Probability of detecting right whales in near real-time using autonomous platforms

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North Atlantic right whales

- Endangered (IUCN)
- Upcall suitable for passive acoustic monitoring (PAM)
- Need for real-time PAM from autonomous platforms
- WHOI developed operational system for gliders and buoys

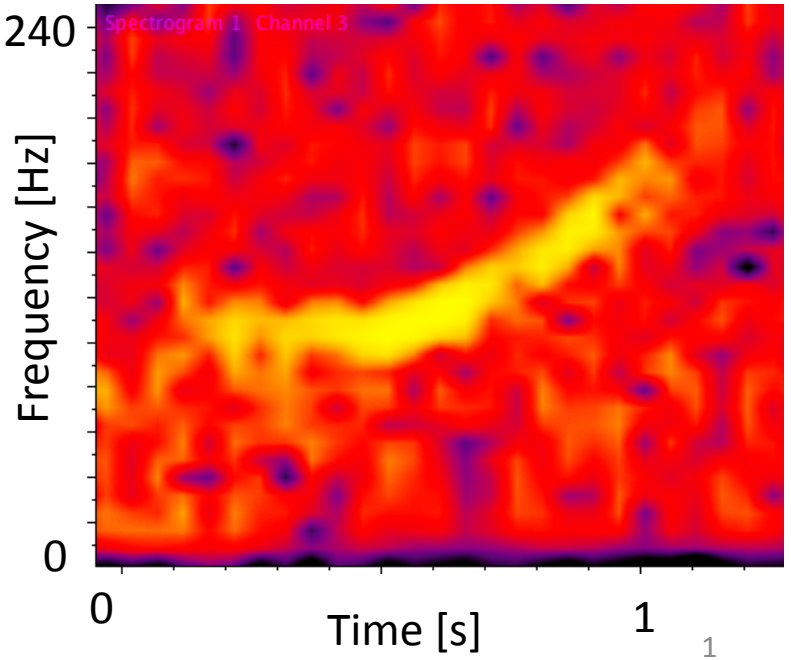
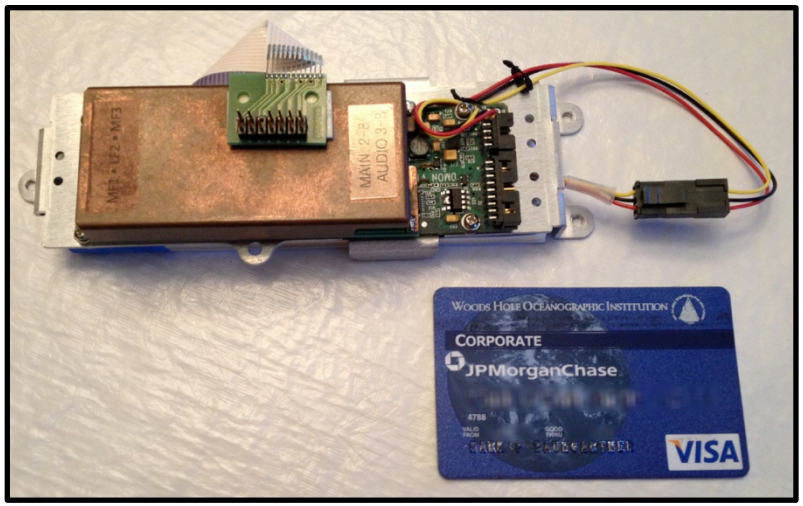


Image credit: whaleopedia.org

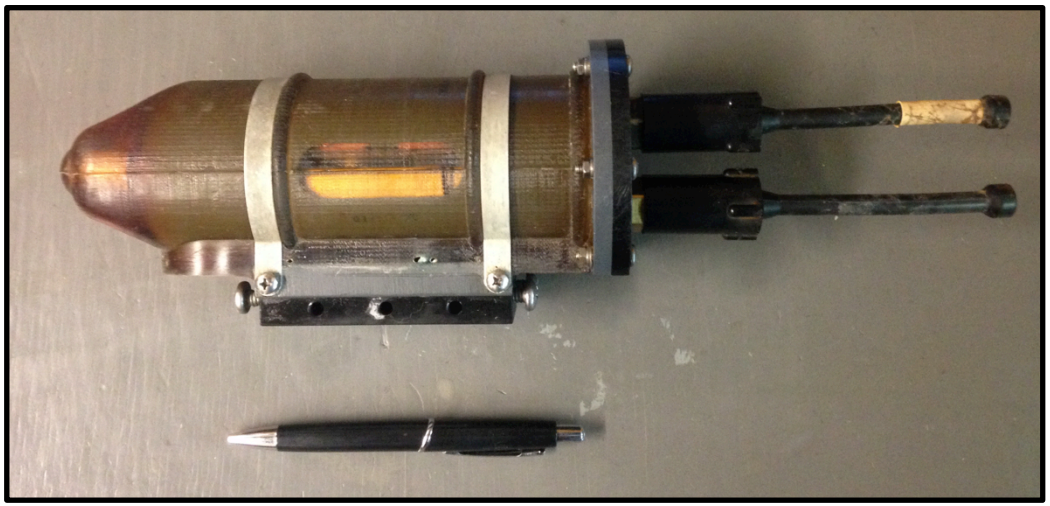
Near real-time acoustic monitoring

Digital acoustic monitoring instrument (DMON)

- Hydrophone + recorder + processor
- Low power



DMON board



DMON in pressure housing

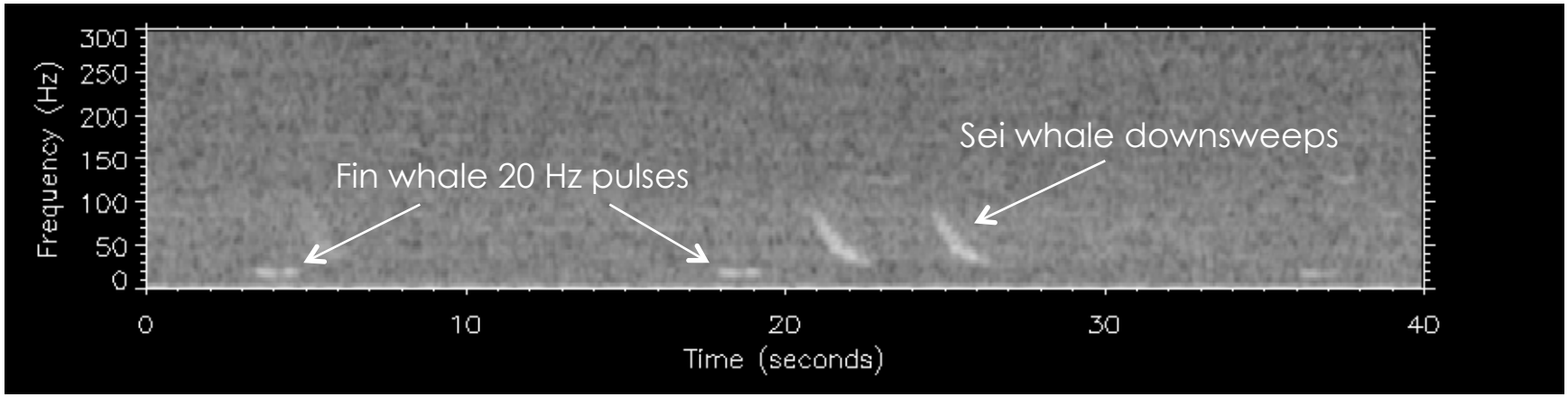
DMON developed by: Mark Johnson, Tom Hurst and Alex Shorter at WHOI

Near real-time acoustic monitoring

Low-frequency detection and classification system (LFDCS)

1. Creates a conditioned spectrogram
2. Detects sounds and 'pitch tracks' them
3. Classifies pitch tracks using discriminate function analysis
4. Pitch tracks sent to shore in near real-time for manual validation

Audio/spectrograms (**archival**)



Successfully detected: right, fin, humpback, sei, blue, bowhead, beluga, walrus, bearded seal

Baumgartner & Mussoline (2011) JASA 129:2889-2902.

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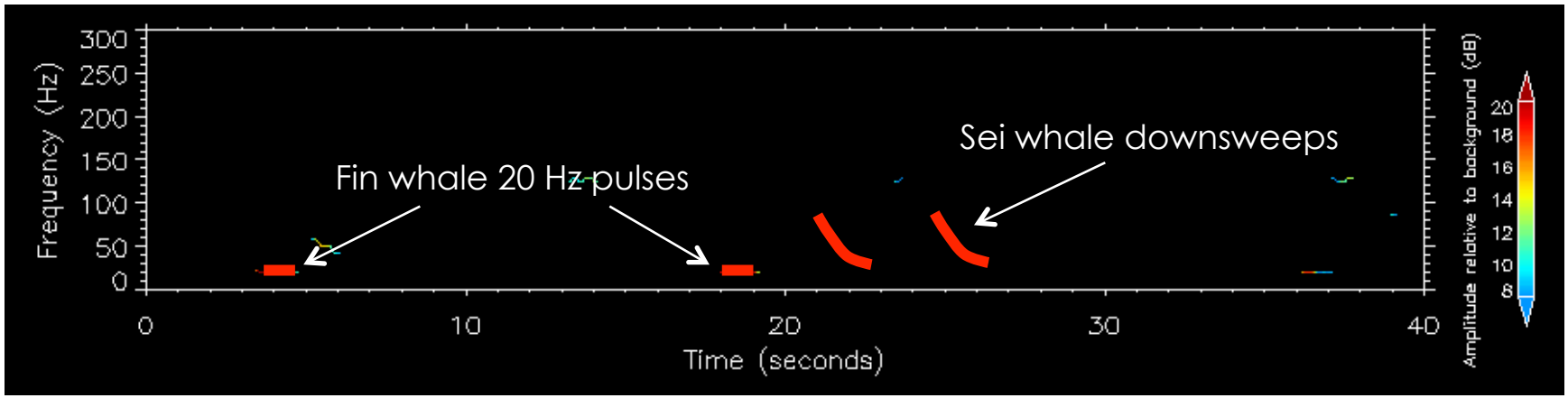
Pitch tracks (**real-time**)



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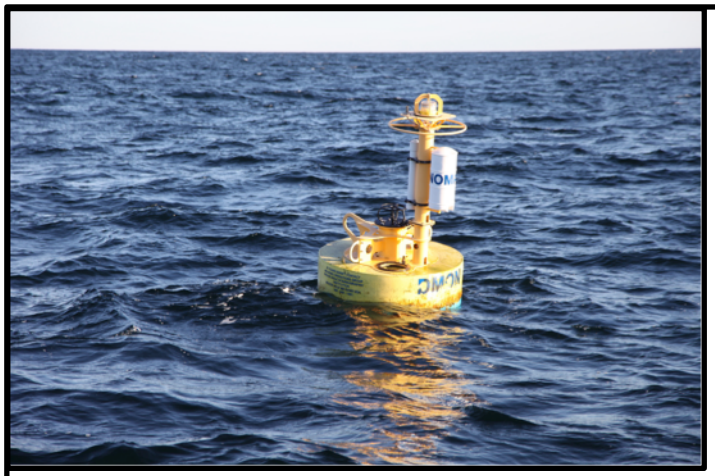
Baumgartner & Mussoline (2011) JASA 129:2889-2902.

