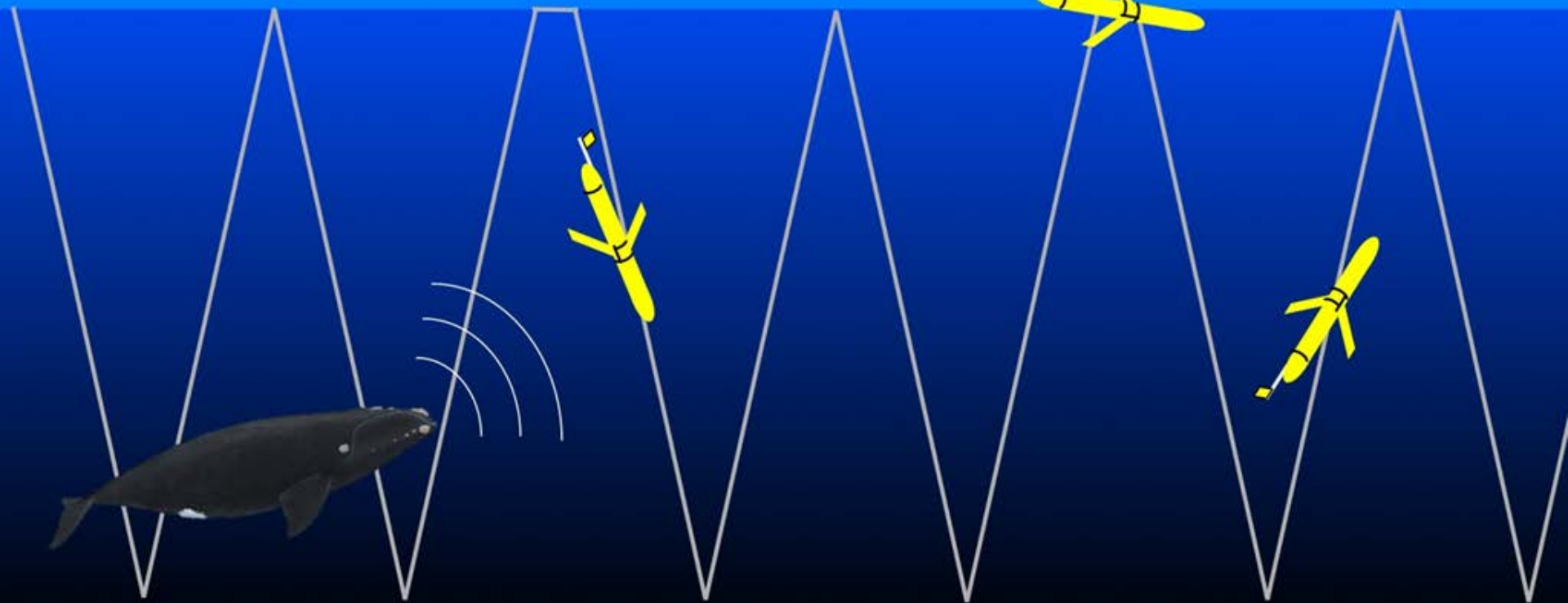


# Using autonomous platforms and near real-time acoustic monitoring to mitigate interactions between large whales and human activities

*Mark Baumgartner*

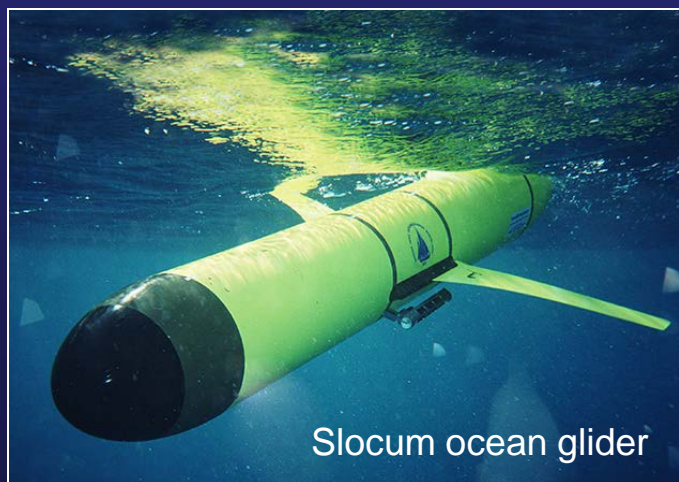
*Woods Hole Oceanographic Institution*



1. Motivation
2. Enabling technology
3. Does the technology work?
4. Applications

## Autonomous platforms

- Cover wide range of spatial/temporal scales
- Oceanographic sensors
- Built-in real-time communications
- Comparatively inexpensive
- Quiet for archival/real-time passive acoustics



## Why real time?

- Immediate action required
  - Direct science operations
  - Mitigation of anthropogenic risks
  
- Recovery of platform is impractical
  - Expendable long-endurance platforms, such as profiling floats or ice-tethered platforms

Sei whale and tanker



APEX profiling float

1. Motivation
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# Digital acoustic monitoring instrument



## DMON



### Features

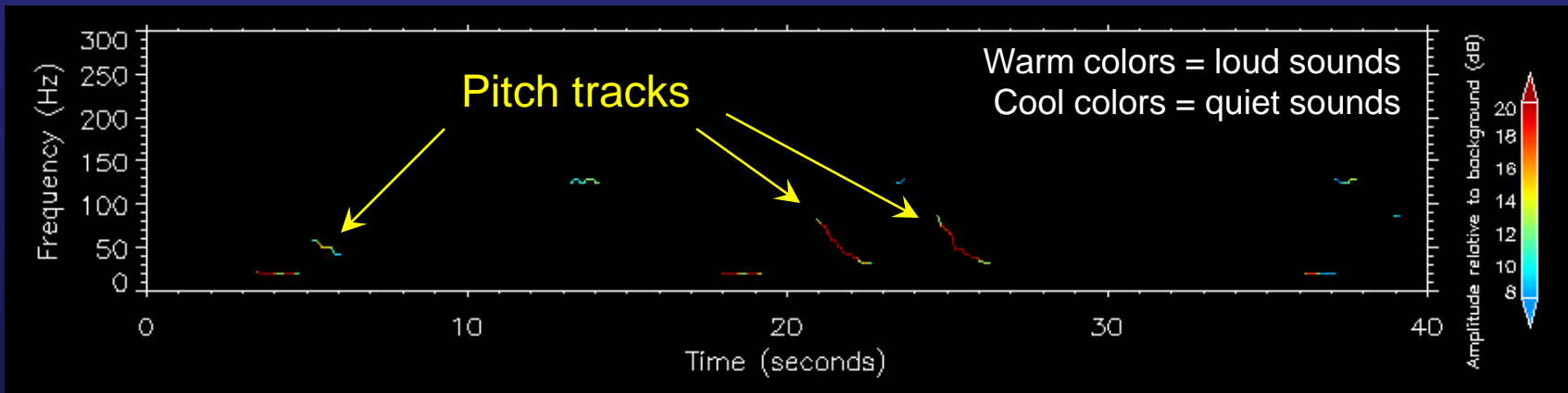
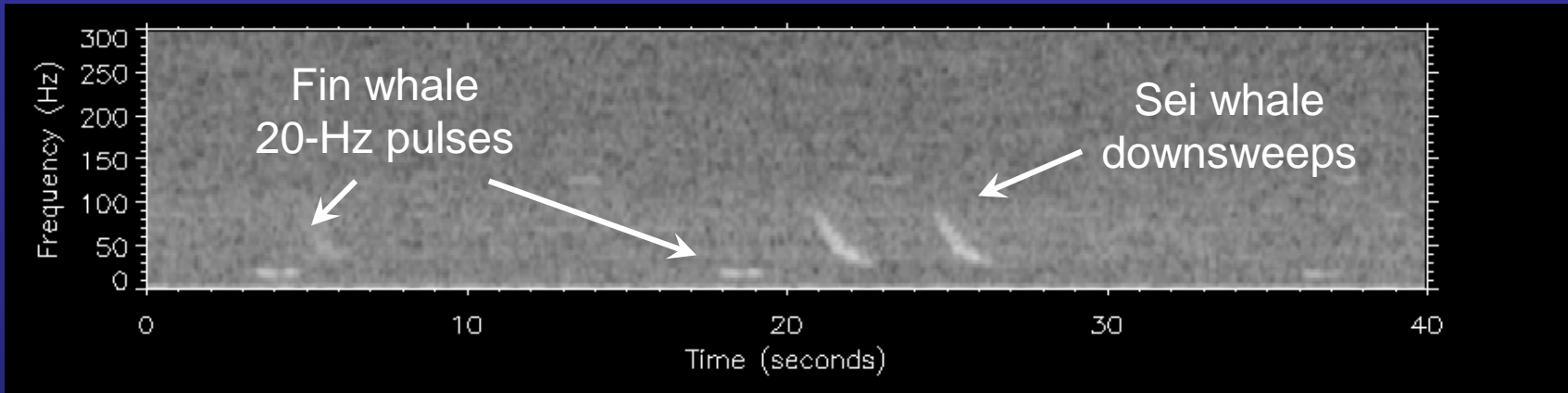
- Low-power fixed-point DSP
- Programmable (C, Assembly)
- Flash memory, serial output
- 3 hydrophones (0.010-7.5, 0.1-50, 1-160 kHz)



