



Using Passive Acoustics to Improve Management and Conservation of Marine Mammals in the W. Atlantic

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Woods Hole, USA



OUR FOCUS AT NEFSC PASSIVE ACOUSTICS

1. Monitoring and mitigation of threats to baleen whales (ESA listed species)
2. Stock abundance & health of all marine mammals
3. Fisheries conservation

THREATS



Whaling



Noise Pollution



Habitat Loss



Entanglement



Ship Strike



ANTHROPOGENIC ACTIVITIES



NAVY



WIND



OIL



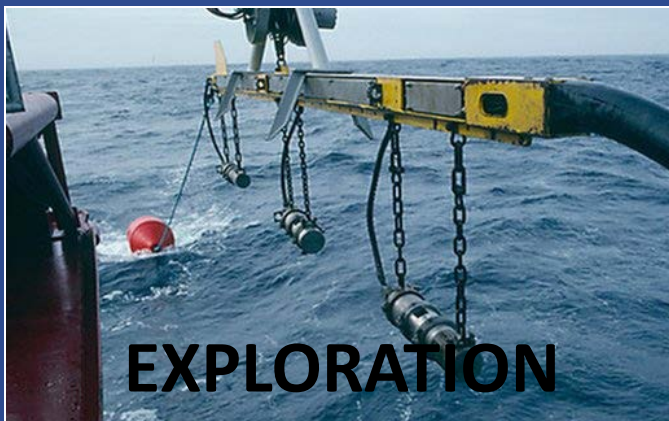
GAS



VESSELS



EXPLORATION



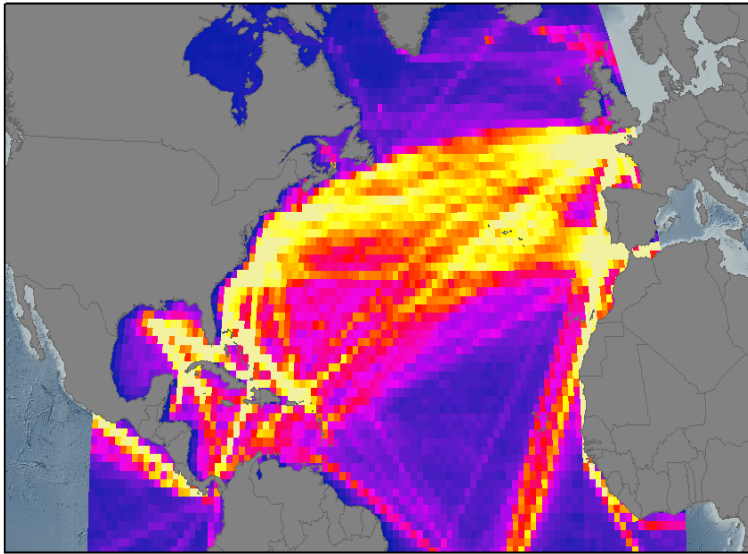
**FISHING, TOURISM,
TRANSPORTATION,
SHIPPING**



THE URBAN WHALE

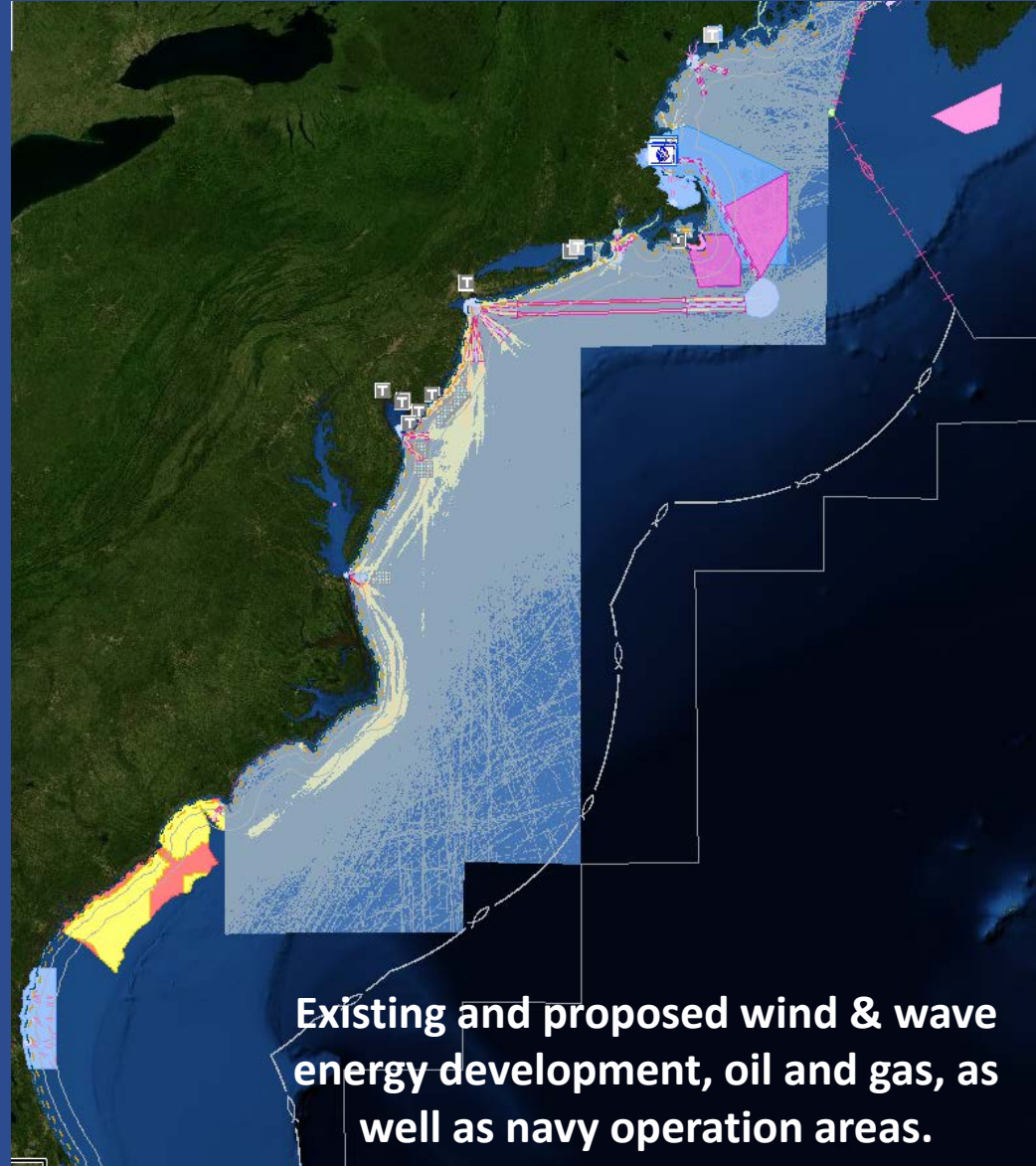


Atlantic shipping routes



Cetsound.noaa.gov

Marine cadastre <http://csc.noaa.gov/mmcviewer/>



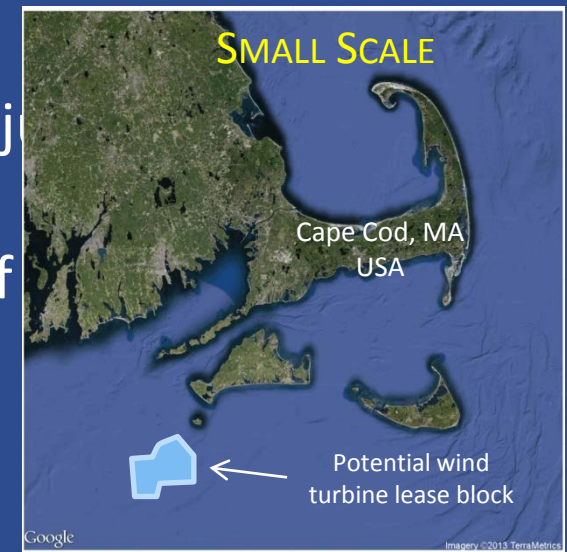
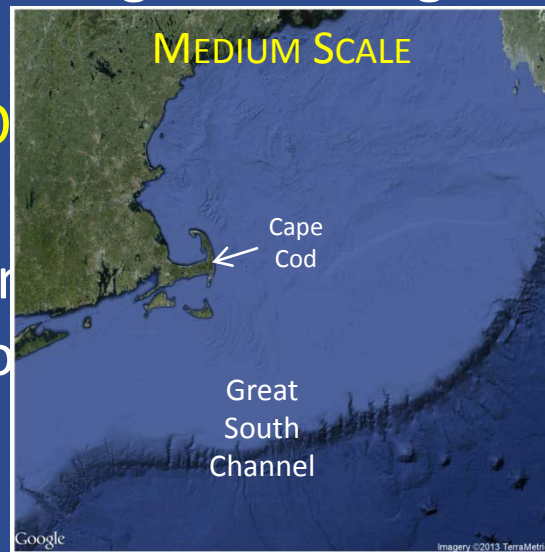
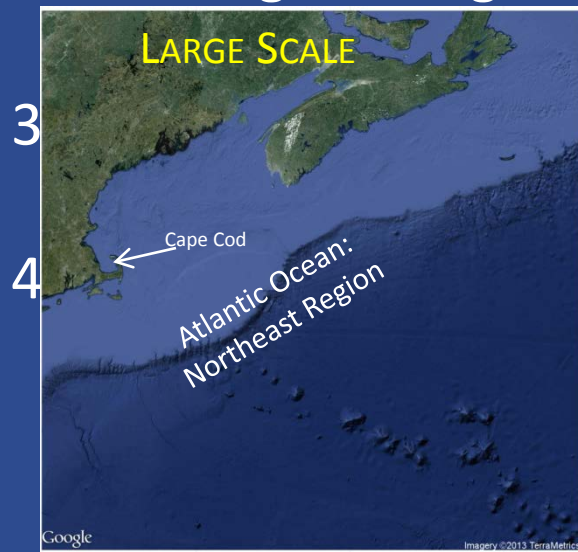
Existing and proposed wind & wave energy development, oil and gas, as well as navy operation areas.

WHAT WE NEED TO KNOW?



For monitoring, management and/or mitigation

1. **SPACE and TIME** - When and for how long does a species use a given area?
2. **BEHAVIOUR** – What behavior are they engaged in?
Feeding/Mating/Travelling/Socialising



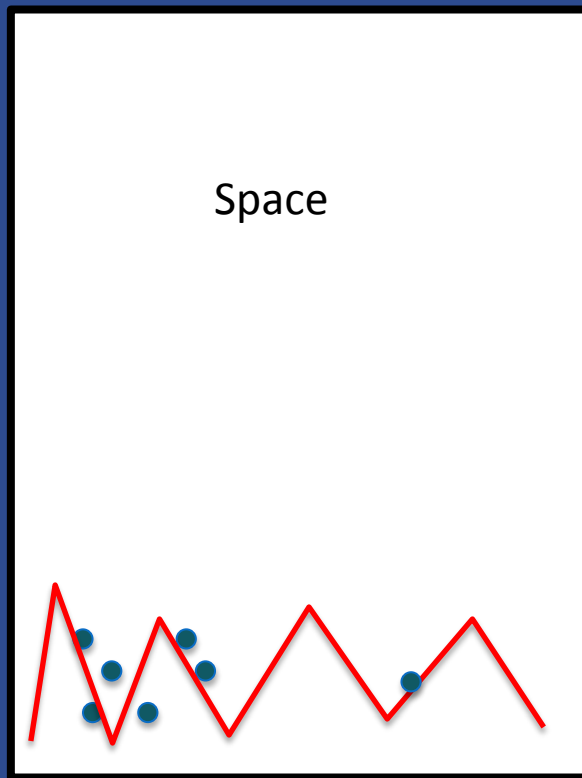
WHY SHOULD WE USE MULTIPLE DATA STREAMS?



