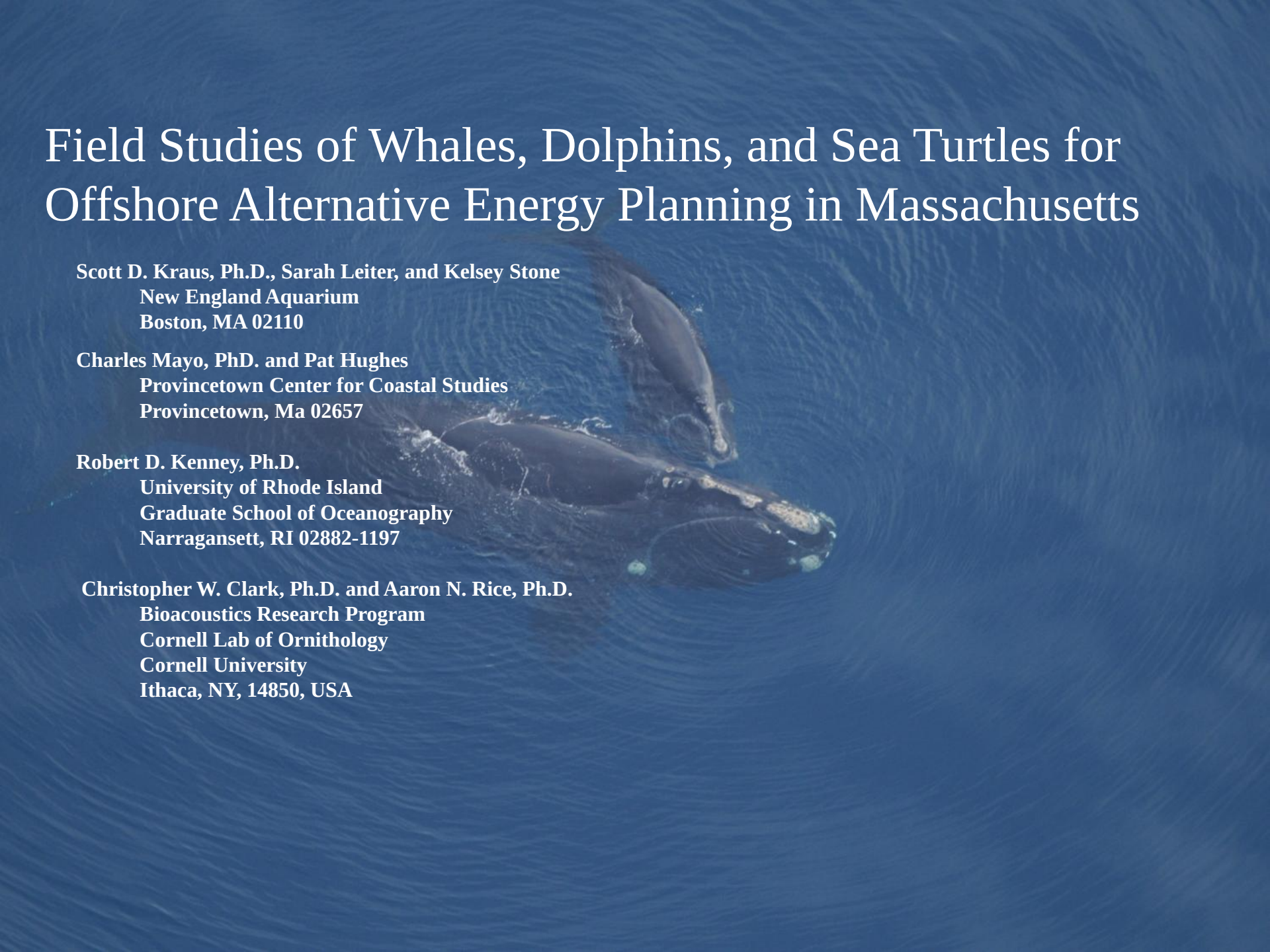
Field Studies of Whales, Dolphins, and Sea Turtles for Offshore Alternative Energy Planning in Massachusetts



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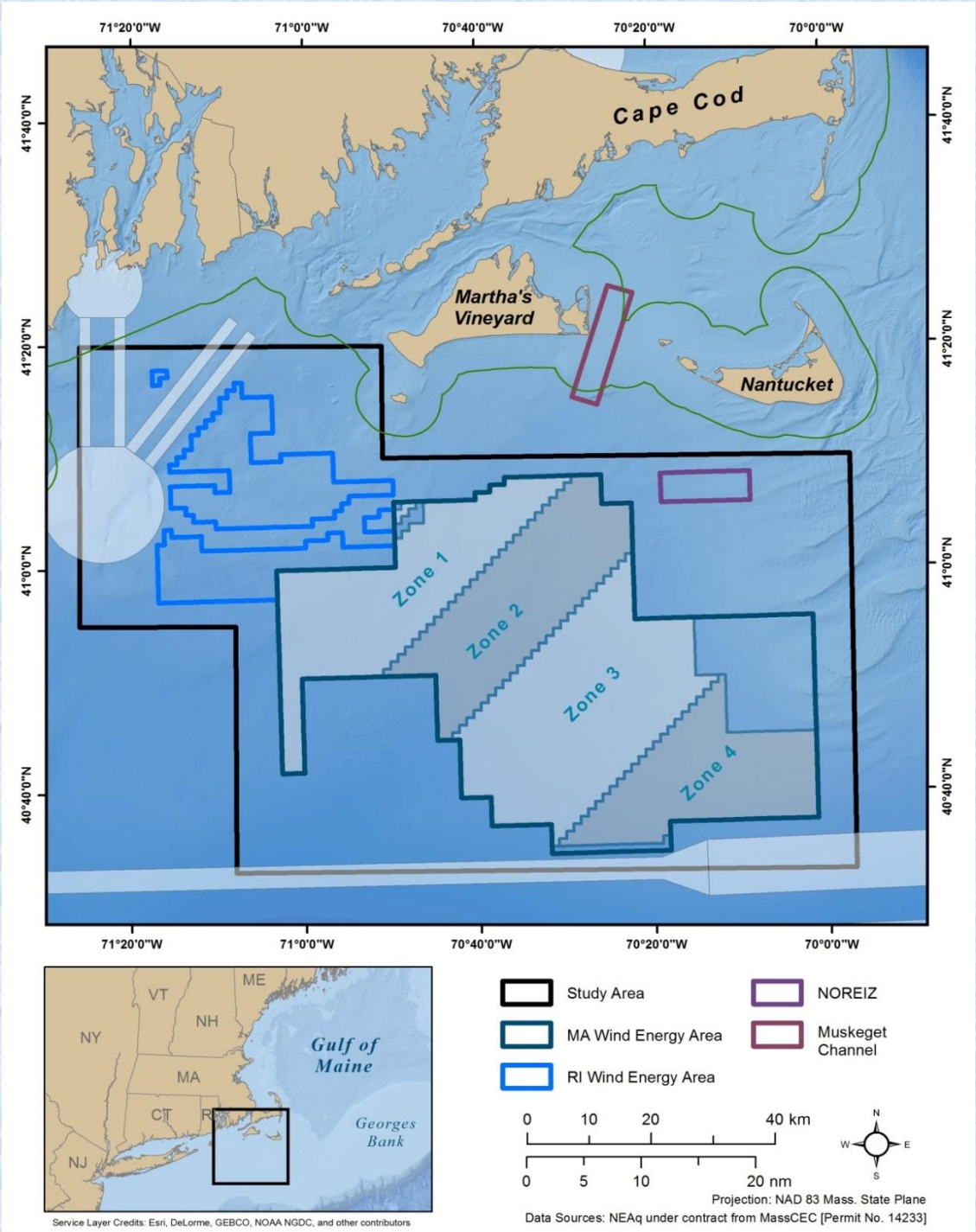
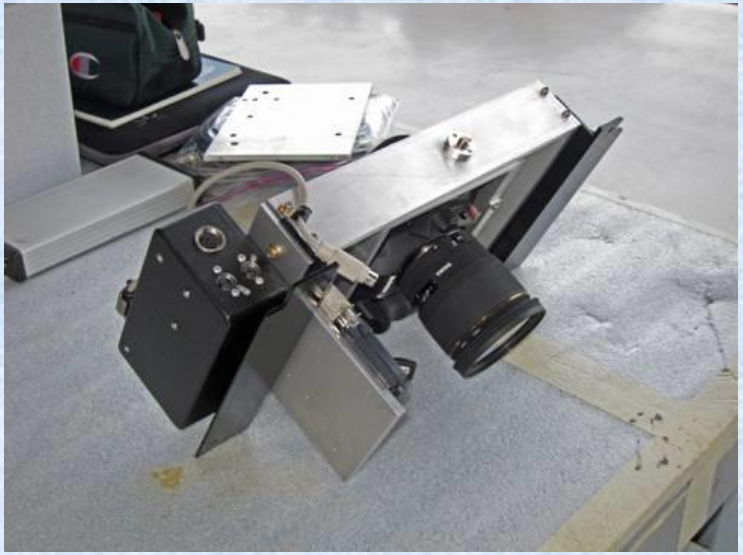
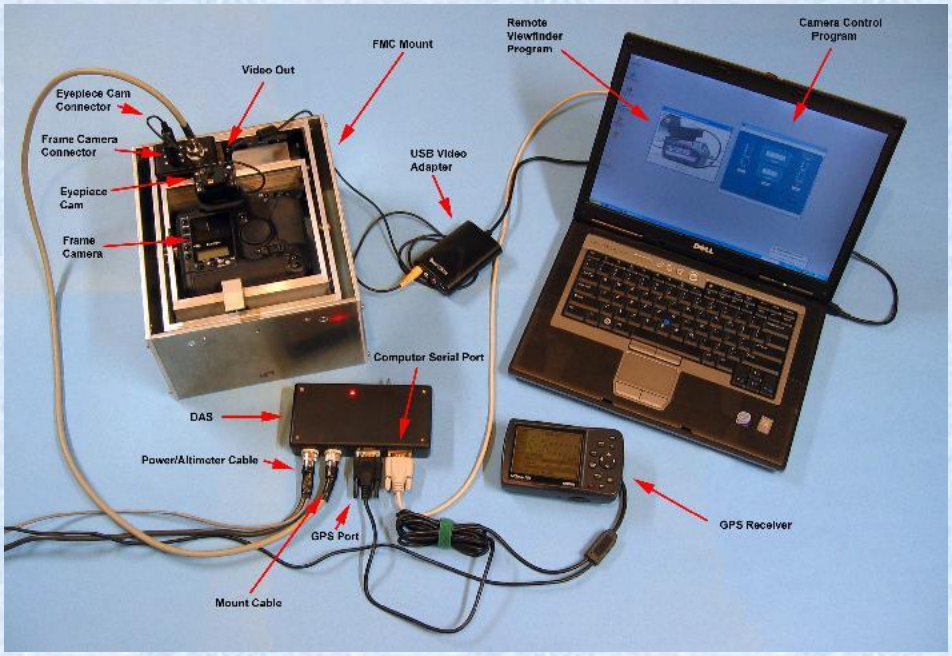
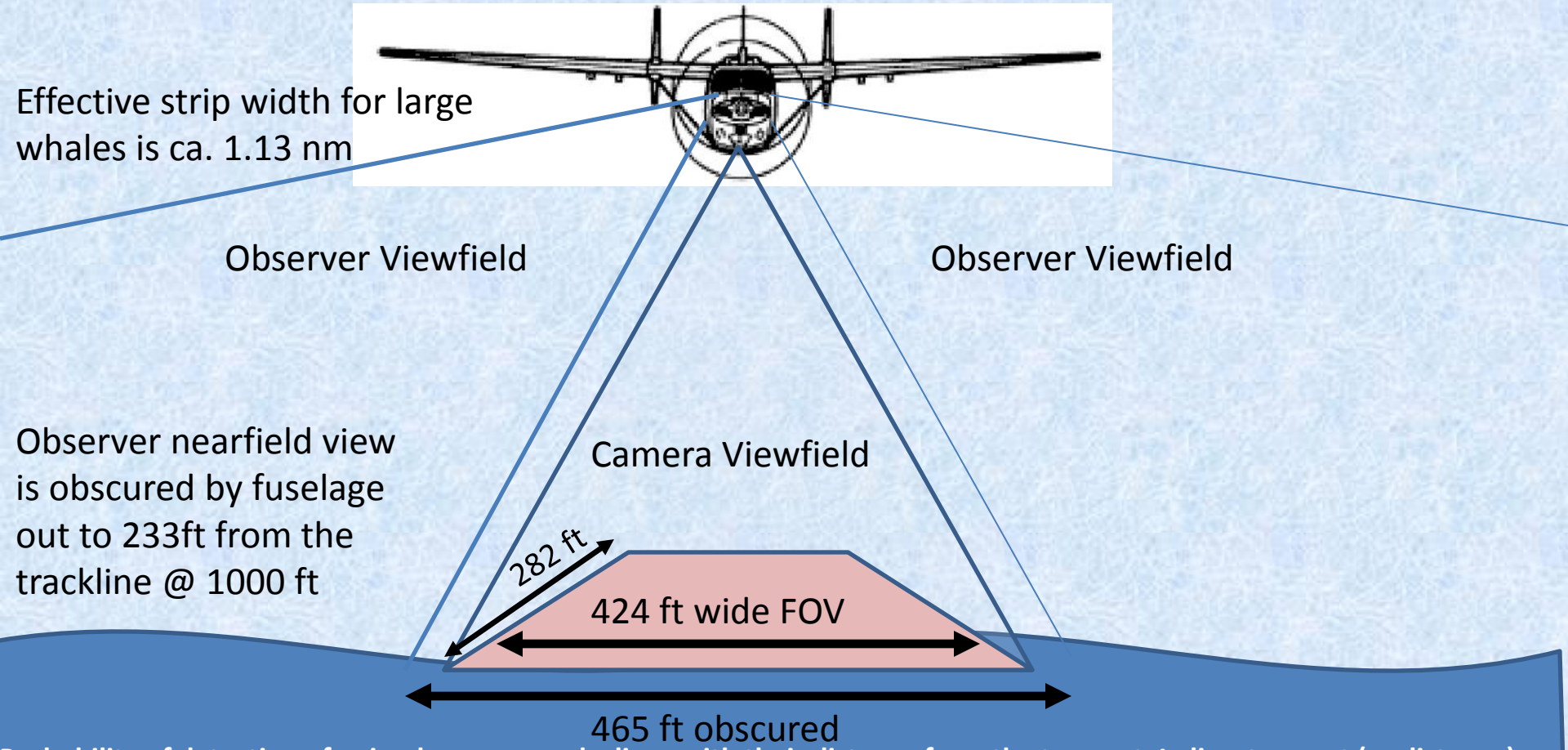