Developed at WHOI by Mark Johnson, Tom Hurst, and Alex Shorter

# Detection and classification

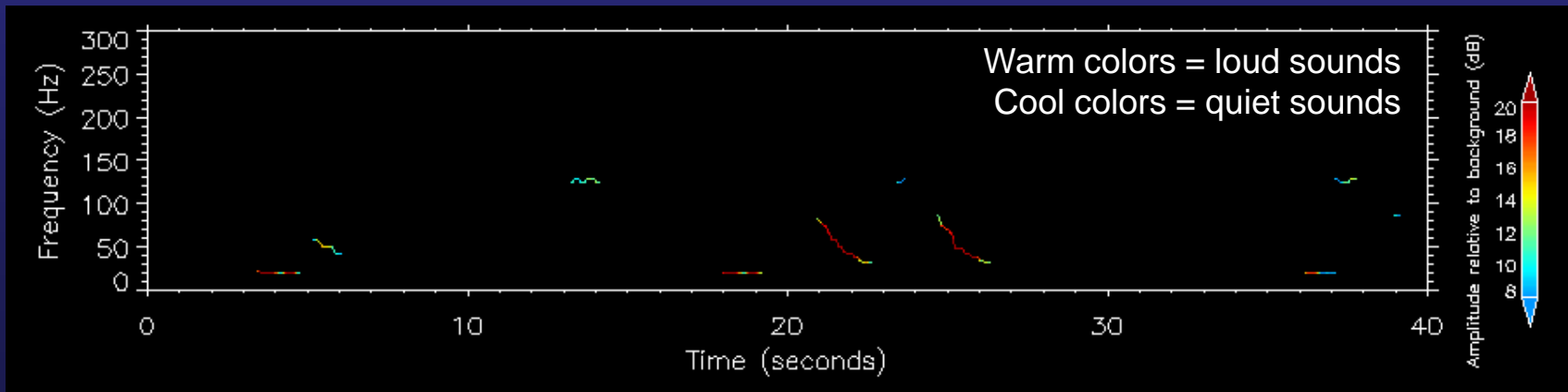
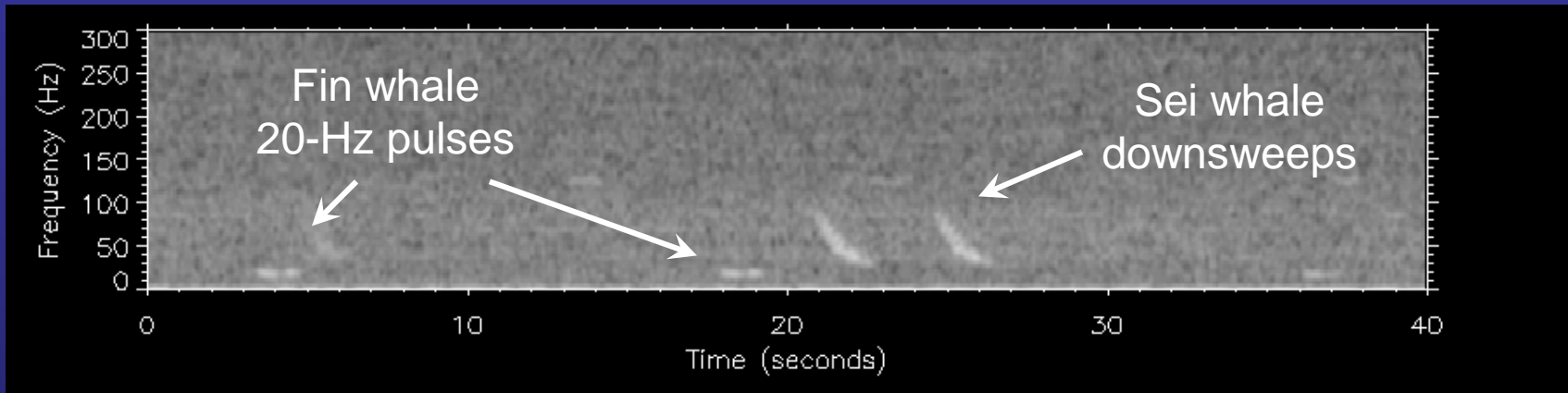
## Low-frequency detection and classification system (LFDCS)



*Baumgartner, M.F. and S.E. Mussoline. 2011. A generalized baleen whale call detection and classification system. Journal of the Acoustical Society of America 129:2889-2902.*