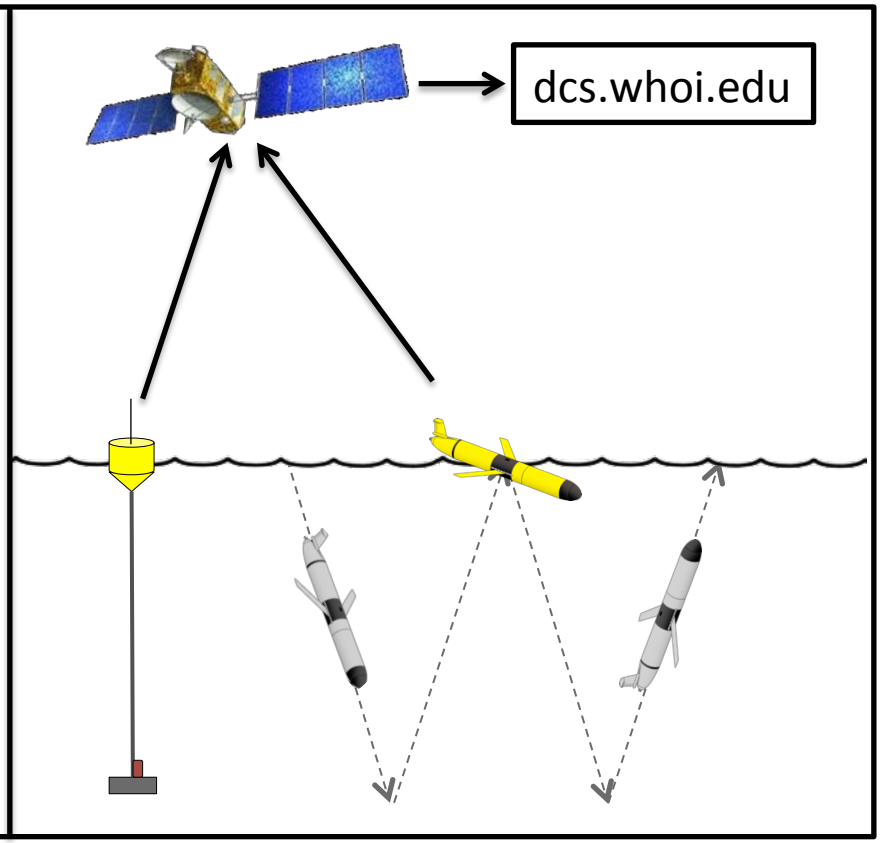
Near real-time acoustic monitoring

DMON-LFDCS operational platforms



DMON-LFDCS buoy

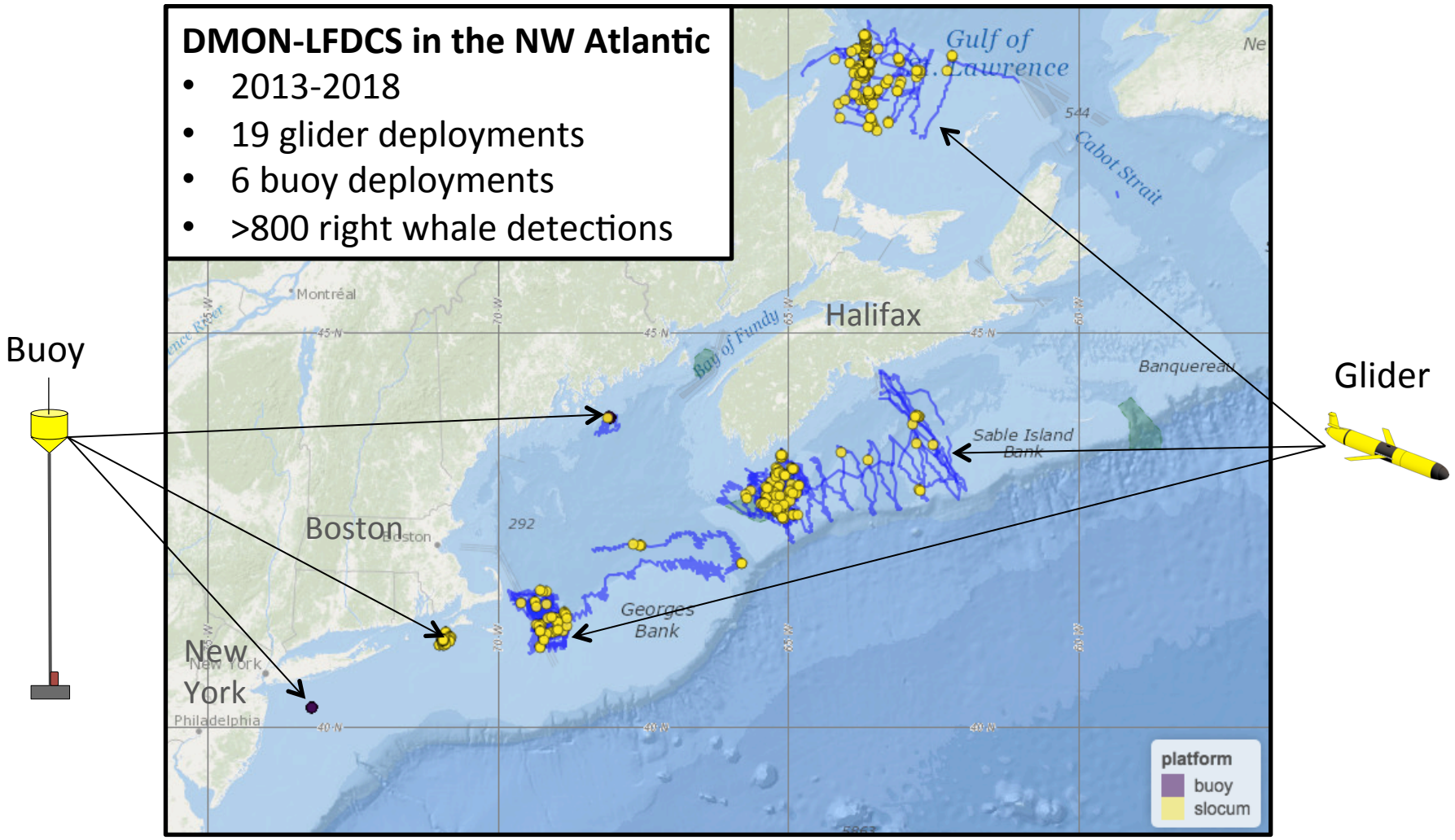
DMON-LFDCS Slocum glider



Near real-time acoustic monitoring

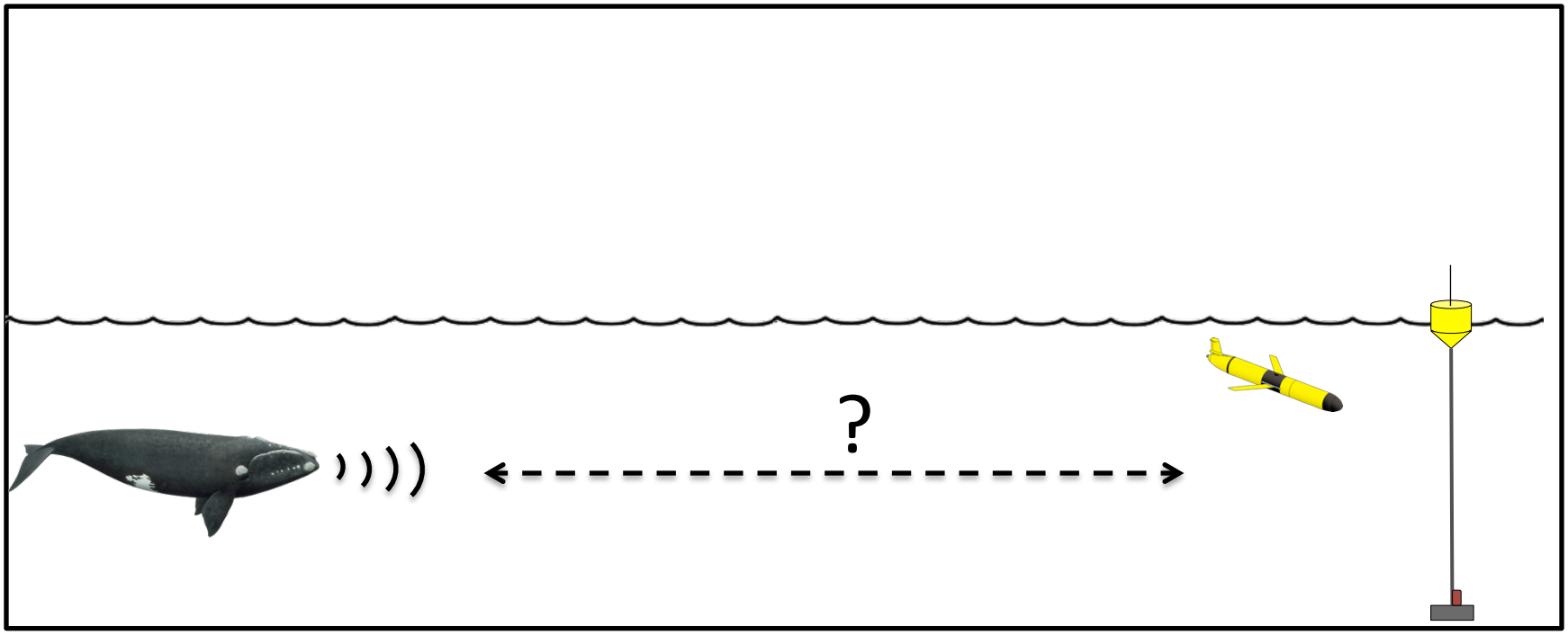
DMON-LFDCS in the NW Atlantic

- 2013-2018
- 19 glider deployments
- 6 buoy deployments
- >800 right whale detections



