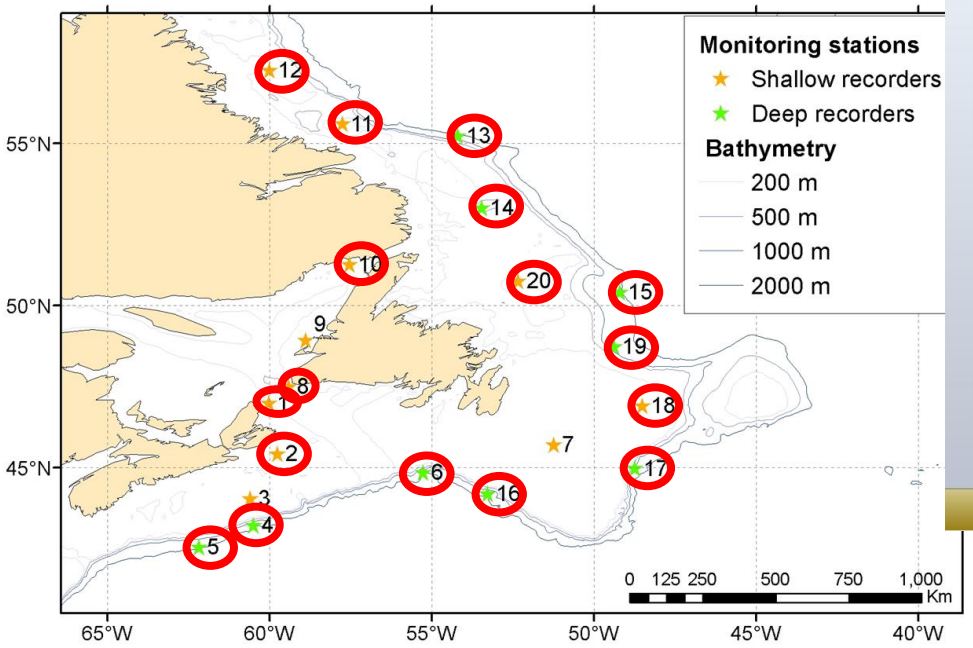


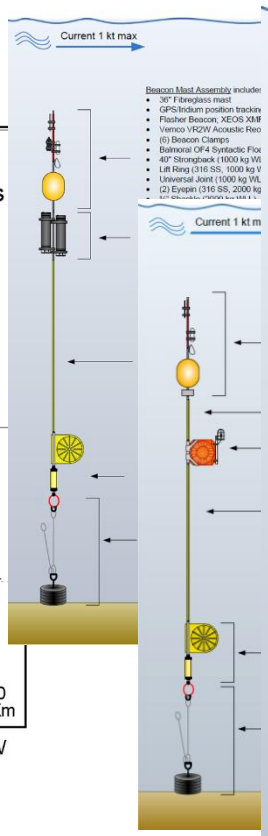
Duty Cycle: 11 min / 20 @ 8 kHz

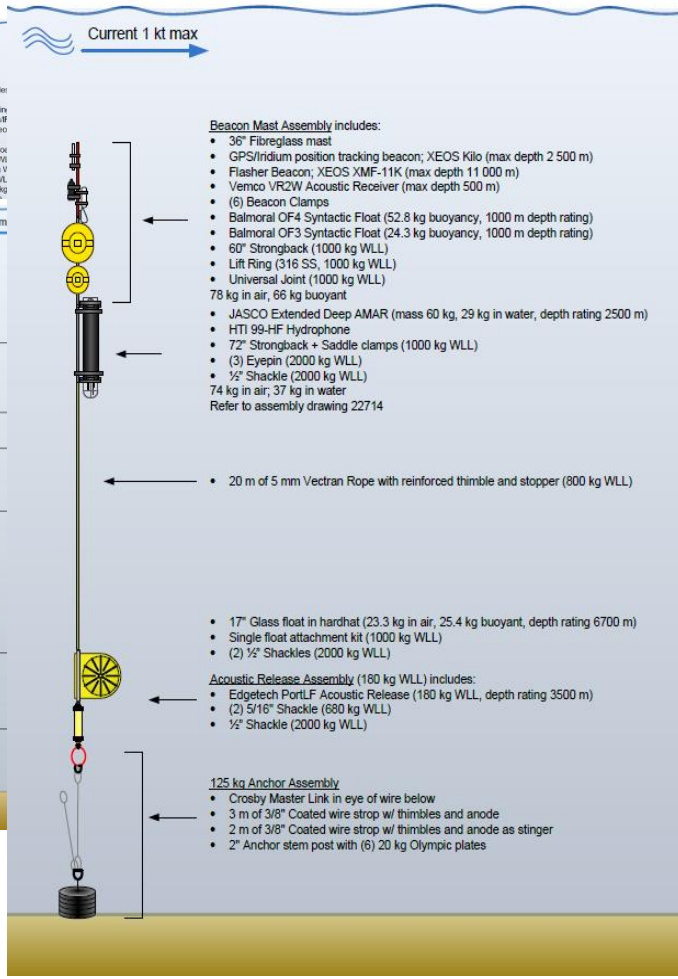
1 min / 20 @ 250 kHz

Data Collection

Stations with more than 80 m water depth





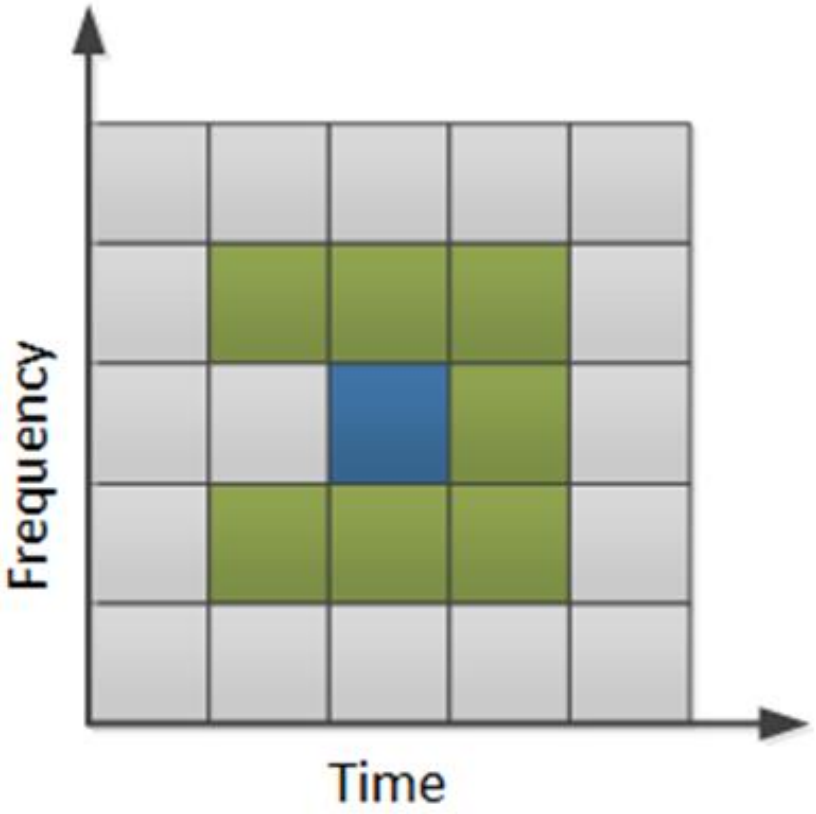


Duty Cycle: 11 min / 20 @ 8 kHz

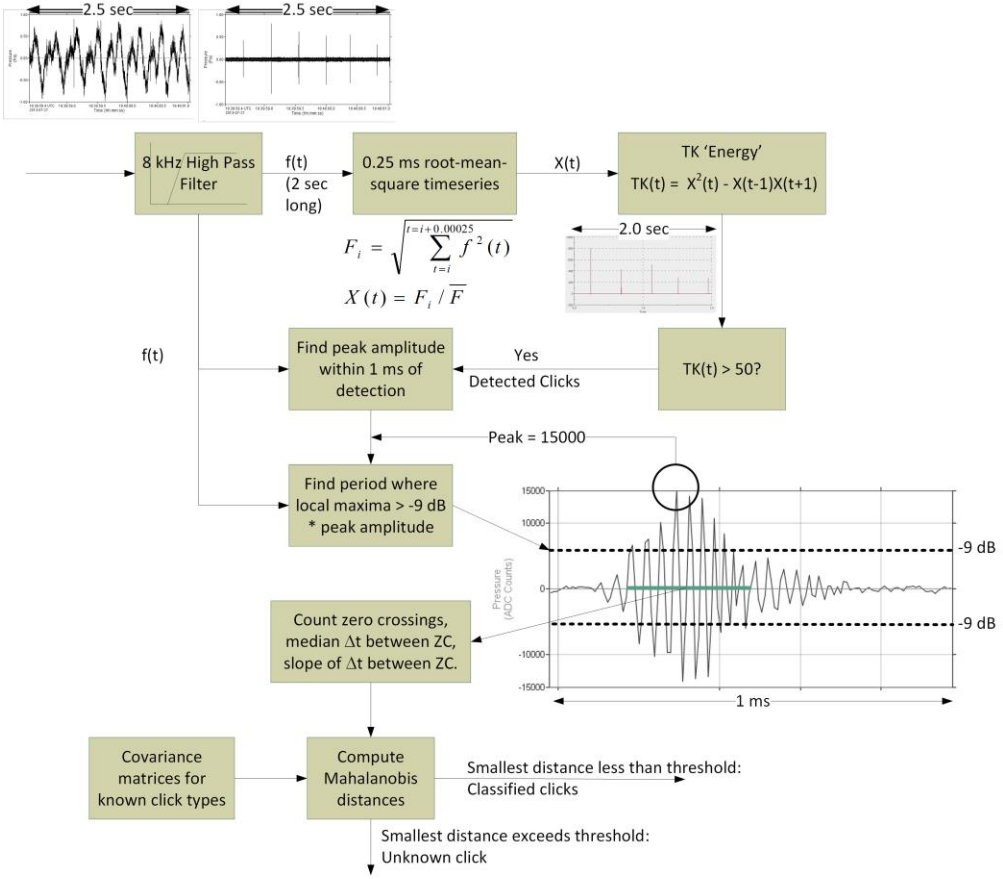
1 min / 20 @ 250 kHz

Analysis: Automated Detectors

Tonal calls: contour detector and sorter

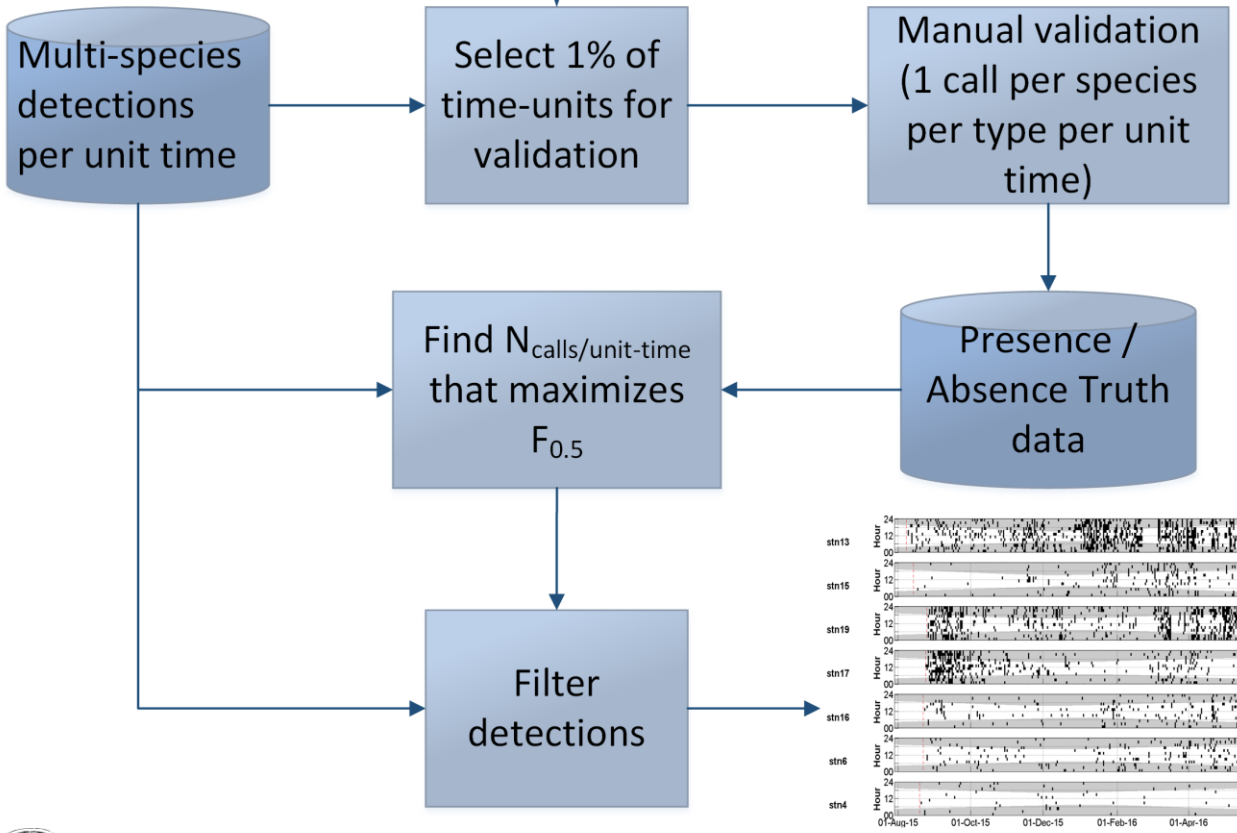


Clicks: Zero crossing detector / classifier



Analysis: Manual Validation

- At least 10 time-units / species
- Even spread across times with high, med, low # species detected
- Distribute selected time-units across whole recording period
- 40%/30%/30% spread across high, med, low detections per unit-time (zeros excluded – these are obtained from the other species selections)



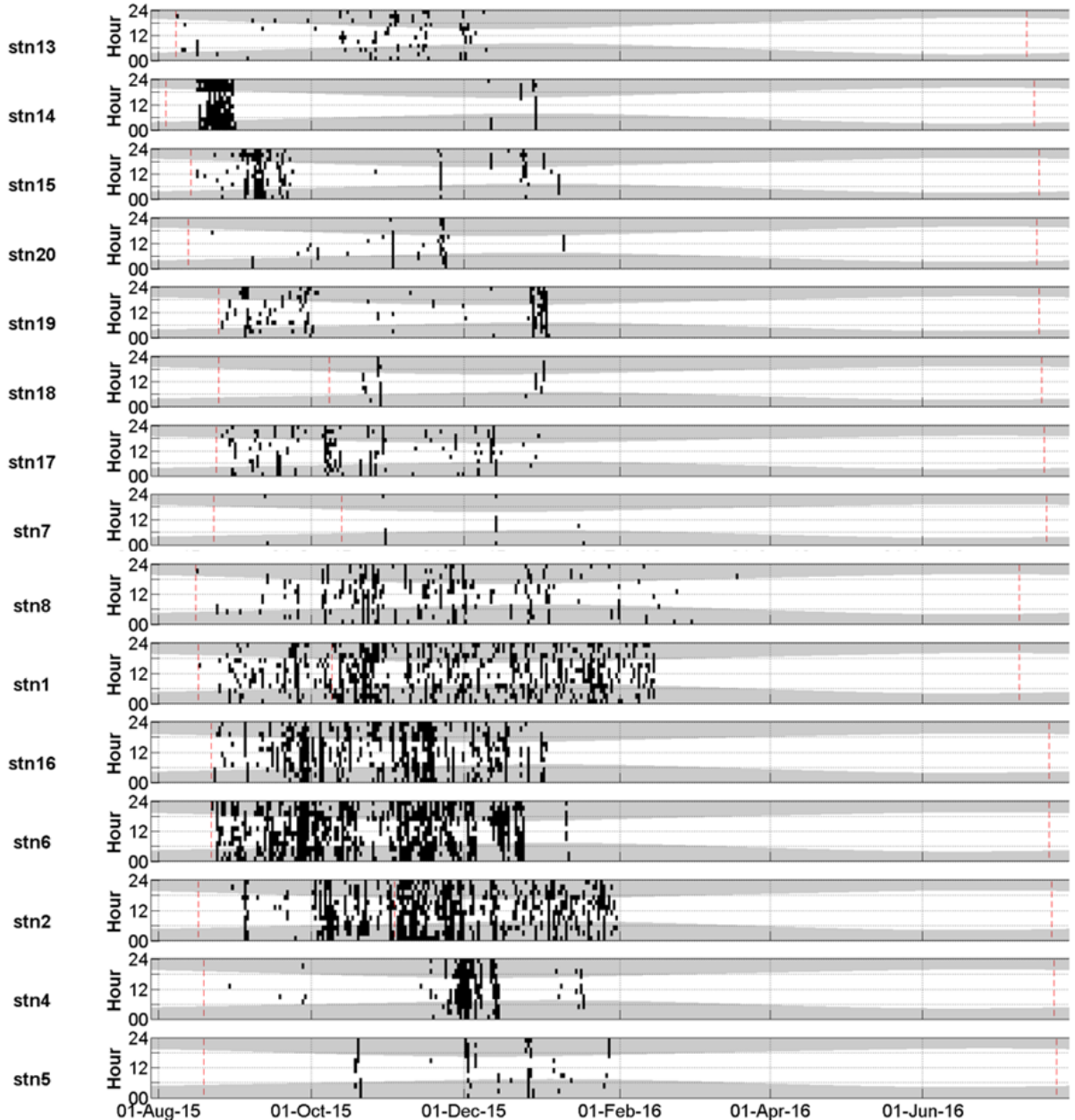
$$P = \frac{TP}{TP + FP}$$

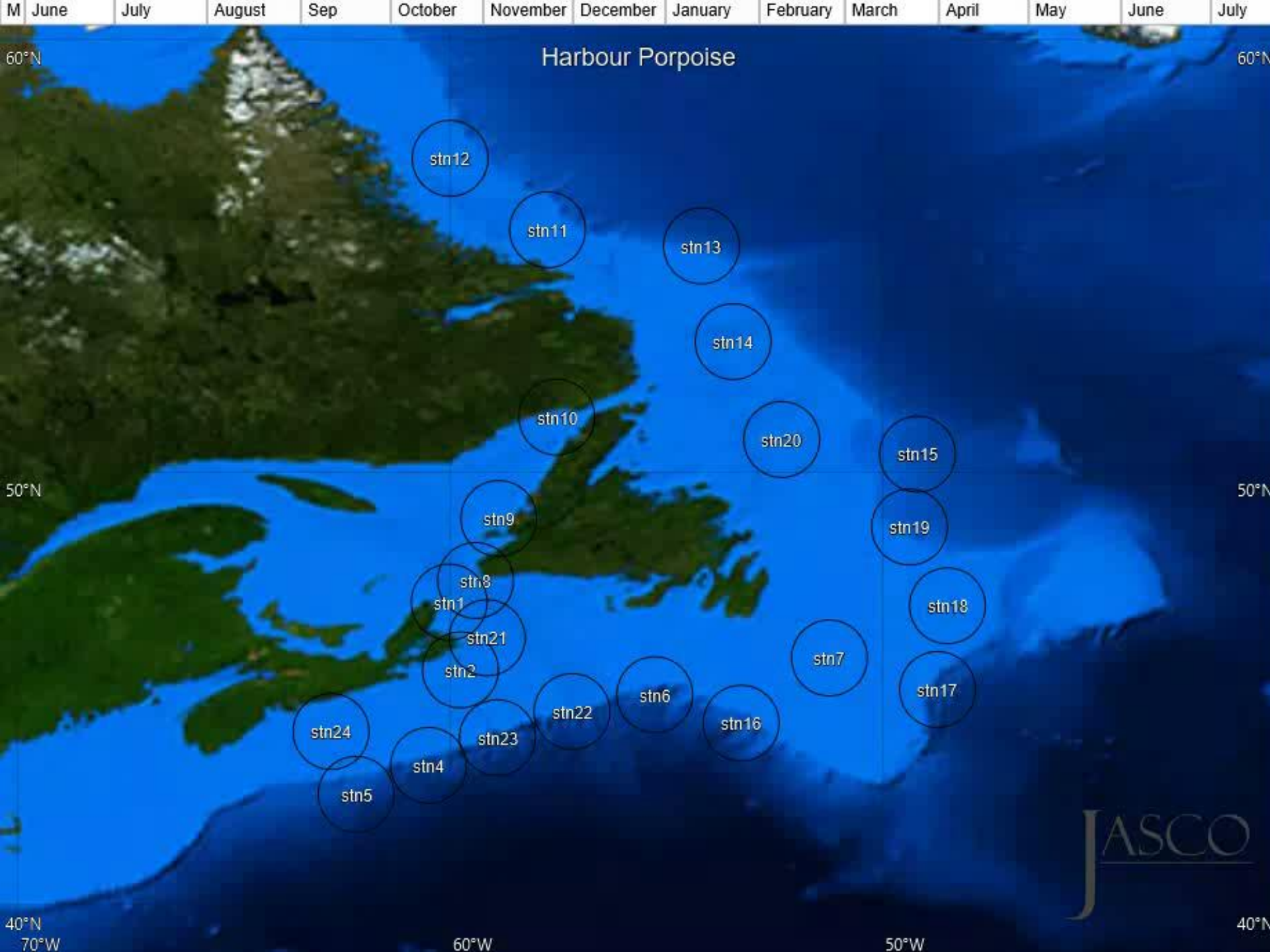
$$R = \frac{TP}{TP + FN}$$

$$F_\beta = \frac{(1 + \beta^2)P * R}{(\beta^2)P + R}$$

Presence Absence Plots

Blue whale infrasound moans



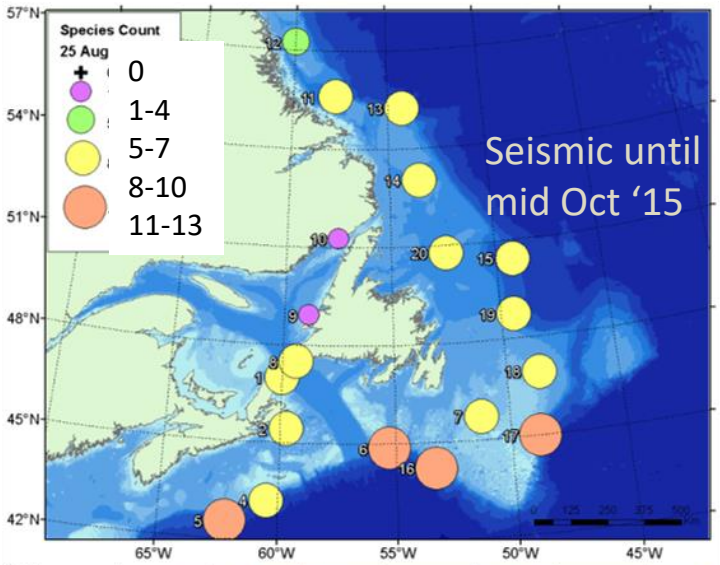

M
June
July
August
Sep
October
November
December
January
February
March
April
May
June
July
Harbour Porpoise
60°N
60°N
stn12
stn11
stn13
stn14
stn10
stn20
stn15
50°N
50°N
stn9
stn19
stn8
stn1
stn18
stn21
stn7
stn2
stn6
stn17
stn22
stn16
stn24
stn23
stn4
stn5
JASCO
40°N
40°N
70°W
60°W
50°W

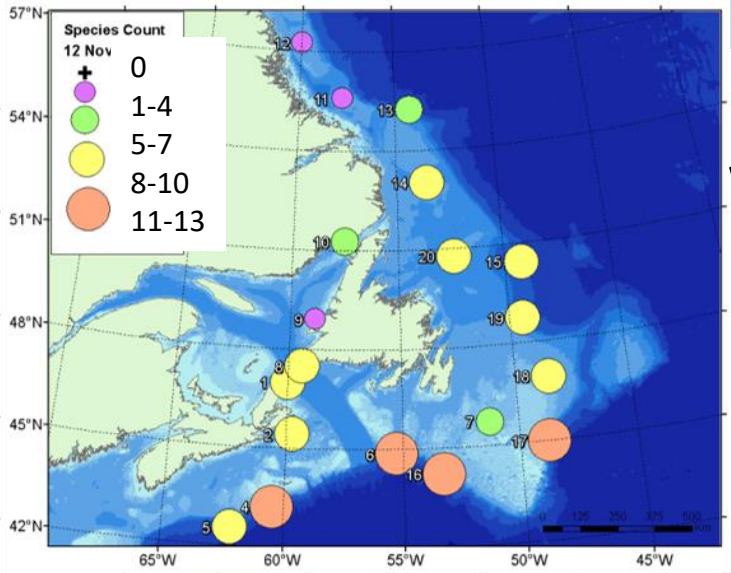
Summaries

- Summarize presence by 18 identifiable species and groups:
  - Mysticetes (6): Fin, blue, sei, right, humpback, minke whales
  - Odontocetes (8): Cuvier's & Sowerby's beaked whales, northern bottlenose whales, sperm whales, harbour porpoise, low whistles(killer & pilot whales); high whistles (white beaked, white sided, Risso's, common, perhaps bottlenose and striped dolphins); delphinid clicks.
  - Pinnipeds (4): Atlantic walrus, grey, bearded and harp seals.
- Periods:
  - Fall: 25 Aug – 11 Nov.
  - Early winter: 12 Nov – 29 Jan
  - Late winter: 30 Jan – 16 Apr
  - Spring: 17 April – 5 July.

Species per season

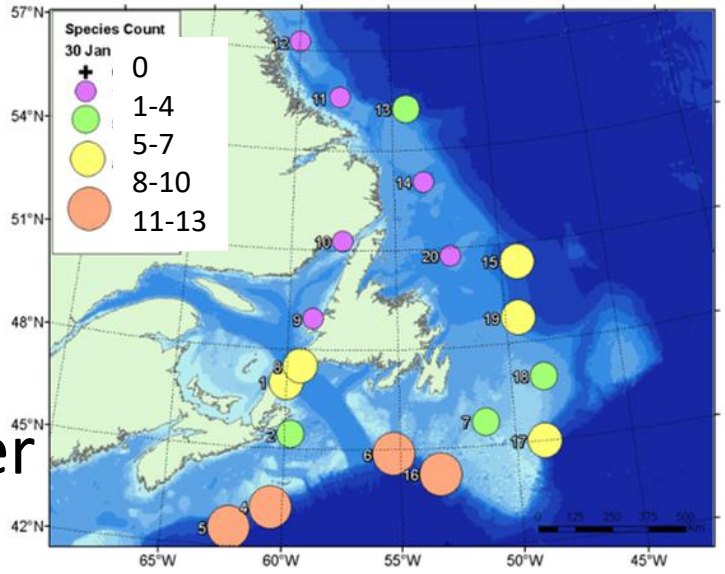
Fall

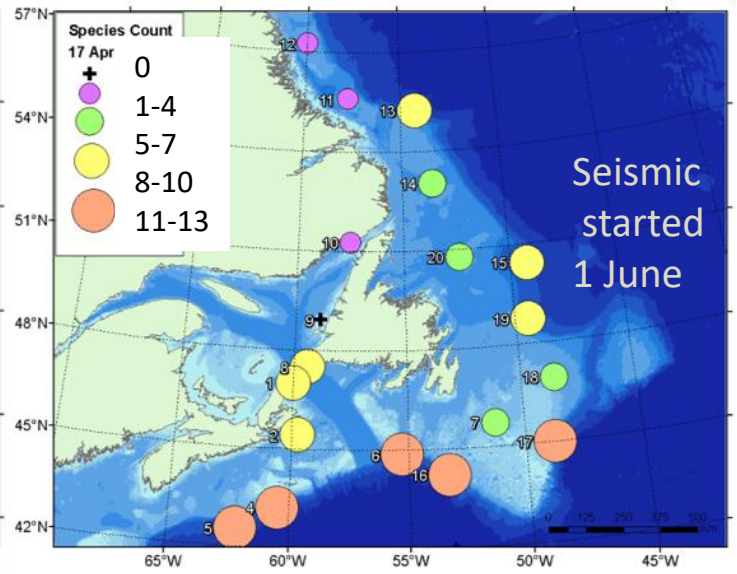




Early Winter

Late Winter



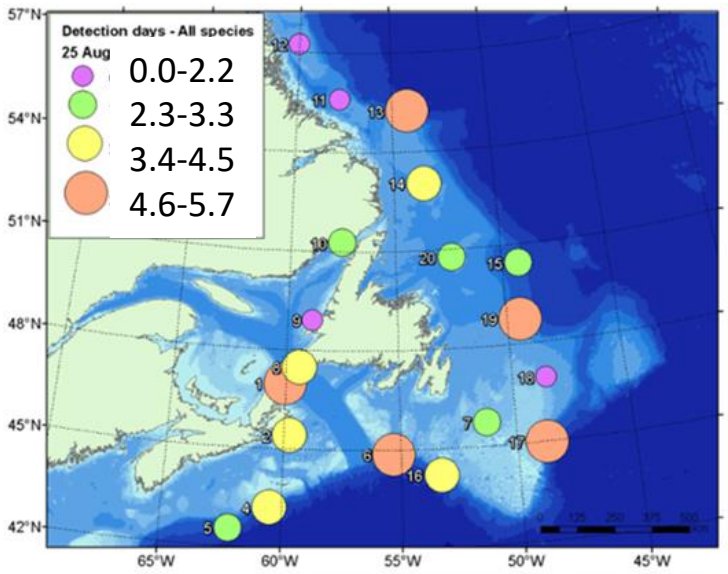


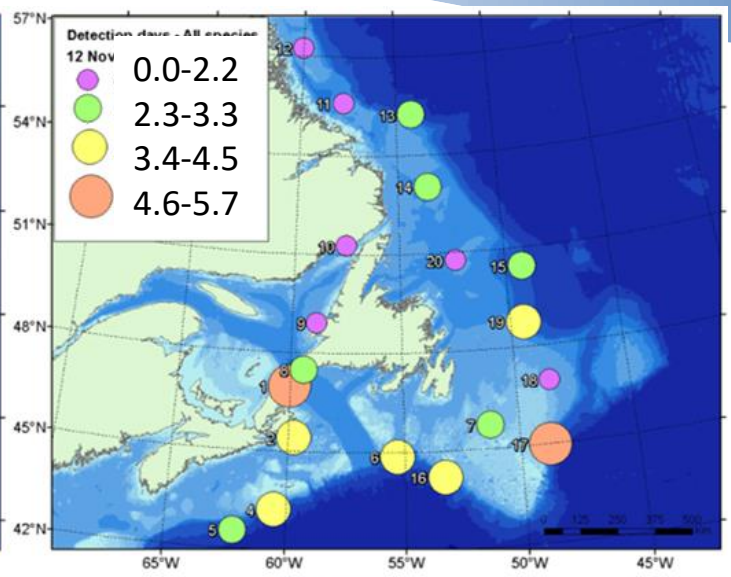
Spring

Martin et al, Marine Mammal Species Diversity on Canada's East Coast.

Species per day

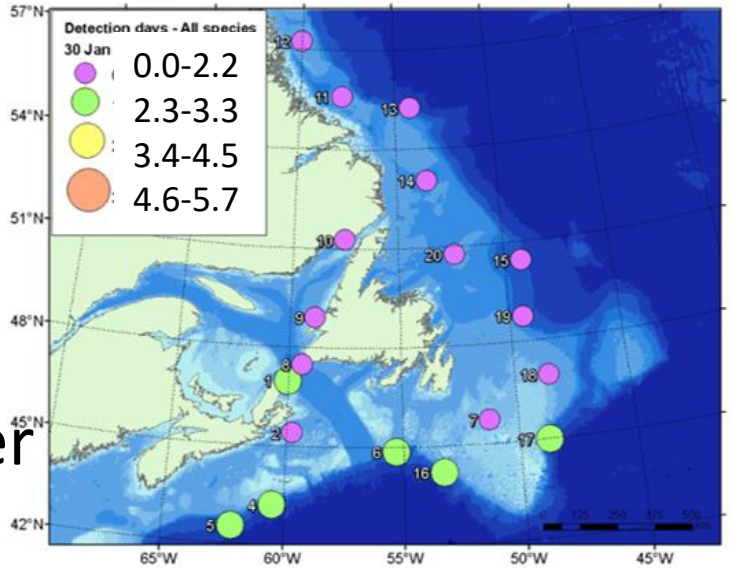
Fall

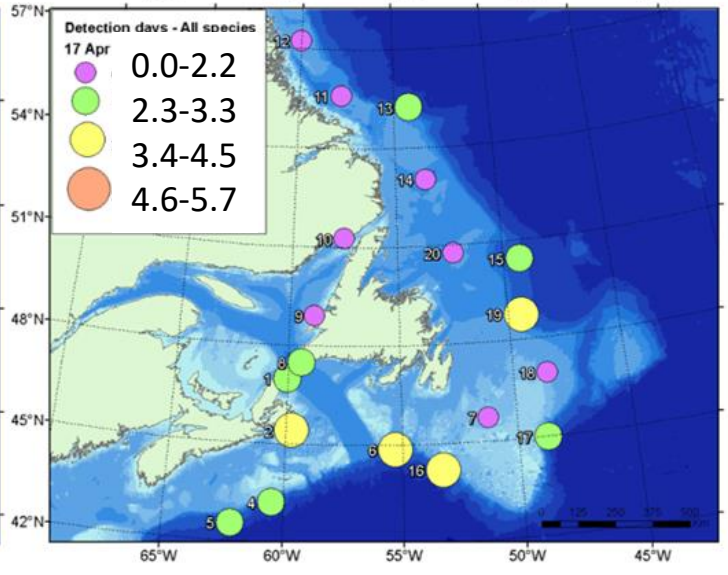




Early Winter

Late Winter

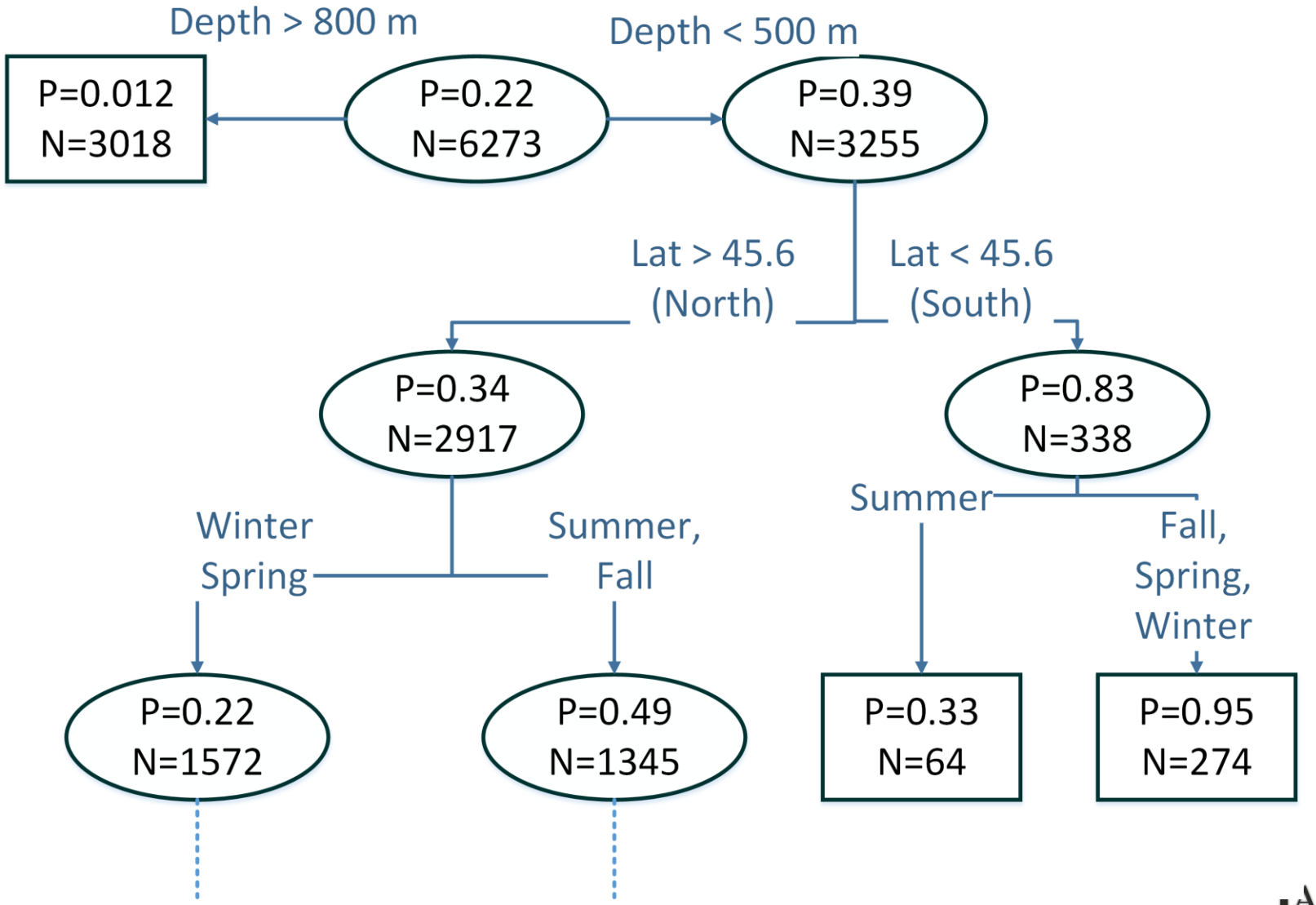




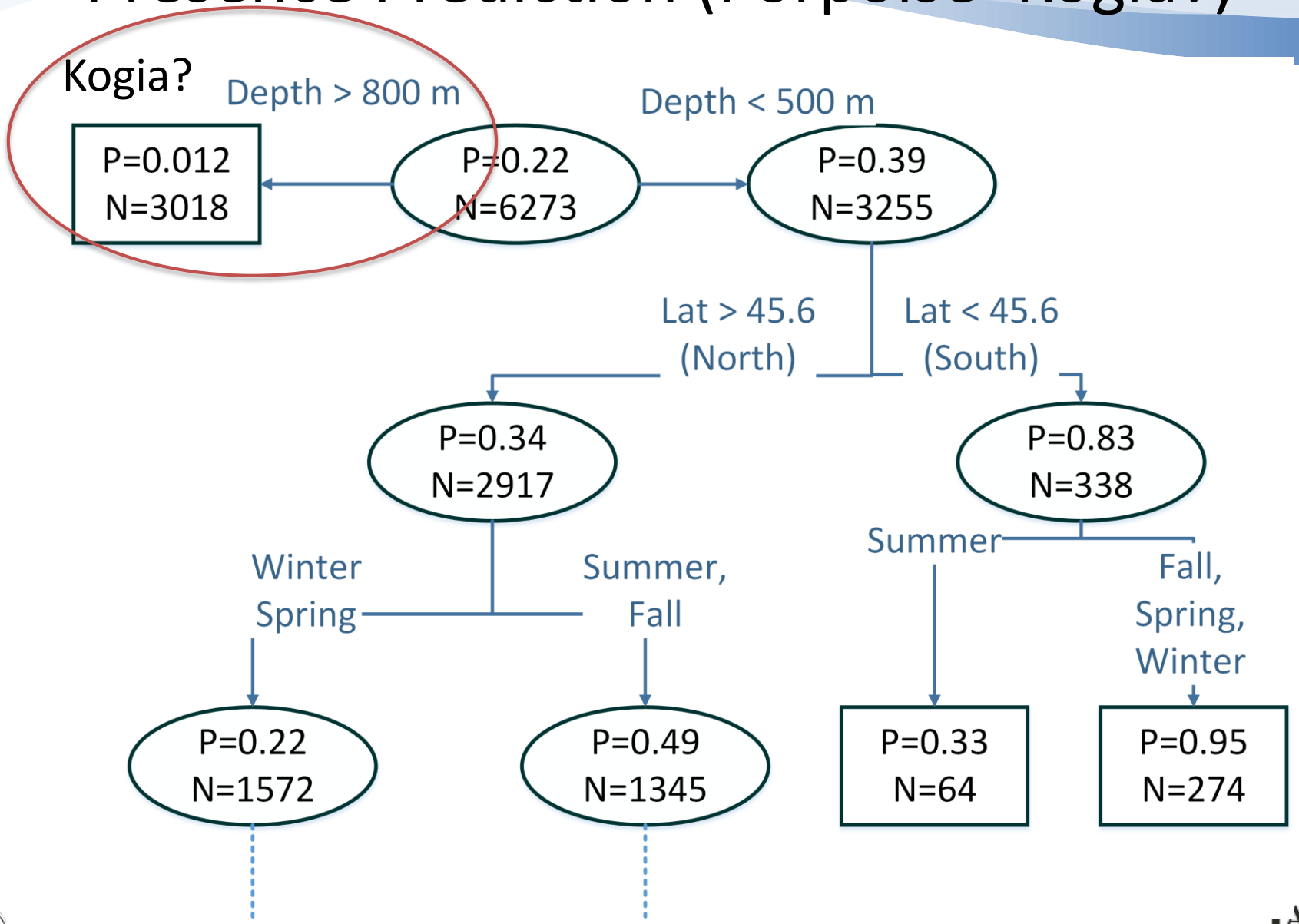
Spring

Martin et al, Marine Mammal Species Diversity on Canada's East Coast.

Presence Prediction (Porpoise)



Presence Prediction (Porpoise+Kogia?)



Ongoing & Future Work

- Classifier improvements
- Add data from BIO, Dalhousie, DFO Newfoundland to the mammal presence
- 2016-2017 analysis
- Extend results of Davis et al (2017) north … how to merge the analysis methods?
- Investigate whether soundscape metrics could have provided the same results.

Conclusions

- Demonstrated an efficient combination of automated and manual methods to analyze large multi-species data sets
- All areas have at least one species acoustically present everyday
- Marine mammal species diversity is greater:
  - South than north
  - Shelf break than shelf
  - Summer and fall than winter and spring

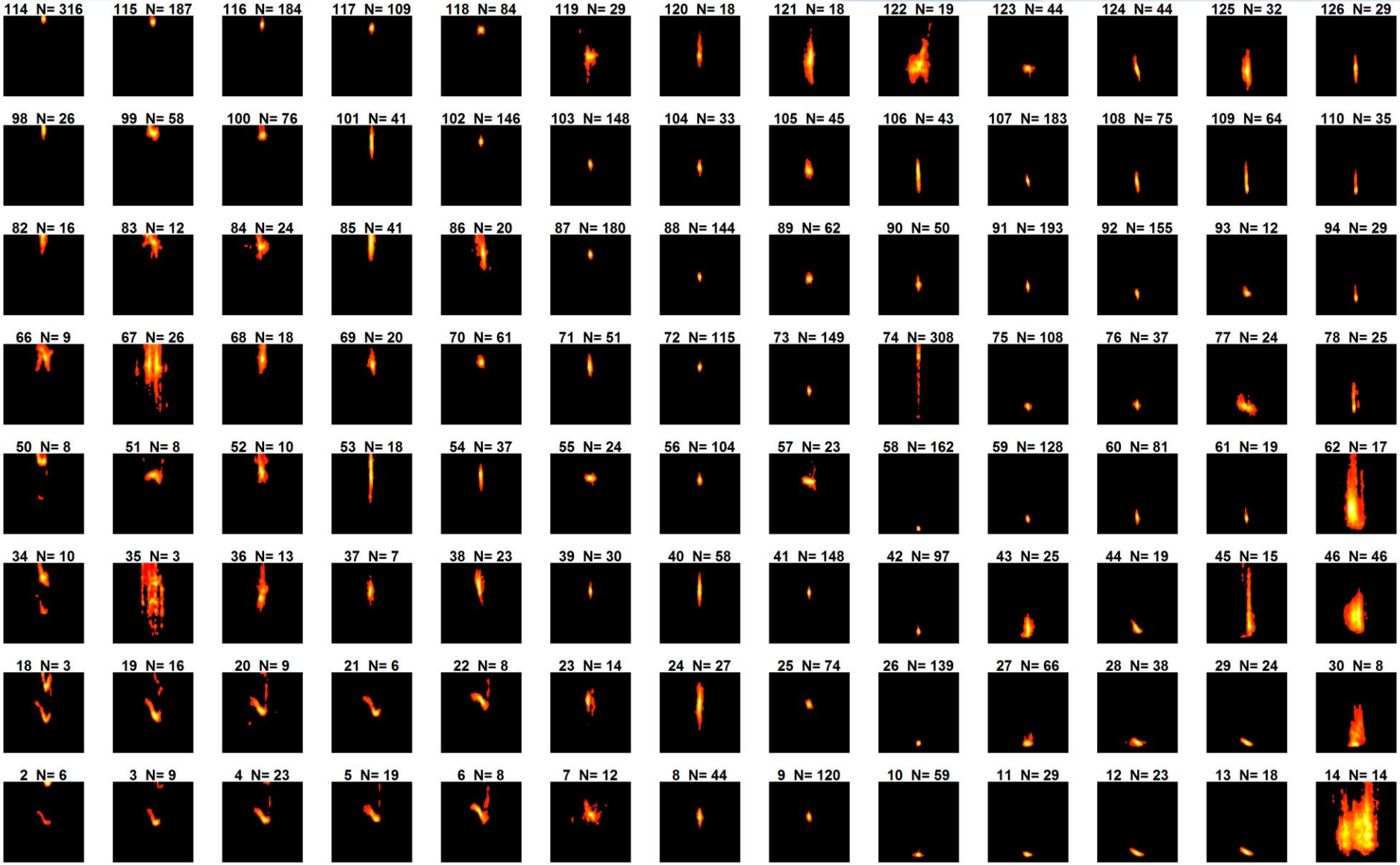
Acknowledgements

- **Environmental Studies Research Fund** for permission to present the East Coast Canada data.
- JASCO's field teams & the Masters and crews of all the vessels used in the ESRF program.
- All of our collaborators at BIO, DFO, and Dalhousie

Improving the Program

- Issues with flow-induced noise: no flow-on-a-rope moorings ever.
- Measure prey field as predictive factor

Improving Classifiers



The spatio-temporal distribution of marine mammals off Canada's east coast is generally poorly understood. Current knowledge is largely based upon visual observations from coastal areas and a small number of dedicated boat and aerial surveys that have occurred in the summer months. To address these information gaps (among others) the Environmental Sciences Research Fund supported a wide area passive acoustic monitoring (PAM) program which deployed 20 recorders from the Nain Basin off Labrador to Dawson Canyon off southwest Nova Scotia. For every 20-minute time window in the two-year data set we recorded for 11 minutes at 8000 samples per second (sps) to study pinniped and mysticete presence, and 1 minute at 250000 sps to study odontocete presence. The recordings were transferred to a high-performance computing cluster whose hardware and software is designed for efficient automated and manual analysis of PAM data. Calls from a total of 18 marine mammal species were identified by our automated detectors and the results validated by experienced analysts. By strategically selecting 1% of files with detections for manual validation we generated thresholds for the number of detections per unit time from the automated detector that maximized the accuracy of the presence-absence results. A maximum of 12 species per month were present at any of the 20 recorders. Species diversity was highest along the Scotian Shelf and southern Grand Banks throughout the year. Community-wide acoustic occurrence declined throughout the area in winter, with the southern stations retaining the greatest combined frequentation. This program provides a wealth of new information on the spatio-temporal distribution of marine mammals on Canada's east coast and can serve as a template for the efficient analysis of wide-area PAM programs targeting entire marine mammal communities.

Analysis: Manual Validation

$$P = \frac{TP}{TP + FP}$$

$$R = \frac{TP}{TP + FN}$$

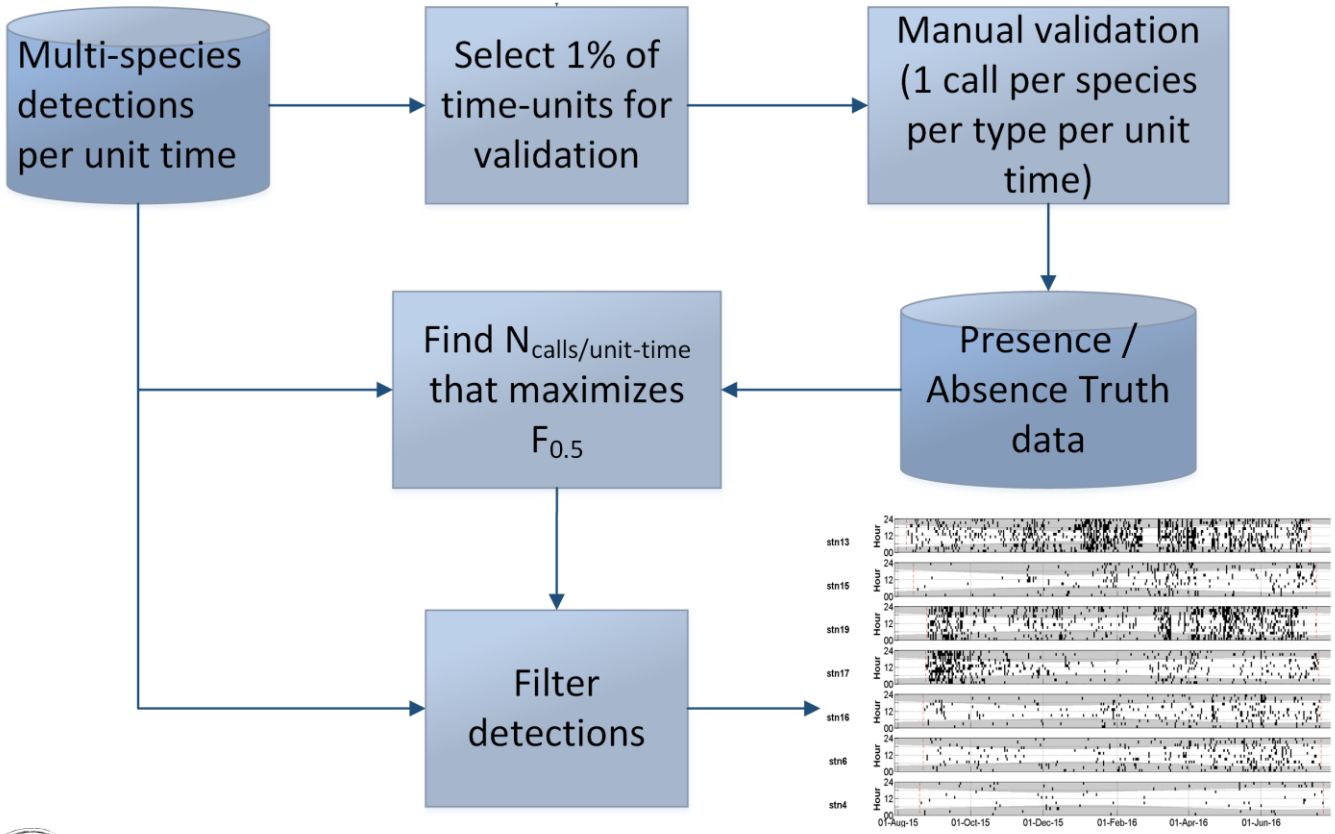
Analysis: Manual Validation

$$P = \frac{TP}{TP + FP}$$

$$R = \frac{TP}{TP + FN}$$

$$F_\beta = \frac{(1 + \beta^2)P * R}{(\beta^2)P + R}$$

Analysis: Manual Validation



$$P = \frac{TP}{TP + FP}$$

$$R = \frac{TP}{TP + FN}$$

$$F_\beta = \frac{(1 + \beta^2)P * R}{(\beta^2)P + R}$$

Predicting Presence (Porpoise)