# Detection and classification

## Low-frequency detection and classification system (LFDCS)

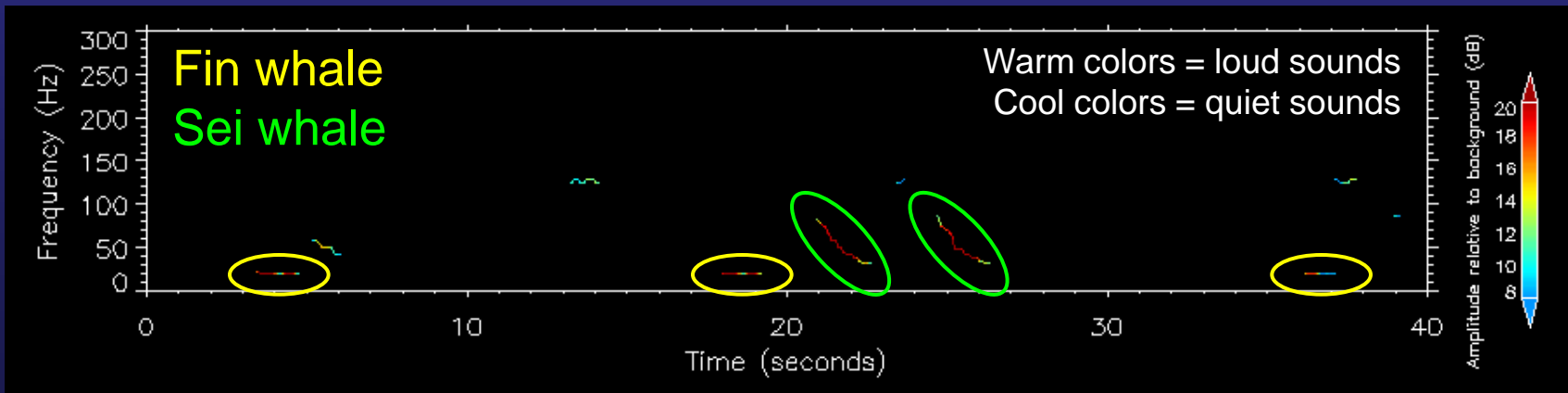
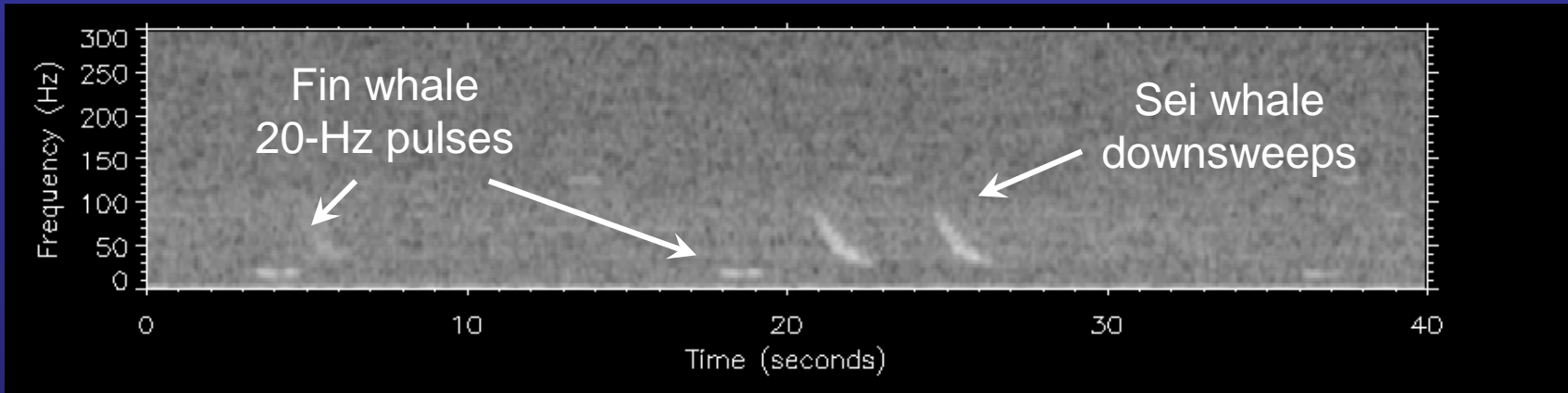


*Baumgartner, M.F. and S.E. Mussoline. 2011. A generalized baleen whale call detection and classification system. Journal of the Acoustical Society of America 129:2889-2902.*



# Detection and classification

## Low-frequency detection and classification system (LFDCS)



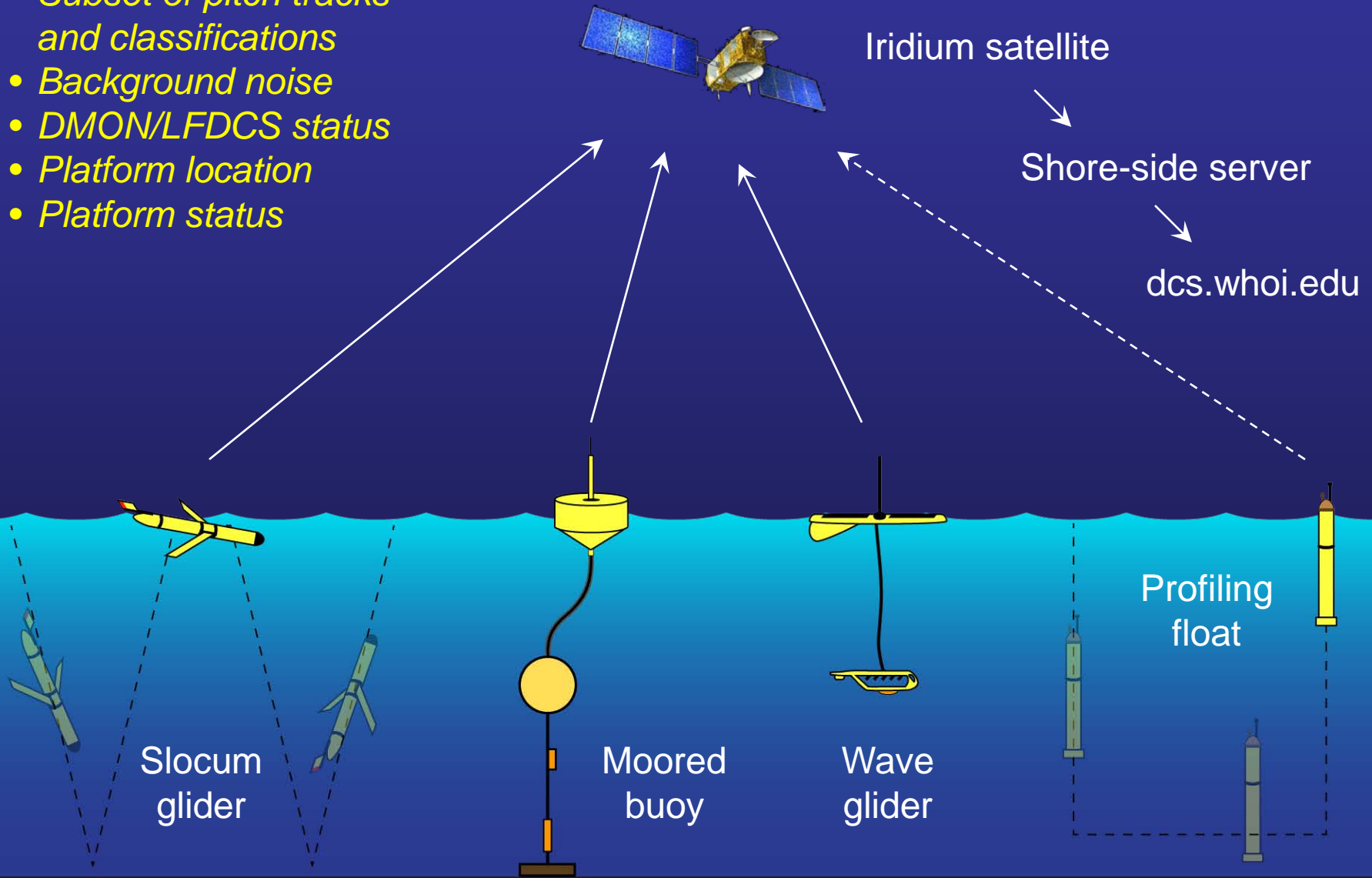
Baumgartner, M.F. and S.E. Mussoline. 2011. A generalized baleen whale call detection and classification system. *Journal of the Acoustical Society of America* 129:2889-2902.