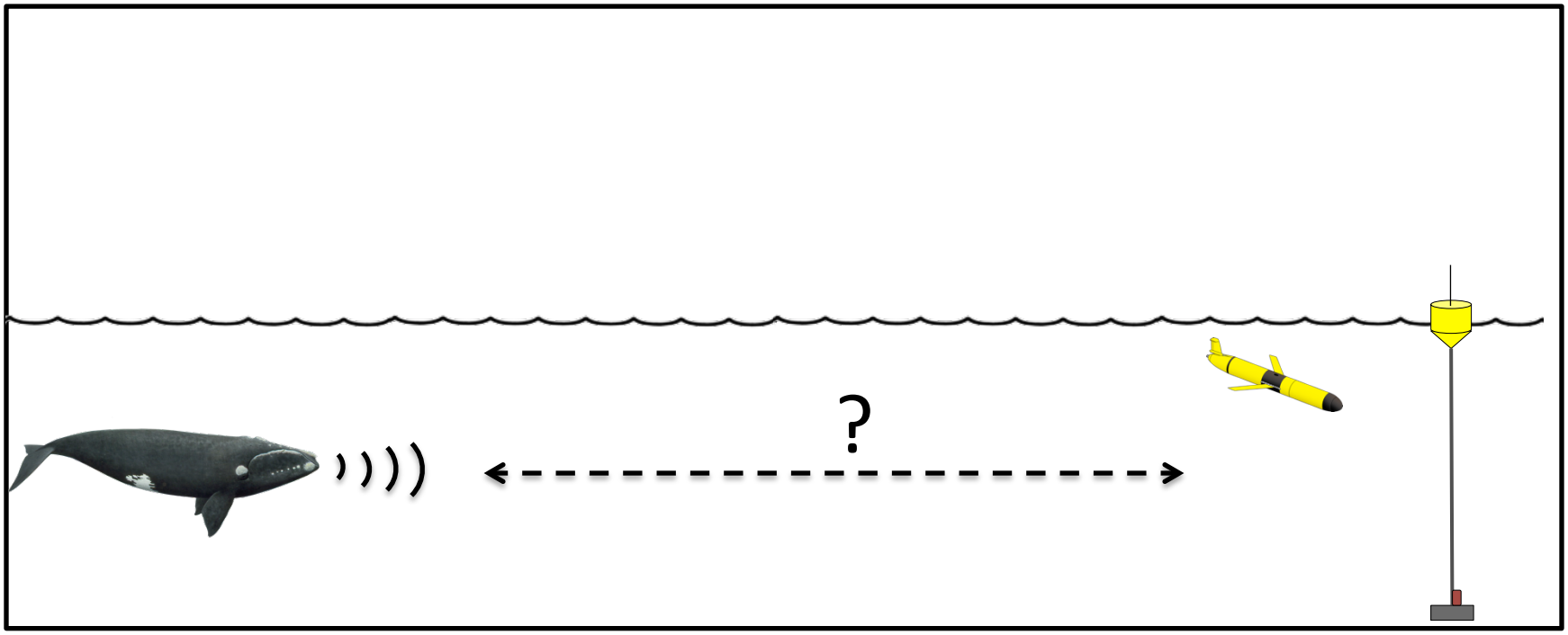
Performance of DMON-LFDCS

- Extensive work to characterize accuracy
  - Mark Baumgartner's talk Wednesday at 11:40am
- Knowledge gap: detection range



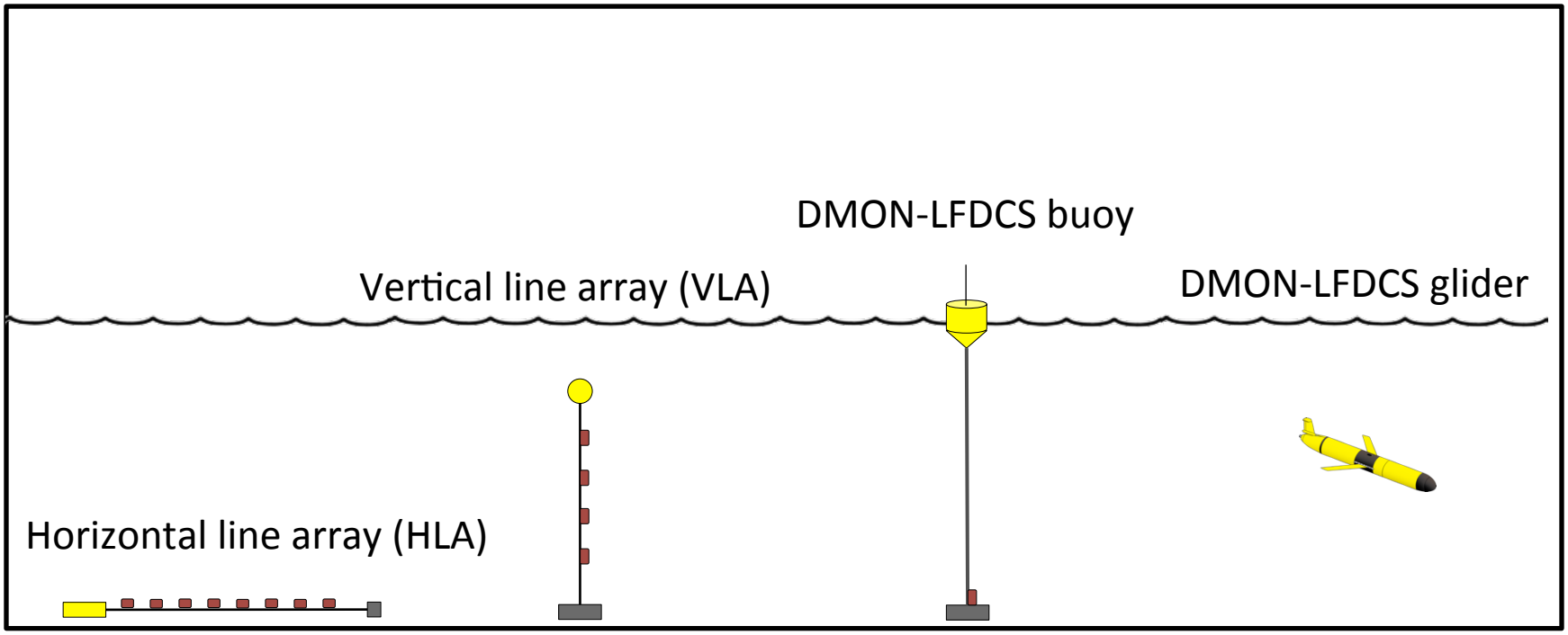
Study Goal:

Quantify the range-dependent probability of detection of the DMON-LFDCS on mobile and fixed platforms



Experimental design

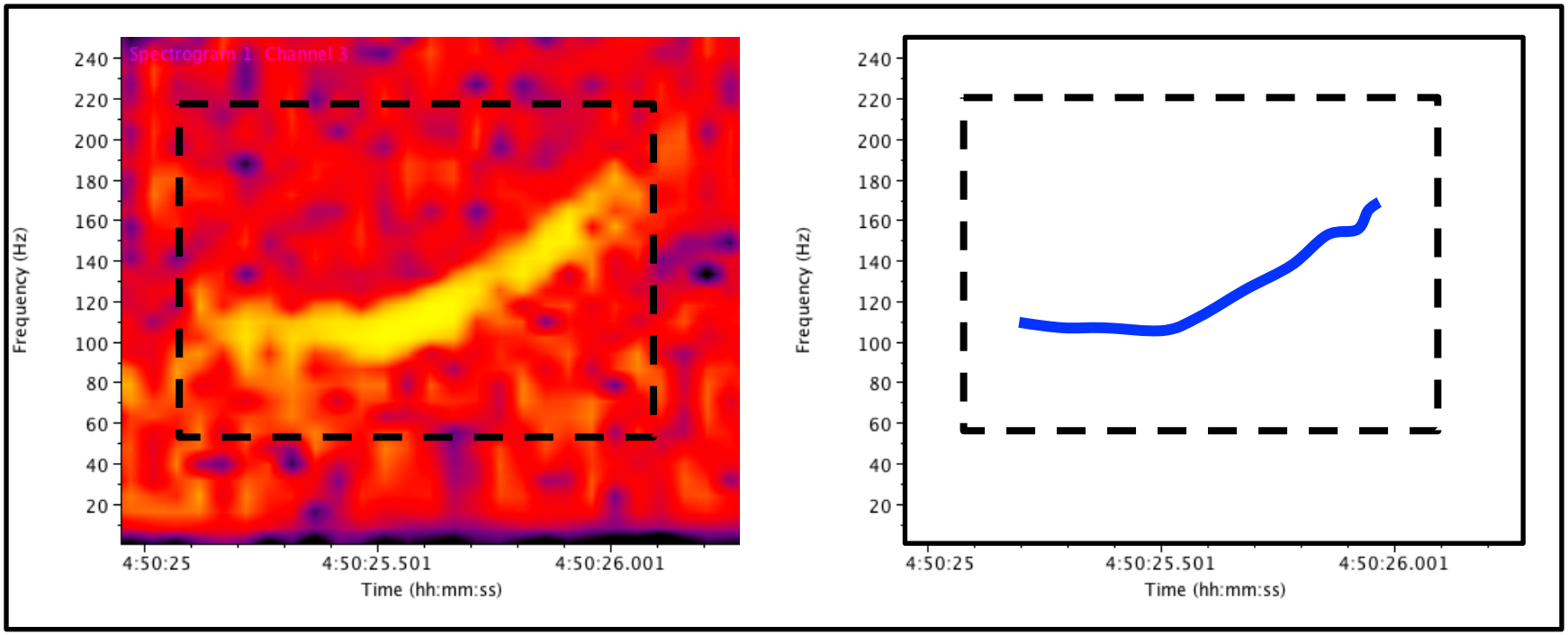
1. Deploy an 8-channel HLA, 4-channel VLA alongside a DMON-LFDCS Slocum glider and DMON-LFDCS moored buoy.



Experimental design

2. Identify all upcalls in acoustic records

- Audio/spectrograms for HLA/VLA [manual; no detector]
- Pitch tracks for glider and buoy



Spectrograms Pitch tracks

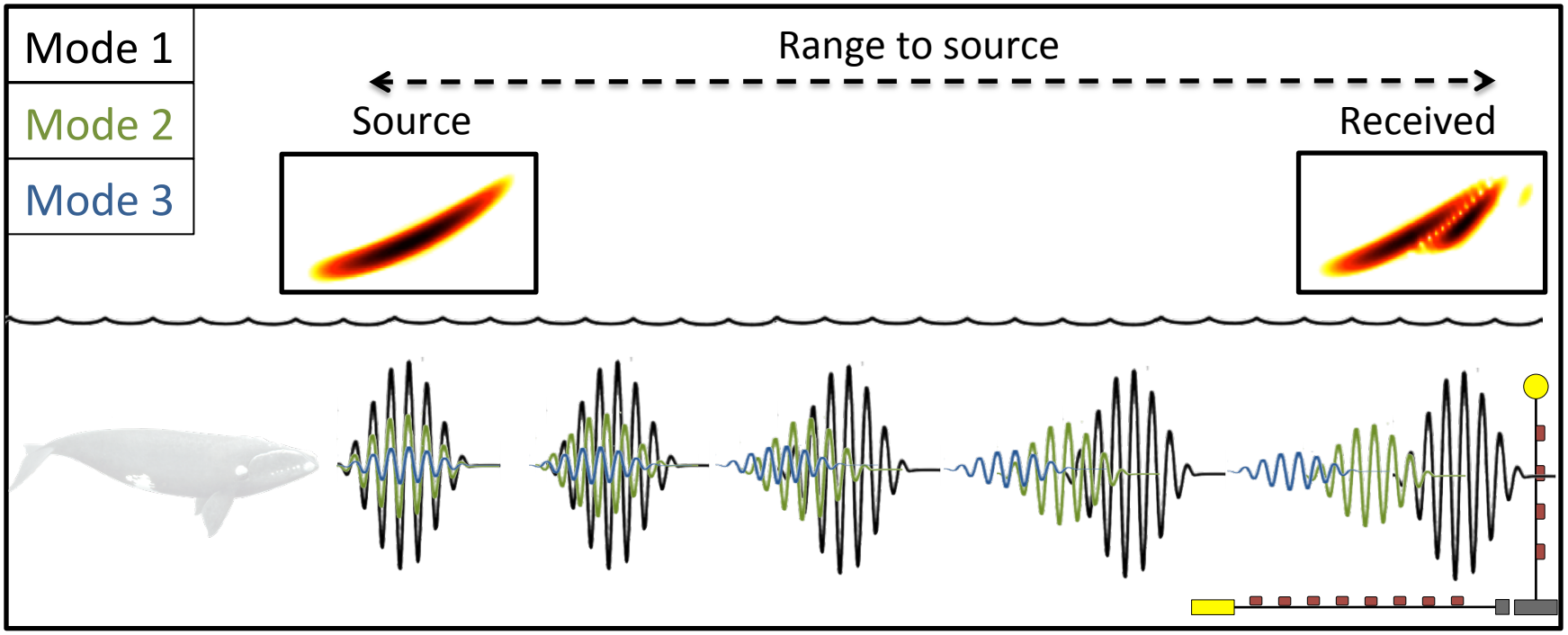
Experimental design

3. Localize calls using normal mode back-propagation

a. Mode filter at VLA

b. Beamform with HLA

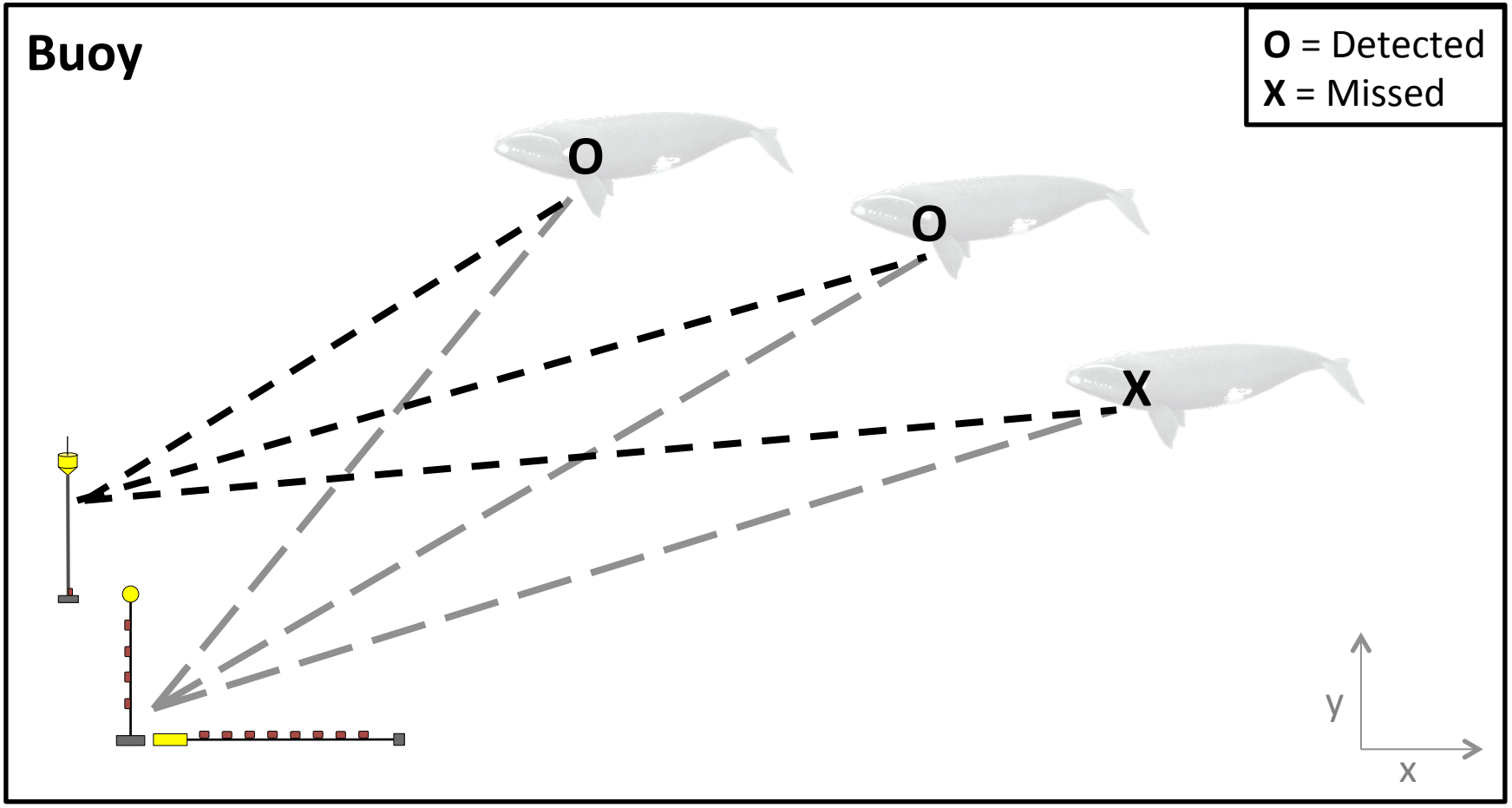
c. Back-propagate, accounting for modal dispersion (below)



Lin et al (2012) JASA 131:1798–1813.

Experimental design

4. Conduct a call-by-call comparison (**buoy** versus array)



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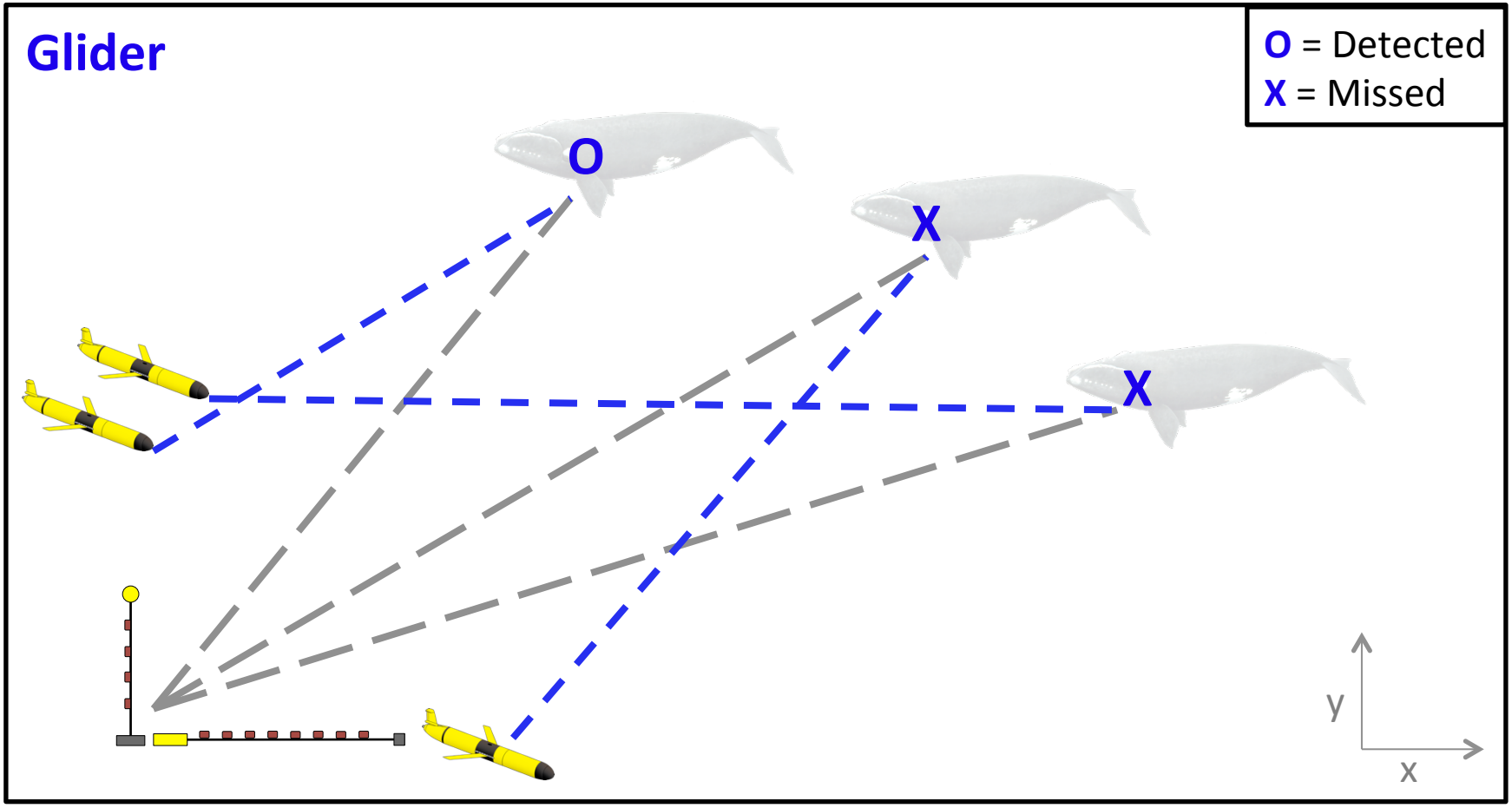
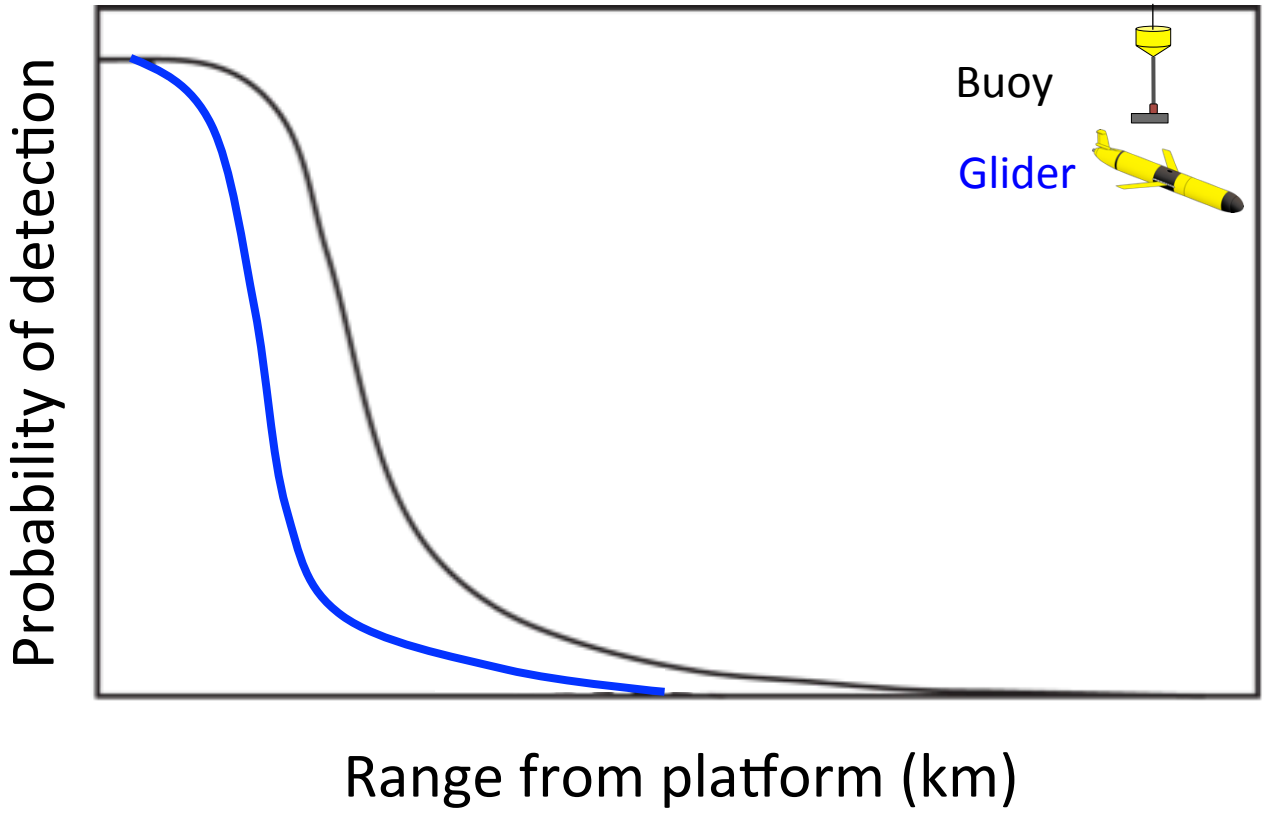


Experimental design

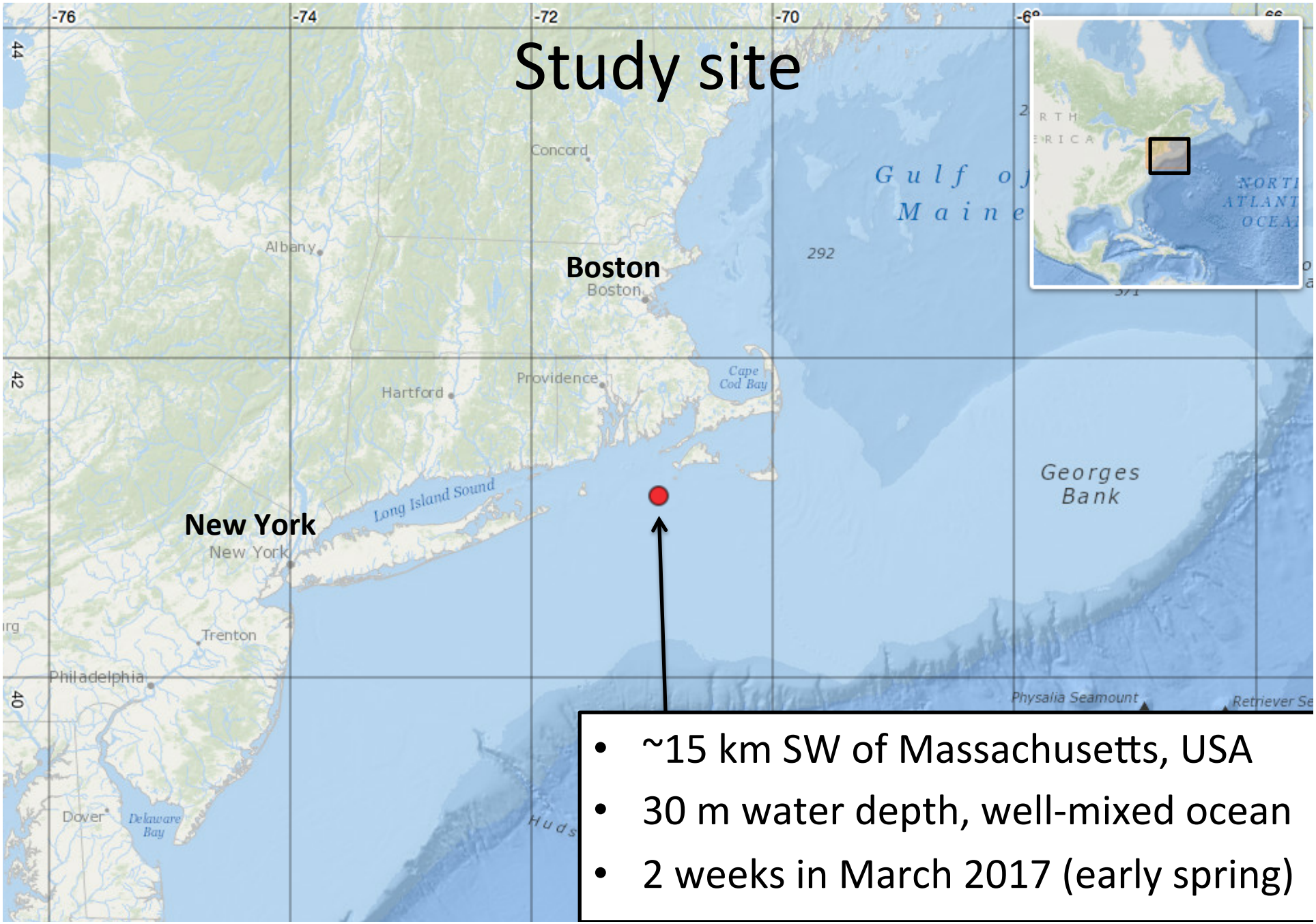
5. Quantify the probability of detection as function of range to the call for each platform



Experimental design

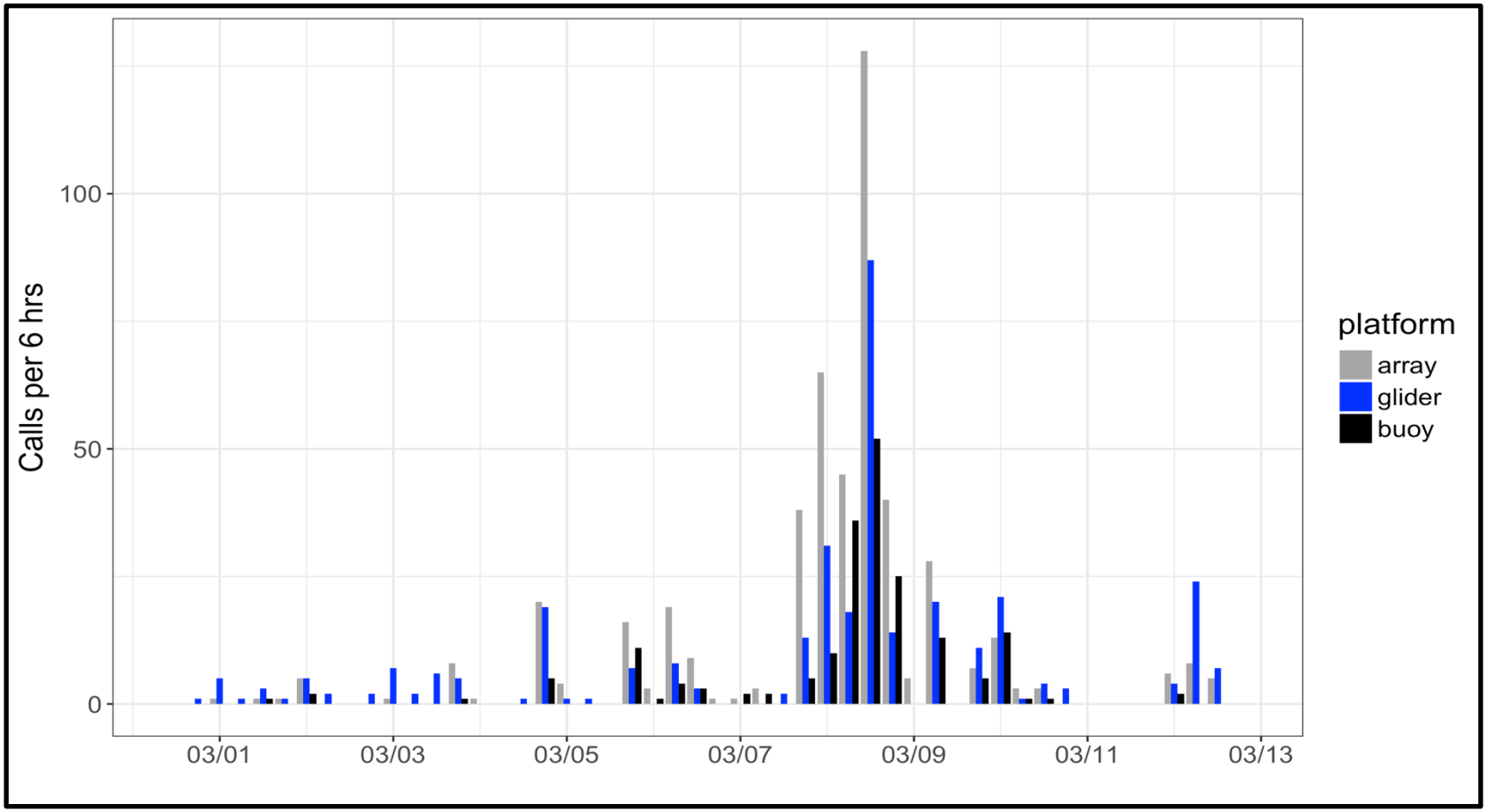
Key assumption:

- Array *localization range* is greater than the *detection range* of the glider or buoy

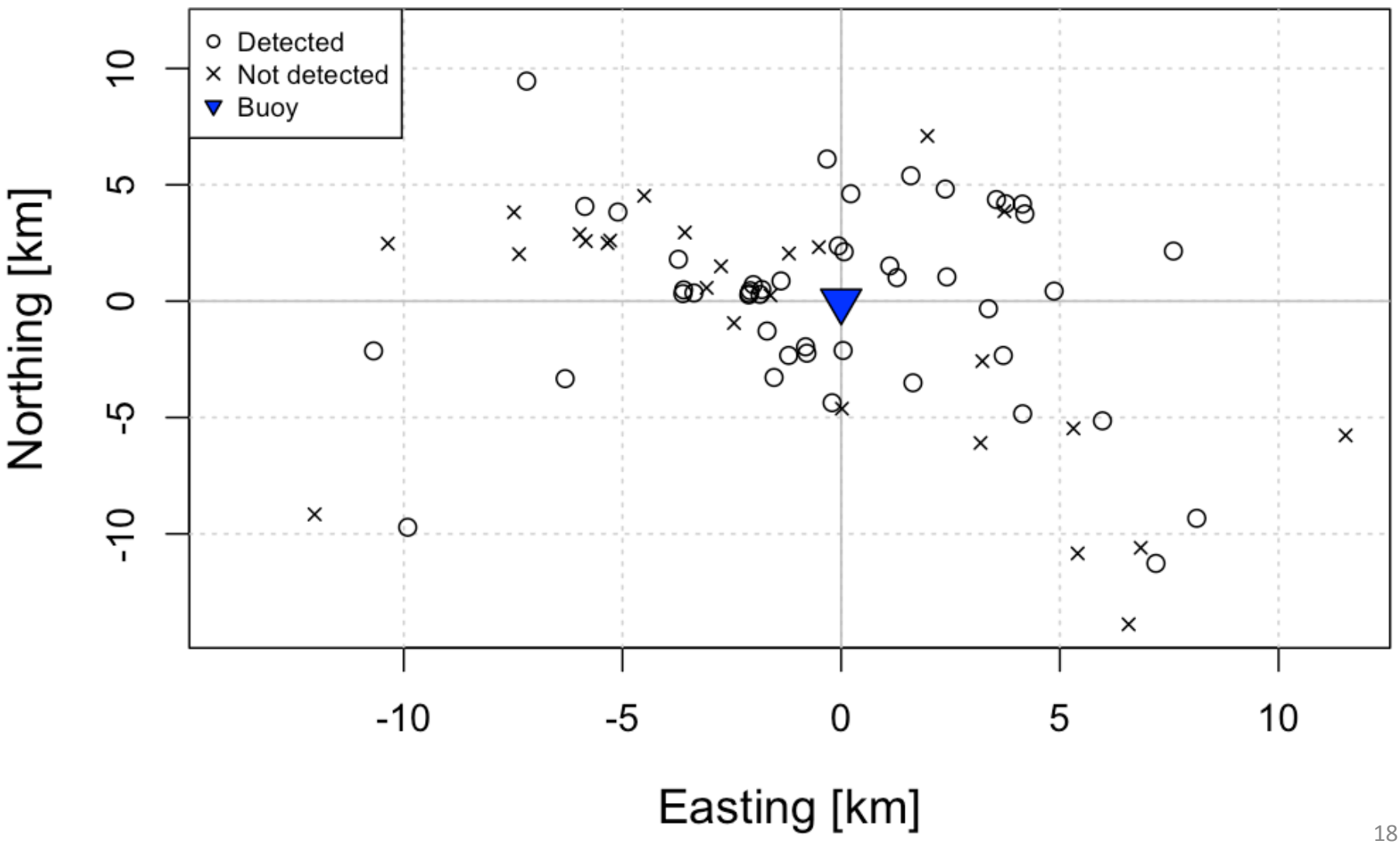

Study site
-76
-74
-72
-70
44
42
40
Concord
Albany
Boston
Boston
Providence
Hartford
Cape Cod Bay
Gulf of Maine
292
Georges Bank
Long Island Sound
New York
New York
Trenton
Philadelphia
Dover
Delaware Bay
Physalia Seamount
Retriever Se
• ~15 km SW of Massachusetts, USA
• 30 m water depth, well-mixed ocean
• 2 weeks in March 2017 (early spring)

Detections

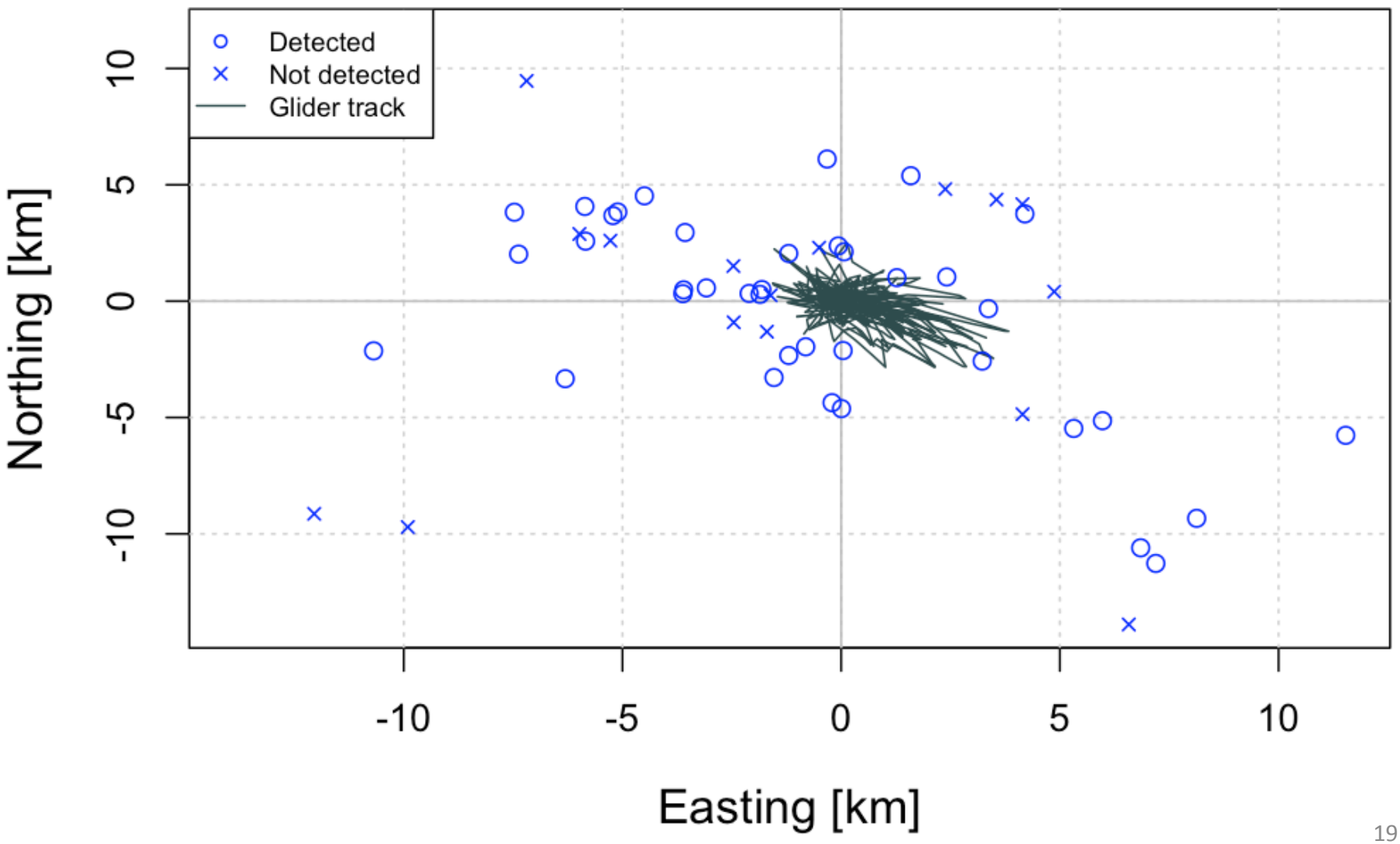
- 488 right whale upcalls detected on the HLA/VLA
- 75 calls localized



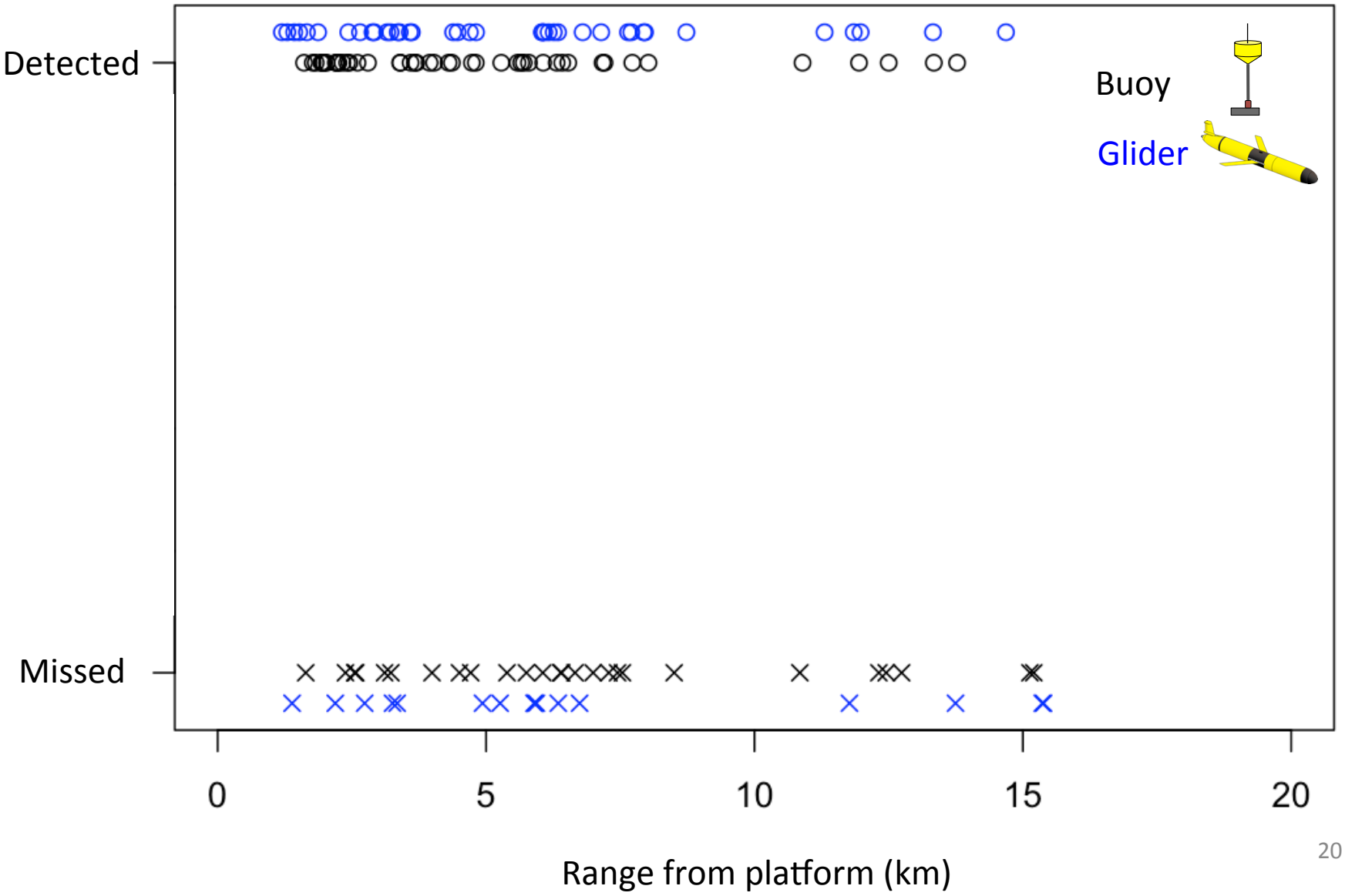
Localizations: buoy



Localizations: glider



Probability of detection



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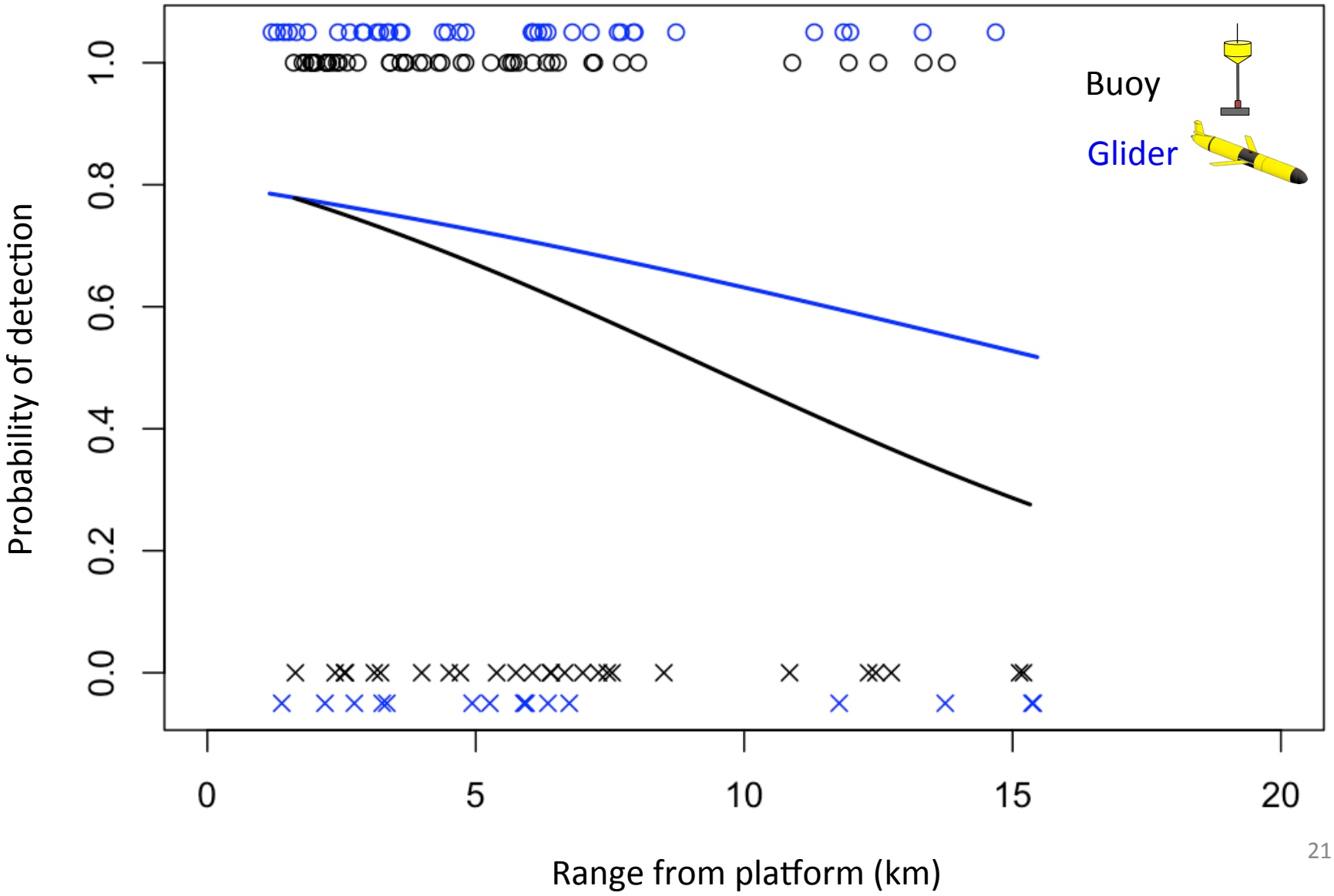
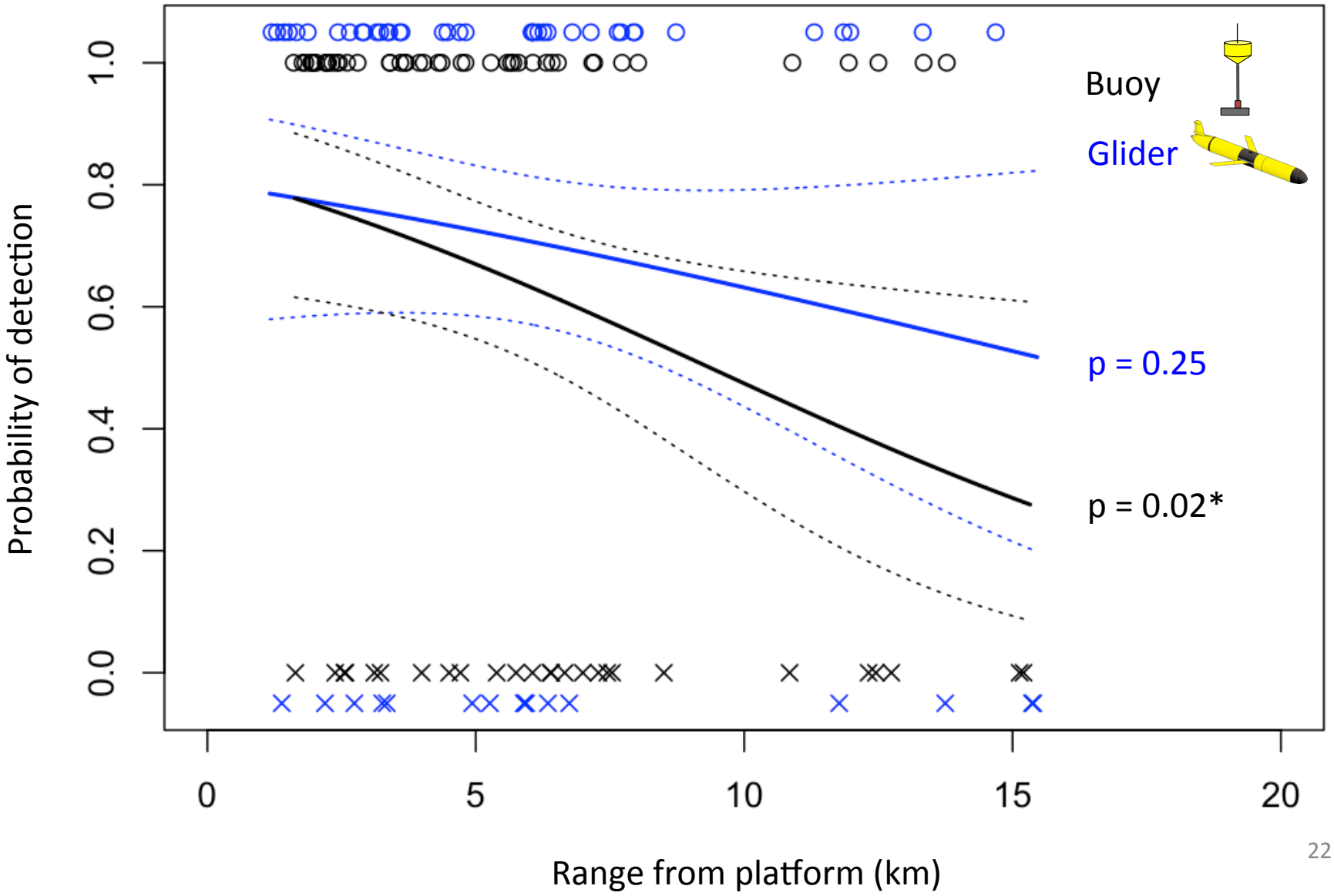
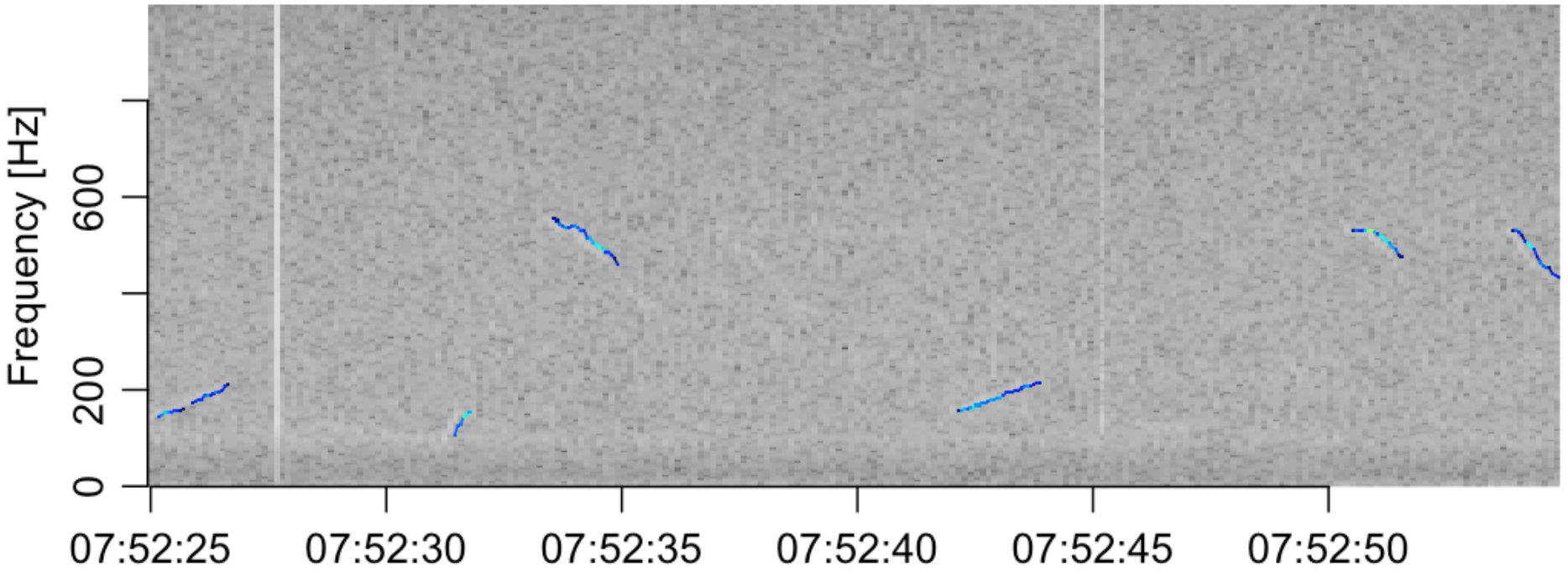


Probability of detection



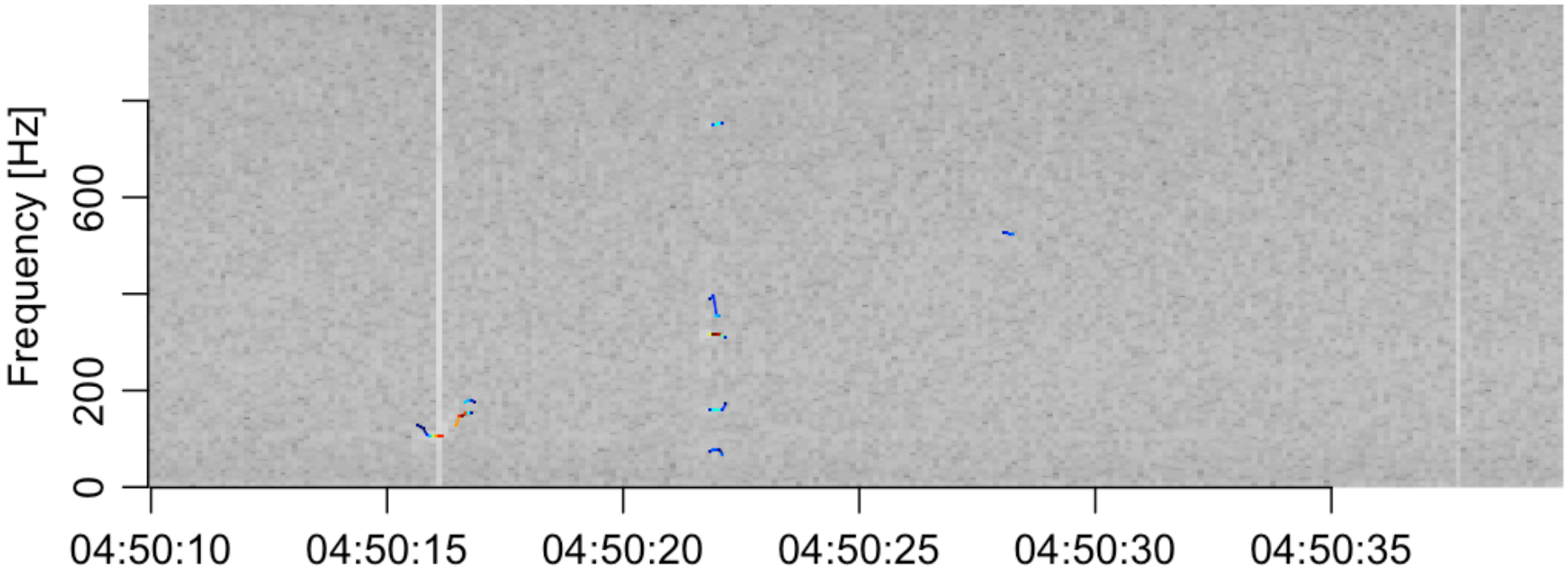
Missed calls: close range

1. Humpback song



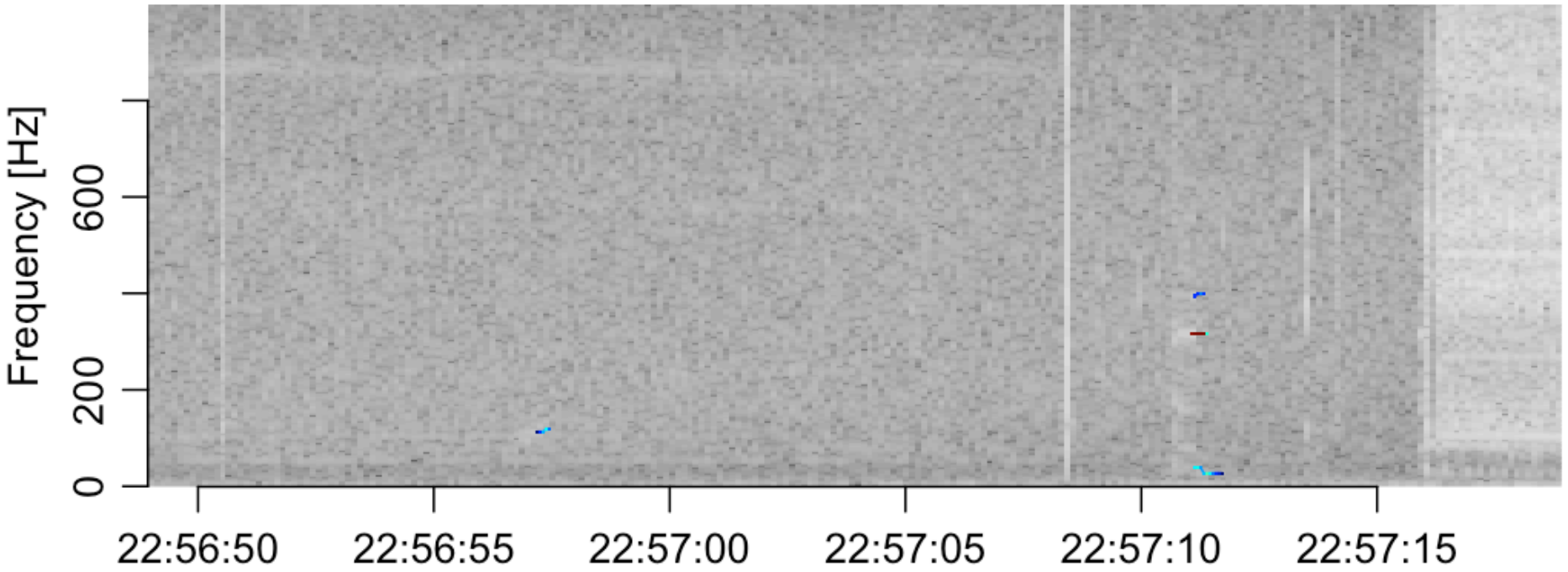
Missed calls: close range

2. Platform noise



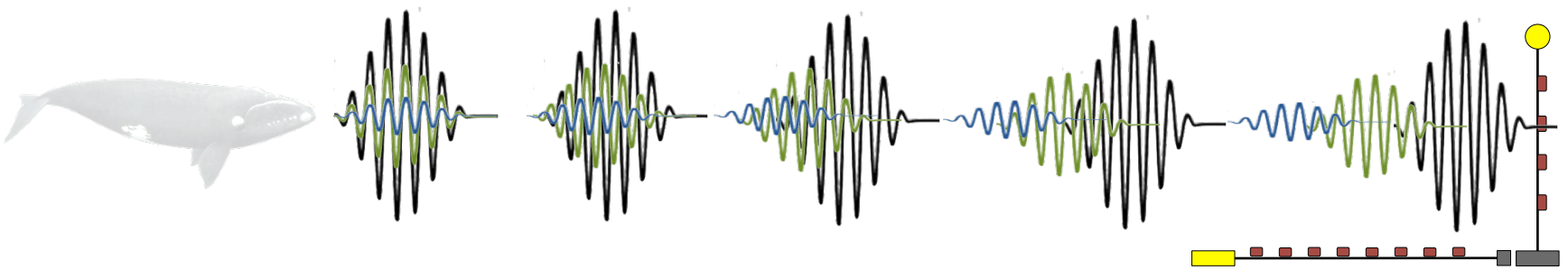
Missed calls: close range

3. Low SNR



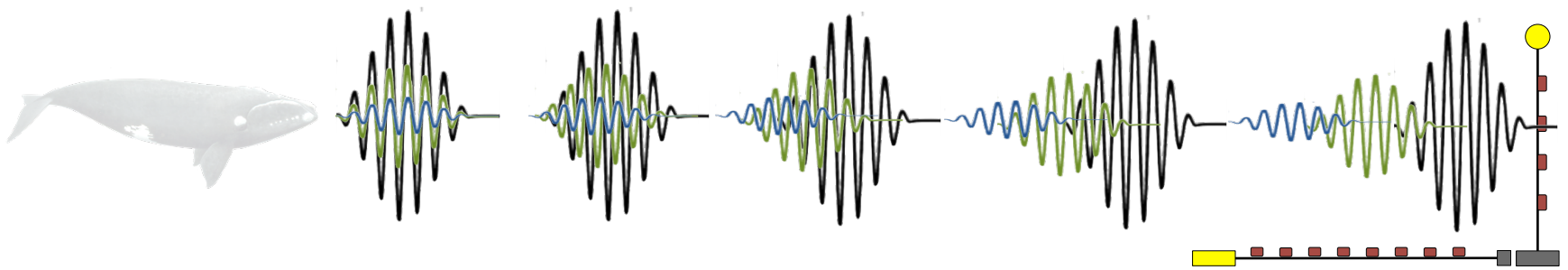
Conclusions

- NMBP technique was successful for right whale localization in shallow water
- Detection curves: buoy is significant, glider marginal
- Factors other than range contribute to missed calls at close range
- Detection probability does not reach 0 at long range
  - Array localization range may not exceed platform detection range



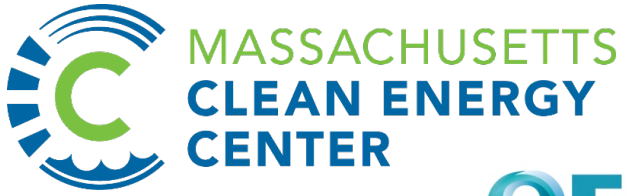
Next steps

- Reduce uncertainty in logistic regression
  - More calls (mode filtering, extra deployment, etc.)
- Parameterize model-based estimates to apply to new areas
- Repeat experiment with distributed array



Questions?

Thanks to:



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