71°20'0"W
71°0'0"W
70°40'0"W
70°20'0"W
70°0'0"W
41°40'0"N
41°20'0"N
41°0'0"N
40°40'0"N
Cape Cod
Martha's Vineyard
Nantucket
Zone 1
Zone 2
Zone 3
Zone 4
ME
VT
NH
NY
MA
CT
RI
NJ
Gulf of Maine
Georges Bank
Service Layer Credits: Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Study Area
MA Wind Energy Area
RI Wind Energy Area
NOREIZ
Muskeget Channel
0 10 20 40 km
0 5 10 20 nm
N
W
E
S
Projection: NAD 83 Mass. State Plane
Data Sources: NEAq under contract from MassCEC [Permit No. 14233]




Remote Viewfinder Program
Camera Control Program
FMC Mount
Video Out
Eyepiece Cam Connector
Frame Camera Connector
USB Video Adapter
Eyepiece Cam
Frame Camera
Computer Serial Port
DAS
Power/Altimeter Cable
GPS Receiver
GPS Port
Mount Cable

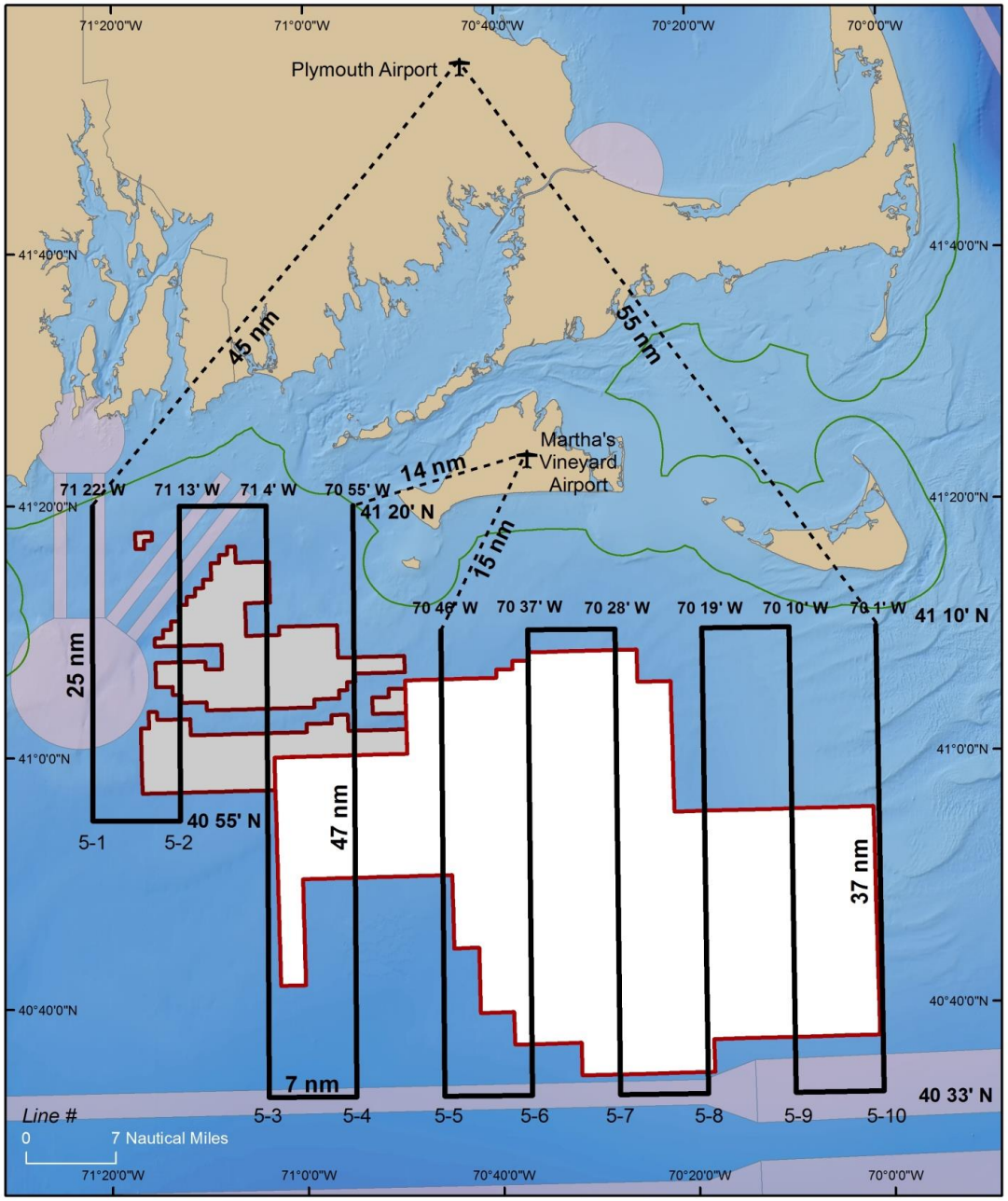
Cessna Skymaster O-2 Observer and Camera Viewfields

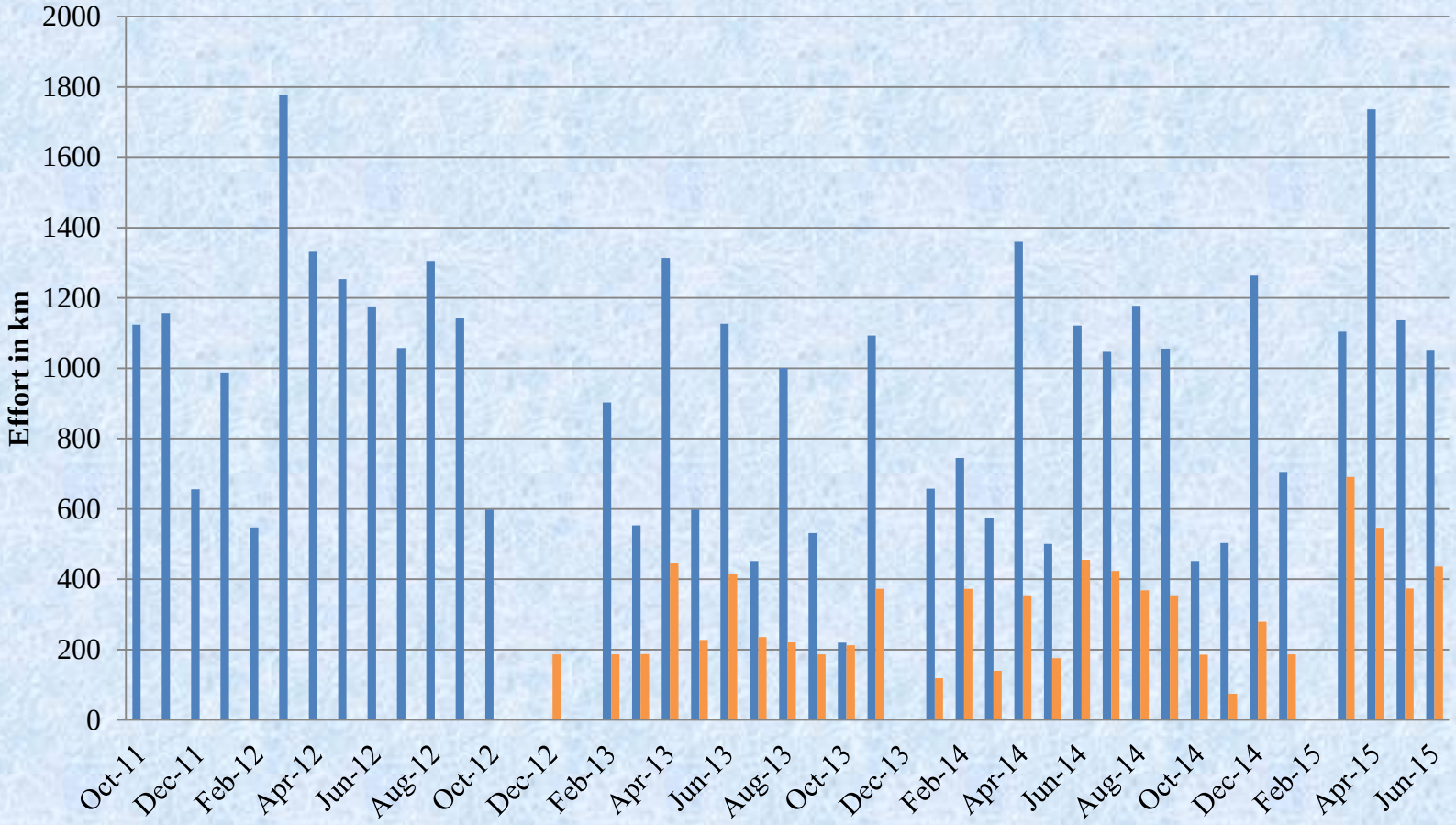


Probability of detection of animals or groups declines with their distance from the transect. In line-transect (or distance) sampling theory, f(0) is the probability density function of right-angle sighting distances (for that species and platform) evaluated at a distance of 0. The reciprocal of f(0) is the "effective strip width," a statistical estimate of the area effectively searched on either side of the transect.

Start line: W to E - Line #5-1: 41 20' N, 71 22' W
E to W - Line #5-10: 41 10' N, 70 1' W

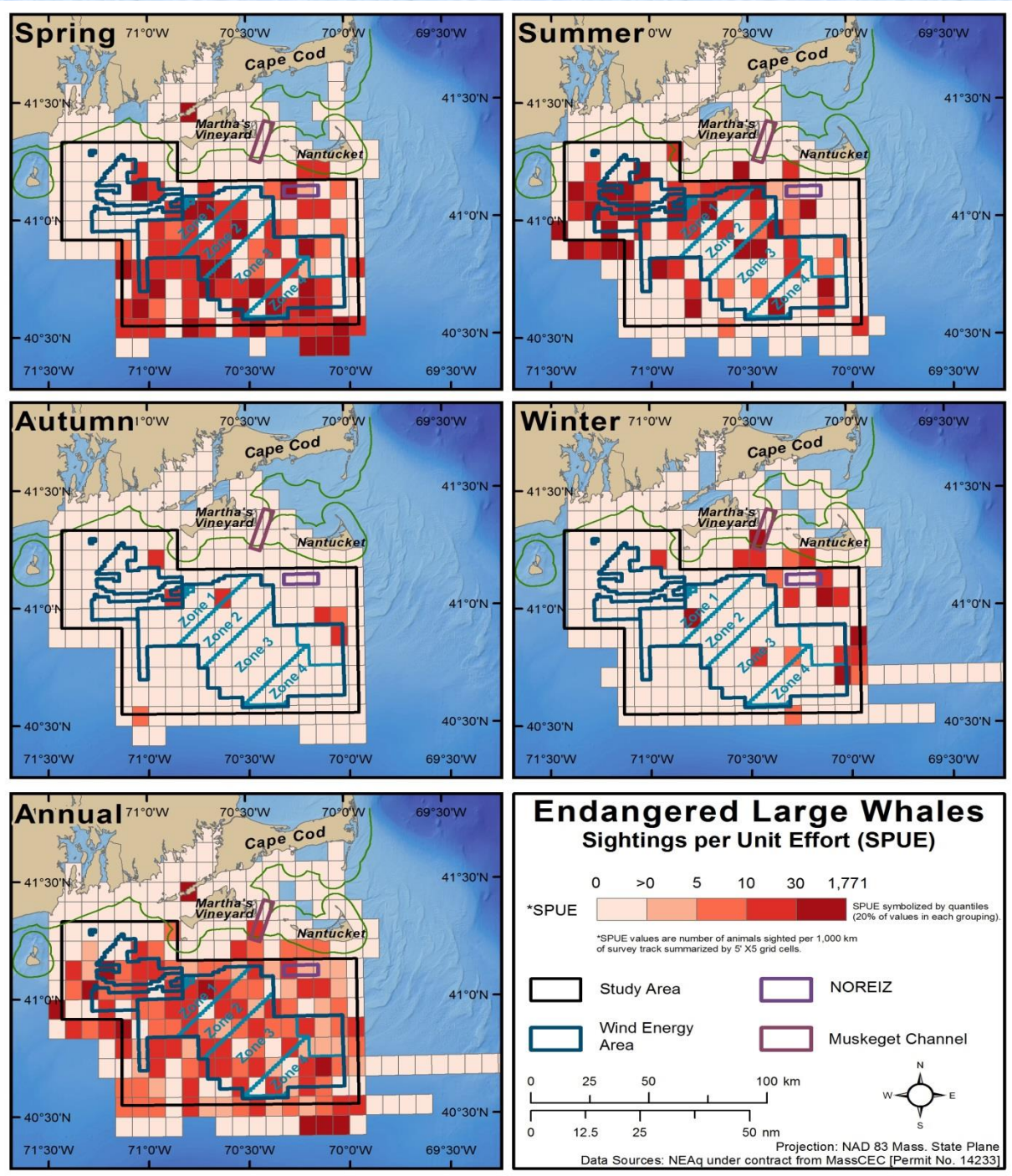
Option #5



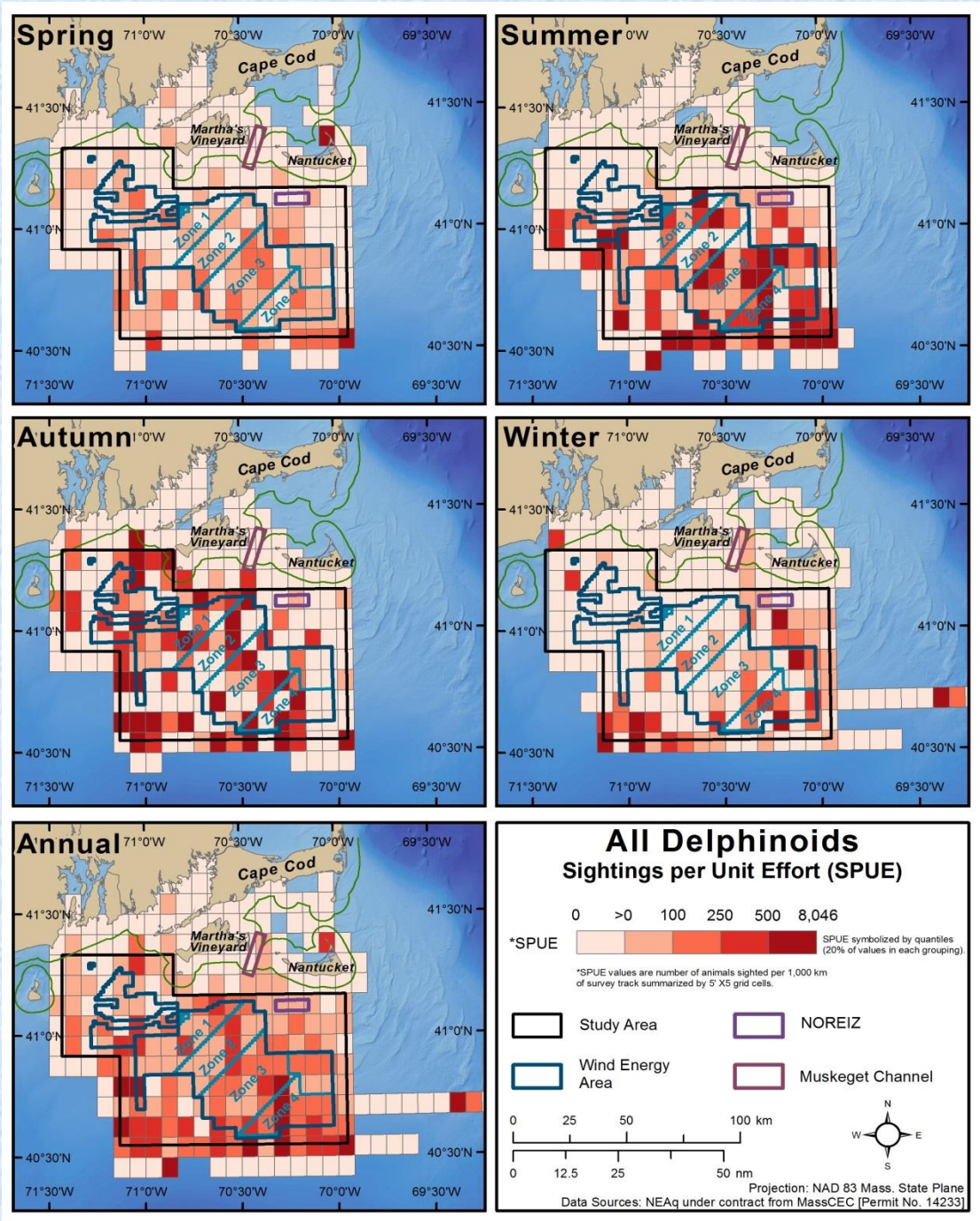


Aerial Survey Effort in km by month and year
in the MAWEA (blue) and RIMA (orange)

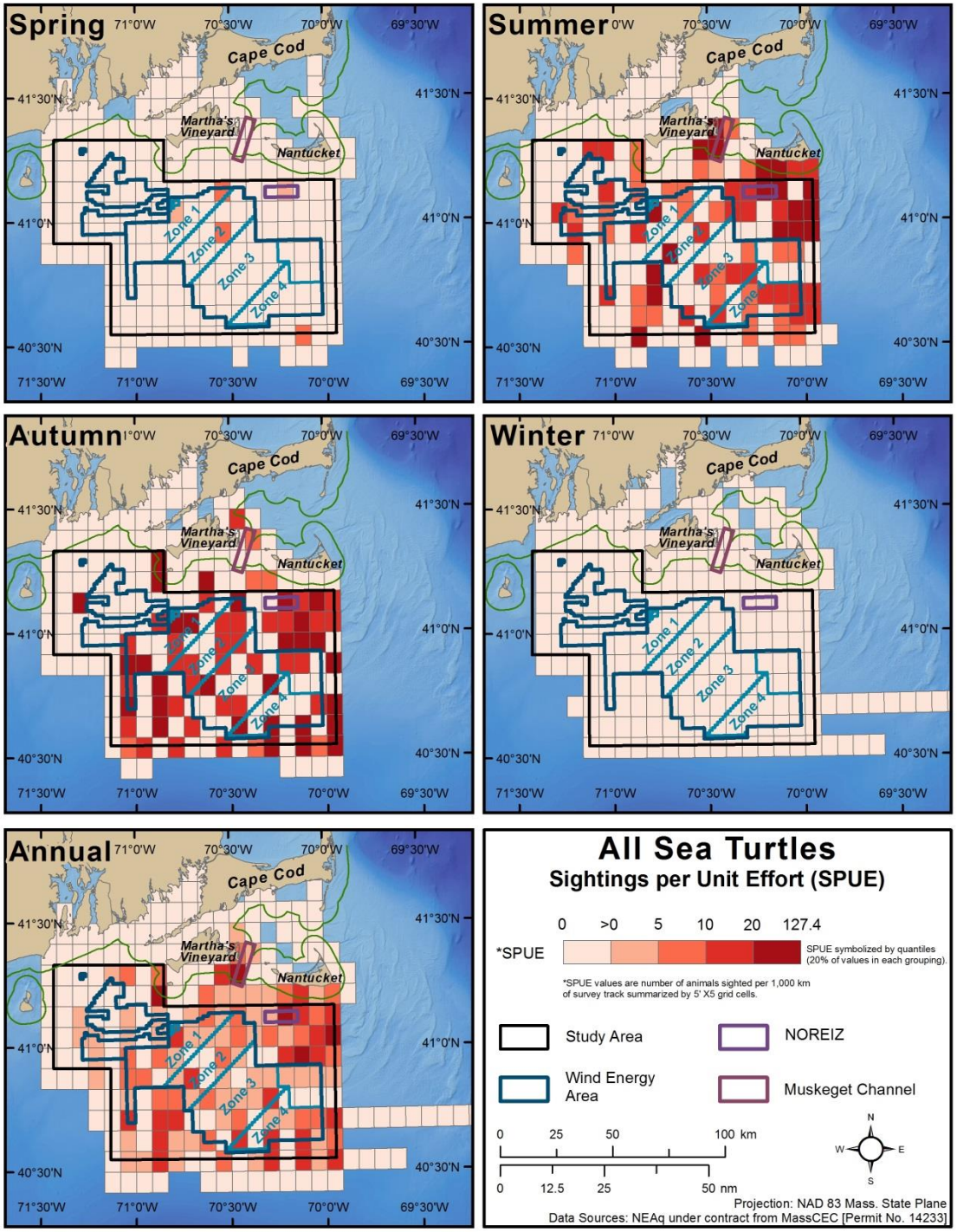
Sightings per Unit Effort of endangered large whales (fin whale, humpback whale, sei whale, sperm whale, and North Atlantic right whale) shown seasonally and annually all years combined (October 2011 – June 2015).

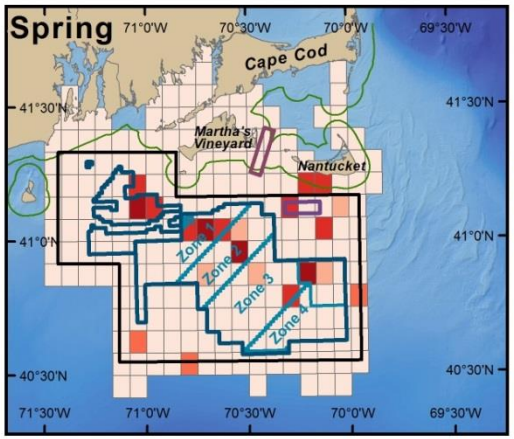


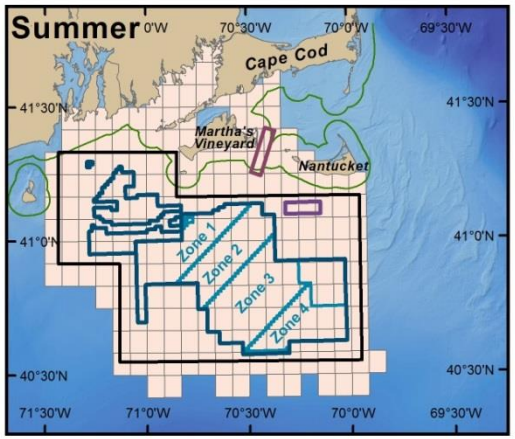
Sightings per Unit Effort of all small cetacean species (includes all dolphin species, harbor porpoise, pilot whales, and sightings of delphinoids not identified down to species) shown seasonally and annually all years combined (October 2011 – June 2015).

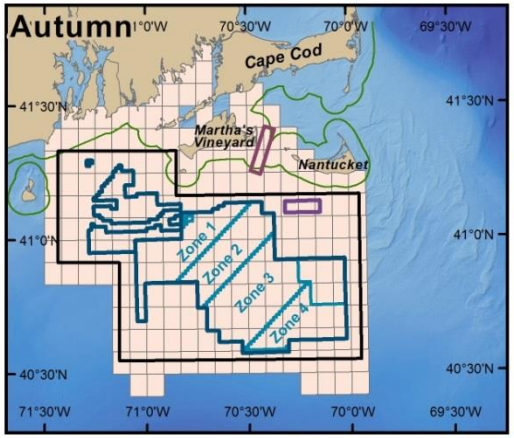


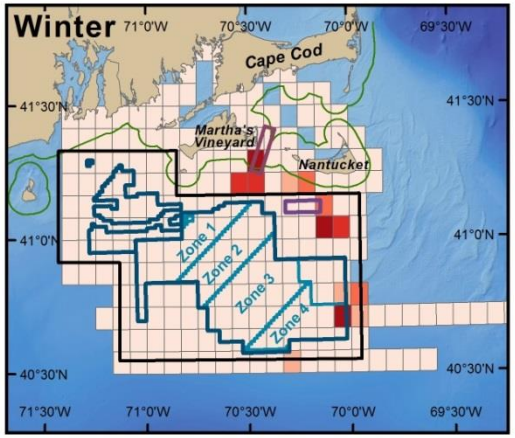
Sightings per Unit Effort (SPUE) of all turtle species (LETU, LOTU, RITU) and unidentified turtles (UNTU) sighted in the study area across the entire study period (October 2011 – June 2015), partitioned seasonally and annually

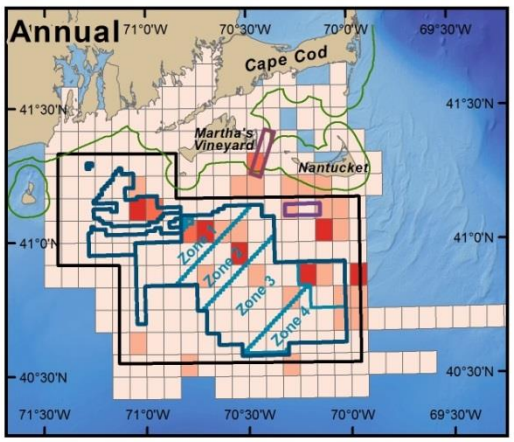


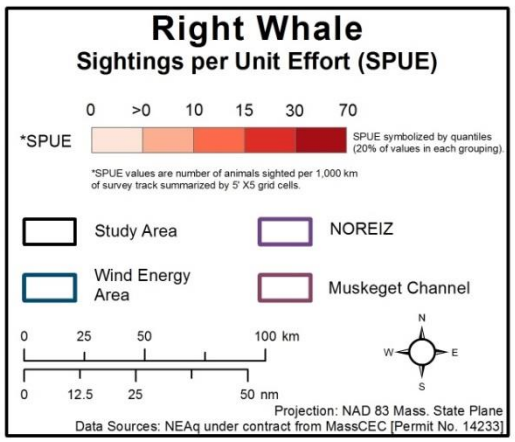












Age class by sex of photo-identified North Atlantic right whales at time of sighting within the Survey Area.

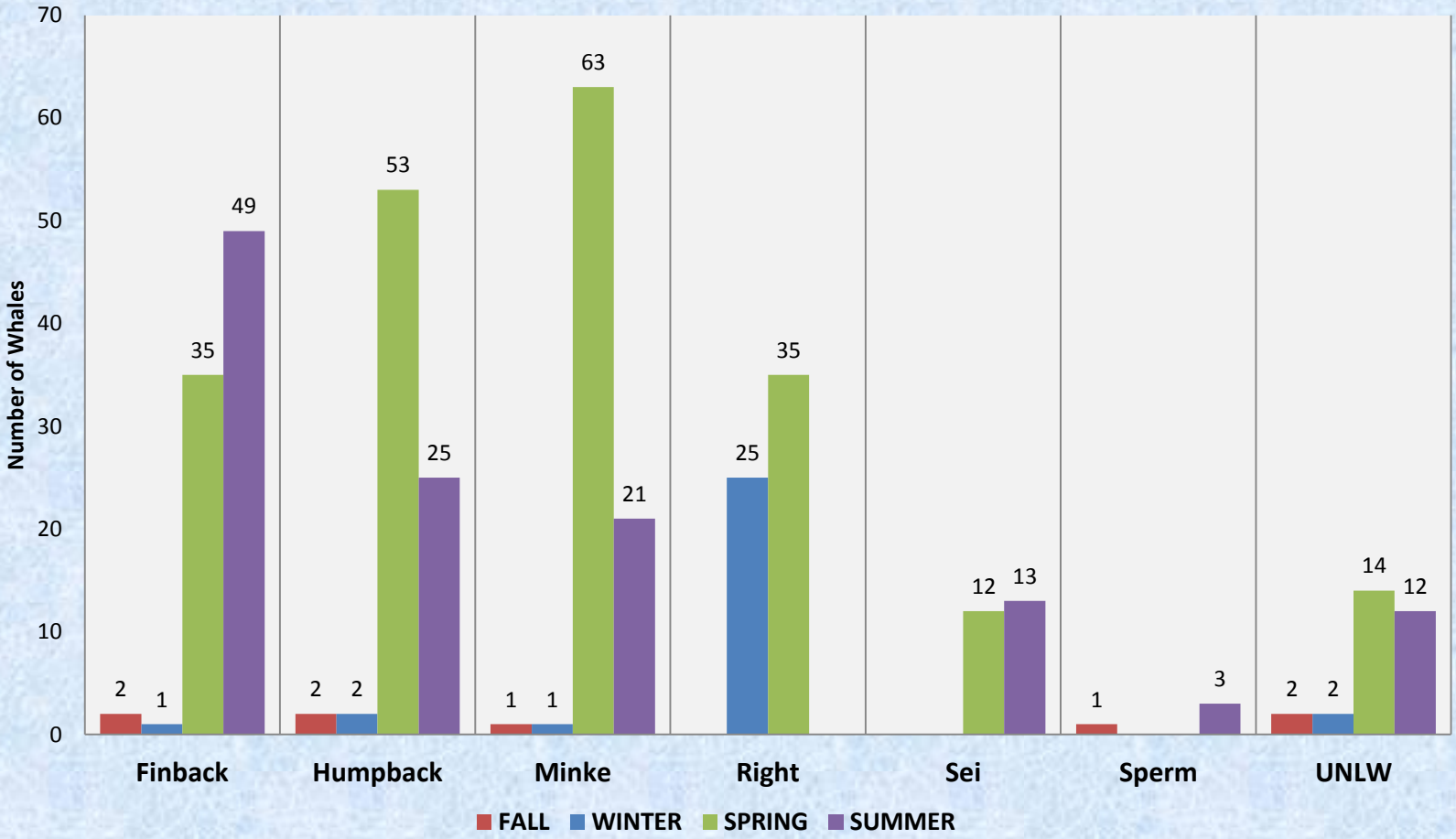
Individuals that were observed on multiple dates were not tallied multiple times within this table. Age classes include: A= adult, J=juvenile, C=calf, U=unknown Age.

Sex	Age Class			
	A	J	C	U
Female (non cow)	4	10	0	1
Female (cow)	12	0	0	0
Male	28	14	0	1
Unknown	2	1	0	4
Total	**46**	**25**	**0**	**6**

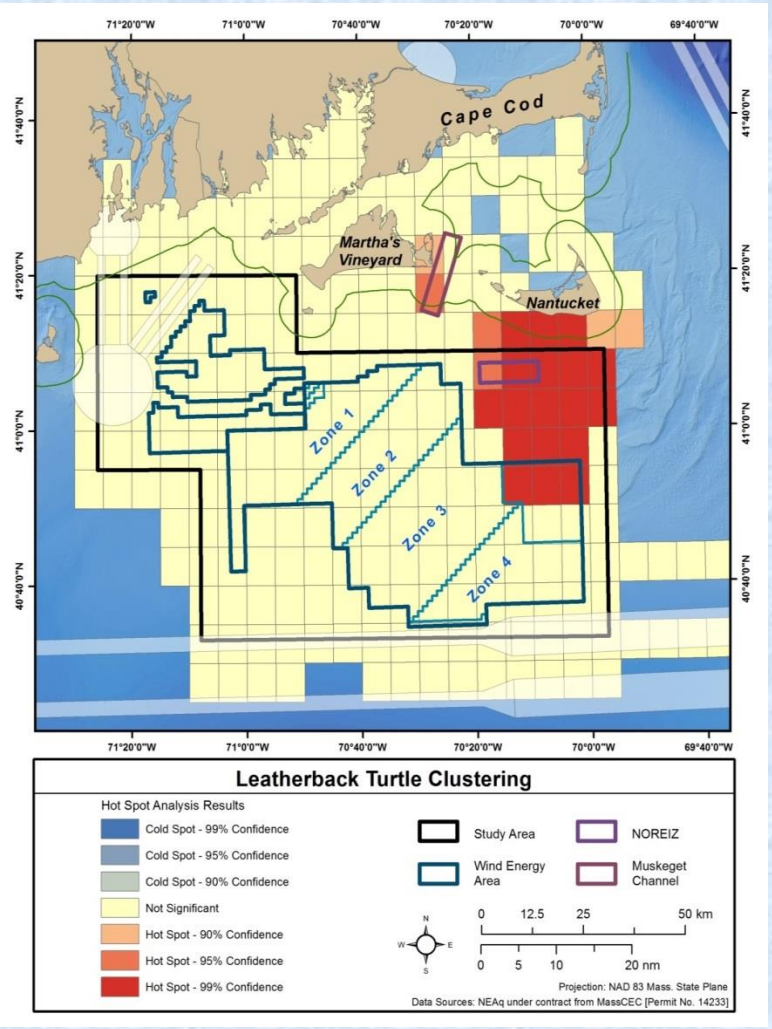
Density and abundance of North Atlantic right whales (*Eubalaena glacialis*) by season-year.

Density and variance are the means of the transect estimates, weighted by transect lengths. T = number of transects flown; G,I = number of groups and individuals sighted; D = density in animals/km^2; V = variance of the density; N = estimated abundance in the study area; CI95=95% confidence interval, with the lower limit changed to zero if it was negative.

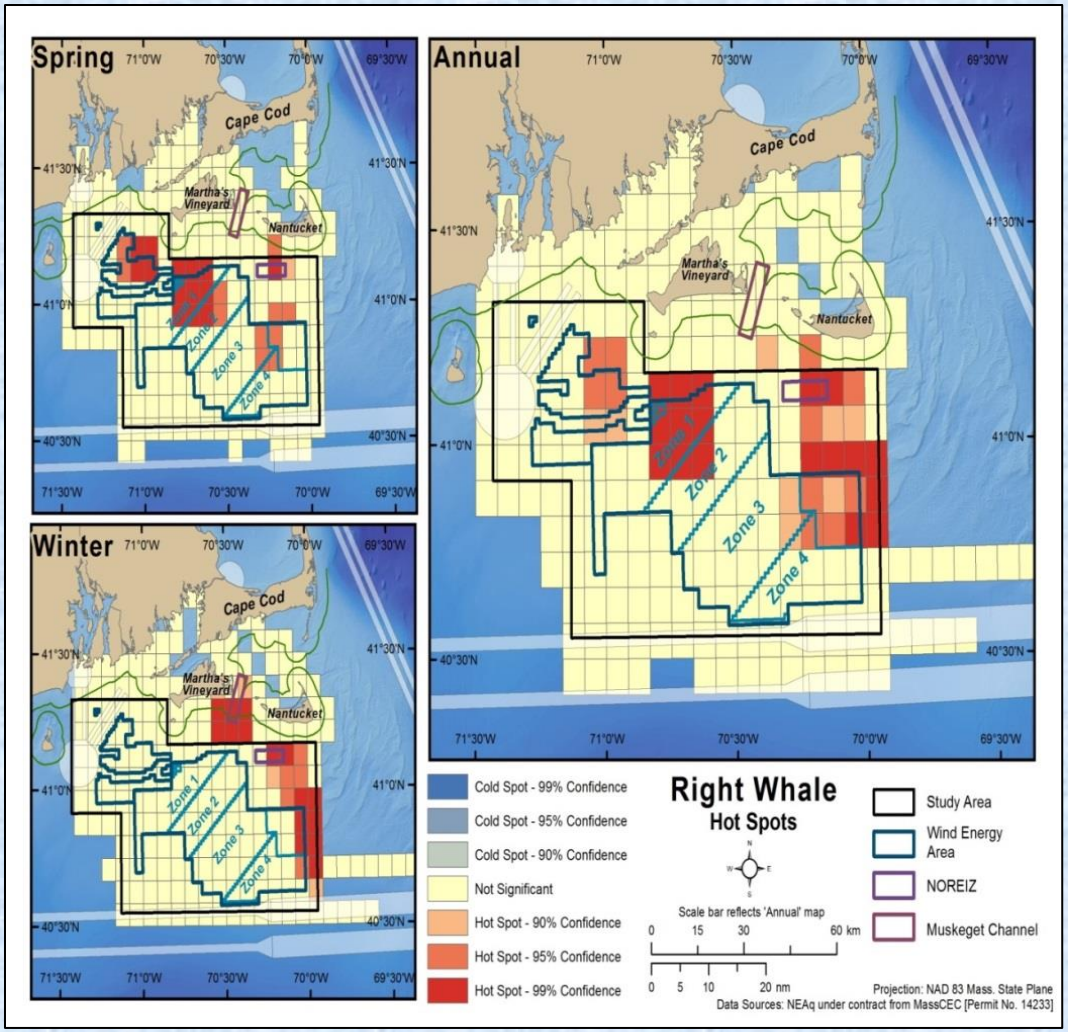
Season-Year	T	G, I	D	V	N	CI95
Fall-2011	32	0, 0	0	–	0	–
Winter-2012	30	0, 0	0	–	0	–
Spring-2012	56	8, 13	0.0035	0.0027	24	0–118
Summer-2012	48	0, 0	0	–	0	–
Fall-2012	24	0, 0	0	–	0	–
Winter-2013	16	3, 5	0.0045	0.004	35	0–296
Spring-2013	39	1, 1	0.0005	0.0003	4	0–43
Summer-2013	46	0, 0	0	–	0	–
Fall-2013	36	0, 0	0	–	0	–
Winter-2014	26	1, 3	0.0008	0.0006	7	0–83
Spring-2014	41	4, 11	0.0019	0.0016	15	0–109
Summer-2014	60	0, 0	0	–	0	–
Fall-2014	39	0, 0	0	–	0	–
Winter-2015	28	4, 15	0.0027	0.002	21	0–155
Spring-2015	65	10, 44	0.0029	0.0021	23	0–111



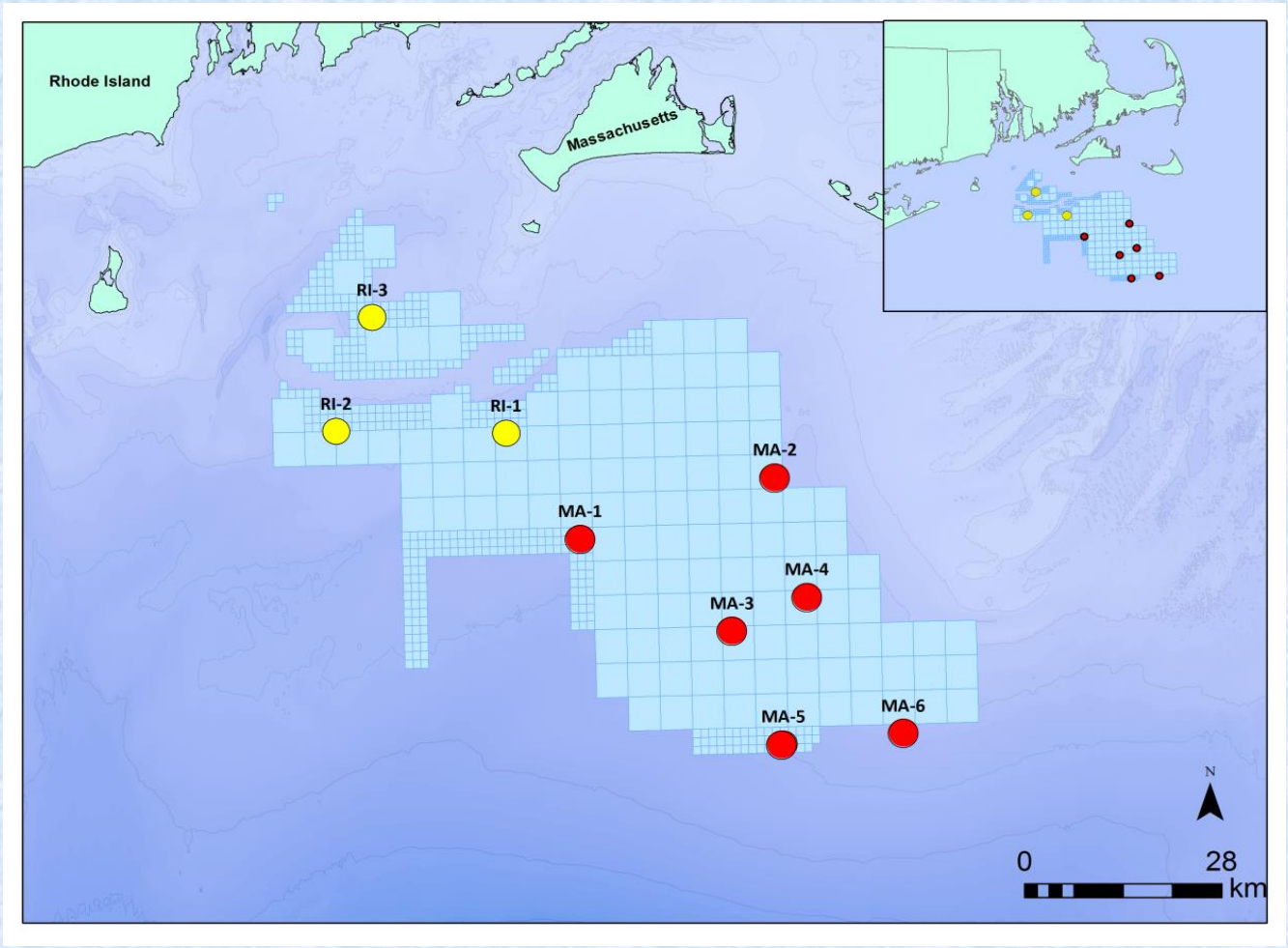
Large whale sightings in the study area by season across all years (UNLW=any large whales not identified down to species)



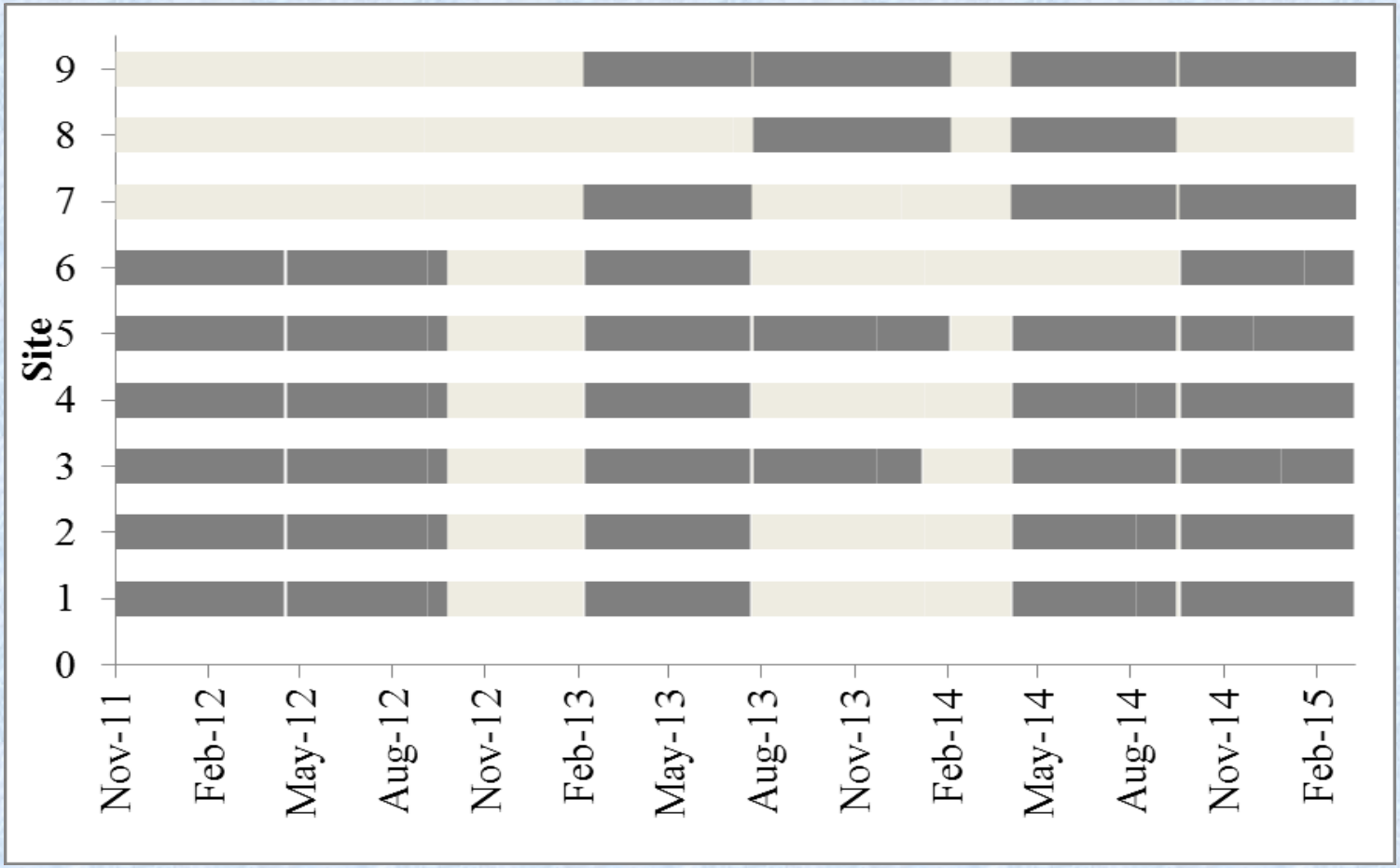
Hot spot analysis of leatherback turtle distribution in the study area (annual distribution , 2012-2015, NEAq survey data only).



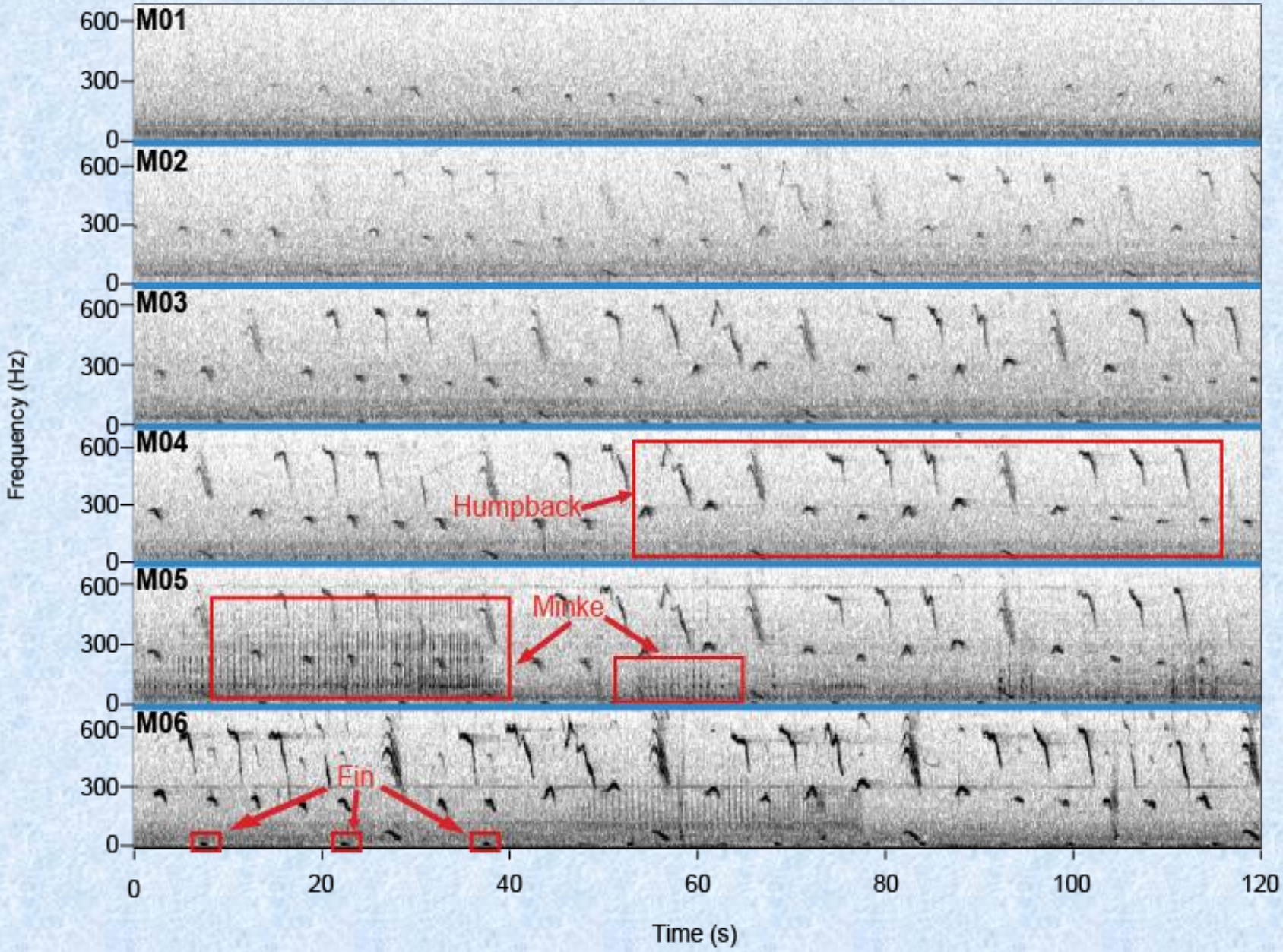
Hot Spot analysis of North Atlantic right whale sightings detected by NEAq showing spring, winter and annual distribution (2012-2015, NEAq Survey data only).

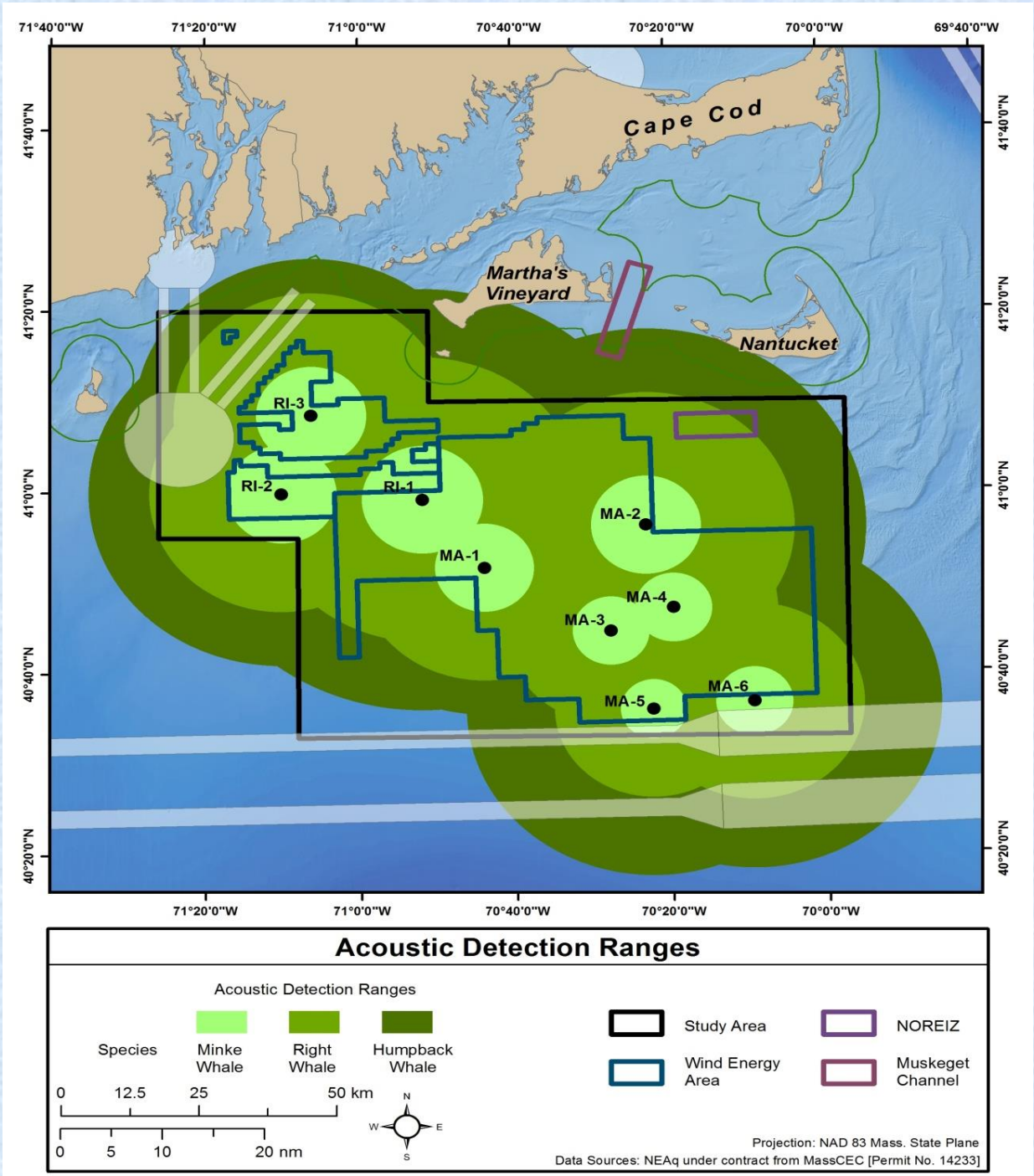


Map of the MA array of MARUs within the Mass Wind area (red circles) and the RIMA array of MARUs within the RIMA WEA (yellow circles). Light blue areas represent lease areas.



Summary of recording effort throughout the study period by MARU (Site # on left). The light grey lines indicate time periods when a MARU was not recording at a given site. The dark grey lines indicate time periods when a MARU was recording at a given site.


M01
M02
M03
M04
M05
M06
600
300
0
Humpback
Minke
Fin
Frequency (Hz)
0
20
40
60
80
100
120
Time (s)



Acoustic Detection Ranges

Acoustic Detection Ranges

Species	Minke Whale	Right Whale	Humpback Whale

0 12.5 25 50 km

0 5 10 20 nm

N W E S

Study Area

Wind Energy Area

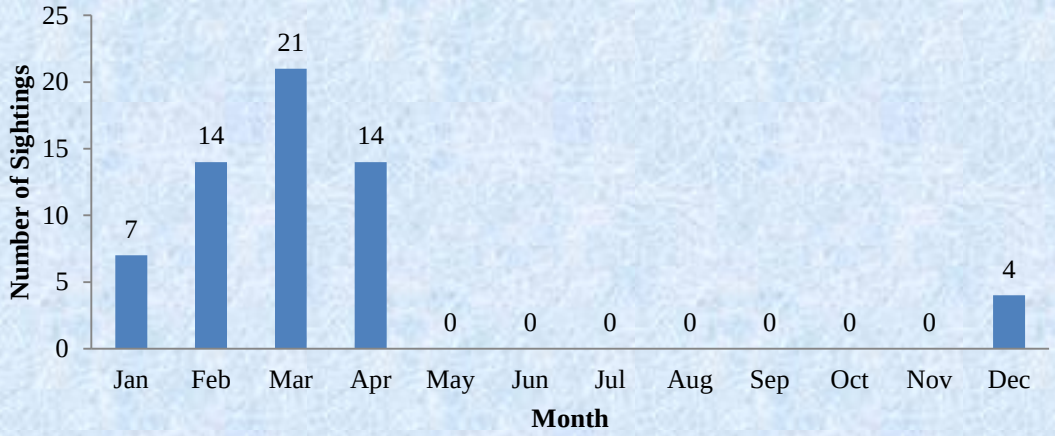
NOREIZ

Muskeget Channel

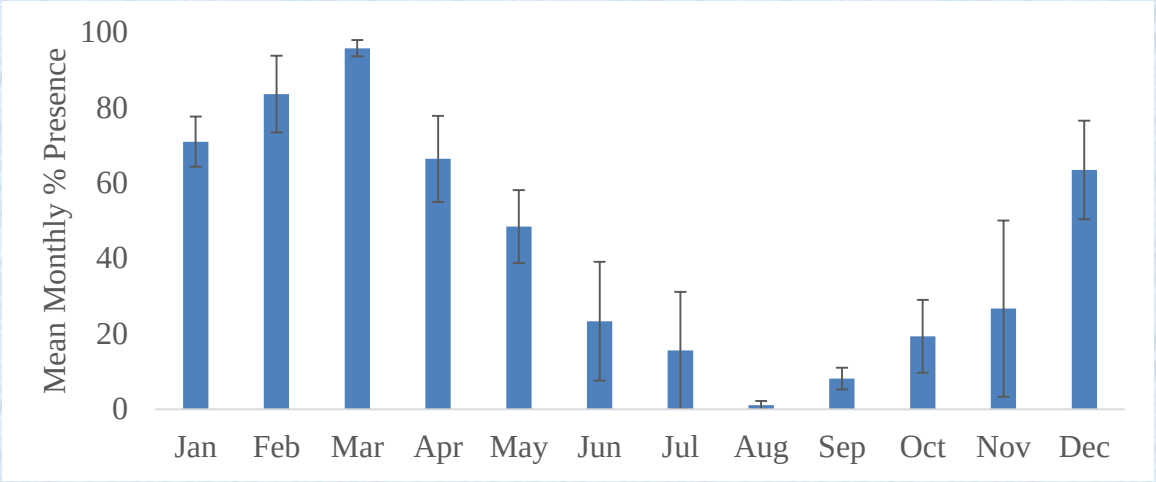
Projection: NAD 83 Mass. State Plane

Data Sources: NEAq under contract from MassCEC [Permit No. 14233]

Right whale sighting totals by month, combined across all survey years (October 2011 – June 2015).



Right whale mean monthly acoustic presence ± standard error for all years combined.



NEAq/MA CEC Study – Data, Analyses, and Limitations

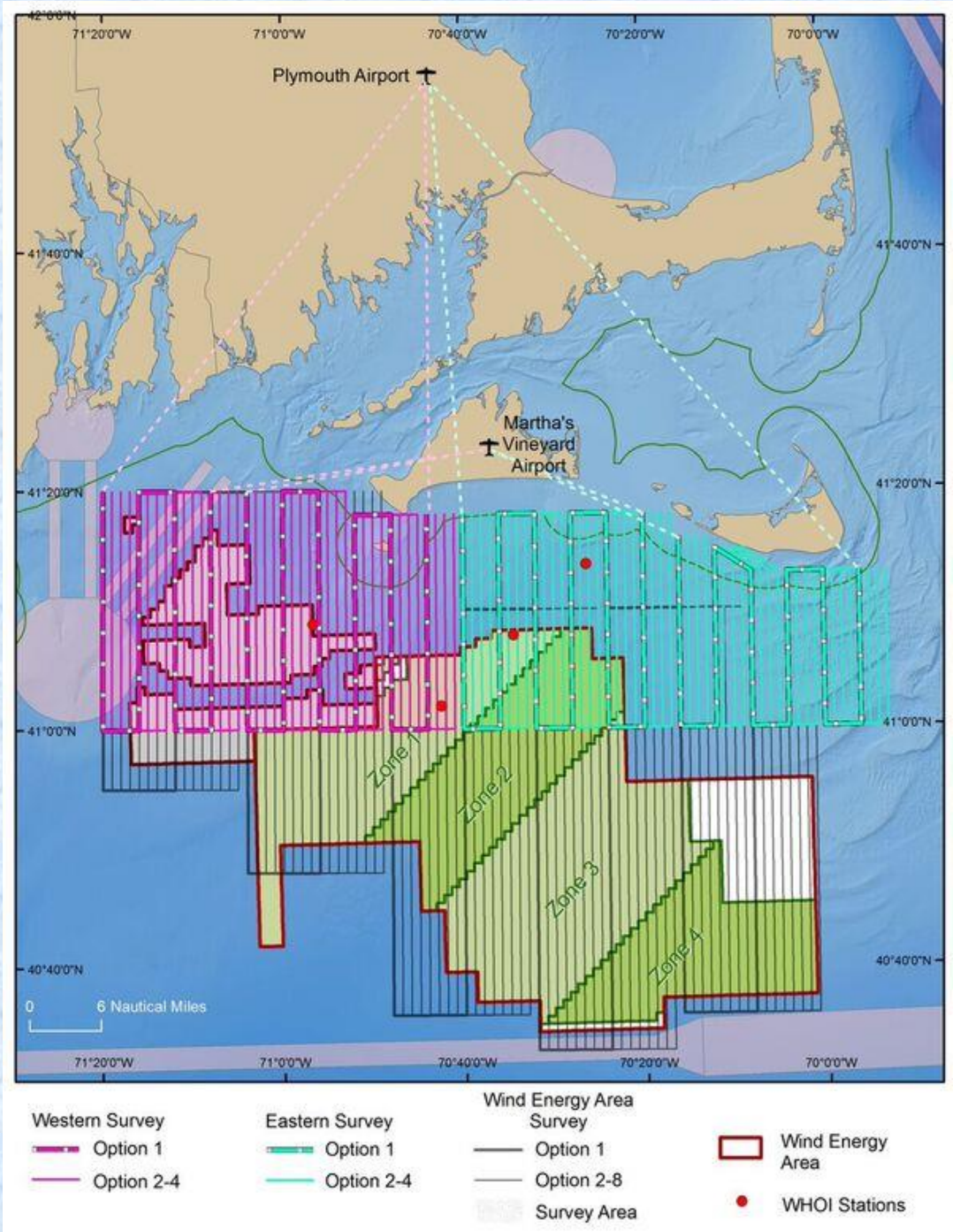
Data Source	Analyses	What they tell us	What they dont tell us
Aerial Survey sightings/ transects	Sightings Rates	Provide relative comparable measures of numbers of observed animals per km, per transect, per survey, per month, as needed.	Absolute abundance
	SPUE	Distribution patterns normalized for variable survey effort	Absolute abundance in each block
	Line transect abundance estimates	Point estimates of absolute abundance, with 95%confidence intervals	Abundance within small subsets of the study area
	Species Richness	How many species were observed within a block	
	Hot spot analyses	Shows areas within the context of the entire study are that are used more consistently than the rest of the area - analyses can be done on absolute numbers, or on species richness	
Belly Camera Photographs	Counts	Sea turtle, shark and small animal counts in the area not seen by observers	Whale distribution and abundance
Photographic Identifications	Demographics	Individual identifications are used to determine age, sex, of known right whales	Photo-id only feasible for right whales from aircraft
	Movements	Photo-id can link whales to other areas and movements	Residence times
	Minimum Counts	Minimum counts provide lower bounds on line-transect estimates	Not for non-right whales
Acoustic Data (MARUs)	Presence of calling whales	Species specific records of occurrence with the detection range of each MARU	How many whales are present, how many silent whales are in the area.
	Ambient Noise	Background noise in the area	
	Presence by MARU site	Occurrence in some MARU sites and not in others provide crude distribution info	How many whales are calling
Acoustic and Survey data	Comparative analyses	Shows the strengths and weaknesses of both data collection methods	

Currently Underway:

- March 2017-Feb 2018
- Aerial surveys - N-S lines as shown. Two full area surveys/mo. (green) and 2-3 NARW focused surveys (pink and turquoise) per month (Feb-May).
- Simultaneous shipboard oceanographic sampling (red dots)to determine why right whales are present in the winter and spring.

Partners: NEAq, WHOI, and PCCS

Supported by MA CEC and BOEM



Acknowledgements

Funding was provided by the Massachusetts Clean Energy Center, and the Bureau of Ocean Energy Management. We appreciate the support and good counsel of Tyler Studds, Nils Bolgen, and Brian Hooker through the process. Observers and photo-analysts during these surveys included Laura Ganley, Jessica Taylor, Tracy Montgomery, Sarah Mussoline, Marianna Hagbloom, Leah Crowe, Orla O'Brien, and Jessica Thompson. Thanks to our aircraft vendor Assist Aviation Solutions LLC, including Rick Bartle (Operations Manager), Aidan Wilps (Aircraft Maintenance Manager), project pilots Dan Fields, Don Turner, Keith Lapierre, Raymond Sevard, Richard Euler, and Scott Patten. Additionally, we thank New England Aquarium right whale data analyst Monica Zani for her assistance with processing North Atlantic right whale photographs and data. The NLPSC also thanks Captain Mark Leach of the F/V Sea Holly of Harwichport, MA, for overseeing the MARU deployment and retrieval cruises.