# Operation

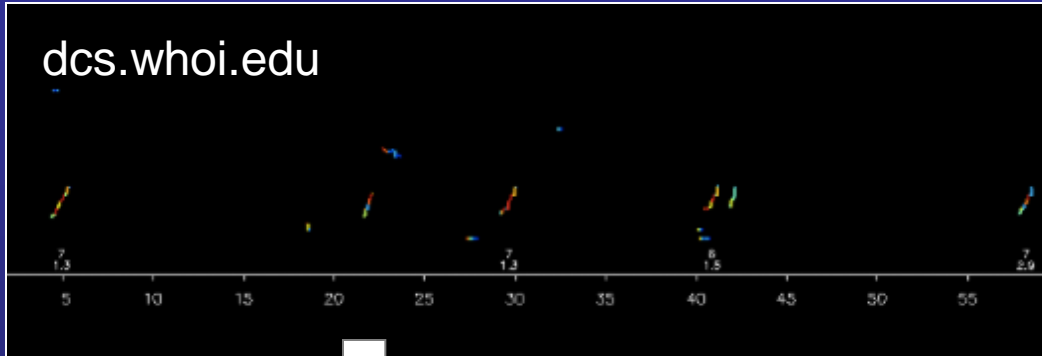


## Transmit to shore:

- *Subset of pitch tracks and classifications*
- *Background noise*
- *DMON/LFDCS status*
- *Platform location*
- *Platform status*



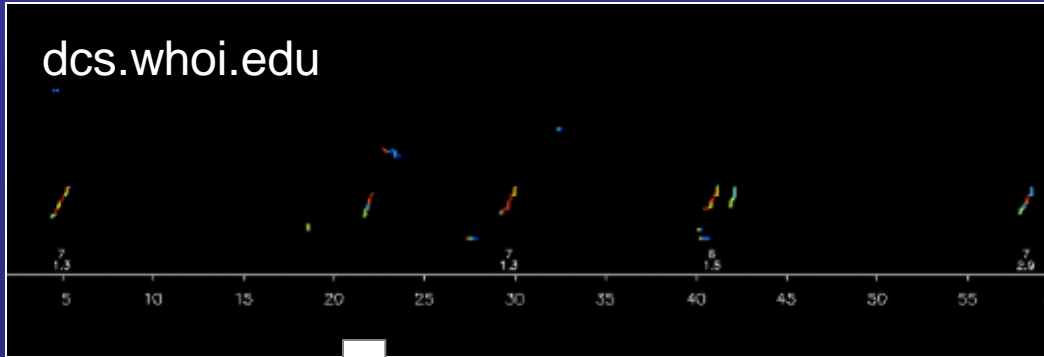
# Operation



## Analyst reviews:

- Pitch tracks
- Classifications
- Context

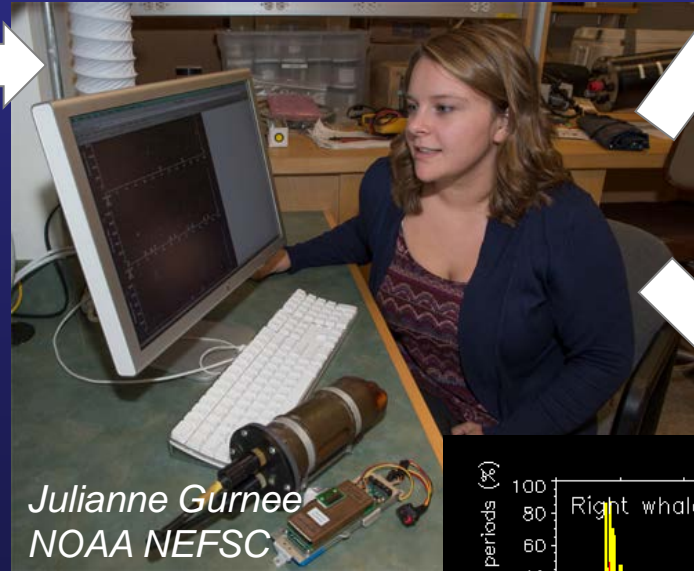
# Operation



Daily analyst review:

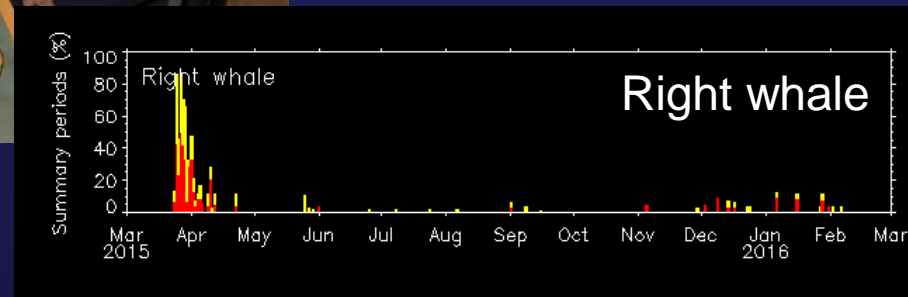
Date	Sei whale	Fin whale	Right whale	Humpback whale
<a href="#">09/04/2015</a>	Detected	Detected	Not detected	Not detected
<a href="#">09/03/2015</a>	Possibly detected	Detected	Detected	Not detected
<a href="#">09/02/2015</a>	Possibly detected	Detected	Detected	Not detected
<a href="#">09/01/2015</a>	Detected	Detected	Possibly detected	Not detected
<a href="#">08/31/2015</a>	Possibly detected	Detected	Not detected	Not detected
<a href="#">08/30/2015</a>	Possibly detected	Detected	Not detected	Not detected
<a href="#">08/29/2015</a>	Detected	Detected	Not detected	Detected
<a href="#">08/28/2015</a>	Detected	Detected	Not detected	Not detected

■ Detected  
■ Possibly detected  
■ Not detected



## Analyst reviews:

- Pitch tracks
- Classifications
- Context



# Distribution

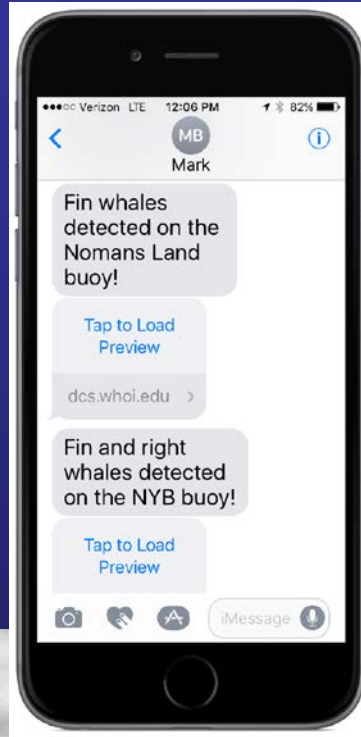


dcs.who.edu

Daily analyst review:

Date	Sei whale	Fin whale	Right whale	Humpback whale
09/04/2015	Red	Red	Red	Grey
09/03/2015	Yellow	Red	Red	Grey
09/02/2015	Yellow	Red	Red	Grey
09/01/2015	Yellow	Red	Yellow	Grey
08/31/2015	Yellow	Red	Red	Grey
08/30/2015	Yellow	Red	Red	Grey
08/29/2015	Red	Red	Red	Red
08/28/2015	Red	Red	Red	Red

## Text message



## Email message

**Mark Baumgartner**  
 To: undisclosed-recipients;;  
 Fin whales detected on the Nomans Land buoy

---

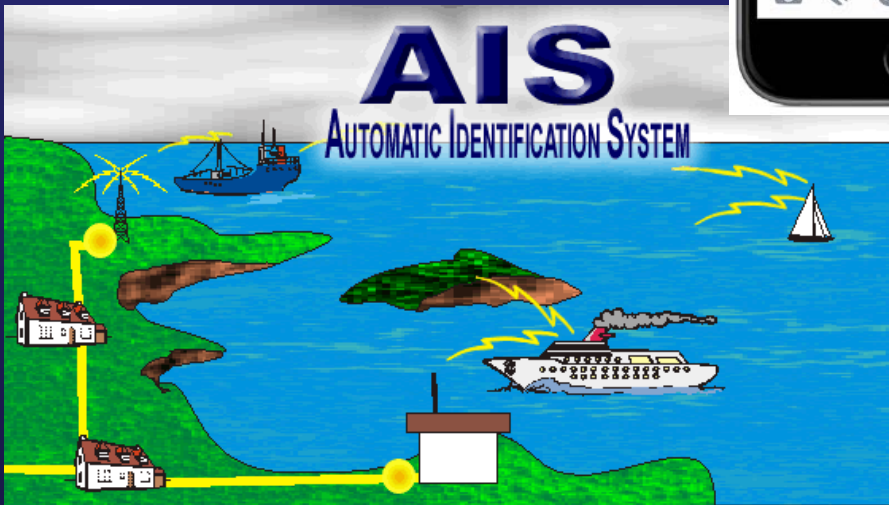
Time now: 12/13/16 12:00 EST

Fin whales detected on the Nomans Land buoy! Latest detections: 2.8 hours ago.