All our data collection is limited in space & time.

SPACE: coastal flights

TIME: more in summer, all are snapshots, with some missed months.

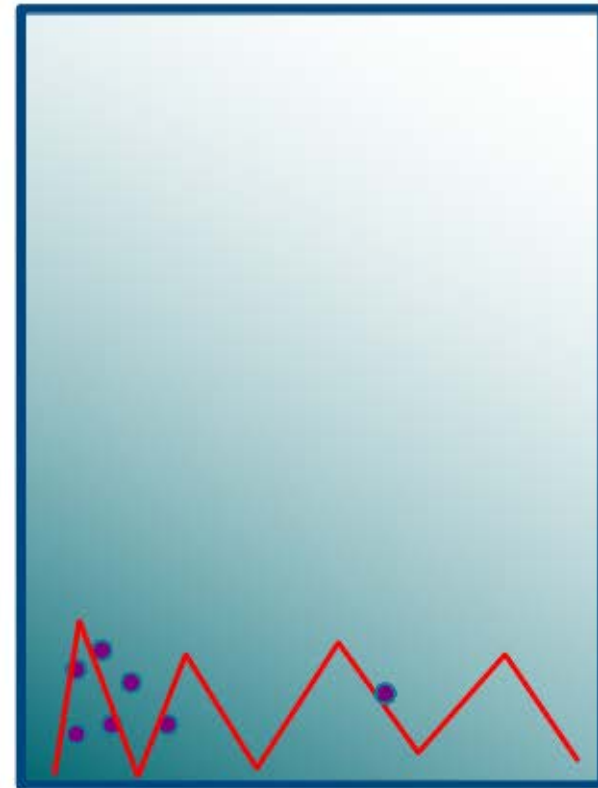
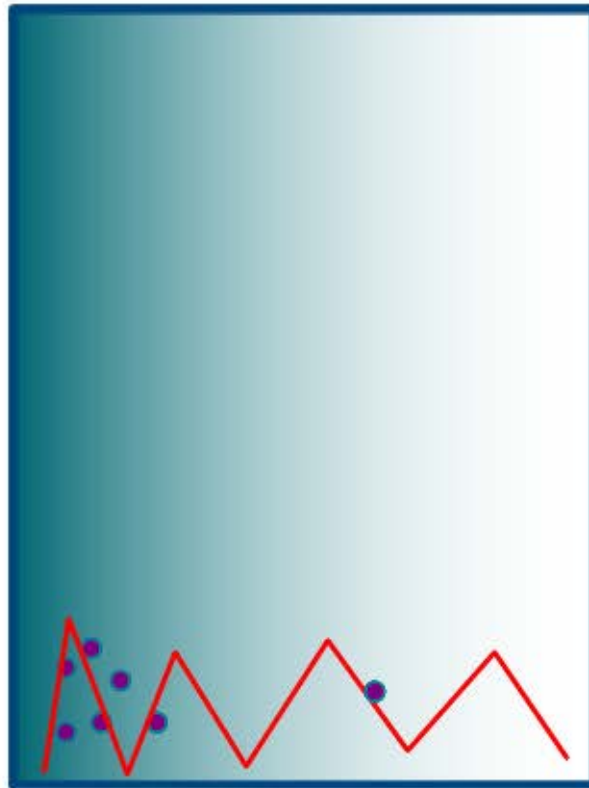


Time

FILL IN THE GAPS WITH A SINGLE DATA STREAM



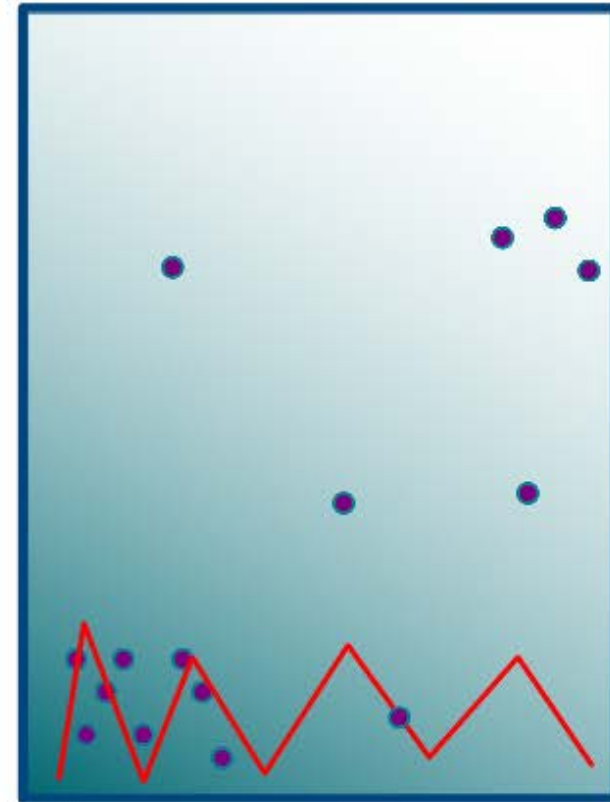
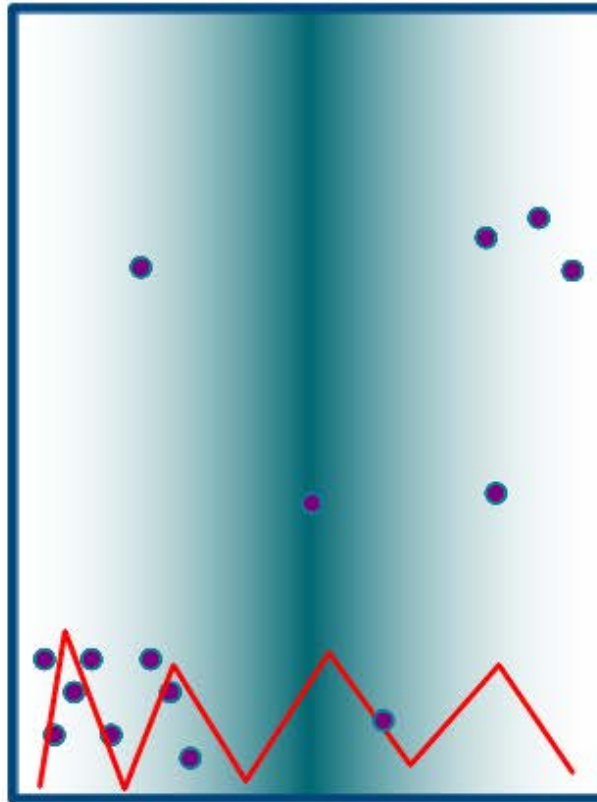
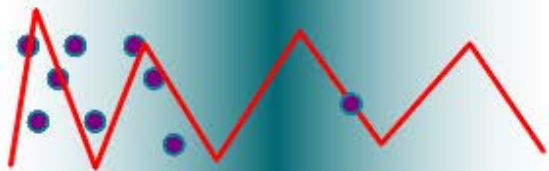
No Estimate
No Presence or
Distribution data



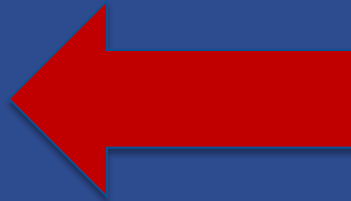
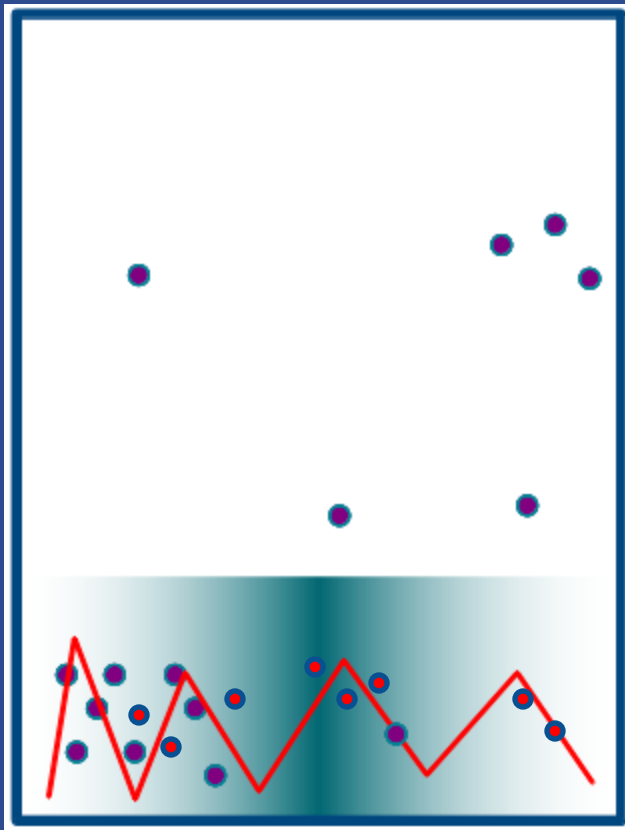
TRUE DISTRIBUTION WITH A SINGLE DATA STREAM



No Estimate
No Presence or
Distribution data



VALUE OF USING MULTIPLE DATA STREAMS



Aerial/boat
surveys

Passive acoustics

Tags,
oceanography etc..



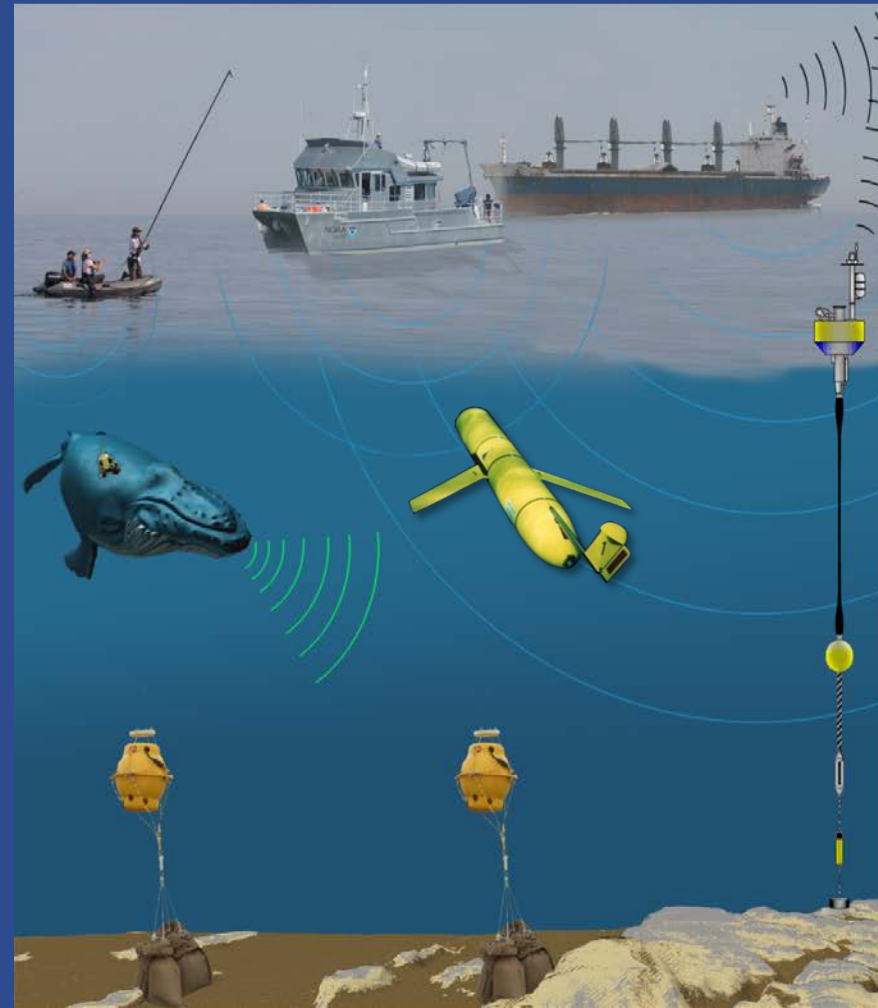
Aerial surveys

Passive acoustics

WHY ADD PASSIVE ACOUSTICS TO OUR APPROACH?



- Versatile - stationary, mobile, archived or real time
- Not restricted by weather & daylight
- Monitors 24/7
- Can go anywhere

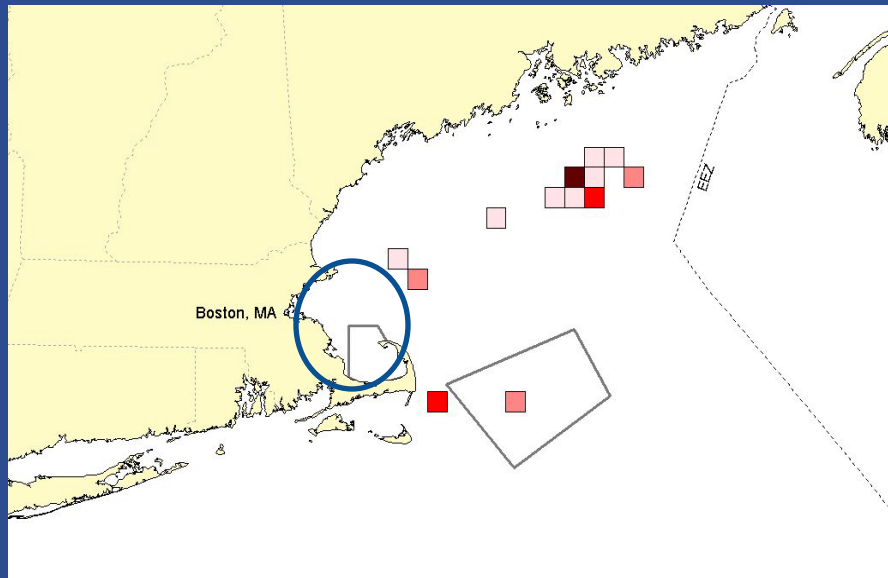


LISTEN AND YOU WILL HEAR WHALES

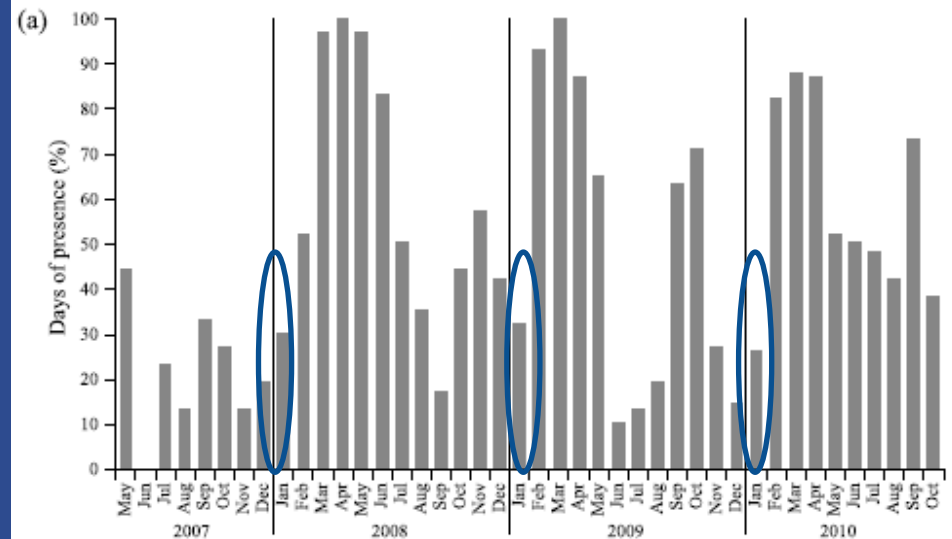


JANUARY:
Visual sightings versus acoustic
presence of right whales

15 + years of visual sightings per unit effort



PAM recordings of NARW upcalls over 3 years



PASSIVE ACOUSTIC PLATFORMS BEING USED BY NEFSC



❖ Towed Hydrophone Arrays

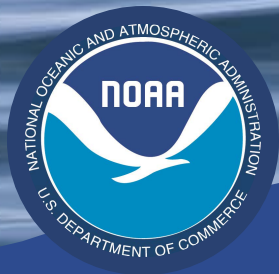


❖ Bottom-mounted Recorders

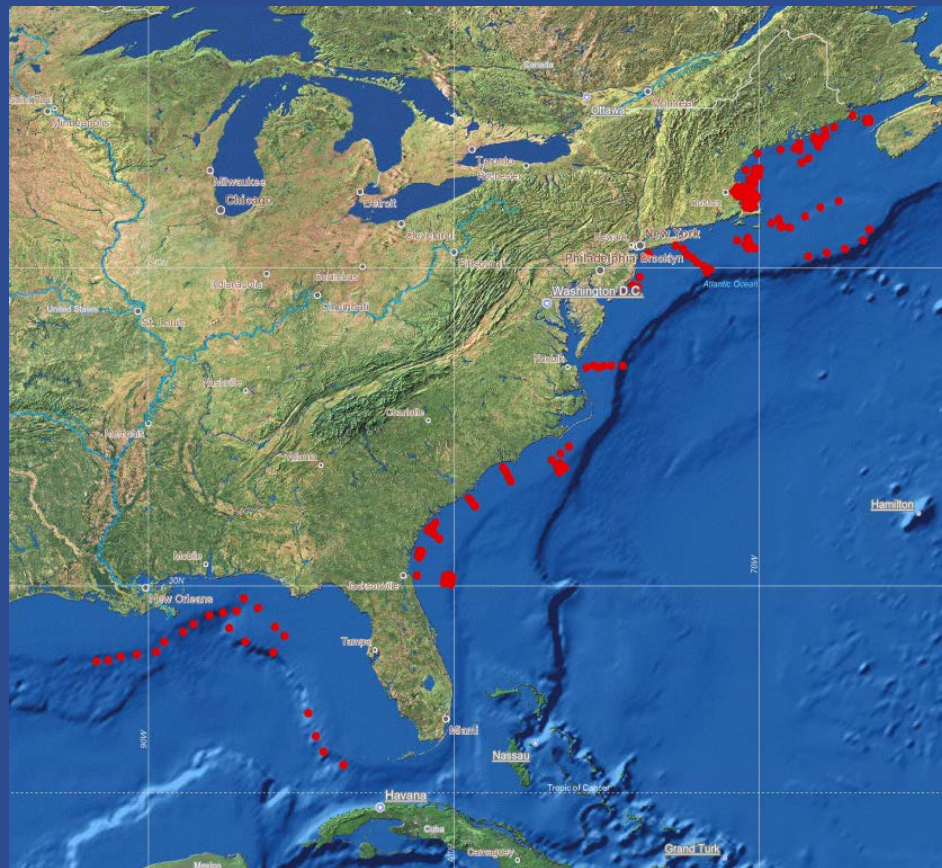


❖ Autonomous underwater vehicles 'gliders'

PAM FOR SPATIAL SCALES



LARGE SCALE



MEDIUM SCALE

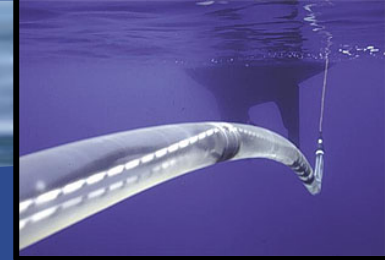


SMALL SCALE

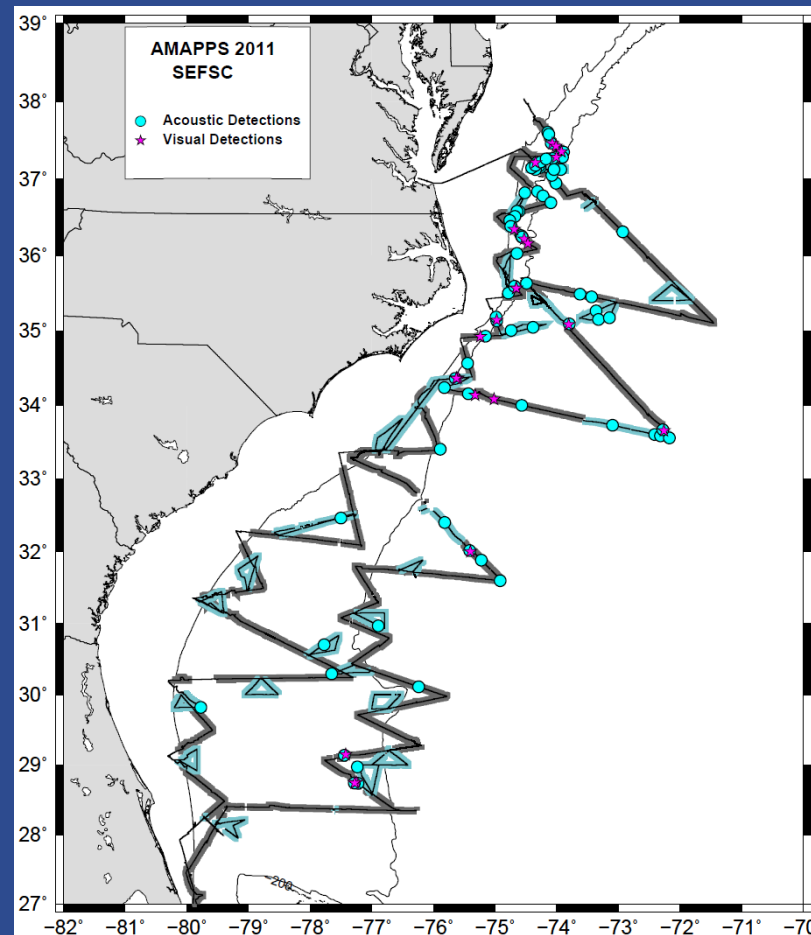
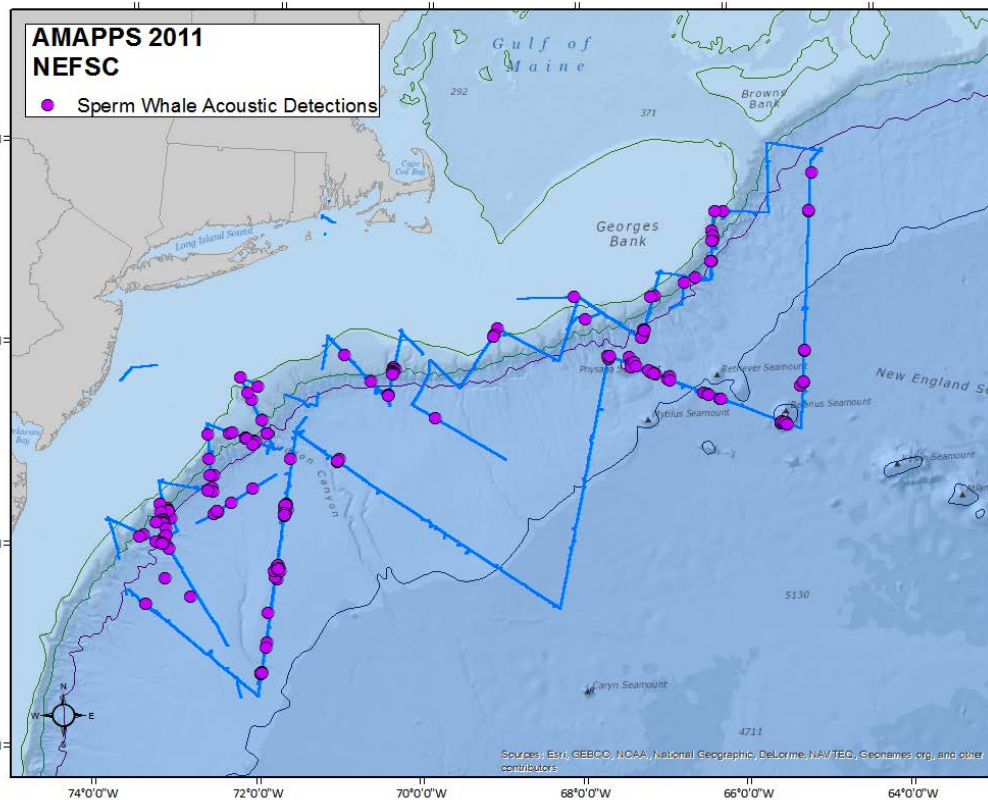




Ex 1. LARGE SPATIAL — SHORT TEMPORAL SCALE

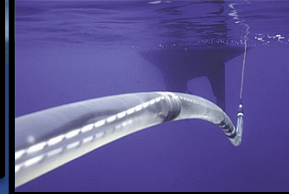


Towed Arrays: AMAPPS





Towed Hydrophone Array: Overview



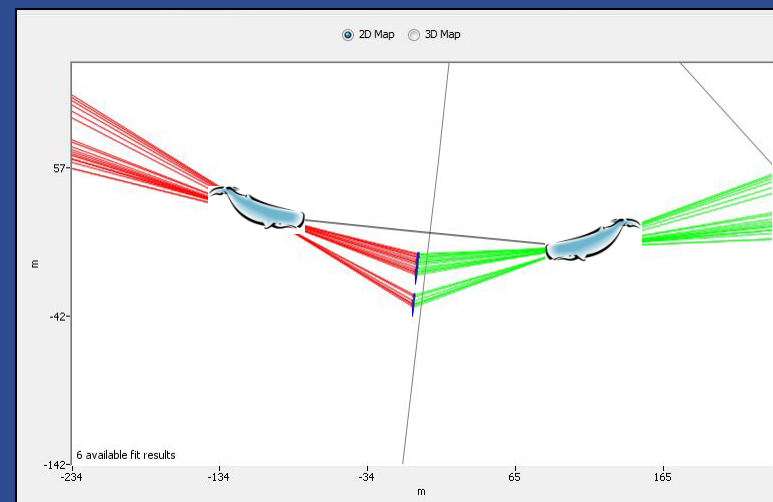
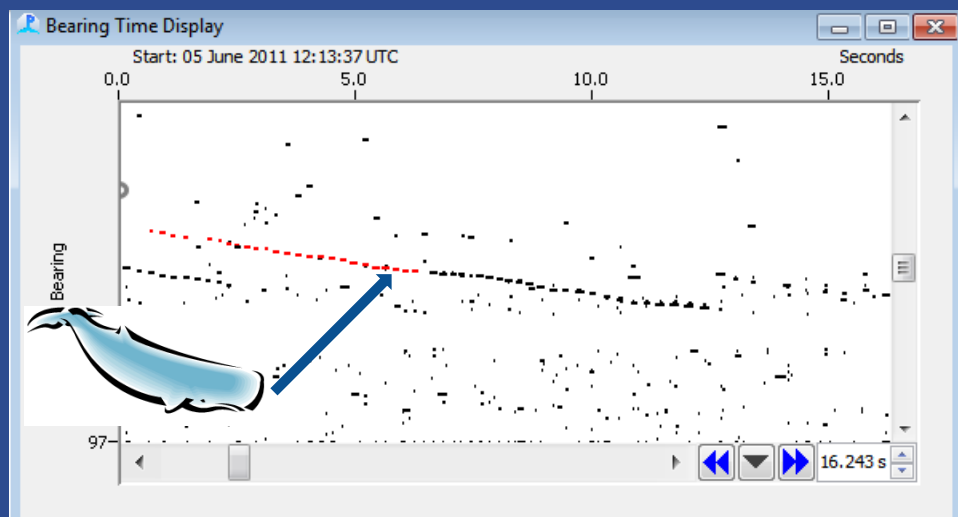
Common Name	NEFSC 2011	NEFSC 2013	SEFSC 2011	SEFSC 2013
Bottlenose Dolphin	20	12	45	56
Common Dolphin	26	11	1	
Atlantic Spotted Dolphin	20	8	15	21
Pantropical spotted dolphin			2	3
Striped Dolphin	23	17	5	2
Stenella spp.		2		6
Risso's dolphin	9	20	20	16
Clymene's dolphin	1	1	1	2
Rough-toothed Dolphin	3			3
Pilot Whale	12	7	22	21
Sperm Whale	87	65	75	193
Sowerby's beaked whale	2	2		
Kogia spp				1
Mixed Species Groups	15	7	4	8
UNID Myseticete (Humpback per acoustic)				1
Groups without species assignment	138	111	228	418
TOTAL	356	263	423	769



Species Highlights: Sperm Whales

AMAPPS 2011: Methodology, Stage 1

- Detect all sperm whale clicks
- Track individual sperm whales as they pass the beam of the ship
- Localize to calculate perpendicular distance
- Done in Matlab or Pamguard





Species Highlights: Sperm Whales

AMAPPS 2011: Methodology, Stage 2

- Using program DISTANCE*
- Import perpendicular distances for all animals
- Estimate relevant variables ($g(0)$, etc)
- Calculate detection function
- Calculate abundance estimates

Distance - Sperm_whale_2011

File View Tools Data Window Help

Project Browser

Data Maps Designs Surveys Analyses Simulations

Data layers

- Study area
 - Region
 - Line transect
 - Observation

Contents of Observation layer 'Observation' and all fields from higher layers

Study area			Region			Line transect			Observation	
ID	Label		ID	Label	Area	ID	Label	Line length	ID	Perp distance
ID	Label		ID	Label	Decimal	ID	Label	Decimal	ID	Decimal
n/a	n/a		n/a	n/a	km2	n/a	n/a	km	n/a	m
Int	Int		Int	Int	Int	Int	Int	Int	Int	Int
						1	3	56.58382	1	1375.75102
									2	1431.783698
									3	120.3474981
									4	341.8135726
									5	598.5145834
									6	1157.63261
									7	798.4510072
									8	96.34131524
									9	219.3772787
						2	4	75.892292	10	1078.033176
									11	470.1026364
									12	570.9138522
									13	864.2390001
									14	401.3471356
									15	373.4744334
									16	328.4063886
									17	2346.269958
1	Sperm_whale_2011		1	1	54376				18	1059.483415
						3	5	55.6901	19	891.3972589
									20	2179.004055
									21	1965.439004
									22	837.9630647
									23	3026.364475
									24	545.4932061
						4	6	75.89229	25	604.4482357
									26	1296.759801
									27	1305.226884
									28	990.2248862
						5	7	80.18132	29	1301.998364
						6	8	75.89229	30	496.8536479
									31	3955.129762
						7	10	72.43186	32	522.3375385

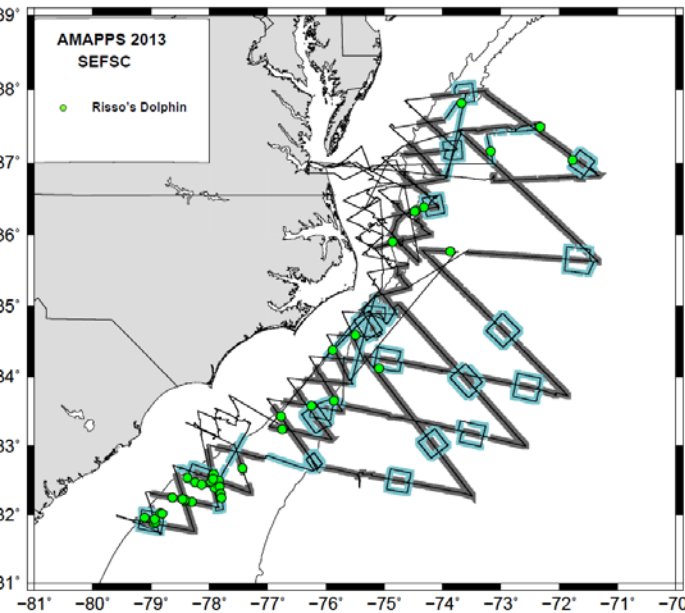
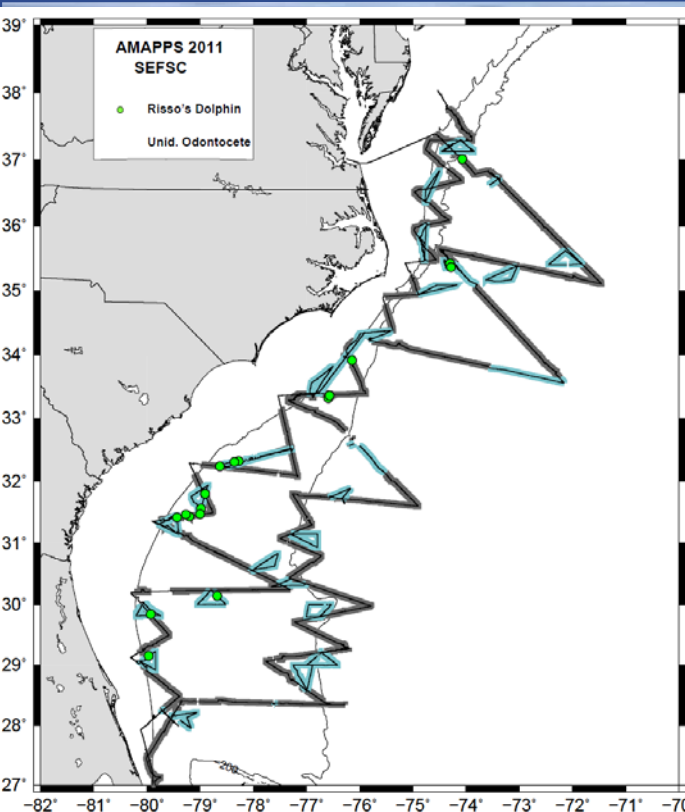
* Thomas, L., S.T. Buckland, E.A. Rexstad, J. L. Laake, S. Strindberg, S. L. Hedley, J. R.B. Bishop, T. A. Marques, and K. P. Burnham. 2010. Distance software: design and analysis of distance sampling surveys for estimating population size. Journal of Applied Ecology 47: 5-14.



Species Highlights: Sperm Whales

AMAPPS 2011: Preliminary Acoustic Abundance Estimates

	NEFSC	SEFSC
# Detected	415	286
# Localized	288	222
Acoustic Abundance	3439 (CV 0.34)	1168 (CV 0.33)
Slope Strata	991 (CV 0.21)	
Deep Water Strata	2447 (CV 0.47)	
Visual Abundance	1,593 (CV 0.36)	695 (CV 0.38)



Risso's dolphins

Comparison of Risso's **Visual** & **Acoustic** Detections

	Leg 1	Leg 2	Leg 3	Total
2011				
Visual Sighting	9	10		19
Missed Visual Sighting (or UD)	1	1		2
Acoustics w/o Visual Effort	2	8		10
2013				
Visual Sighting	2	6	11	19
Missed Visual Sighting (or UD)	-	4	8	12
Acoustics w/o Visual Effort	2	3	15	20

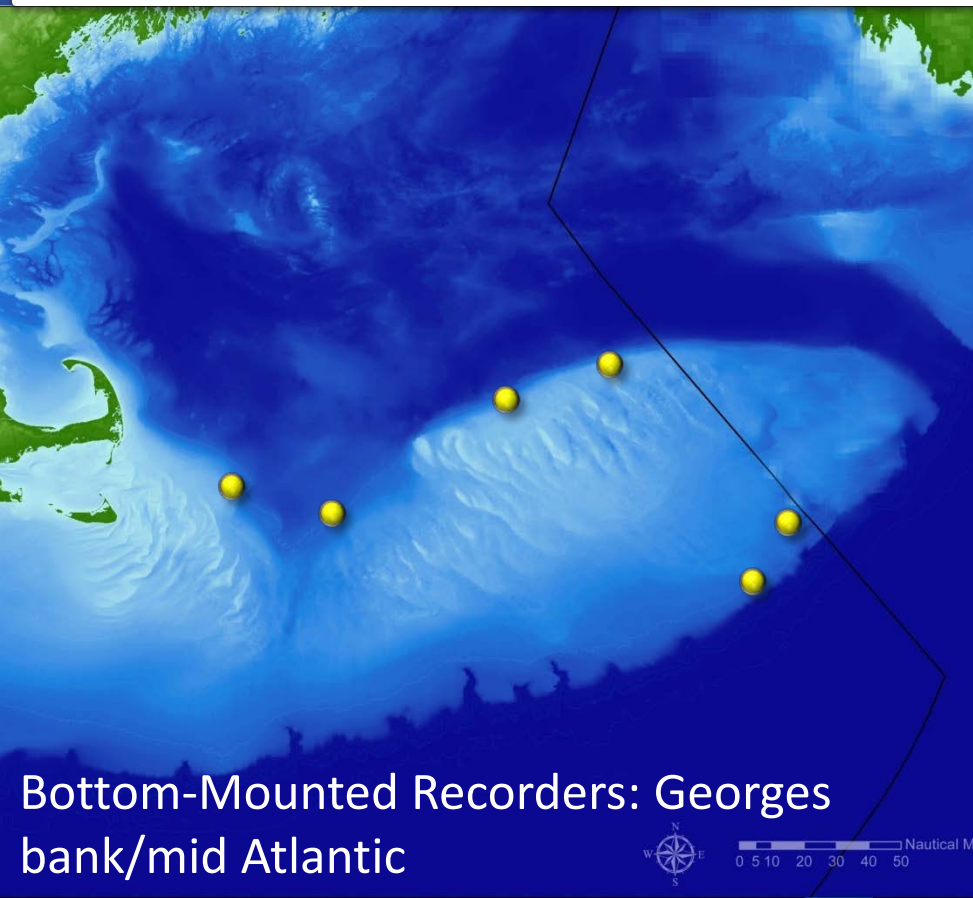
Acoustically identifying Risso's increases detections 50-150%!



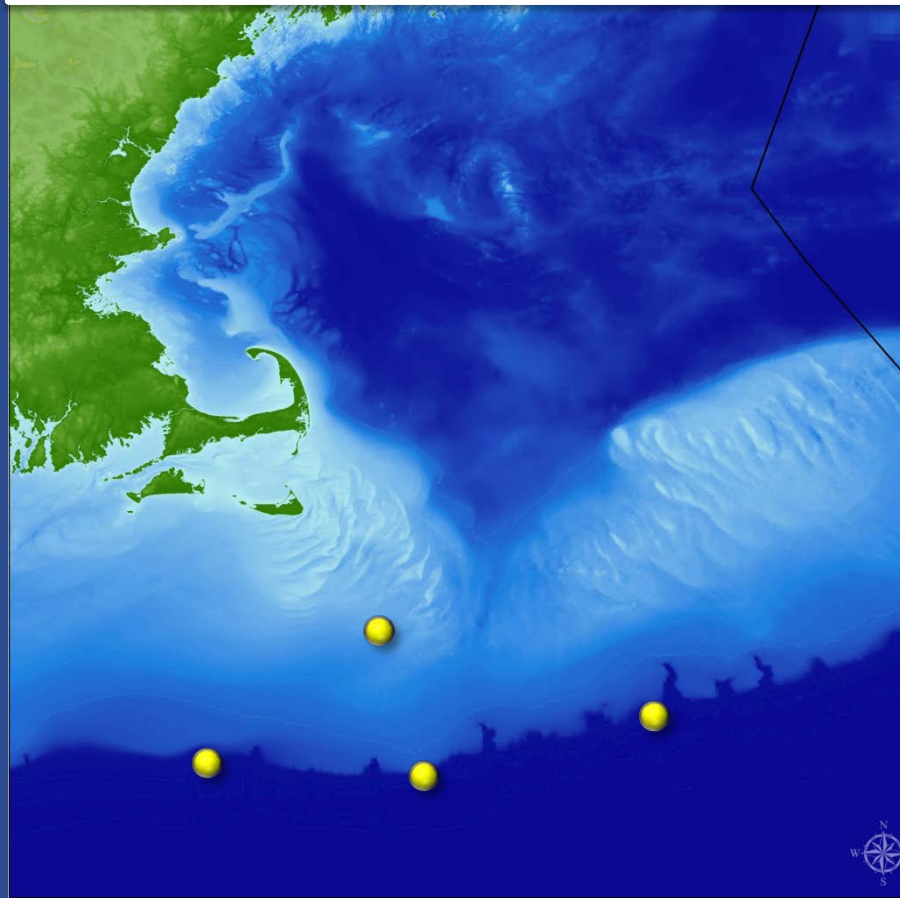
Ex 2. MEDIUM SPATIAL & LONG TEMPORAL SCALES



March-June 2012 : 6 Buoys



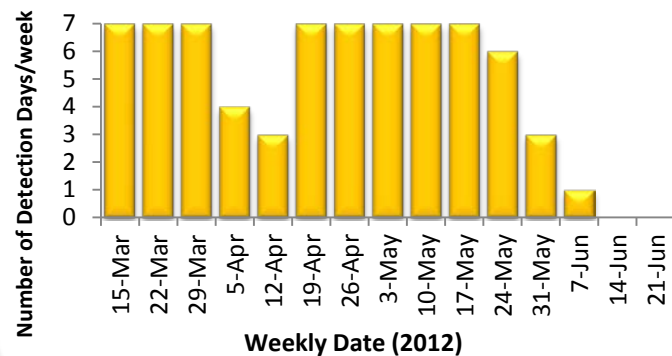
May- August 2013 : 4 Buoys



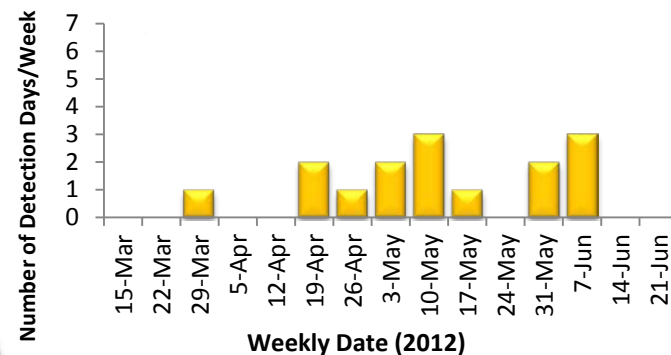
Bottom-Mounted Recorders: Georges bank/mid Atlantic

2012 NARW Acoustic Detections

Buoy 1

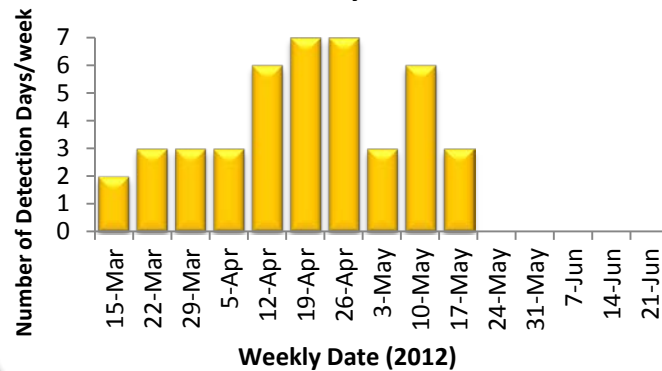


Buoy 4



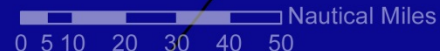
Buoys 5, 9, & 10
0 Detections

Buoy 2



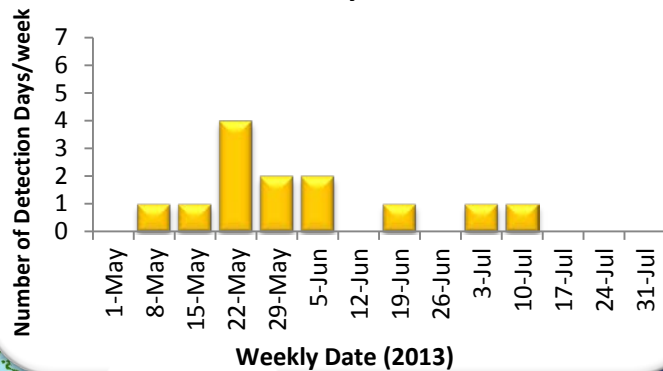
0 5 10 20 30 40 50 Nautical Miles

2012 NARW Acoustic + Visual Sightings

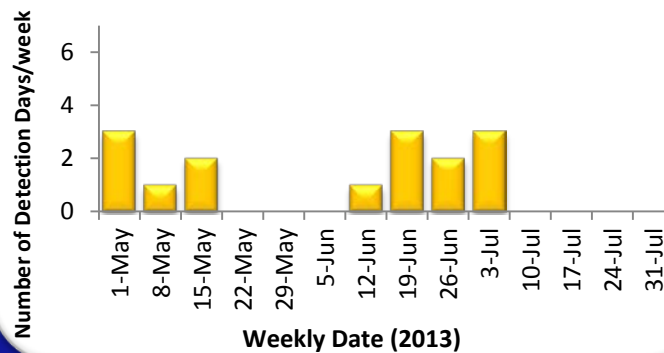


2013 NARW Acoustic Detections

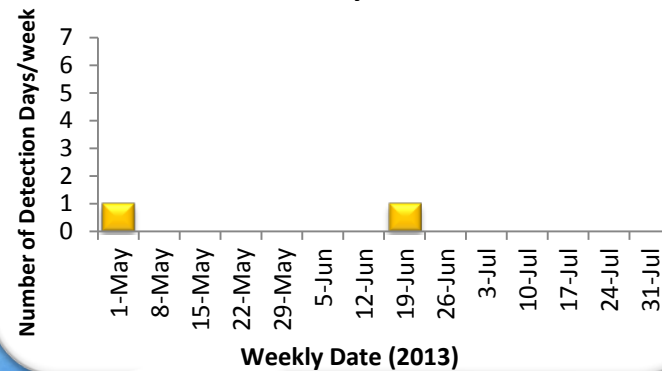
Buoy 2



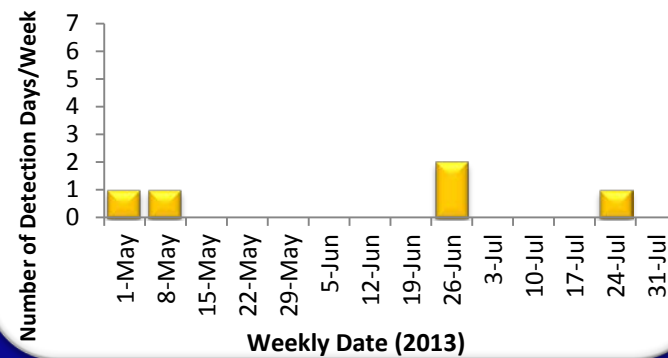
Buoy 1



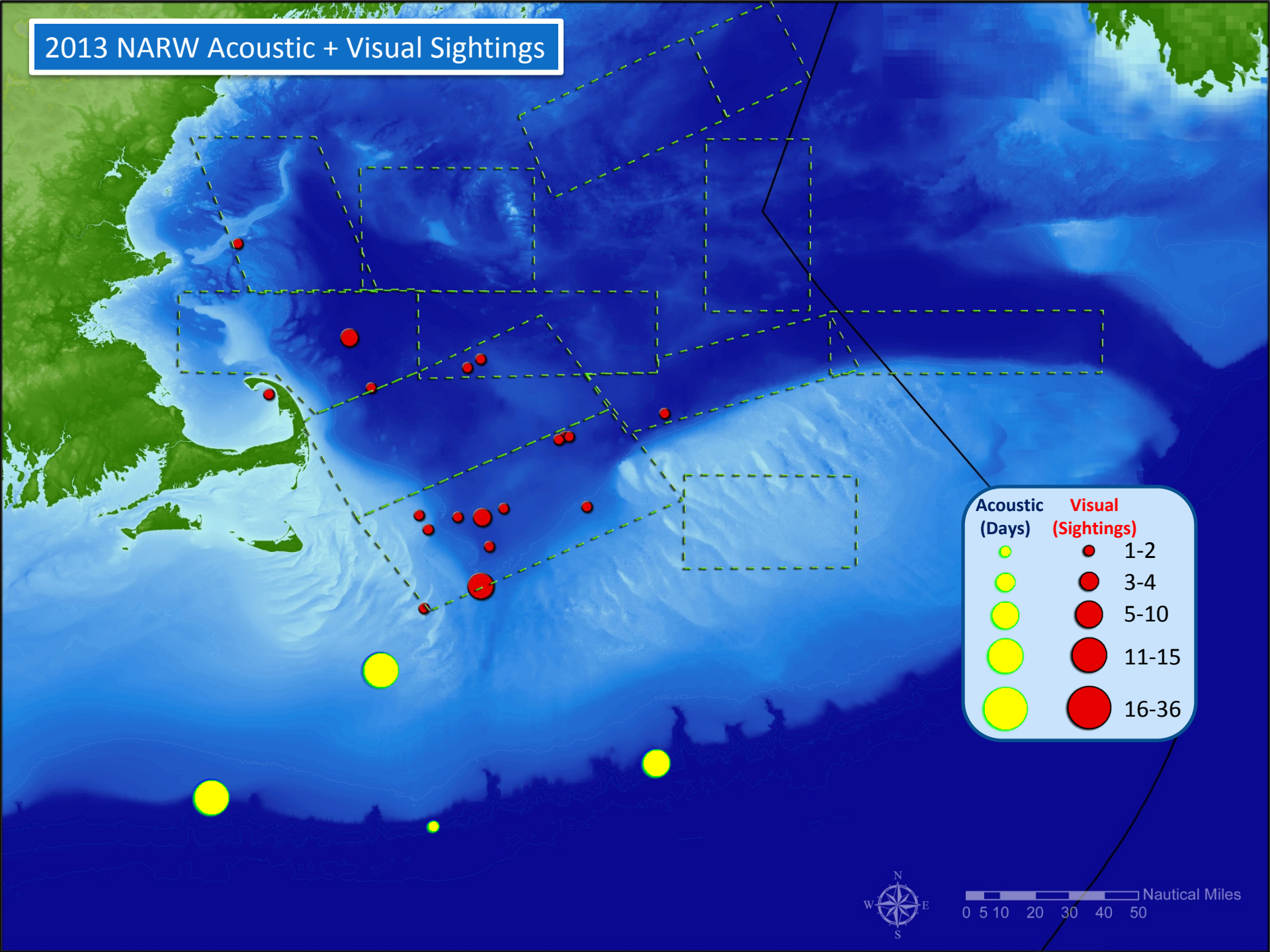
Buoy 3



Buoy 4



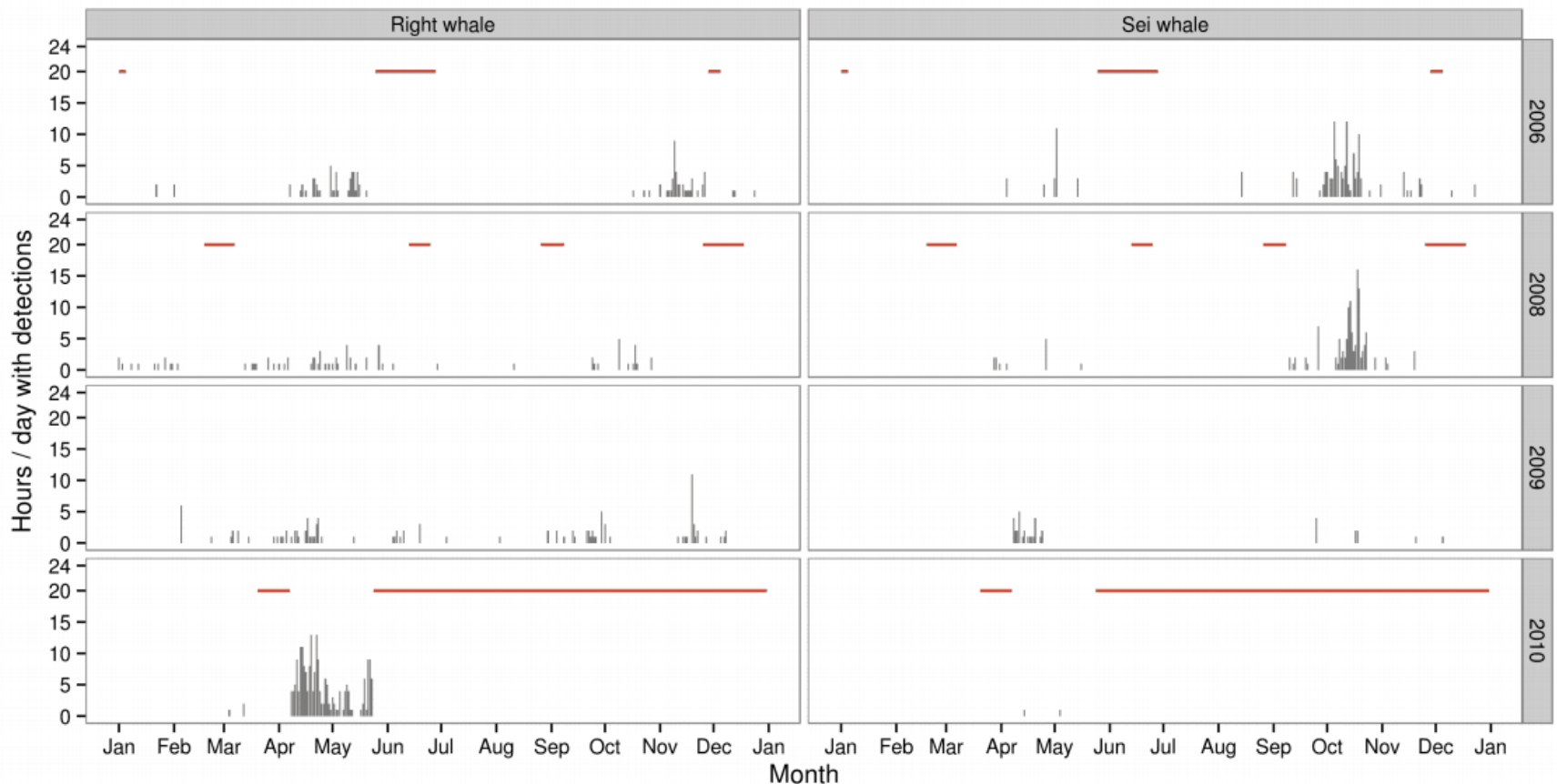
2013 NARW Acoustic + Visual Sightings



Ex. 3 SMALL SPATIAL — LONG TEMPORAL SCALE



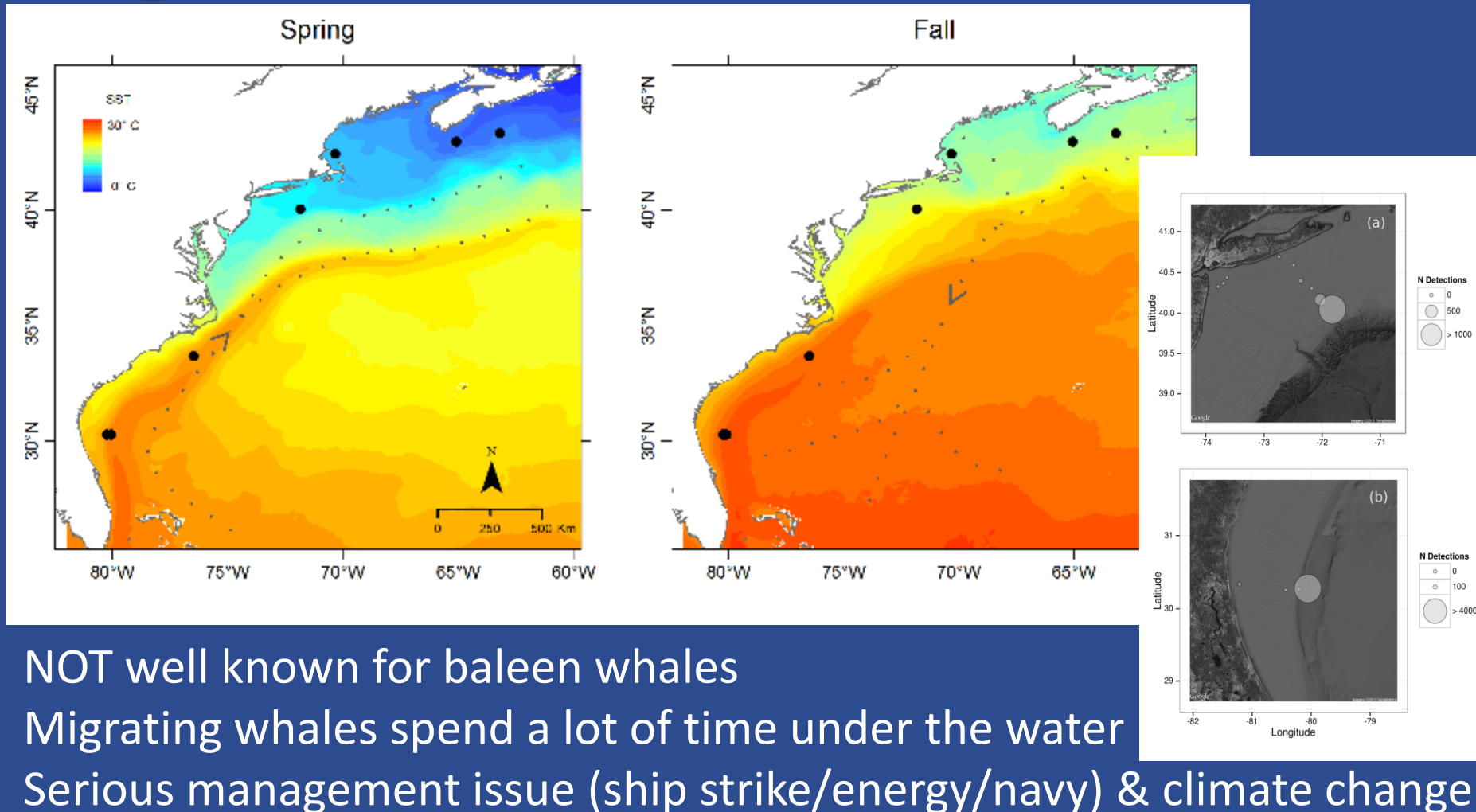
OVER SEASONS AND 5 YEARS



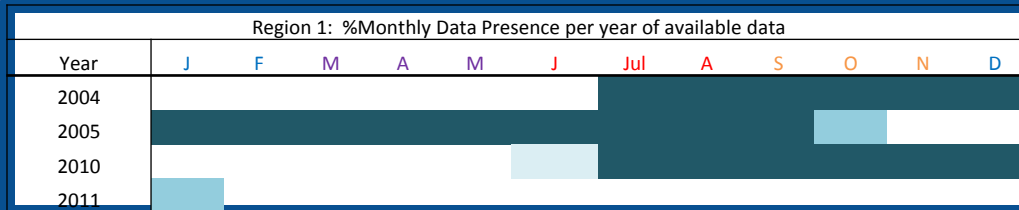
PAM FOR MIGRATION CORRIDORS



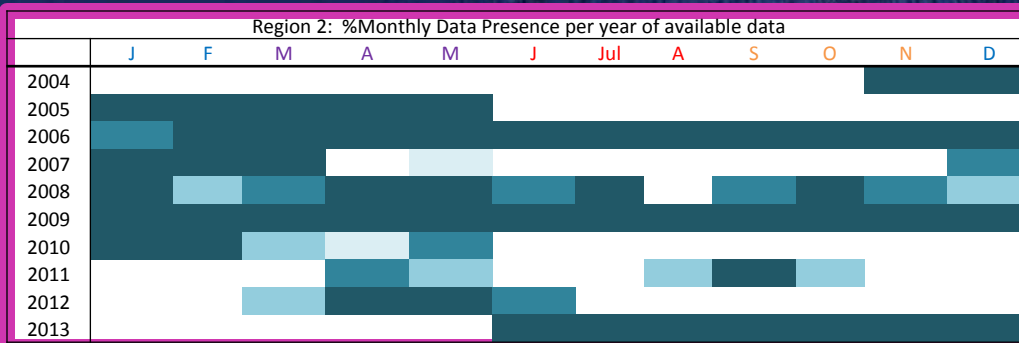
Minke whale migration routes from PAM



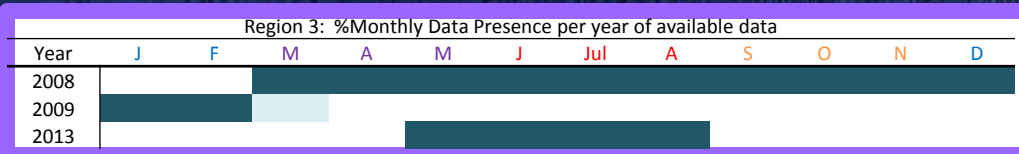
Region 1



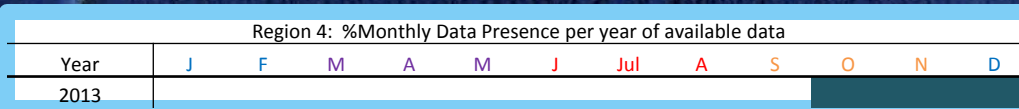
Region 2



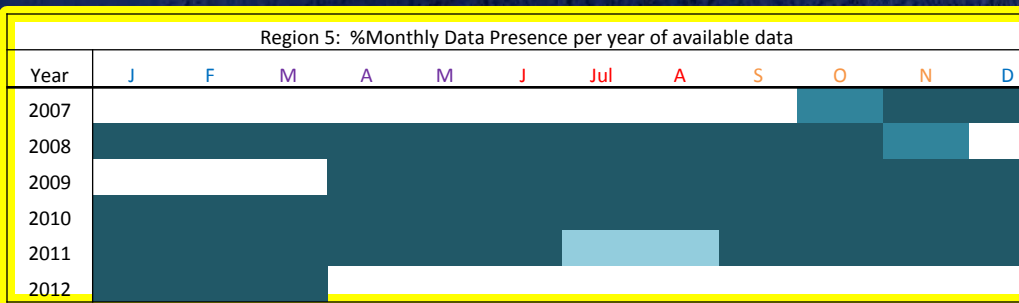
Region 3



Region 4



Region 5



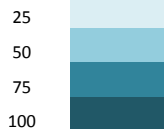
Region 6

Saba, Caribbean

Samana Bay, DR

Key:

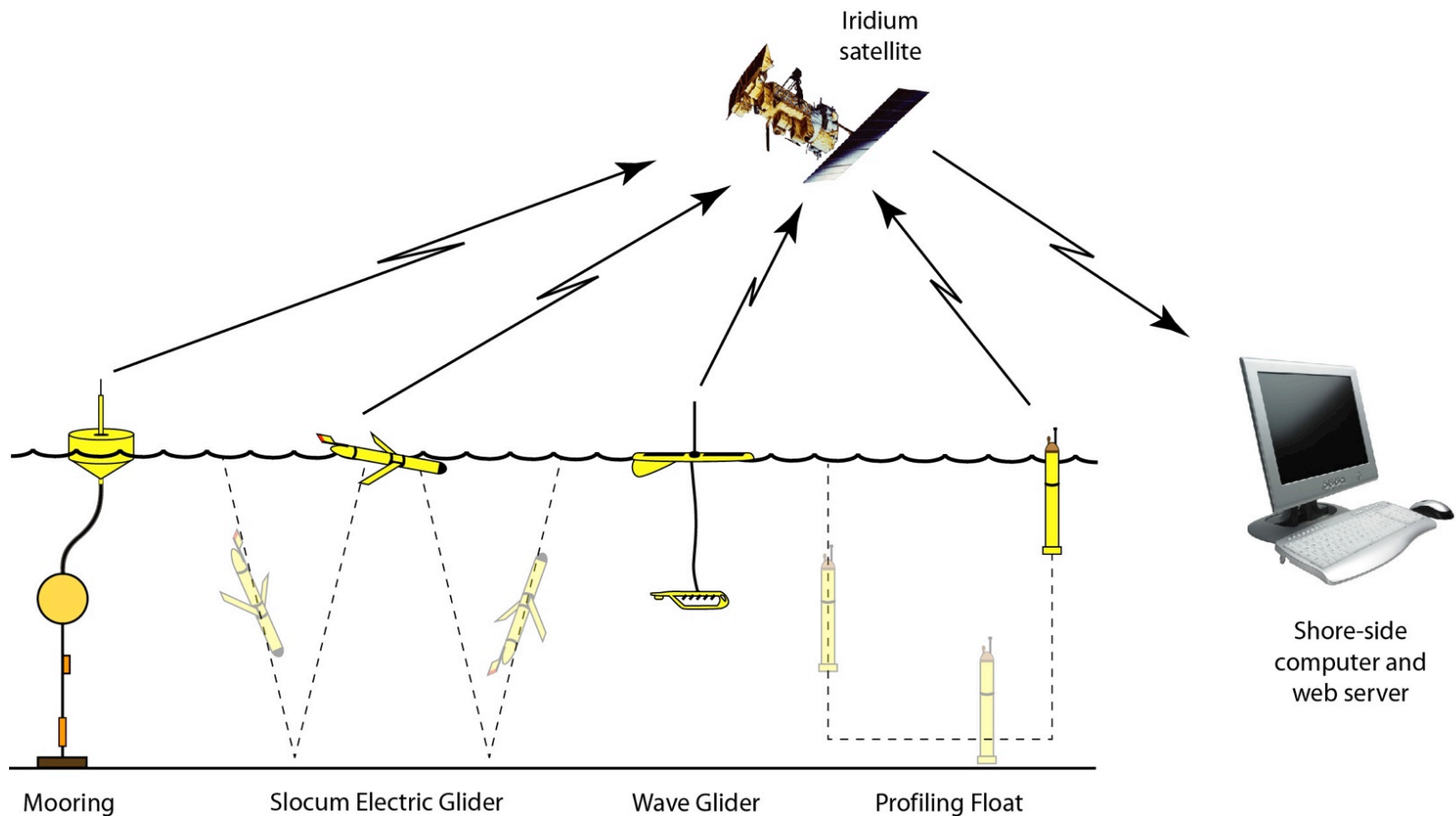
% of Month Color Code



REAL TIME MONITORING & MITIGATION



Spatial scale – small to large
Temporal scale – days to months



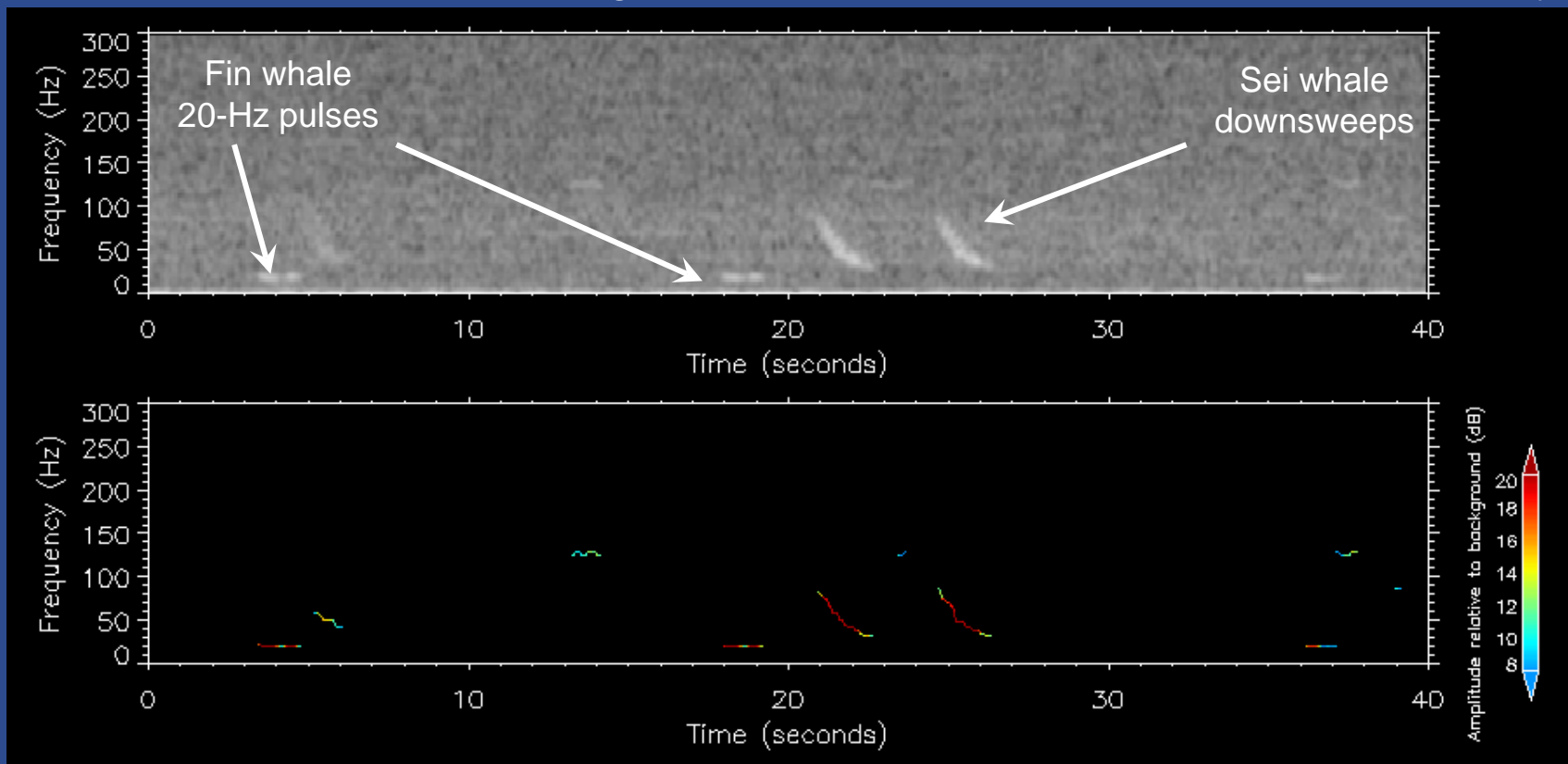
REAL TIME MONITORING & MITIGATION



Low Frequency Detection and Classification System*

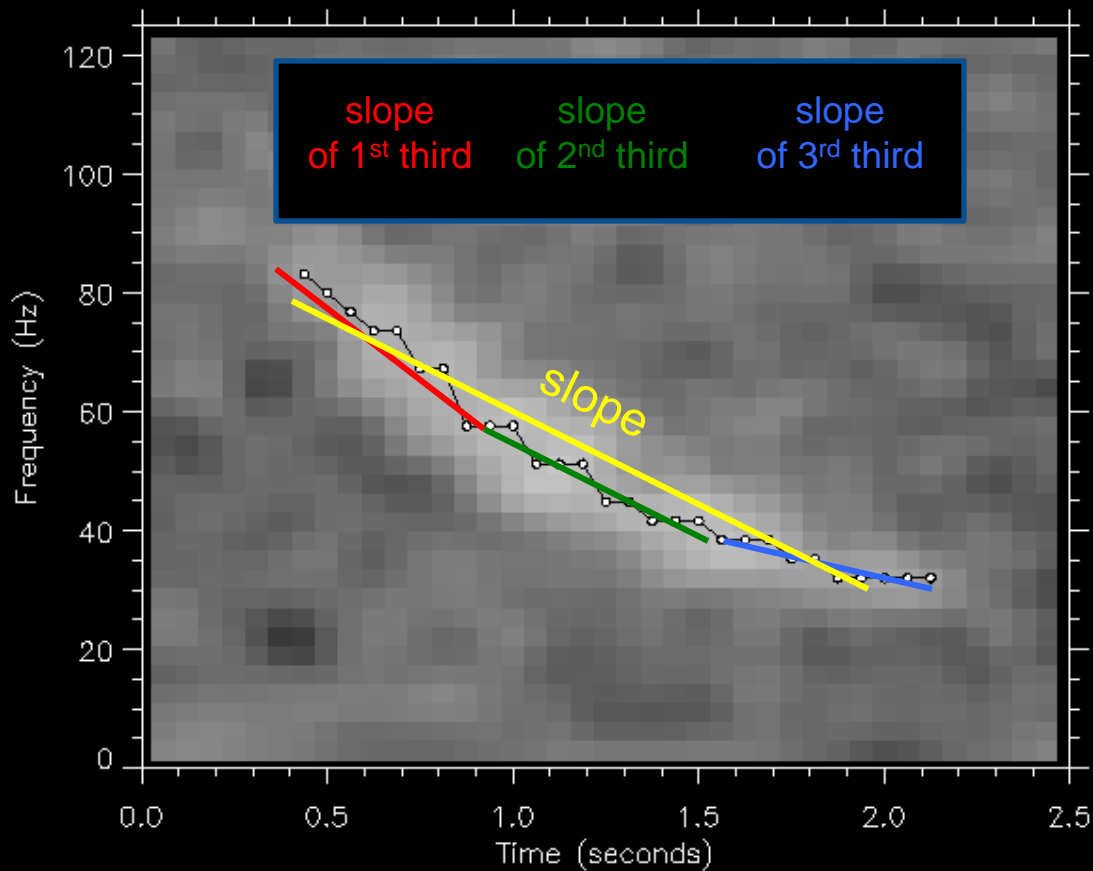


Create and condition spectrogram, then pitch track, extract attributes, classify



* 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.

ATTRIBUTE EXTRACTION



average
frequency

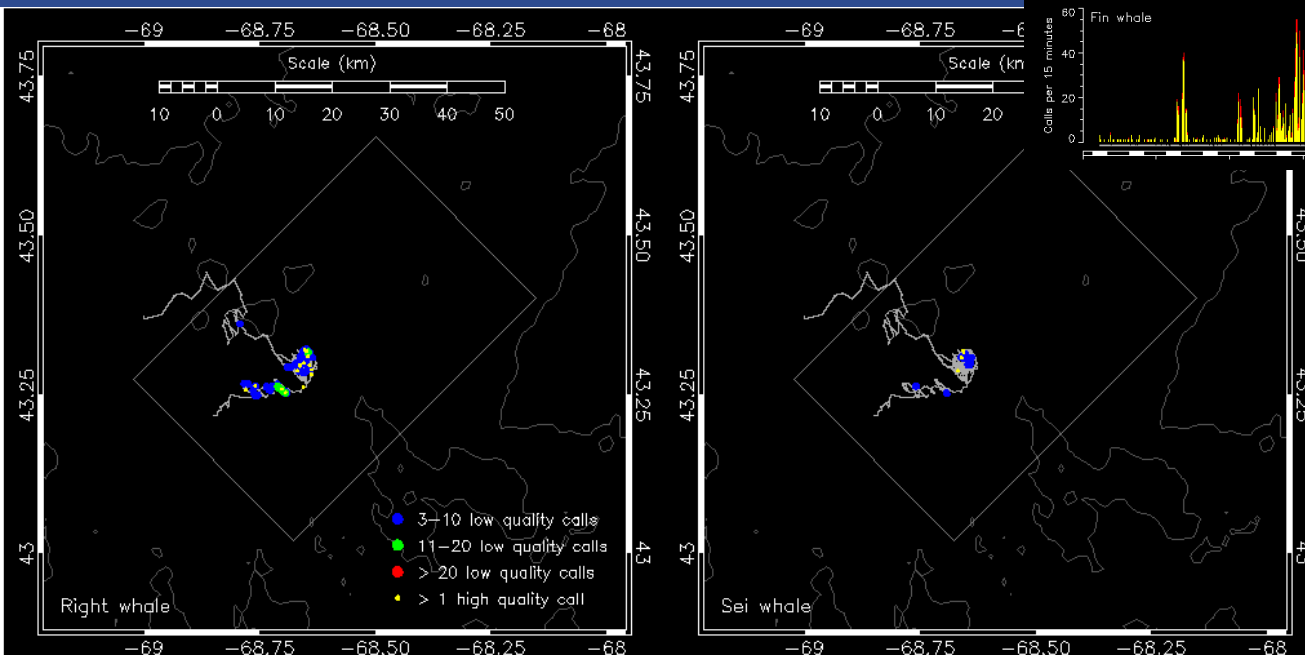
frequency
range

REAL TIME MONITORING & MITIGATION

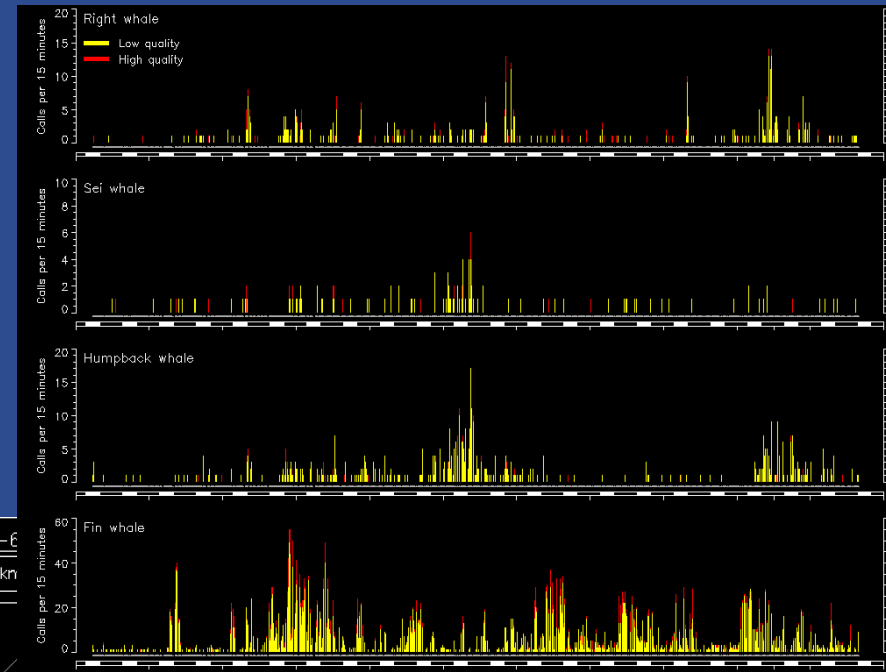


Baumgartner, M.F., D.M. Fratantoni, T.P. Hurst, M.W. Brown, T.V.N. Cole, S.M. Van Parijs, and M. Johnson. 2013. **Real-time reporting of baleen whale passive acoustic detections from ocean gliders.** *Journal of the Acoustical Society of America* 134:1814-1823.

Location of detections



Multispecies Detections

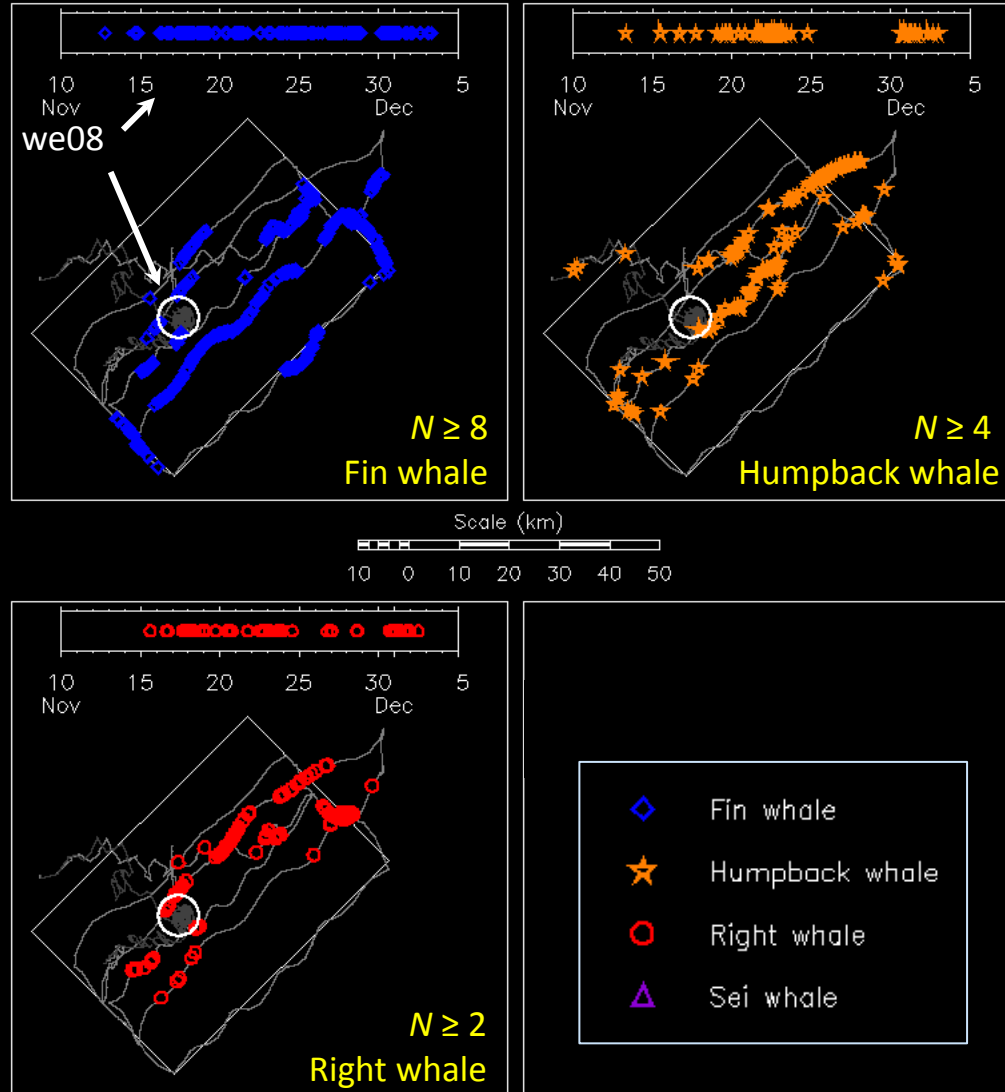


Web display:
<http://dcs.who.edu>

REAL TIME MONITORING & MITIGATION



Field study
– predicted
occurrence
from tallies



Applications for fish



- Seasonal and temporal distribution of spawning cod.
- Long term presence on spawning grounds using archived data
- Establishing closures throughout spawning
- Run glider transects to find new spawning areas.



THANK YOU



My amazing group



Steven Brady, Danielle Cholewiak,
Genevieve Davis, Samara Haver,
Denise Risch, Robert Valtierra

My incredible colleagues



Mark Baumgartner, Chris Clark, Aaron Rice, Peter
Corkeron, Leila Hatch, Susan Parks, Heather Haas

and more.....