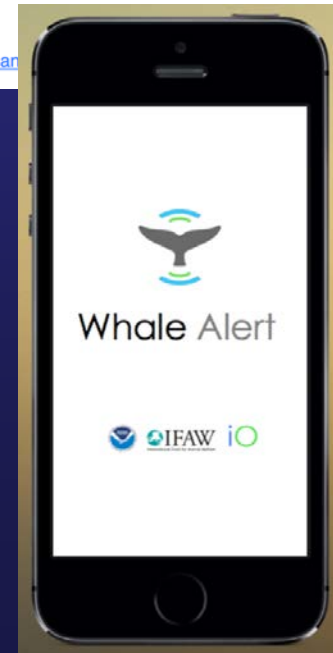
Fin whale detections:  
 12/12/16 18:09 EST (17.8 hr ago)  
 12/12/16 19:09 EST (16.8 hr ago)  
 12/12/16 20:09 EST (15.8 hr ago)  
 12/12/16 21:09 EST (14.8 hr ago)  
 12/12/16 23:09 EST (12.8 hr ago)  
 12/13/16 00:09 EST (11.8 hr ago)  
 12/13/16 01:09 EST (10.8 hr ago)  
 12/13/16 02:09 EST (9.8 hr ago)  
 12/13/16 02:24 EST (9.6 hr ago)  
 12/13/16 03:09 EST (8.8 hr ago)  
 12/13/16 05:09 EST (6.8 hr ago)  
 12/13/16 06:09 EST (5.8 hr ago)  
 12/13/16 07:09 EST (4.8 hr ago)  
 12/13/16 08:09 EST (3.8 hr ago)  
 12/13/16 09:09 EST (2.8 hr ago)

See <http://dcs.who.edu/nomans0916/nomans>

AIS (2018?)



Whale Alert app  
 (spring 2017)



1. Motivation
2. Enabling technology
3. Does the technology work?
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# How well does it work?

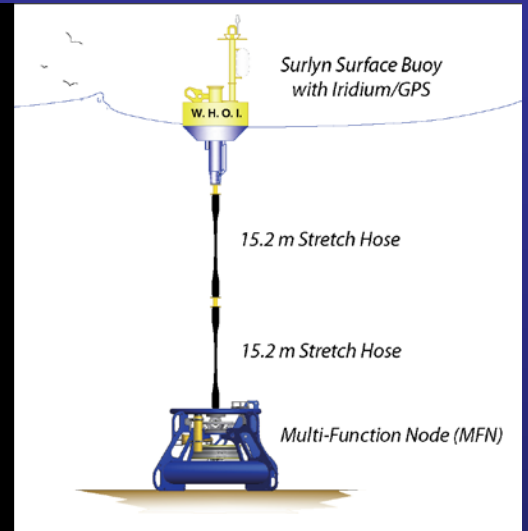
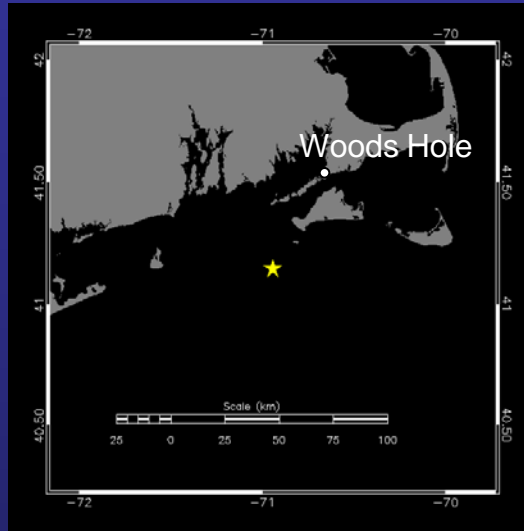


## Evaluation datasets

Moored buoy

Noman's Land Island

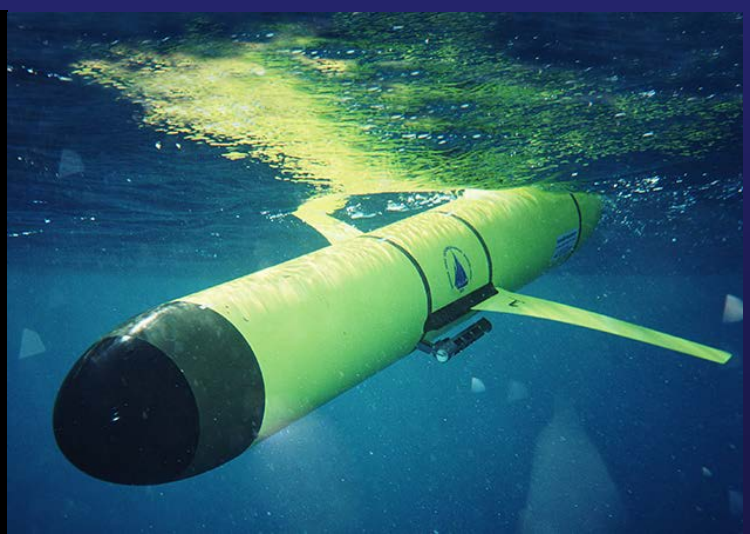
March 2015 - March 2016



Slocum glider

Great South Channel

April - July 2015



# How well does it work?

Right whale



Humpback whale



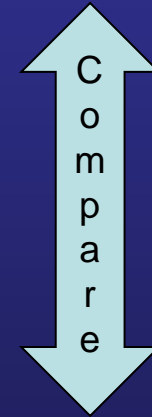
Sei whale



Fin whale



Near real-time analysis  
of pitch tracks



Audio analysis of  
archived recordings



# How well does it work?



	Number of days	Missed occurrence (%)	False occurrence (%)	Accuracy (%)
<u><i>Slocum glider</i></u>				
Right whale	85	8.3	0.0	97.6
Humpback whale	95	23.3	0.0	77.9
Sei whale	86	28.8	5.1	80.2
Fin whale	104	21.3	0.0	81.7
<u><i>Moored buoy</i></u>				
Right whale	133	28.0	0.0	94.7
Humpback whale	119	32.7	0.0	84.9
Sei whale	124	38.8	0.0	84.7
Fin whale	148	10.5	3.1	90.5

*Evaluation of near real-time estimates of daily whale occurrence  
Truth = analysis of recorded audio*

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*Most missed calls occur during non-monitored periods – missed occurrence can be improved by increasing transmitted data*

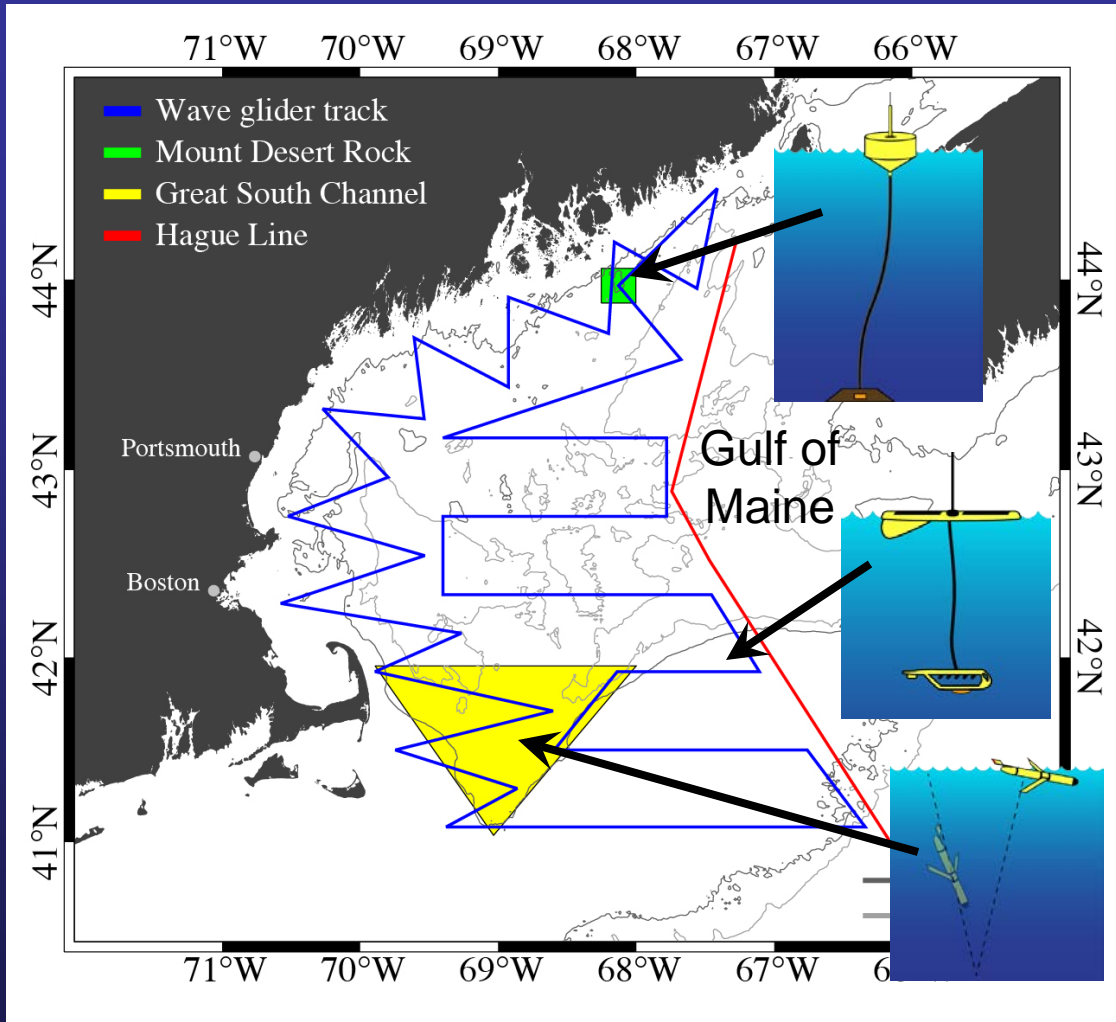
# How well does it work?



- Analyst estimates of species' presence are highly accurate
- Analyst can miss presence when species are actually present, but this can be greatly improved by transmitting more data via satellite in near real time
- Accuracy sufficient for monitoring and mitigation

1. Motivation
2. Enabling technology
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# Large-scale monitoring in the Gulf of Maine

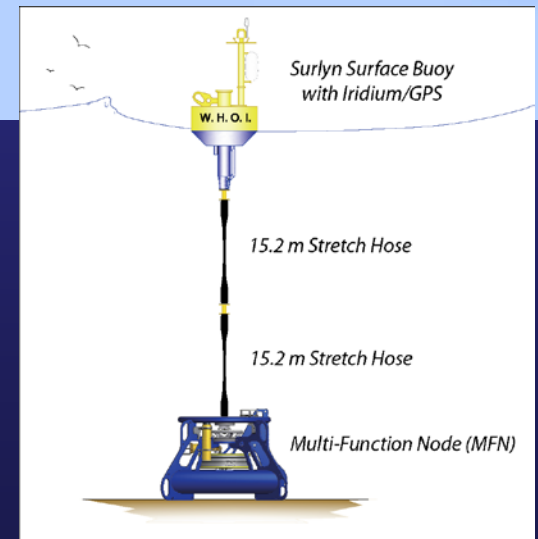
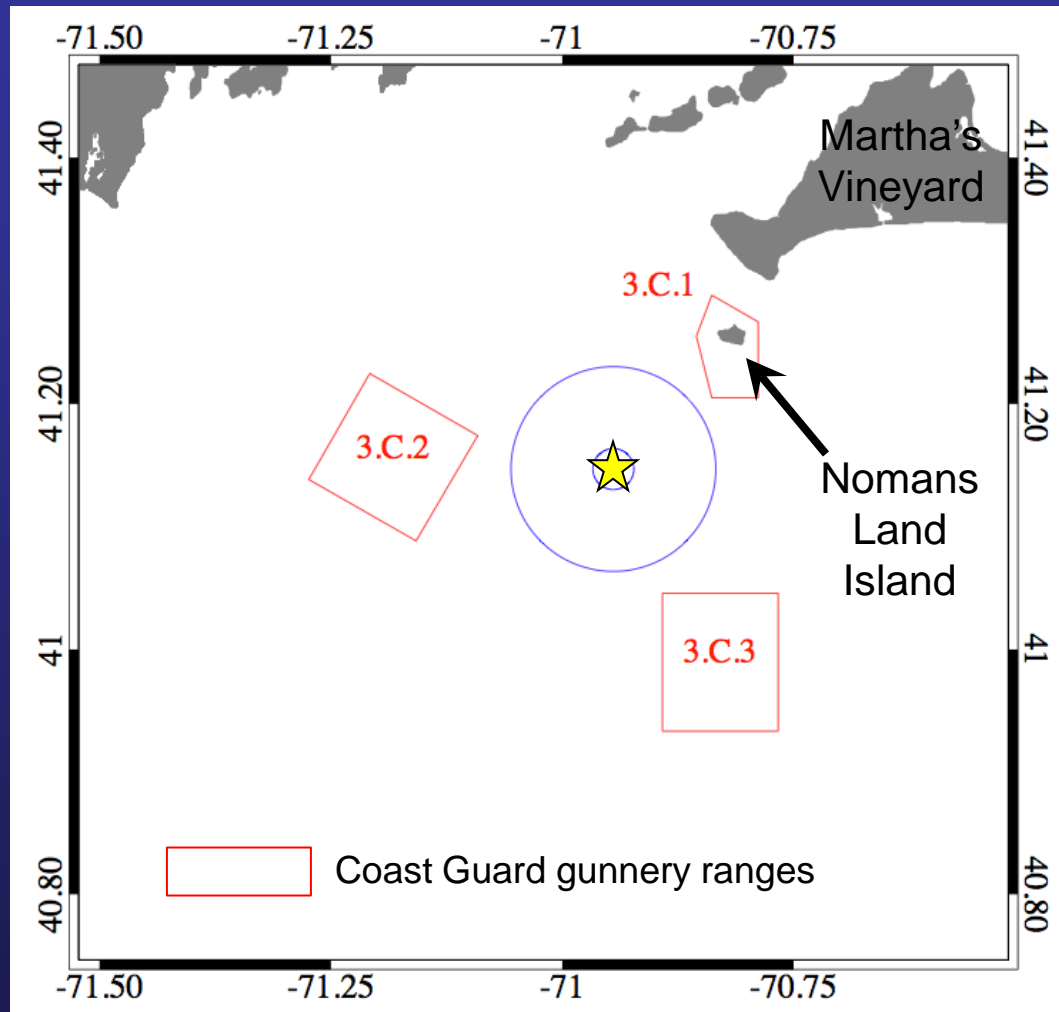


North Atlantic right whale



Collaborators: Cara Hotchkin (NAVFAC Atlantic)  
Sofie Van Parijs, Peter Corkeron, and Tim Cole (NOAA NEFSC)

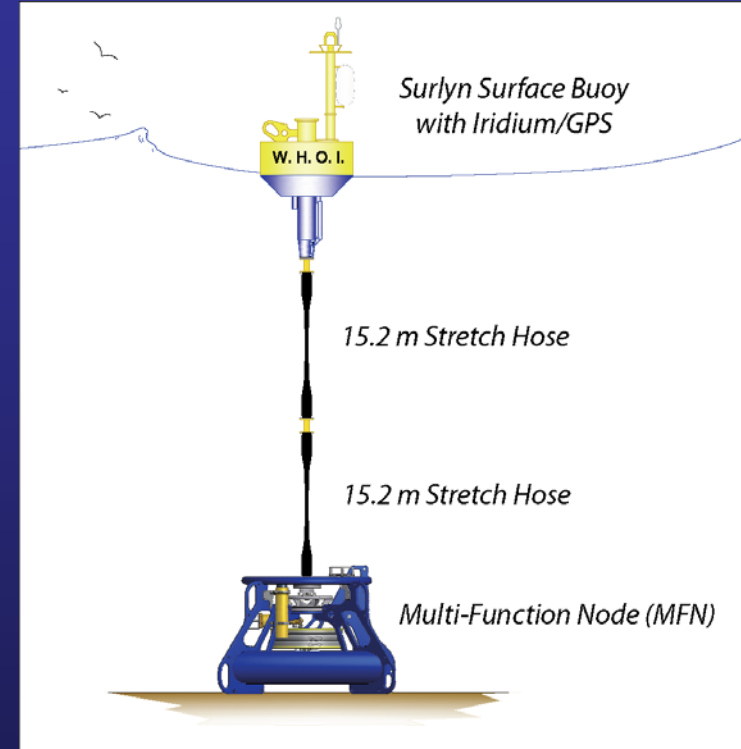
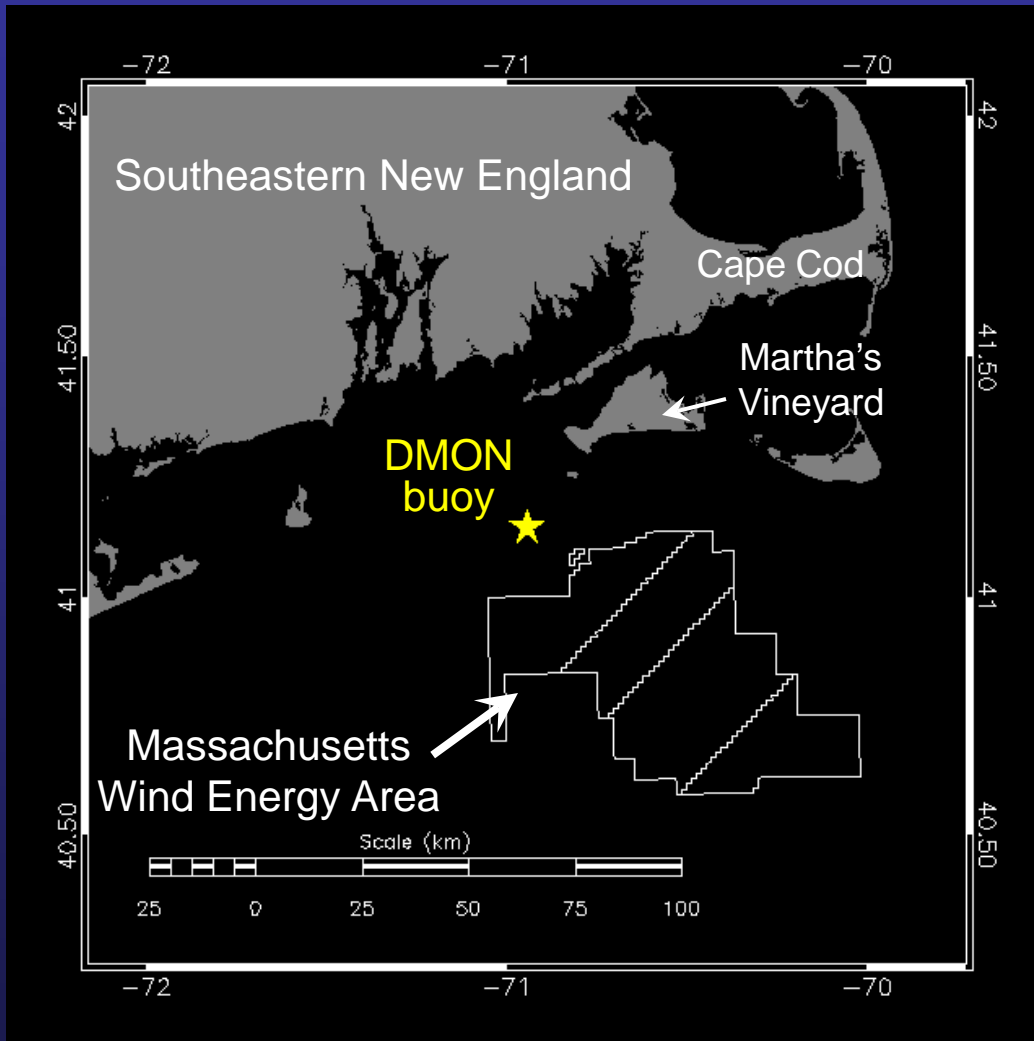
# Monitoring a Coast Guard gunnery range



Collaborators: Tim Cole, Peter Corkeron, and Sofie Van Parijs (NOAA NEFSC)  
Andy Stokes (Coast Guard SE New England)

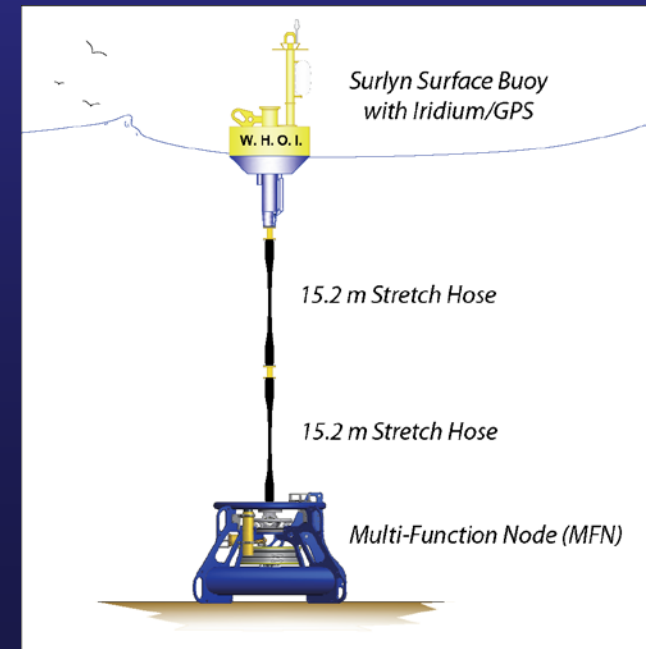
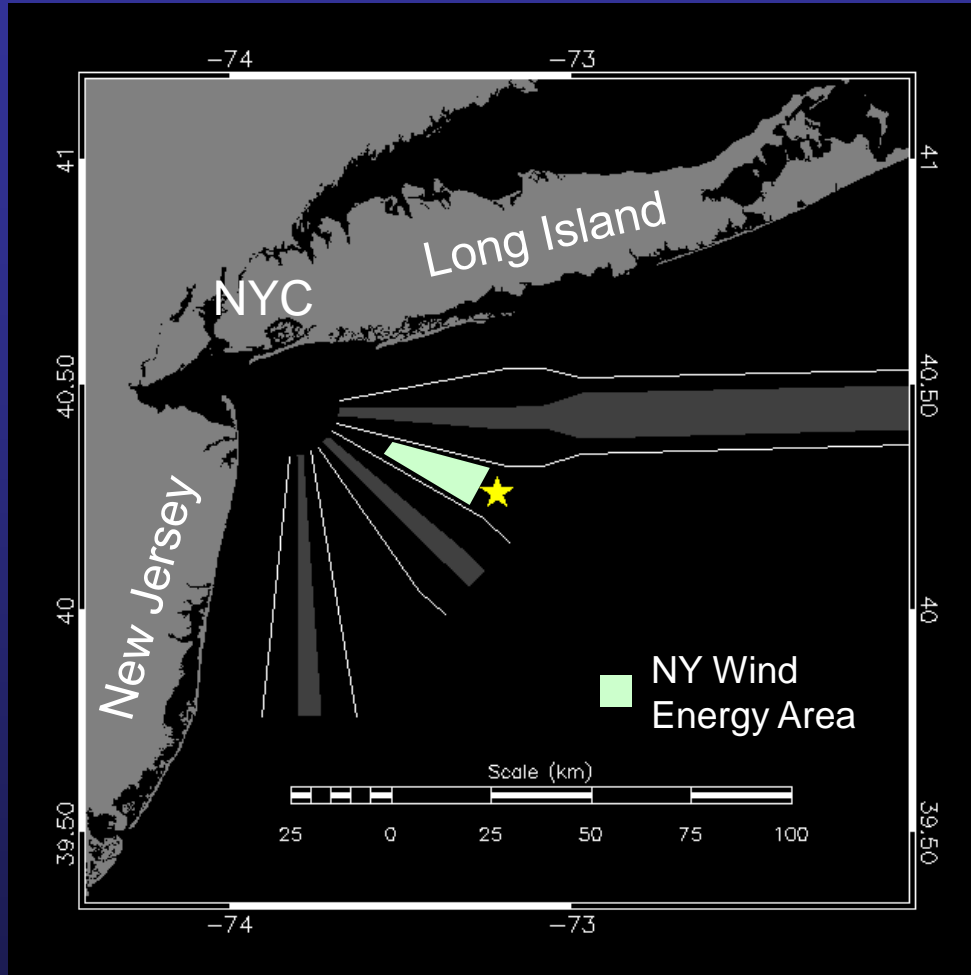


# Monitoring Massachusetts Wind Energy Area



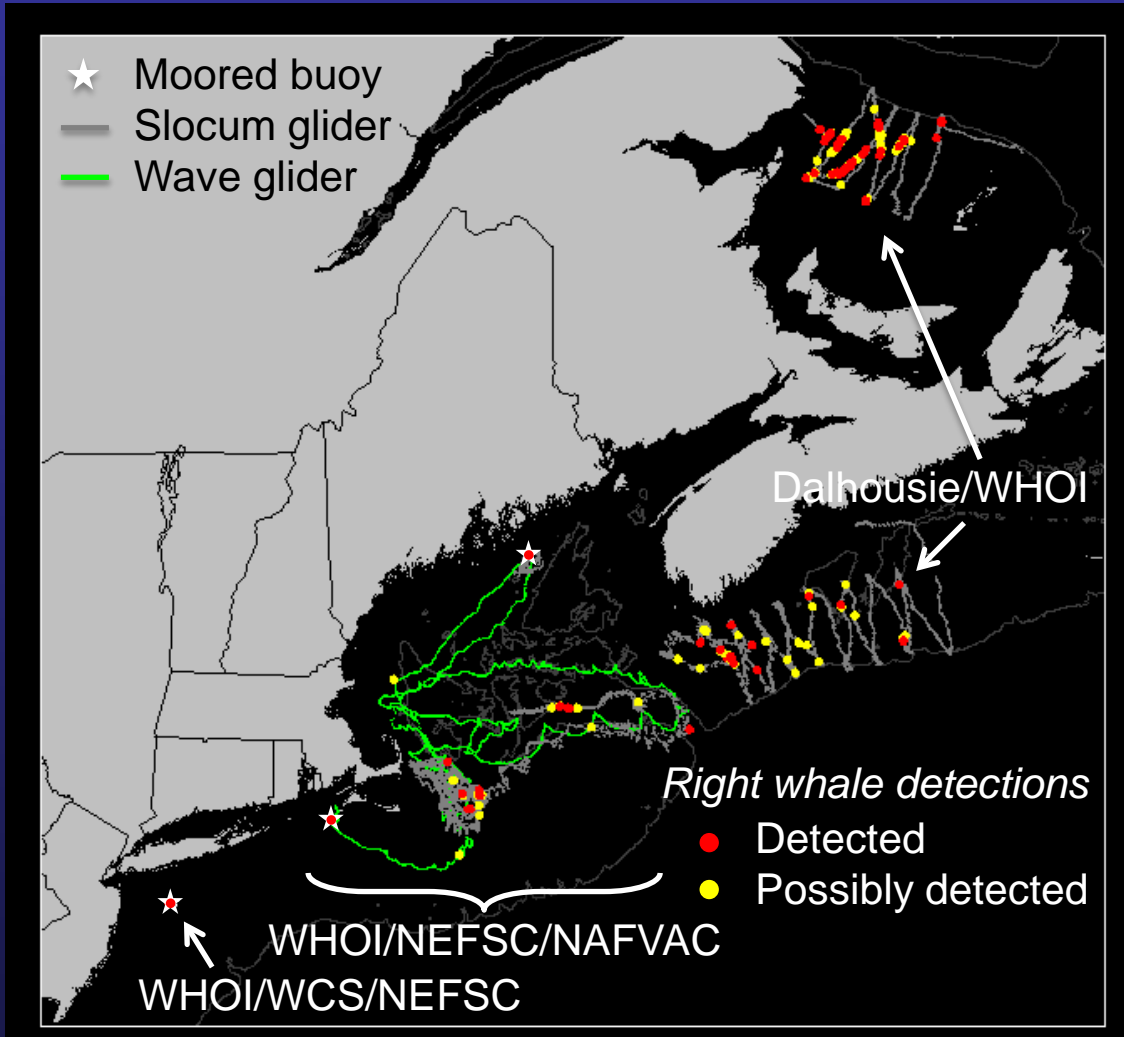
Collaborators: YT Lin (WHOI) and Sofie Van Parijs (NOAA NEFSC)

# Monitoring shipping lanes in New York Bight



Collaborators: Howard Rosenbaum (WCS)  
Sofie Van Parijs (NOAA NEFSC)

# Field work in 2016



# Summary



- Developed system for passive acoustic recording and near real-time detection/classification of marine mammals from autonomous platforms
- System is very accurate, especially for right whales
- Operational for Slocum gliders and moored buoys
- Can be used for monitoring and mitigation

# Engineers, collaborators, and funders



## WHOI Engineers:

- Jim Partan, Keenan Ball, Tom Hurst
- Léo-Paul Pelletier
- Lee Freitag
- Ben Hodges
- John Kemp, Don Peters
- Kris Newhall, Jeff Pietro
- Mark Johnson (formerly WHOI)

## Collaborators:

- Sofie Van Parijs (NOAA NEFSC)
- Cara Hotchkin (NAVFAC Atlantic)
- Kim Davies and Chris Taggart (Dalhousie)
- Peter Corkeron, Tim Cole (NOAA NEFSC)
- Howard Rosenbaum (WCS)
- Dave Fratantoni (formerly WHOI)

Analyst: Julianne Gurnee (NOAA NEFSC)

## Funders:

