Greater Atlantic Regional Fisheries Office

Atlantic Large Whale Take Reduction Team Webinar

Risk Reduction Decision Support Tool

For questions, contact
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978 281-9181

Risk Reduction Decision Support Tool

Purpose:

Introduce the Decision Support Tool

- Describe elements of the tool
  - Duke's Whale Habitat Density Model
  - IEC's updated Line Model
  - Risk Landscape
  - Consider how to apply to identify relative value of risk reduction elements toward risk reduction goal

Agenda

Welcome, call protocols – Colleen Coogan, Take Reduction Team Coord**.**

- Meeting for the Atlantic Large Whale Take Reduction Team. Interested parties will have an opportunity to comment at the end of the call
- Recording call to post on webpage (anyone else recording?)
- Operator assisted, participants names collected so will not take attendance verbally

Leadership Message – Jon Hare, Director,
Northeast Fisheries Science Center (NEFSC)

Right Whale Density Model – Jason Roberts
Duke Marine Geospatial Ecology Lab

Vertical Line Model – Neal Etre
Industrial Economics Inc.

Risk Reduction Decision Support Tool – Sean Hayes, Chief
NEFSC Protected Species Branch

Discussion/Questions - TRT

Wrap Up – Colleen Coogan

Leadership Message; Jon Hare, Director, NEFSC

We know the issue:

- Post 2010 decline in North Atlantic right whale population, exacerbated by 2017 mortalities. Entanglements in U.S. and Canadian fisheries continue to be the primary human cause of mortalities

TRT has worked hard over the past 18 months:

- These efforts have positioned us to take action despite remaining uncertainty
- Choices aren't new, including: closures, gear modifications (weak rope, sleeves), line reduction (effort caps, ropeless options)

Challenge is: how to decide – Introducing Decision Support Tool

- Decision making in the face of uncertainty is a common resource management challenge, does not exempt us from action
- Decision support tool introduced today responds to Teams request, and builds on past co-occurrence modeling
- Confident this is the **best scientific information available** to guide the Team through next week's decision making process
- Not possible without the collaboration of Jason Roberts and the Duke Marine Geospatial Ecology Lab and Neal Etre and Industrial Economics
- Pledge to continue to provide Science Center support for the TRT's ongoing challenge; thanks to Burton Shank, Sean Hayes, and others for these efforts

North Atlantic right whale density models

Background Webinar for the April 2019 ALWTRT Meeting

Jason Roberts, Rob Schick, and Pat Halpin

Marine Geospatial Ecology Lab, Duke University

Duke | NICHOLAS SCHOOL OF THE ENVIRONMENT

Photo: NOAA/NEFSC/Christin Khan (MMPA Permit #17355)

In collaboration with survey programs and scientists from:

Should your logo be here? My apologies! Please email me!

Primary funding for modeling from:

Additional funding from:

How this project got started

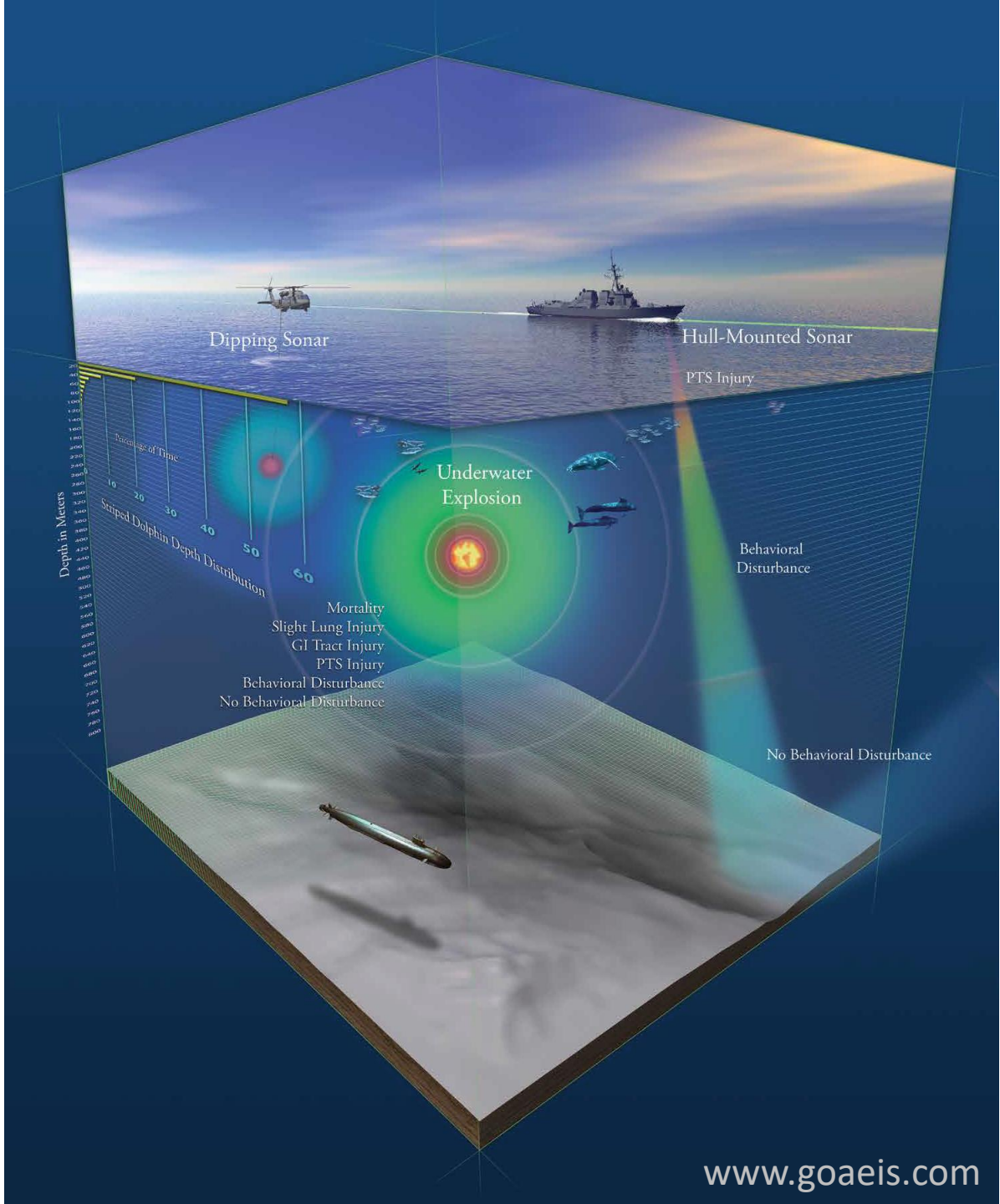
The Navy encounters marine mammals…

Photo: nbcnews.com

Navy MMPA compliance

- Every 7 years*, the Navy must obtain a Letter of Authorization permitting the “take” of marine mammal during training and testing activities
- The permit must estimate the *number of individual animals* of each mammal stock that would be taken

*Prior to 2018, Letters of Authorization lasted 5 years



www.goaeis.com

Navy Acoustic Effects Model (NAEMO)

NAVSEA WARFARE CENTERS NEWPORT

Inputs

Navy Activity Information

Sound Propagation Modeling

Population Density Maps

Exposure History of Each Simulated Individual Animal

Criteria Thresholds Applied

Estimated Number of Exposures

Results Database

Post Analysis Evaluation

Requested Takes

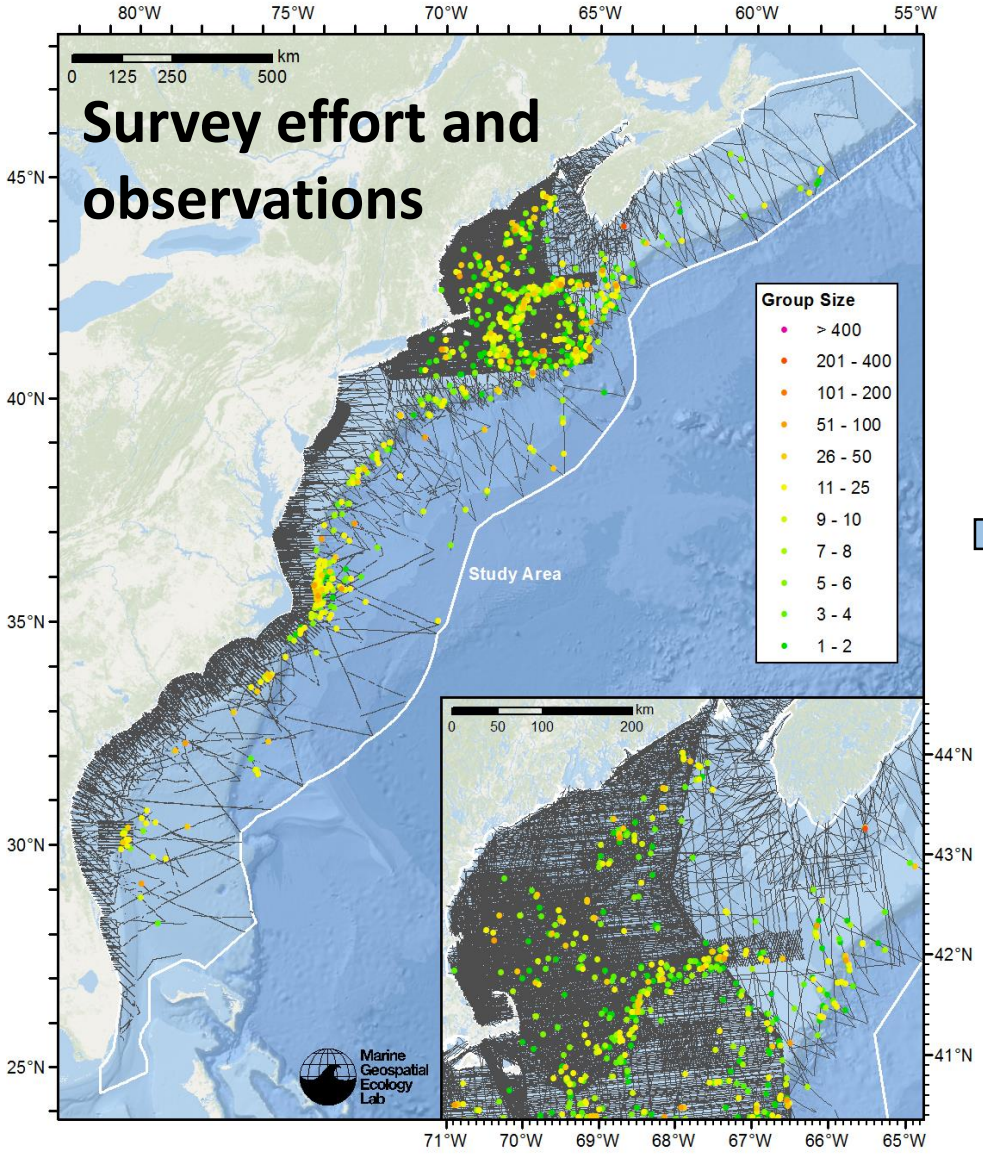
MMPA Request / ESA Consult

Density = *number of individuals per square kilometer*

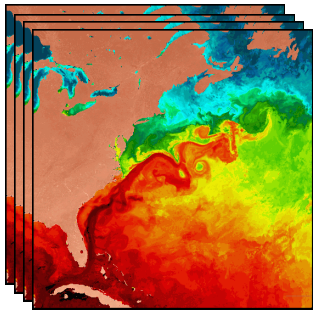
This is where we come in…

UNCLASSIFIED

Density modeling



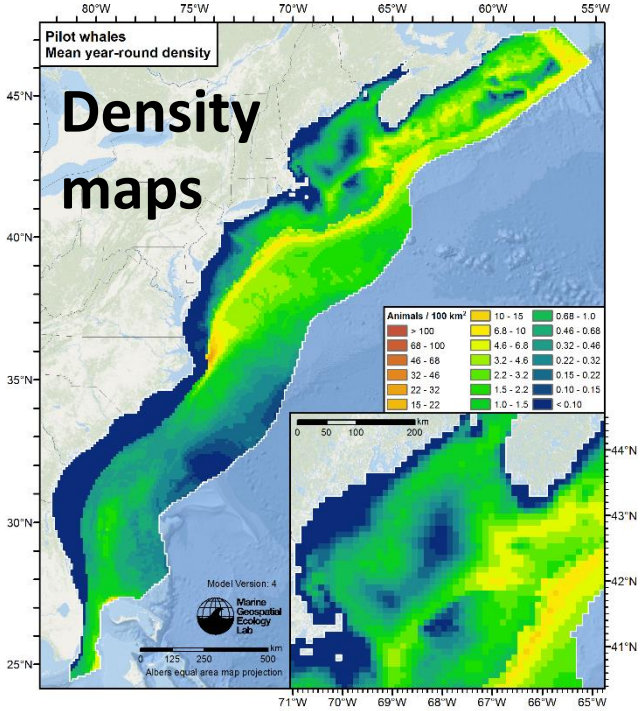
Oceanographic maps

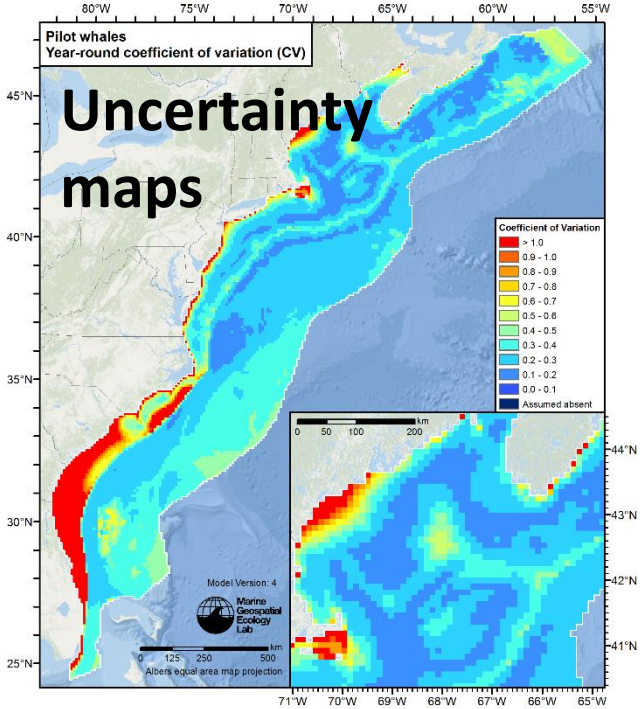


Statistical models

The models relate density (animals / km^2) to ocean conditions known to correlate with species' habitats

From the resulting statistical relationships, we can then predict densities, given maps of conditions





A critical problem:
The farther away they are,
the lower the chance you'll detect them
?
Photo: Scott and Mary Flanders

Shipboard observers

Photo: NOAA

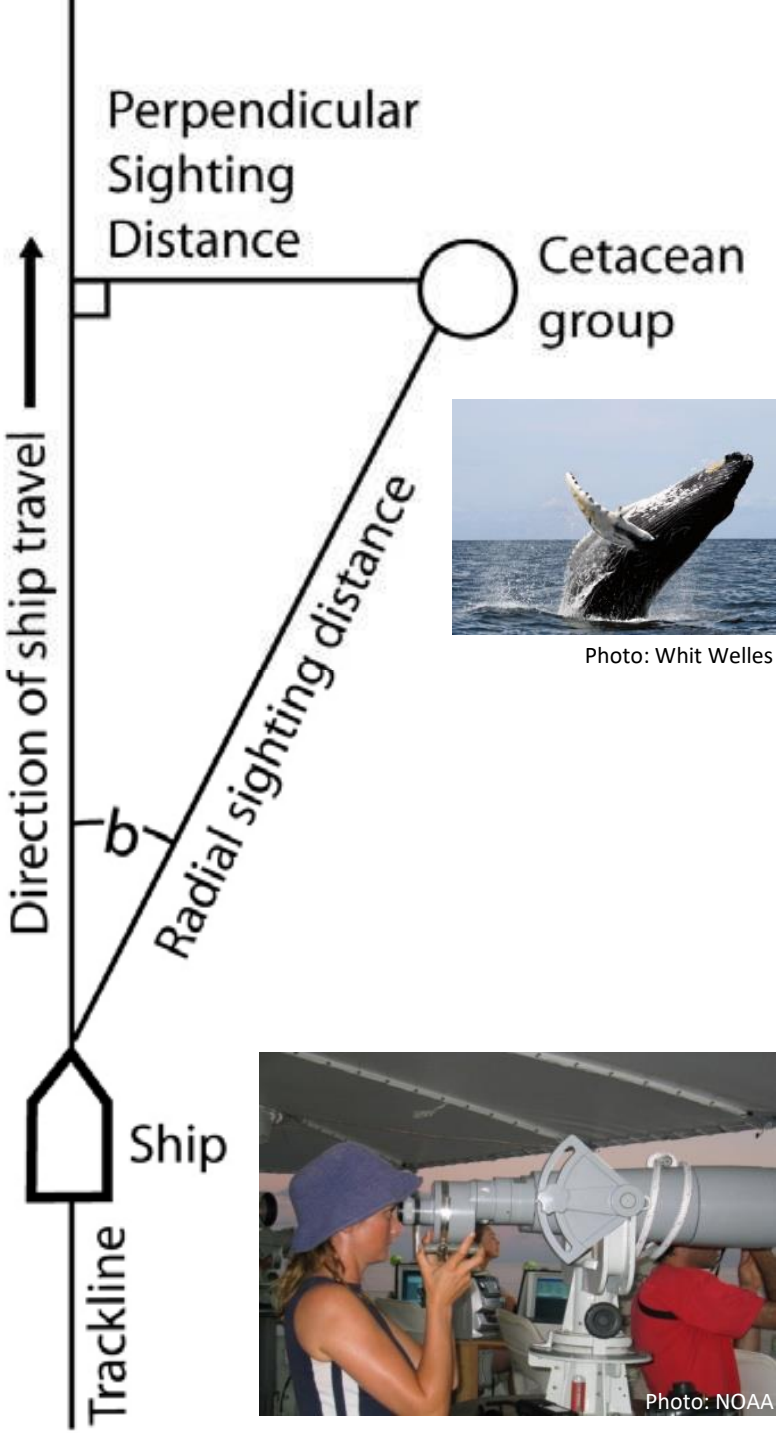


Photo: Whit Welles

Photo: NOAA

Aerial observers

Photo: C. Khan

Photo: C. Khan

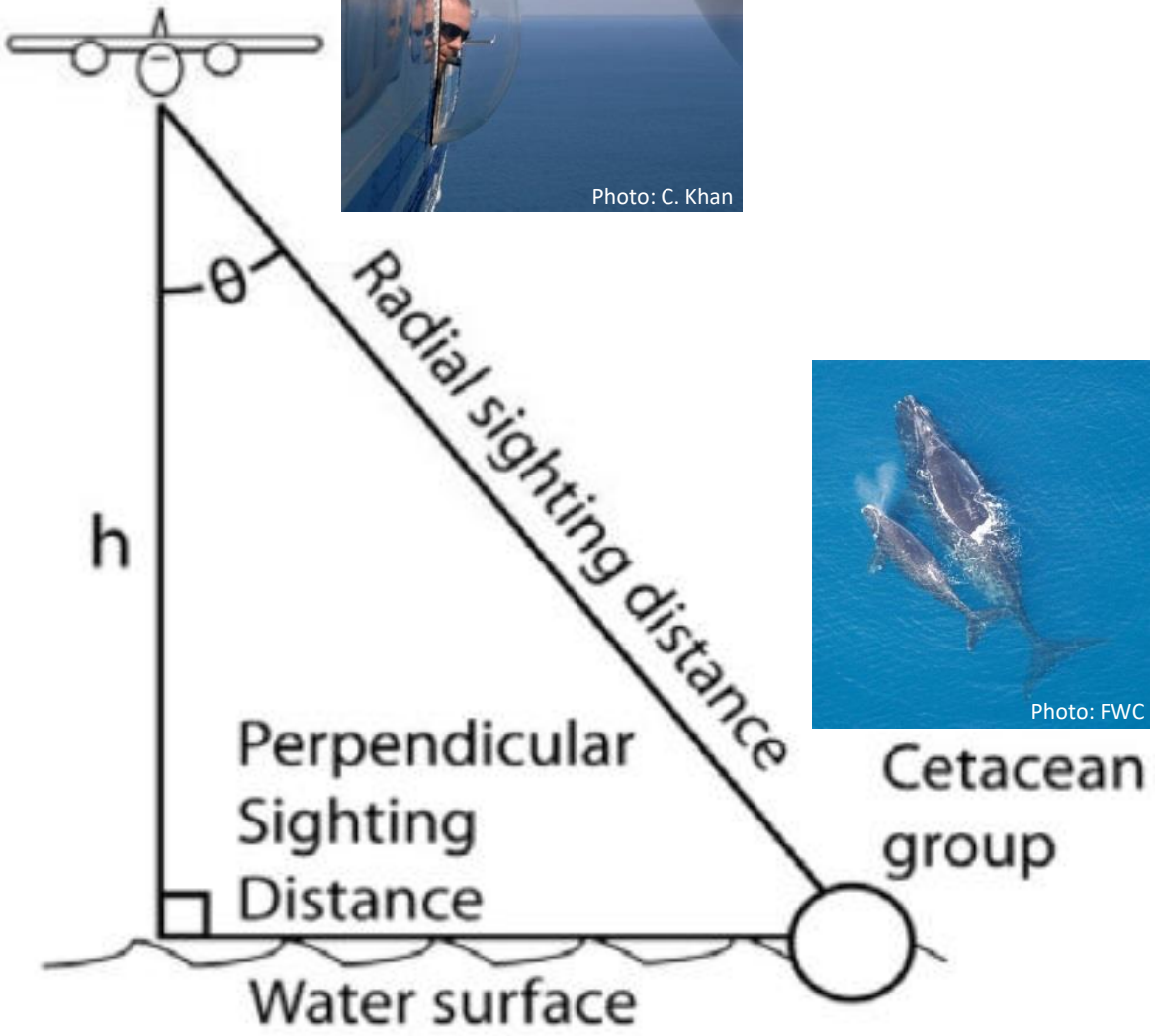
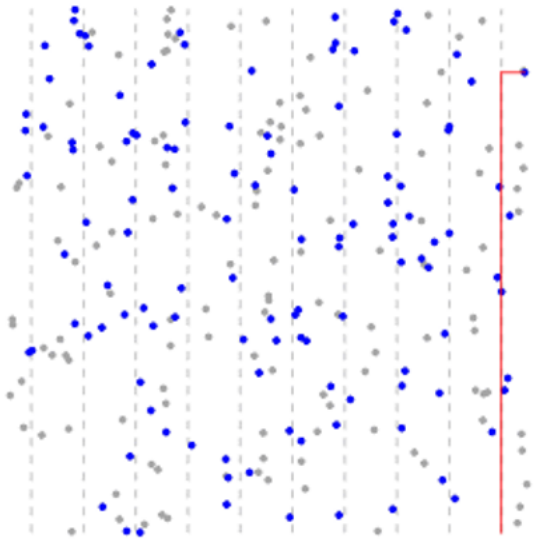


Photo: FWC

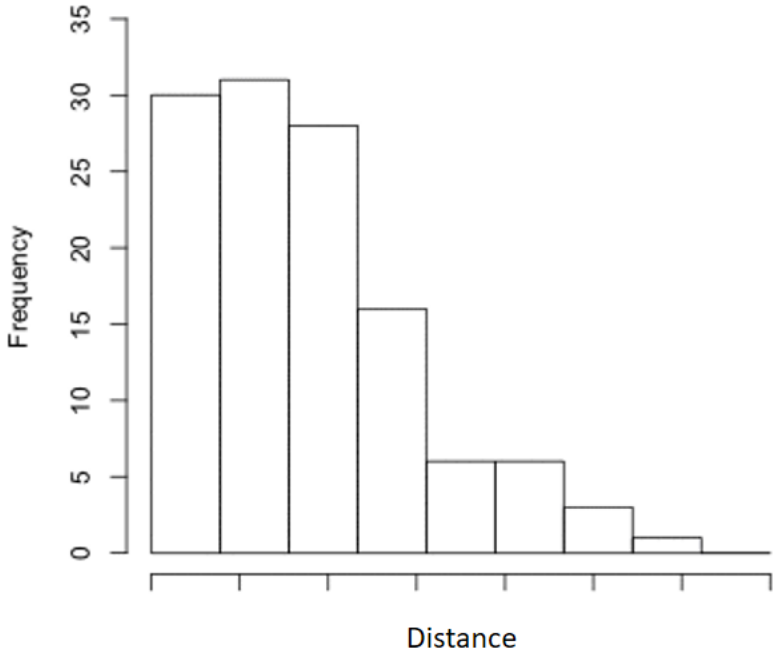
Modeling detectability

Cetacean sightings

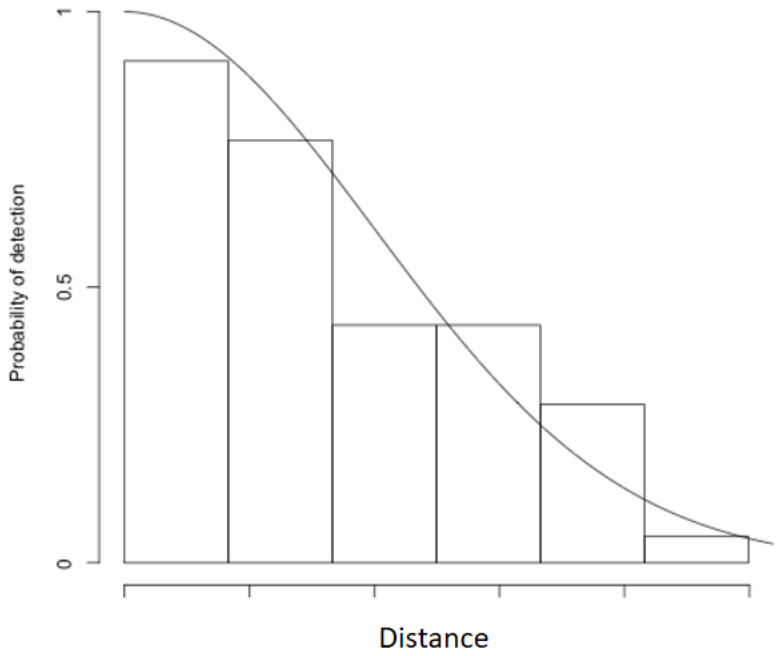


- Vessel trackline
- Cetacean sighted by observers
- Cetacean missed by observers

Histogram of observed distances



Detection function

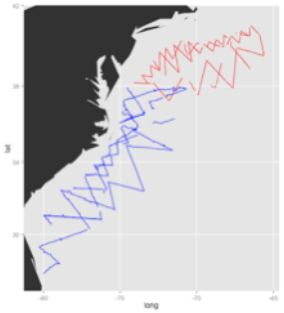


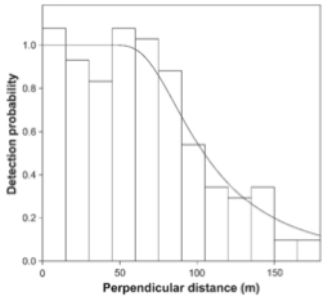
Figures: David L. Miller

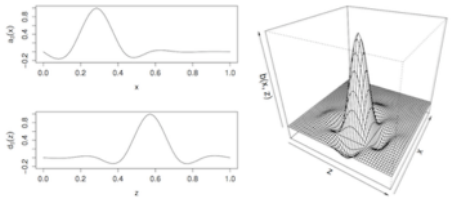
This technique is called “distance sampling”

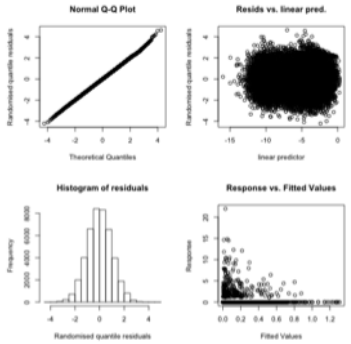
Density surface modeling (DSM)

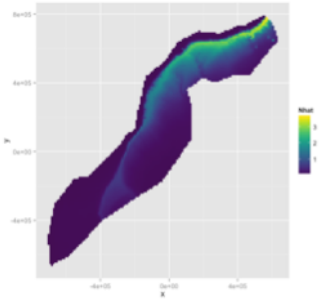
(Hedley and Buckland 2004; Thomas et al. 2010; Miller et al. 2013)











Line transects → Detectability → Spatial model (GAM) ⇄ Model checking/ criticism → Predictions

Oceanographic data → Spatial model (GAM)

Oceanographic data → Predictions

Stage 1

Stage 2

Adapted from figure by David L. Miller

Important limitations of our current approach

1. We can only utilize line transect surveys, and they must be preplanned and laid out systematically (not directed to known animals)

2. We can only utilize surveys that collected distances to animals, so that detectability can be modeled

3. We cannot directly utilize opportunistic sightings, acoustic detections, or other data not conforming to 1 and 2 above

These limitations may be overcome with additional R&D work.
(More on that later…)

Project timeline

2015-2016

Version 5.6

- First model
- Used by Navy for AFTT Phase III EIS and LOA
- Published in Roberts et al. 2016

2017

Version 7

- Incorporated AMAPPS and SEUS NARW surveys
- Released to Navy and NMFS
- Used by NMFS for Atlantic G&G IHA permitting

April 2019

Version 8

- Prepared in time for ALWTRT meeting
- Used same surveys and GAMs as v7
- Filled CCB with Ganley et al. 2019 abundance est.
- Reduced minor edge effects from v7

Presented today

October 2019

Version 9

- Will add surveys from 2017-2018
- Will fit and compare models of recent period (2010-2018?) to older period (1998-2010?)

Surveys used in the v7 and v8 right whale models

Platform	Provider	Program	Survey Effort (1000 km) Extant	Added	Total	% Increase
Aerial	NEFSC	Marine mammal abundance surveys	70	41	112	59
		NARWSS harbor porpoise survey	6		6	
		NARWSS right whale surveys	432	87	520	20
	NJDEP	New Jersey Ecological Baseline Study	11		11	
	SEFSC	Marine mammal abundance surveys	43	66	108	154
	SEUS NARW	FWRI surveys		521	521	
		NEAq surveys		237	237	
		SSA surveys (Skymaster)		279	279	
		SSA surveys (Twin Otter)		291	291	
	UNCW	Cape Hatteras Navy Surveys	19	16	35	86
		Jacksonville Navy Surveys	65	22	87	34
		Marine mammal surveys, 2002	18		18	
		Norfolk Canyon Navy Surveys		12	12	
		Onslow Bay Navy Surveys	49		49	
		Right whale surveys, 2005-2008	114		114	
	VAMSC	MD Wind Energy Area surveys		16	16	
		VA Wind Energy Area surveys	17	5	21	28
	All		844	1591	2435	189
Shipboard	NEFSC	Marine mammal abundance surveys	16	12	28	76
	NJDEP	New Jersey Ecological Baseline Study	14		14	
	SEFSC	Marine mammal abundance surveys	28	15	43	52
	All		58	27	85	47

AMAPPS

Used in v7

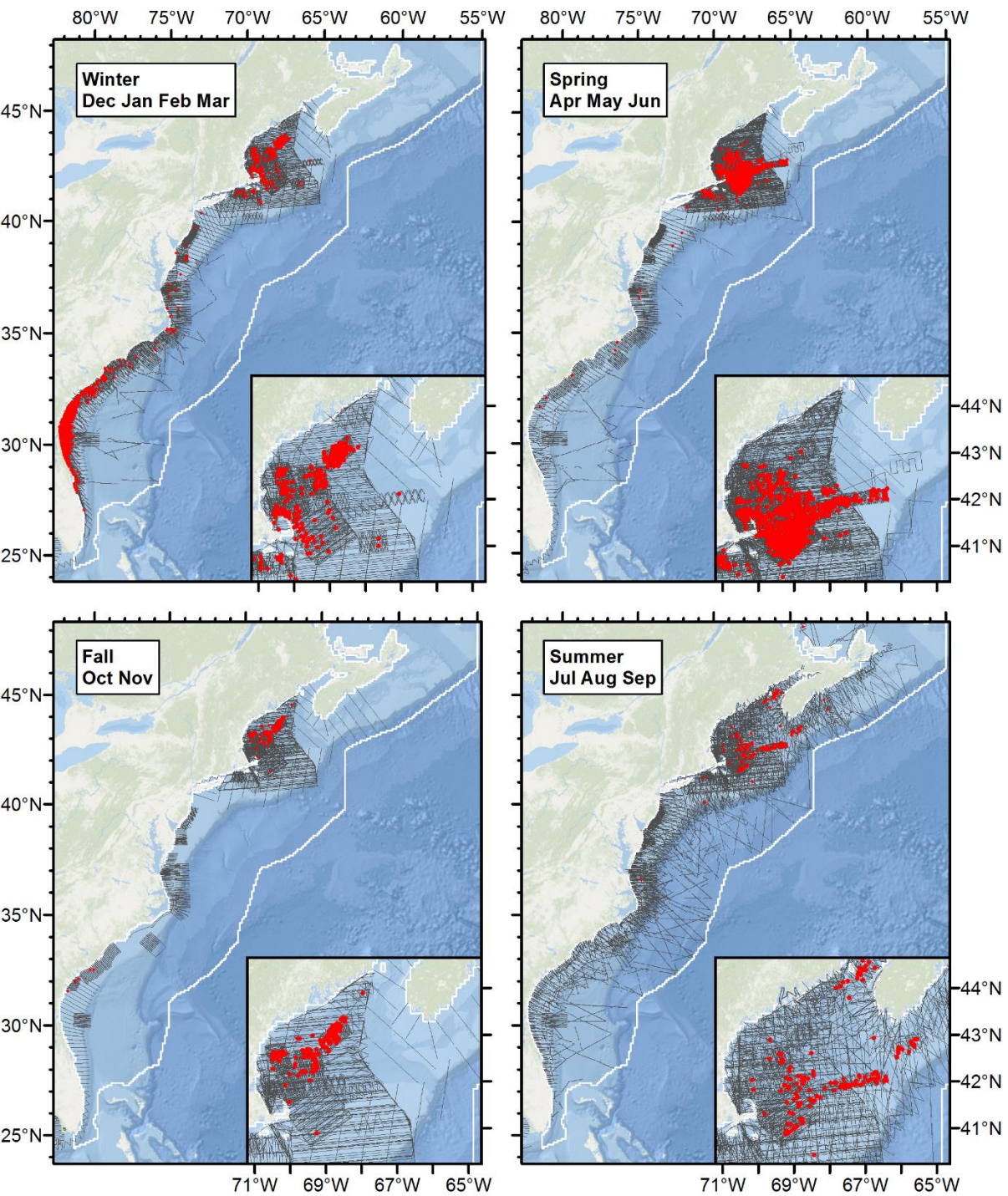
Added for v8

Used in v8

The surveys used in v8, and the v8 model itself, presented today, spanned 1998-2016

Temporal dynamics

- To allow species-environment relationships to vary seasonally and regionally, we split the year into seasons and study area into subregions, based on known right whale ecology, and modeled each independently
  - E.g. whales on the calving groups differ from those overwintering in the northeast
- We compared models that climatological estimates (long term averages) to contemporaneous estimates (resolved to the year and day) of oceanographic covariates
  - Usually climatological covariates performed better
- Based on requests from the Navy and other potential users, we summarized the results into monthly averages:
  - 12 density maps, giving average conditions over the modeled period 1998-2016
  - Uncertainty represented as 12 maps of the coefficient of variation of the GAM



Seasons used in v7 and v8

Winter (December-March)

- Defined as these months because right whales usually known to be present on the calving grounds

Spring (April-June)

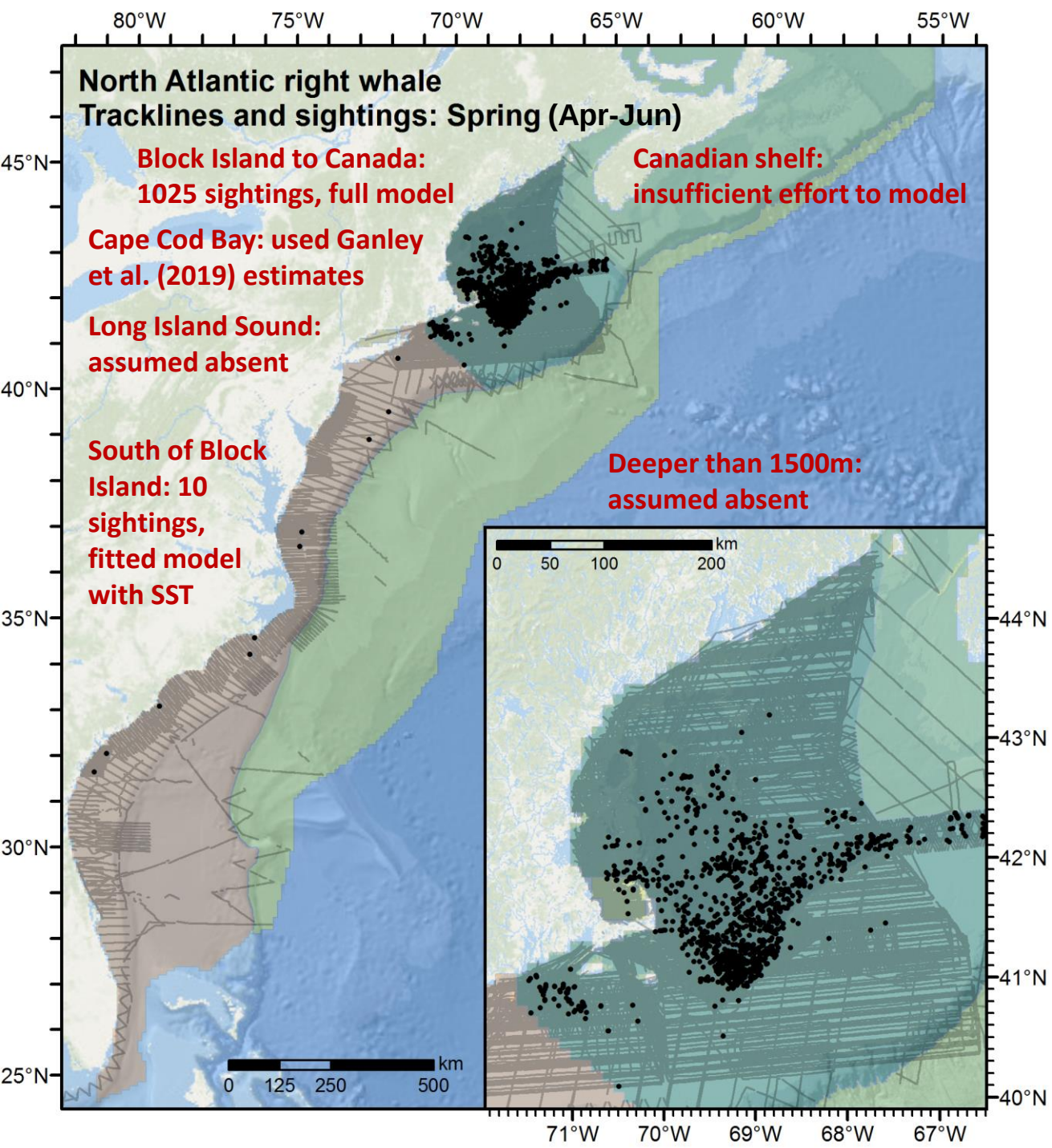
- Most whales found north of New York
- Whales moved from CCB, across GSC, to Geo. Bank
- In July, big drop in sightings in GSC

Summer (July-September)

- Only months with substantial survey effort in Canada (at least from surveys used in this analysis)

Fall (October-November)

- Large numbers of sightings in western Gulf of Maine
- First sightings south of Cape Hatteras (but very few)
- Caution urged: relatively sparse effort everywhere

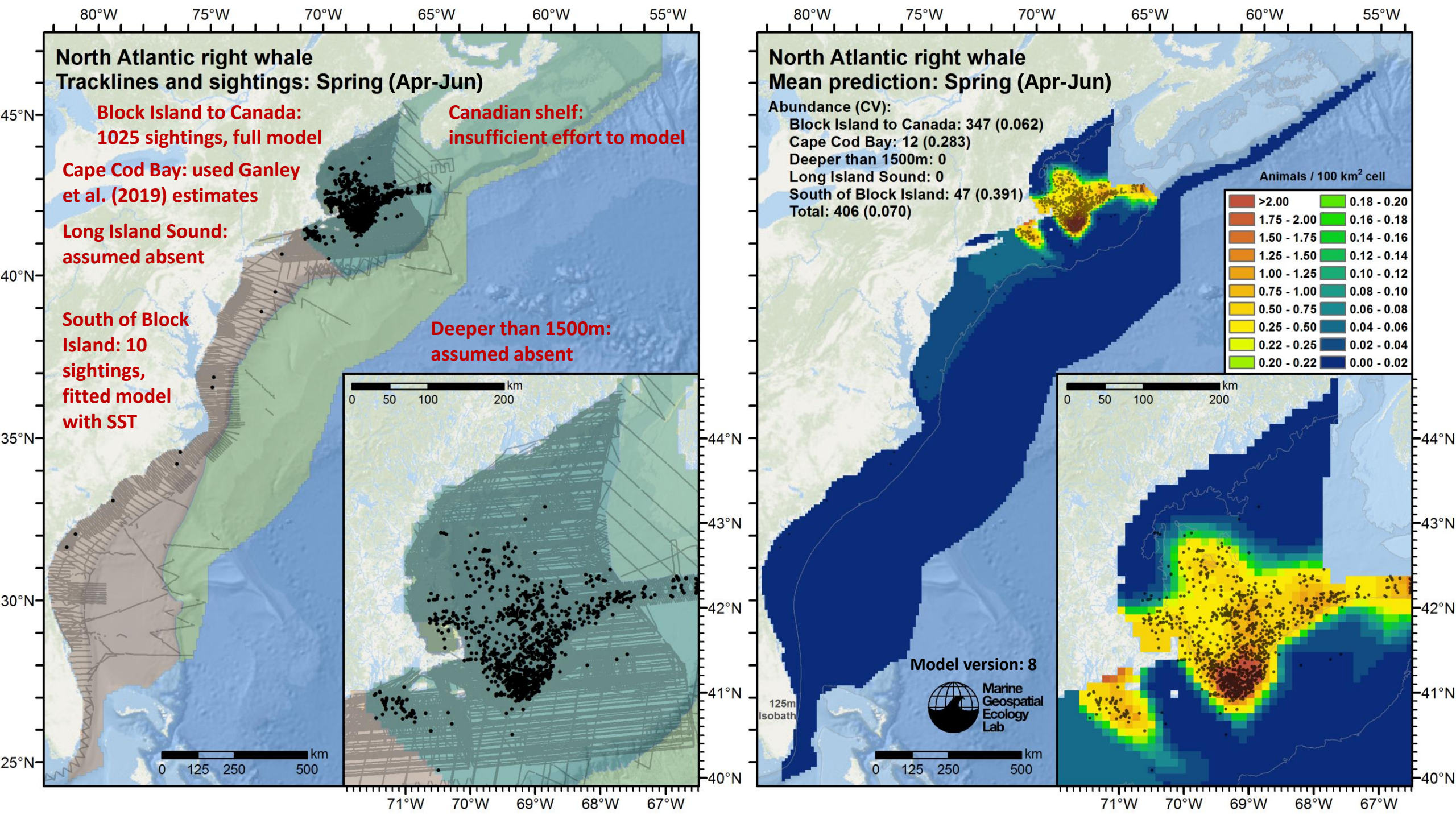


Lets look at each season…

- We'll cycle through: Spring, Summer, Fall, Winter
- Left side is a schematic showing how we split the season into subregions

← Here is the Spring schematic

- Right side (not shown yet) is a map of estimated density, averaged over all years and months of the season


North Atlantic right whale
Tracklines and sightings: Spring (Apr-Jun)
Block Island to Canada:
1025 sightings, full model
Canadian shelf:
insufficient effort to model
Cape Cod Bay: used Ganley et al. (2019) estimates
Long Island Sound:
assumed absent
South of Block Island: 10 sightings, fitted model with SST
Deeper than 1500m:
assumed absent
km
0 125 250 500
0 50 100 200
80°W 75°W 70°W 65°W 60°W 55°W
45°N 40°N 35°N 30°N 25°N
44°N 43°N 42°N 41°N 40°N
71°W 70°W 69°W 68°W 67°W
North Atlantic right whale
Mean prediction: Spring (Apr-Jun)
Abundance (CV):
Block Island to Canada: 347 (0.062)
Cape Cod Bay: 12 (0.283)
Deeper than 1500m: 0
Long Island Sound: 0
South of Block Island: 47 (0.391)
Total: 406 (0.070)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
125m Isobath
Model version: 8
Marine Geospatial Ecology Lab

Density color scale

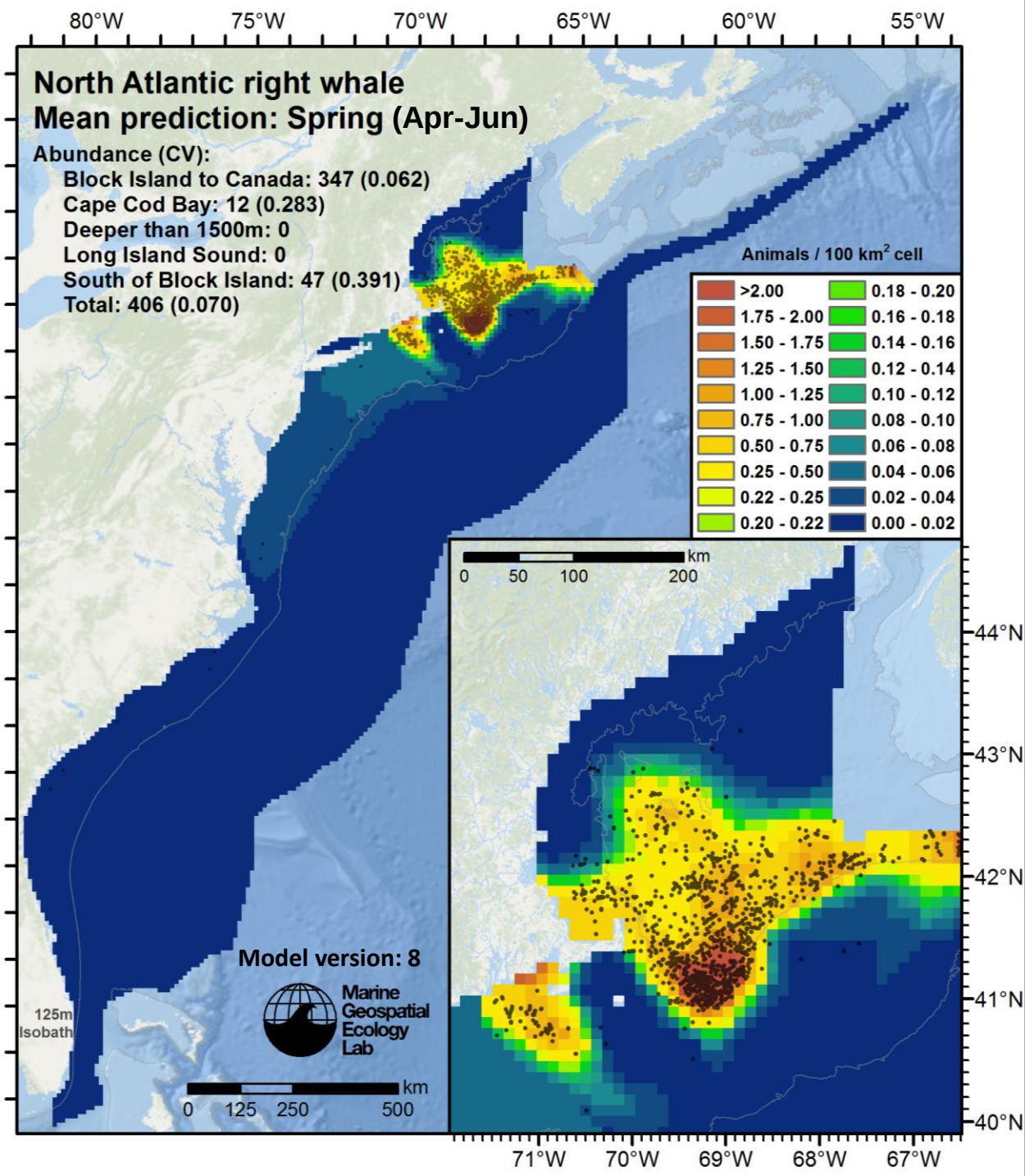
High density range, increments by 0.25

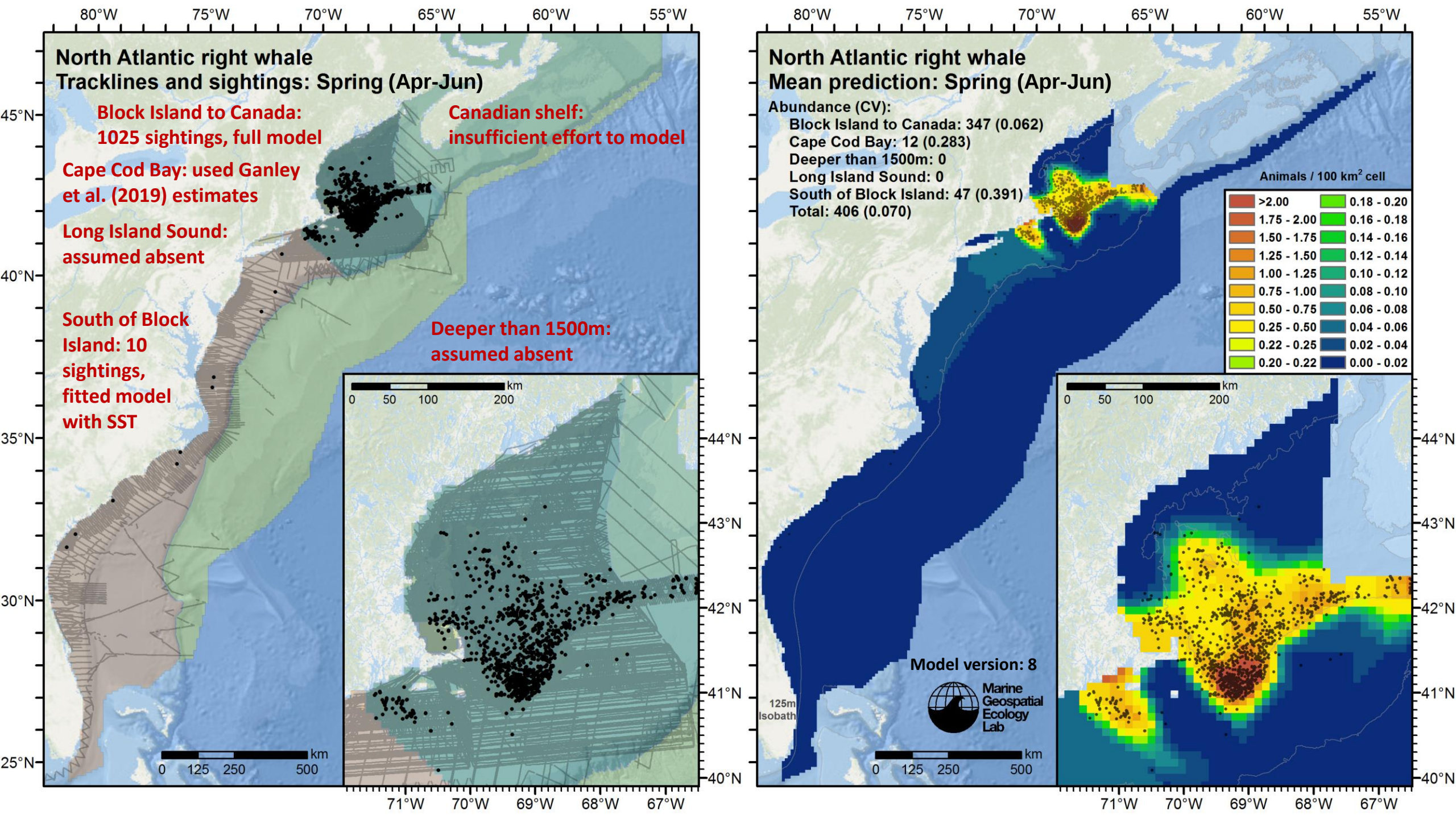
Bright yellow → separates two ranges

Low density range, increments by 0.02

- >2.00
- 1.75 - 2.00
- 1.50 - 1.75
- 1.25 - 1.50
- 1.00 - 1.25
- 0.75 - 1.00
- 0.50 - 0.75
- 0.25 - 0.50
- 0.22 - 0.25
- 0.20 - 0.22
- 0.18 - 0.20
- 0.16 - 0.18
- 0.14 - 0.16
- 0.12 - 0.14
- 0.10 - 0.12
- 0.08 - 0.10
- 0.06 - 0.08
- 0.04 - 0.06
- 0.02 - 0.04
- 0.00 - 0.02

All right whale density maps in this presentation are shown with this scale

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Canadian shelf:
insufficient effort to model
Cape Cod Bay: used Ganley et al. (2019) estimates
Long Island Sound:
assumed absent
South of Block Island: 10 sightings, fitted model with SST
Deeper than 1500m:
assumed absent
km
0 125 250 500
0 50 100 200
80°W 75°W 70°W 65°W 60°W 55°W
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71°W 70°W 69°W 68°W 67°W
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Animals / 100 km² cell
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1.75 - 2.00
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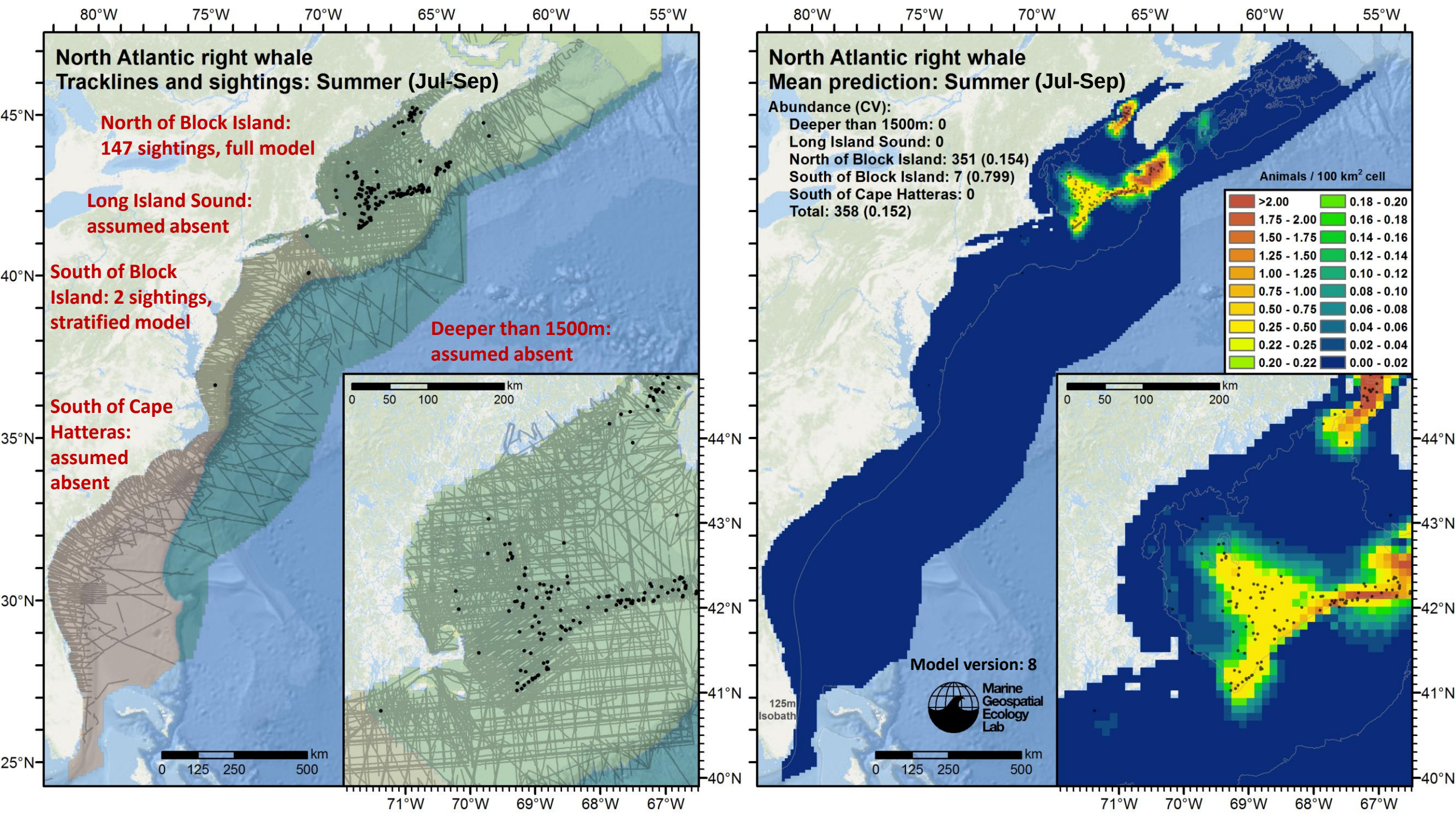
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
125m Isobath
Model version: 8
Marine Geospatial Ecology Lab


North Atlantic right whale
Tracklines and sightings: Summer (Jul-Sep)
North of Block Island:
147 sightings, full model
Long Island Sound:
assumed absent
South of Block
Island: 2 sightings,
stratified model
Deeper than 1500m:
assumed absent
South of Cape
Hatteras:
assumed
absent
km
0 125 250 500
0 50 100 200
80°W 75°W 70°W 65°W 60°W 55°W
45°N 40°N 35°N 30°N 25°N
44°N 43°N 42°N 41°N 40°N
71°W 70°W 69°W 68°W 67°W
North Atlantic right whale
Mean prediction: Summer (Jul-Sep)
Abundance (CV):
Deeper than 1500m: 0
Long Island Sound: 0
North of Block Island: 351 (0.154)
South of Block Island: 7 (0.799)
South of Cape Hatteras: 0
Total: 358 (0.152)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
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Marine
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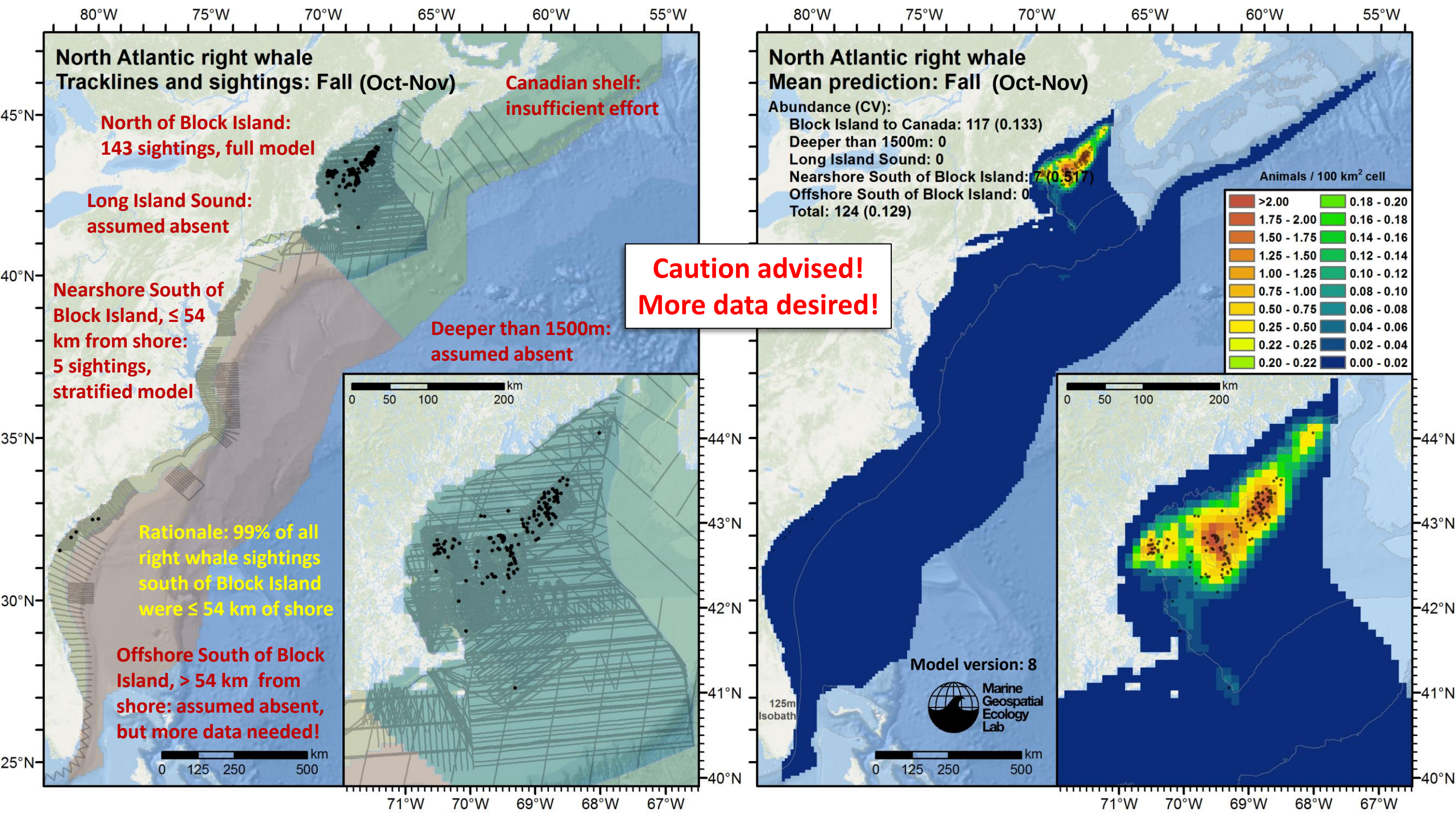
Ecology
Lab


North Atlantic right whale
Tracklines and sightings: Fall (Oct-Nov)
Canadian shelf: insufficient effort
North of Block Island: 143 sightings, full model
Long Island Sound: assumed absent
Nearshore South of Block Island, ≤ 54 km from shore: 5 sightings, stratified model
Deeper than 1500m: assumed absent
Rationale: 99% of all right whale sightings south of Block Island were ≤ 54 km of shore
Offshore South of Block Island, > 54 km from shore: assumed absent, but more data needed!
Caution advised!
More data desired!
North Atlantic right whale
Mean prediction: Fall (Oct-Nov)
Abundance (CV):
Block Island to Canada: 117 (0.133)
Deeper than 1500m: 0
Long Island Sound: 0
Nearshore South of Block Island: 7 (0.517)
Offshore South of Block Island: 0
Total: 124 (0.129)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
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0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
Model version: 8
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125m Isobath
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80°W 75°W 70°W 65°W 60°W 55°W
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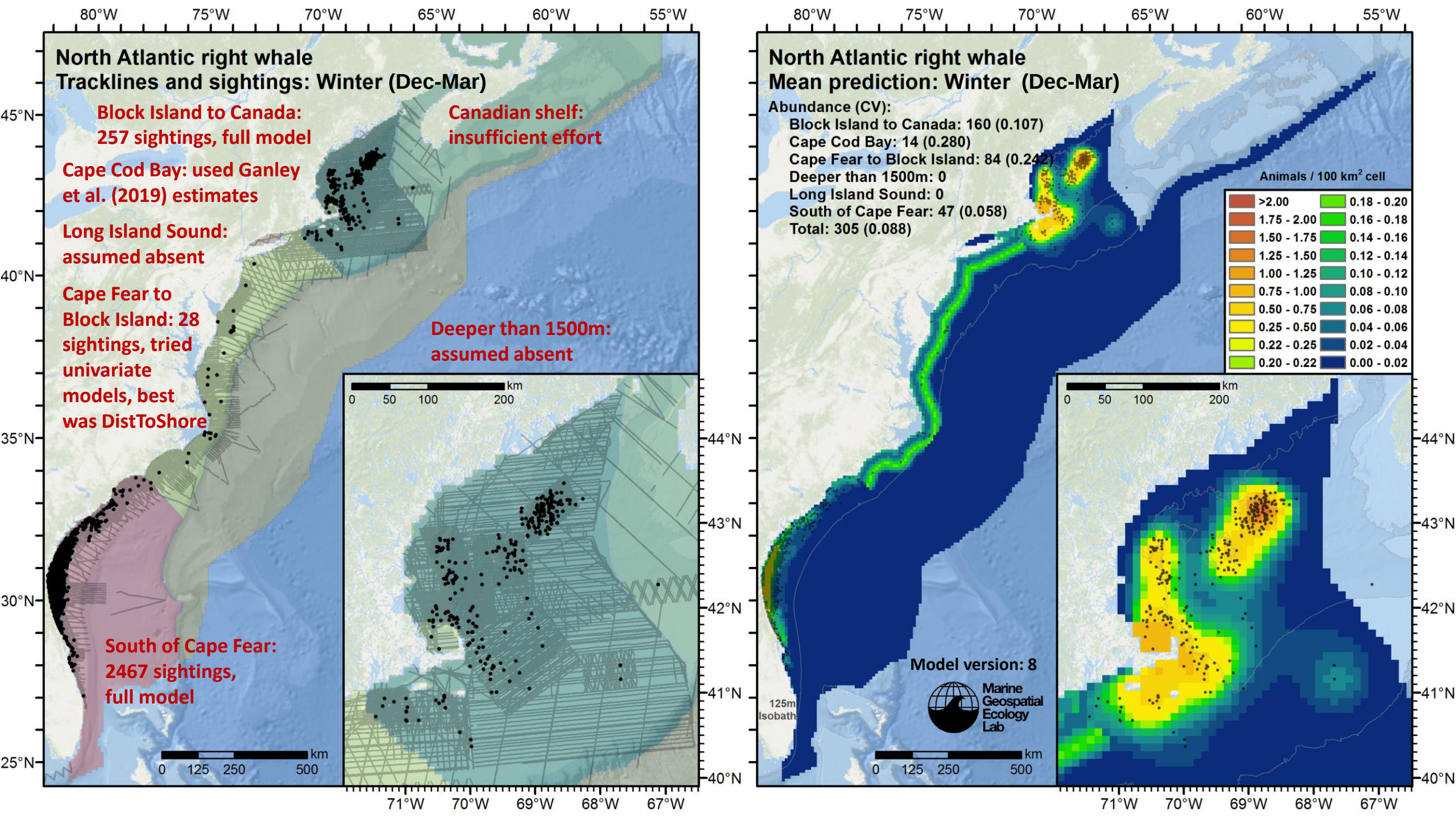
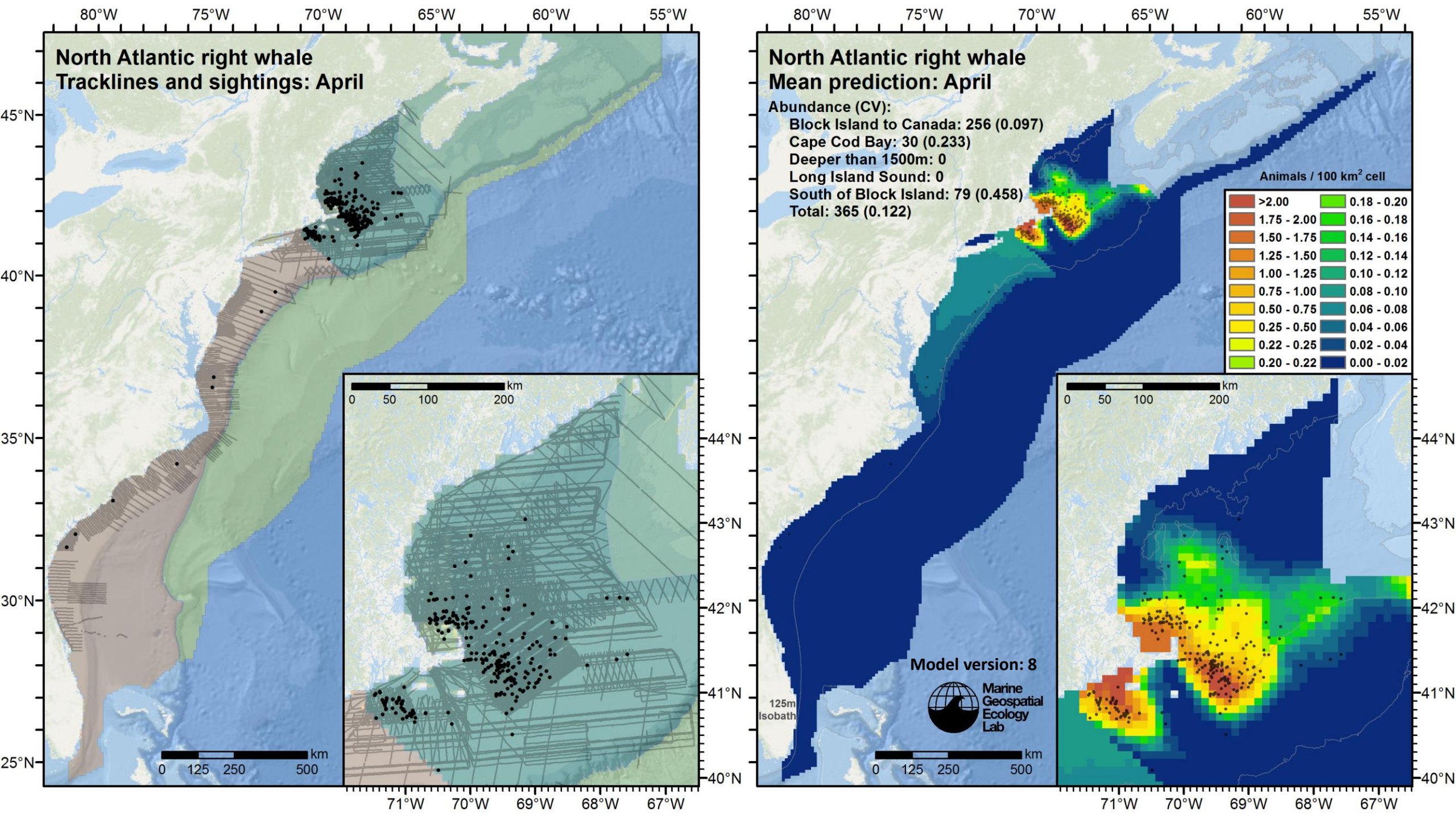
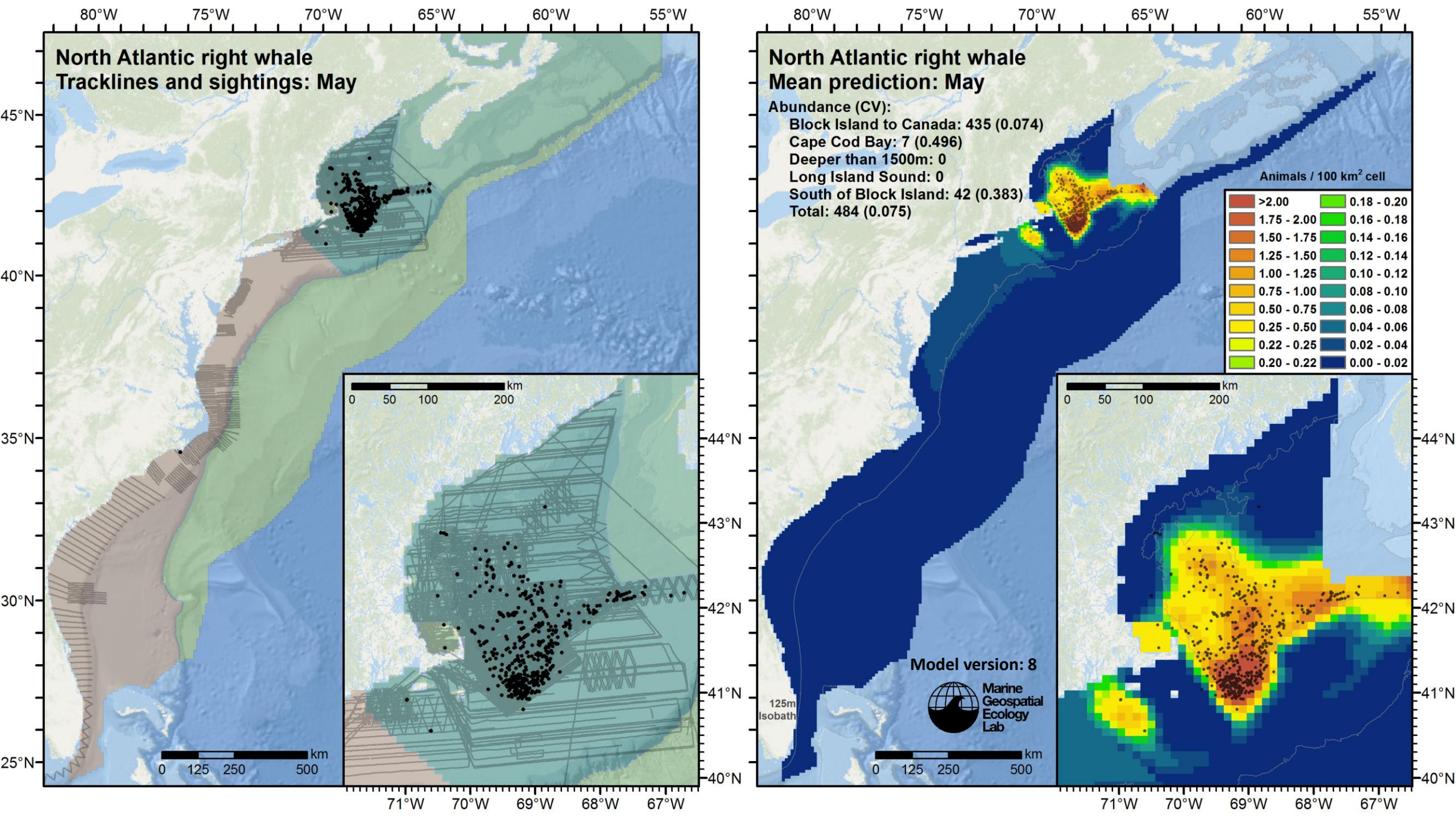
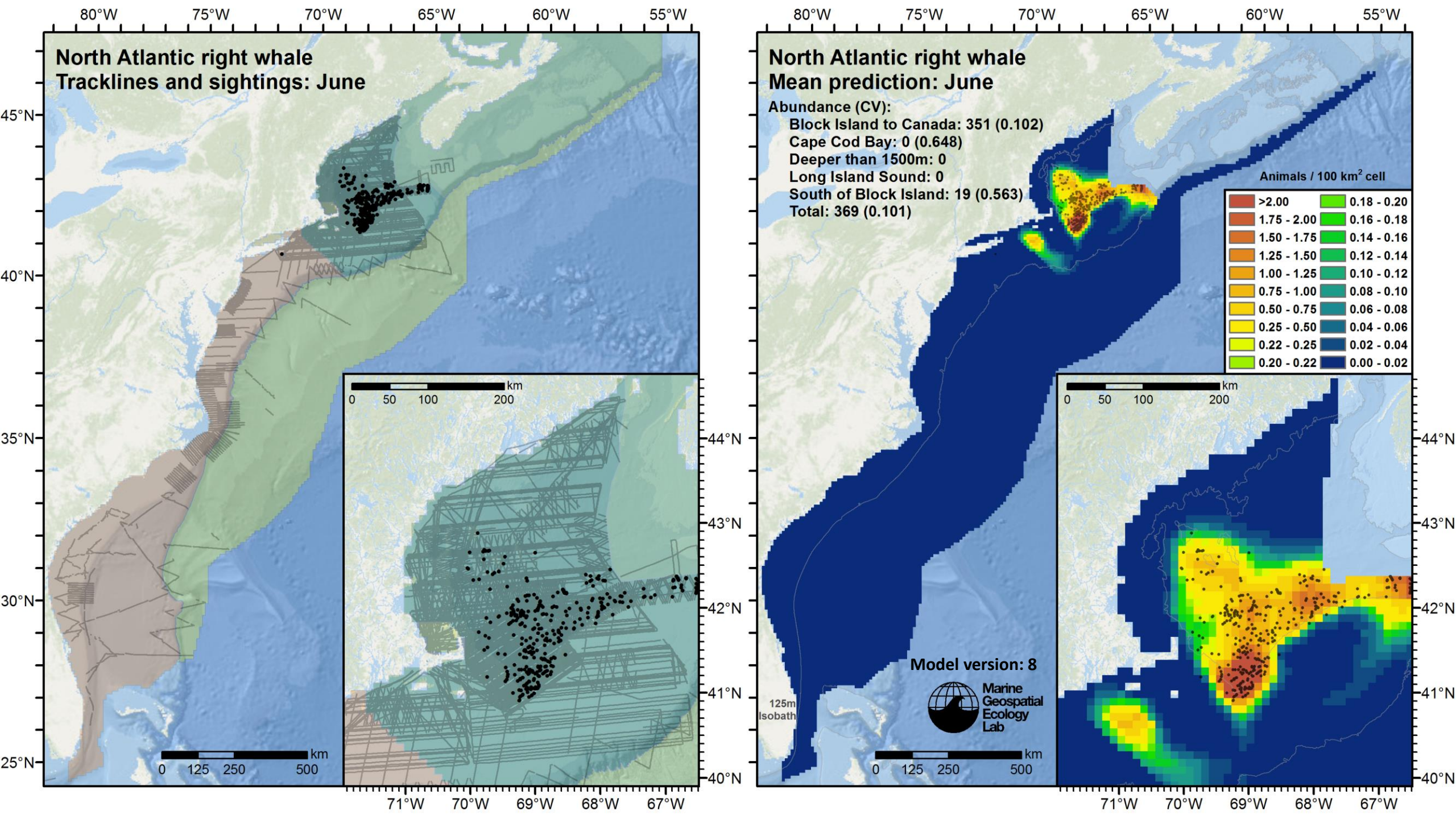
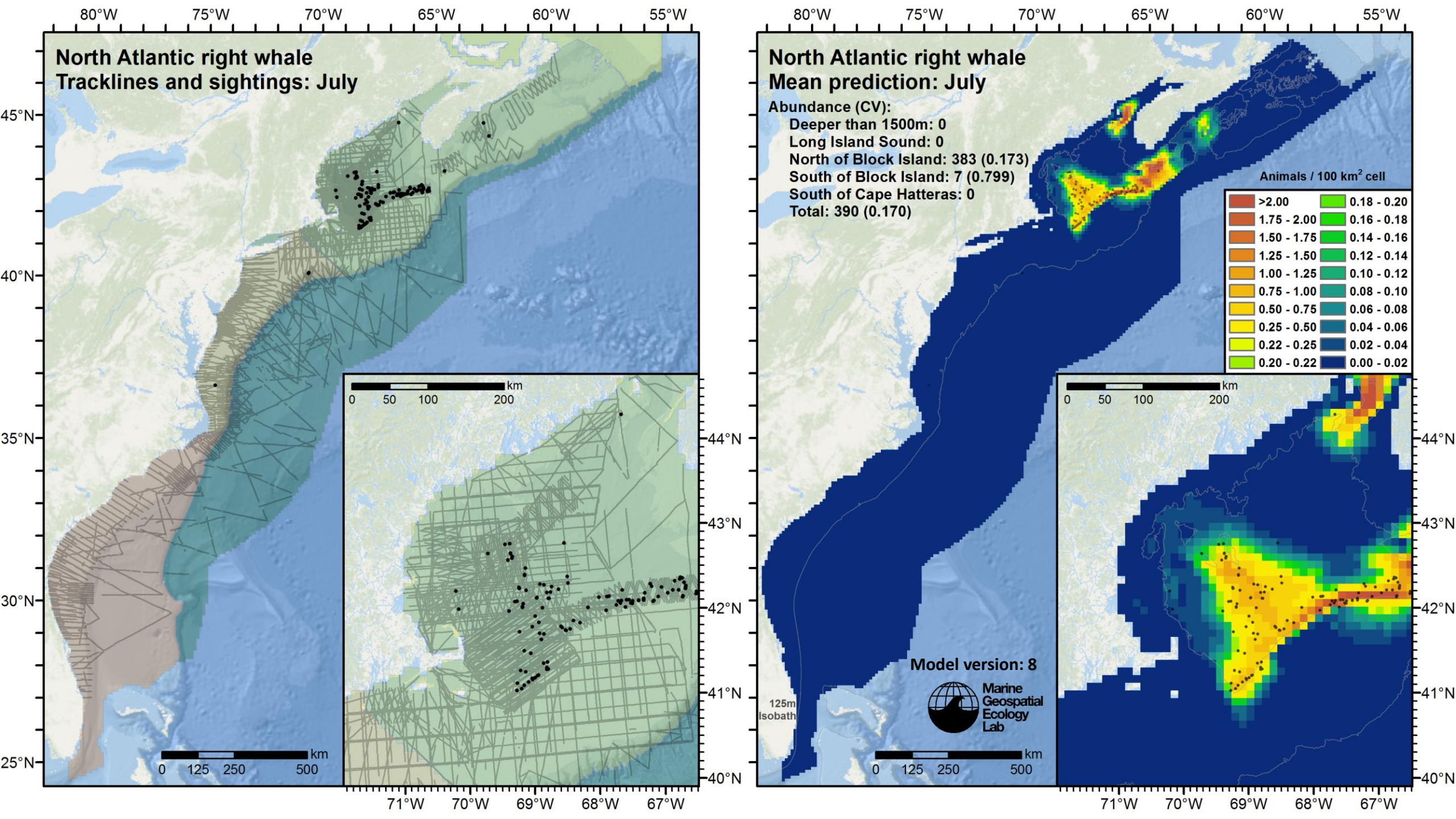

North Atlantic right whale
Tracklines and sightings: Winter (Dec-Mar)
Block Island to Canada: 257 sightings, full model
Canadian shelf: insufficient effort
Cape Cod Bay: used Ganley et al. (2019) estimates
Long Island Sound: assumed absent
Cape Fear to Block Island: 28 sightings, tried univariate models, best was DistToShore
Deeper than 1500m: assumed absent
South of Cape Fear: 2467 sightings, full model
km
0 125 250 500
0 50 100 200
80°W 75°W 70°W 65°W 60°W 55°W
45°N 40°N 35°N 30°N 25°N
44°N 43°N 42°N 41°N 40°N
71°W 70°W 69°W 68°W 67°W
North Atlantic right whale
Mean prediction: Winter (Dec-Mar)
Abundance (CV):
Block Island to Canada: 160 (0.107)
Cape Cod Bay: 14 (0.280)
Cape Fear to Block Island: 84 (0.242)
Deeper than 1500m: 0
Long Island Sound: 0
South of Cape Fear: 47 (0.058)
Total: 305 (0.088)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
125m Isobath
Model version: 8
Marine Geospatial Ecology Lab

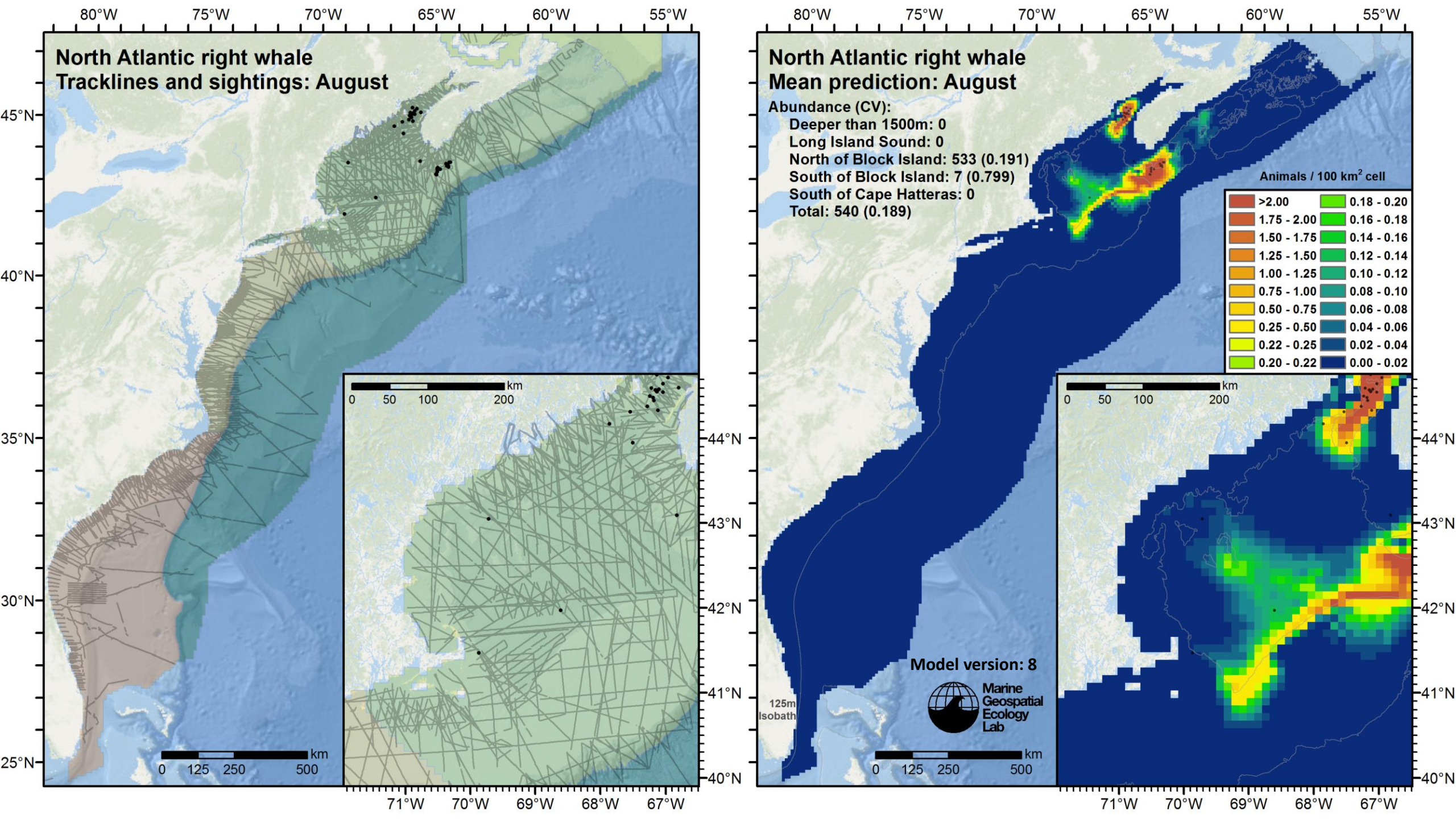
Monthly predictions

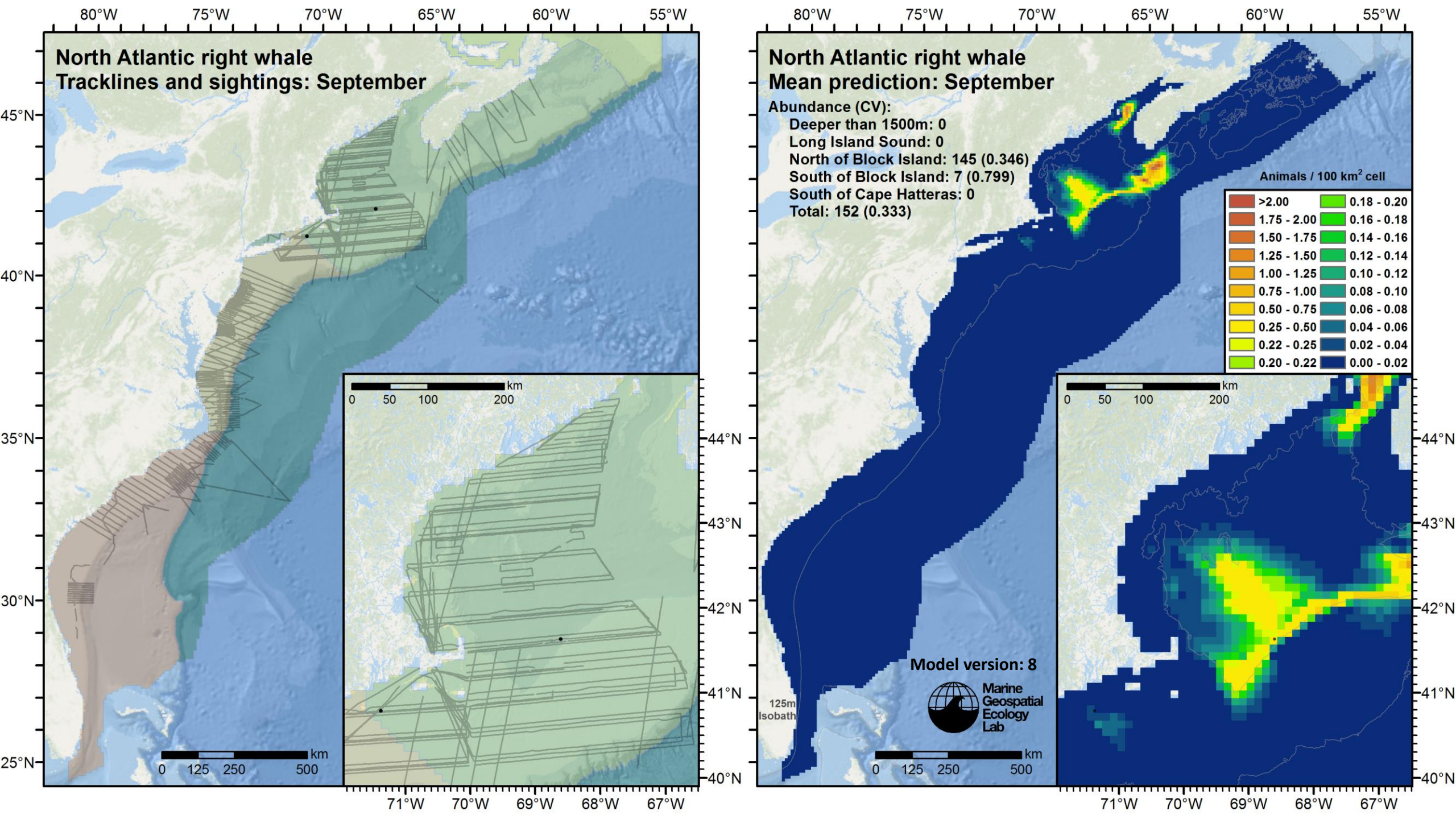

North Atlantic right whale
Tracklines and sightings: April
80°W
75°W
70°W
65°W
60°W
55°W
45°N
40°N
35°N
30°N
25°N
km
0 125 250 500
km
0 50 100 200
71°W
70°W
69°W
68°W
67°W
44°N
43°N
42°N
41°N
40°N
North Atlantic right whale
Mean prediction: April
Abundance (CV):
Block Island to Canada: 256 (0.097)
Cape Cod Bay: 30 (0.233)
Deeper than 1500m: 0
Long Island Sound: 0
South of Block Island: 79 (0.458)
Total: 365 (0.122)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
125m Isobath
Model version: 8
Marine Geospatial Ecology Lab

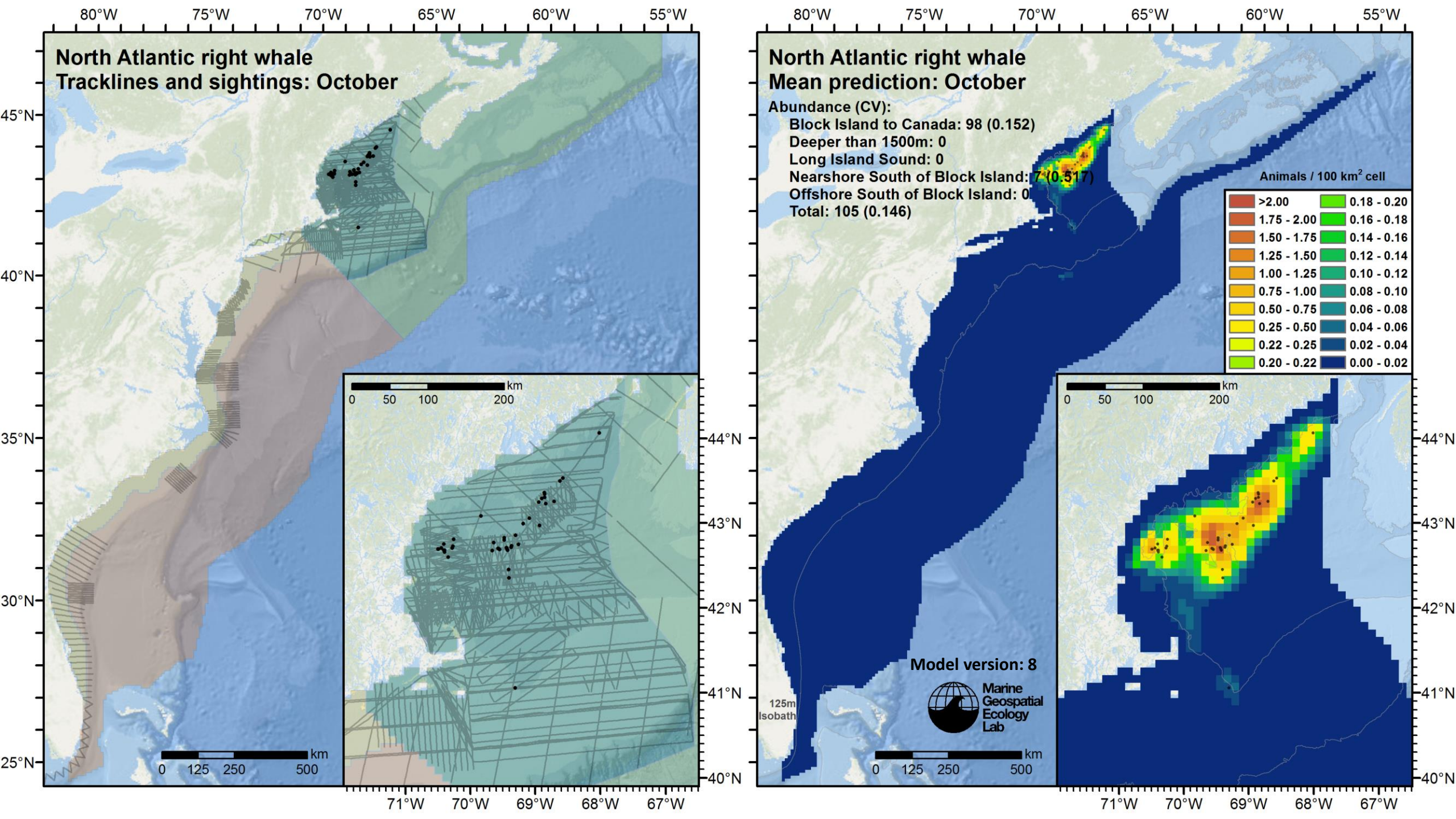

North Atlantic right whale
Tracklines and sightings: May
North Atlantic right whale
Mean prediction: May
Abundance (CV):
Block Island to Canada: 435 (0.074)
Cape Cod Bay: 7 (0.496)
Deeper than 1500m: 0
Long Island Sound: 0
South of Block Island: 42 (0.383)
Total: 484 (0.075)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
Model version: 8
Marine Geospatial Ecology Lab
125m Isobath
km
0 125 250 500
0 50 100 200
80°W 75°W 70°W 65°W 60°W 55°W
45°N 40°N 35°N 30°N 25°N
44°N 43°N 42°N 41°N 40°N
71°W 70°W 69°W 68°W 67°W

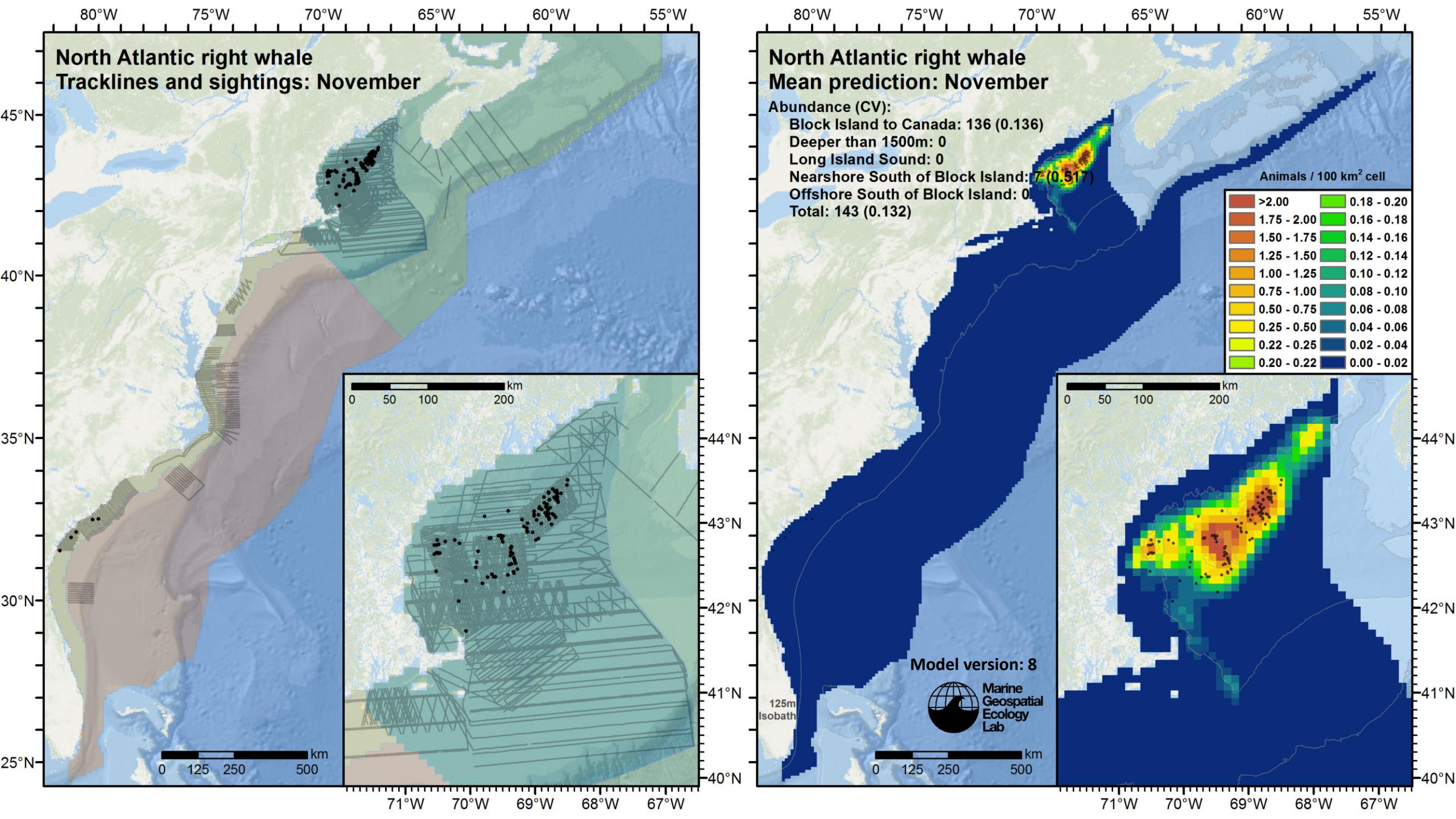

North Atlantic right whale
Tracklines and sightings: June
80°W
75°W
70°W
65°W
60°W
55°W
45°N
40°N
35°N
30°N
25°N
0 125 250 500 km
0 50 100 200 km
44°N
43°N
42°N
41°N
40°N
71°W
70°W
69°W
68°W
67°W
North Atlantic right whale
Mean prediction: June
Abundance (CV):
Block Island to Canada: 351 (0.102)
Cape Cod Bay: 0 (0.648)
Deeper than 1500m: 0
Long Island Sound: 0
South of Block Island: 19 (0.563)
Total: 369 (0.101)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
125m Isobath
Model version: 8
Marine Geospatial Ecology Lab

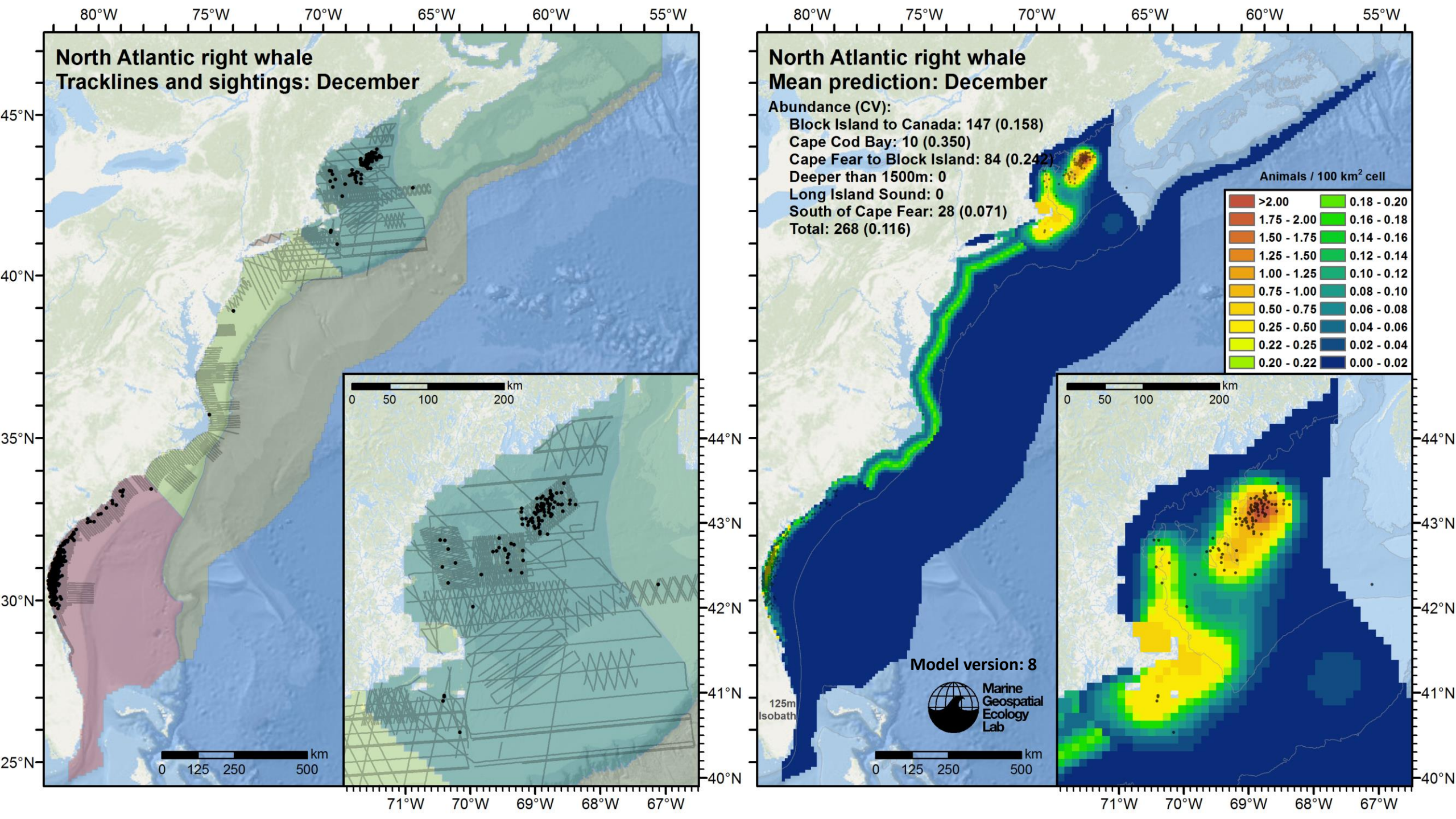

North Atlantic right whale
Tracklines and sightings: July
80°W
75°W
70°W
65°W
60°W
55°W
45°N
40°N
35°N
30°N
25°N
km
0 125 250 500
km
0 50 100 200
44°N
43°N
42°N
41°N
40°N
71°W
70°W
69°W
68°W
67°W
North Atlantic right whale
Mean prediction: July
Abundance (CV):
Deeper than 1500m: 0
Long Island Sound: 0
North of Block Island: 383 (0.173)
South of Block Island: 7 (0.799)
South of Cape Hatteras: 0
Total: 390 (0.170)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
125m Isobath
Model version: 8
Marine Geospatial Ecology Lab

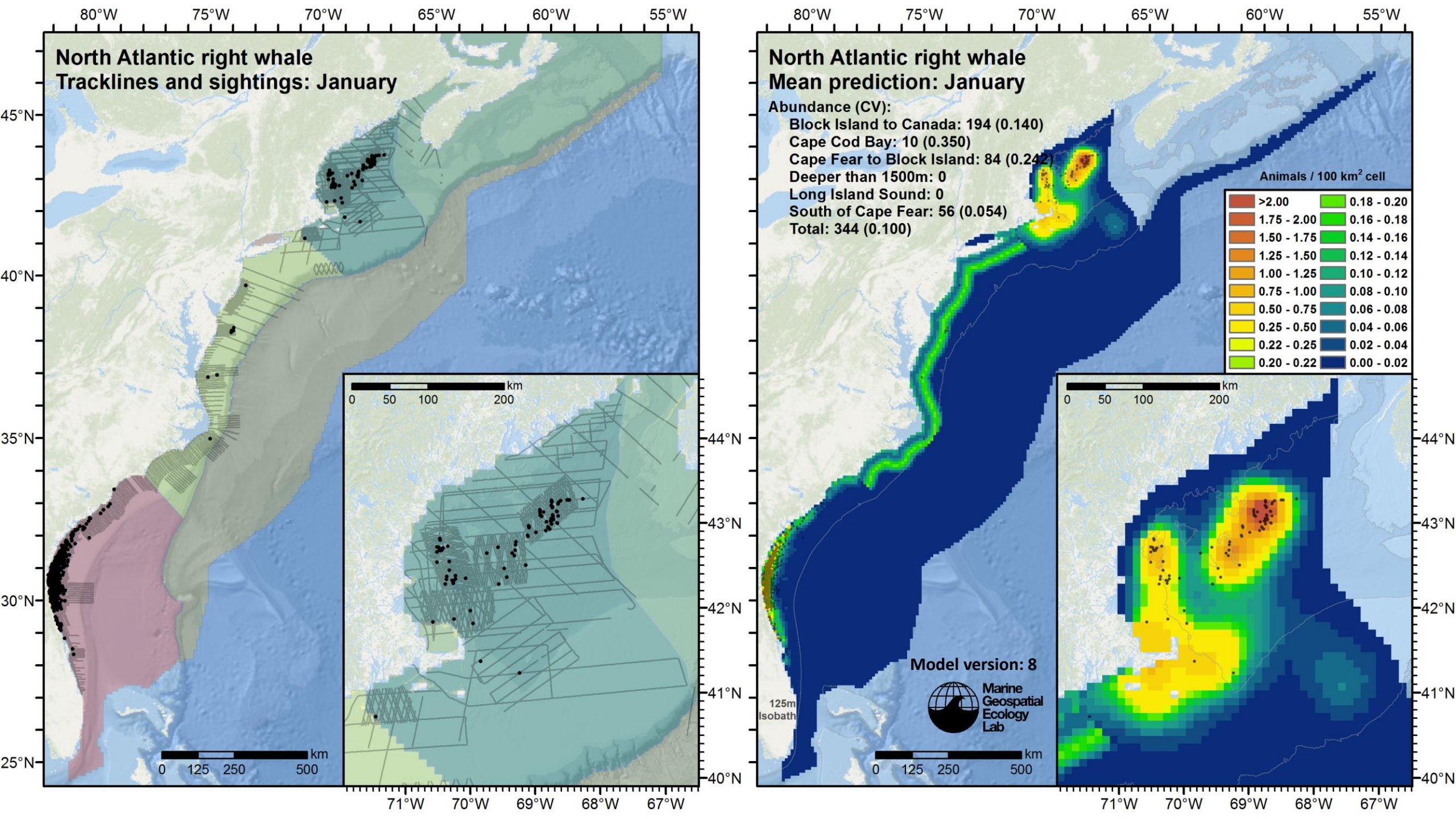

North Atlantic right whale
Tracklines and sightings: August
80°W
75°W
70°W
65°W
60°W
55°W
45°N
40°N
35°N
30°N
25°N
0 125 250 500 km
0 50 100 200 km
71°W
70°W
69°W
68°W
67°W
44°N
43°N
42°N
41°N
40°N
North Atlantic right whale
Mean prediction: August
Abundance (CV):
Deeper than 1500m: 0
Long Island Sound: 0
North of Block Island: 533 (0.191)
South of Block Island: 7 (0.799)
South of Cape Hatteras: 0
Total: 540 (0.189)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
125m Isobath
Model version: 8
Marine Geospatial Ecology Lab

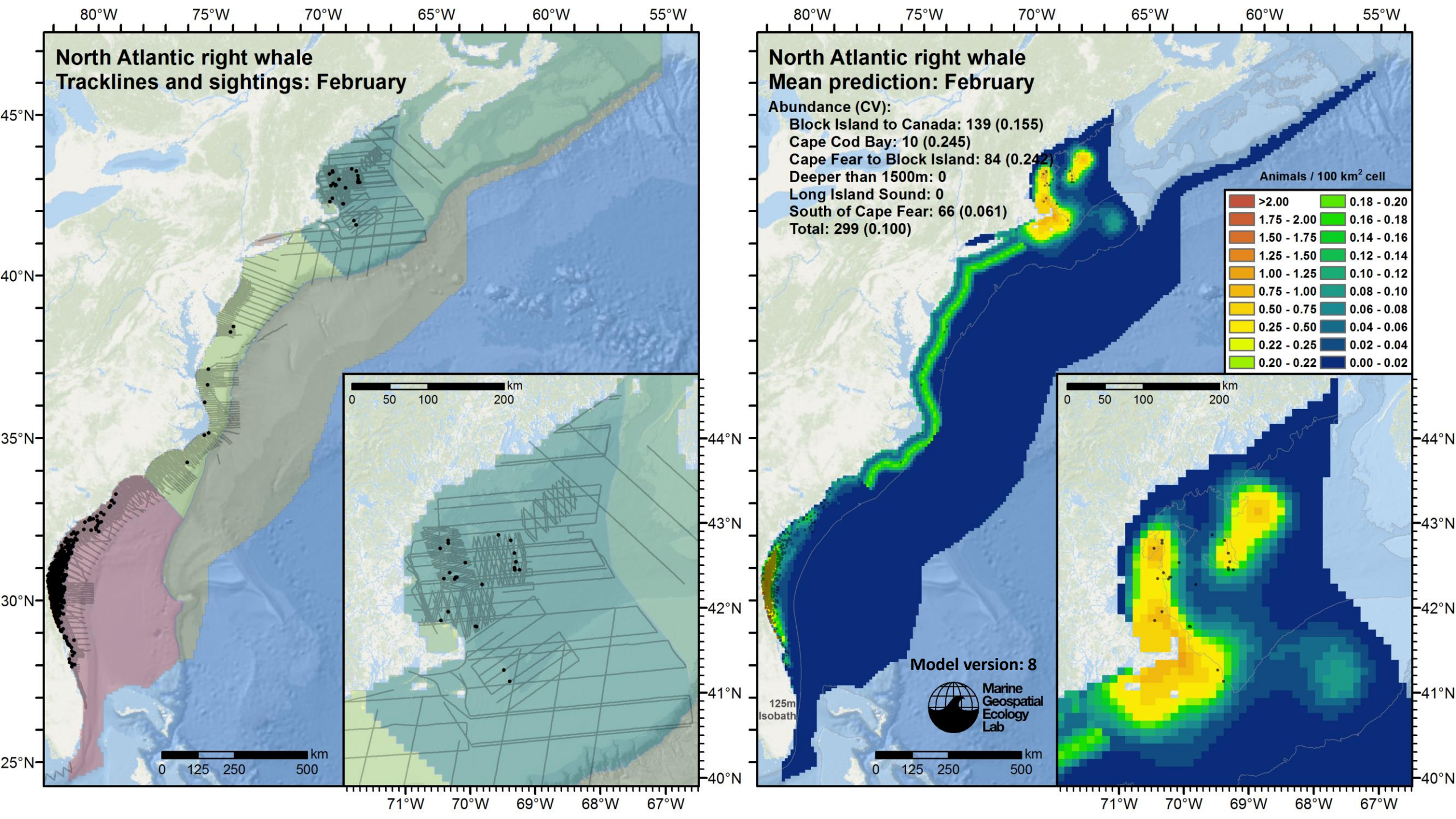

North Atlantic right whale
Tracklines and sightings: September
80°W
75°W
70°W
65°W
60°W
55°W
45°N
40°N
35°N
30°N
25°N
km
0 125 250 500
km
0 50 100 200
71°W
70°W
69°W
68°W
67°W
44°N
43°N
42°N
41°N
40°N
North Atlantic right whale
Mean prediction: September
Abundance (CV):
Deeper than 1500m: 0
Long Island Sound: 0
North of Block Island: 145 (0.346)
South of Block Island: 7 (0.799)
South of Cape Hatteras: 0
Total: 152 (0.333)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
125m Isobath
Model version: 8
Marine Geospatial Ecology Lab

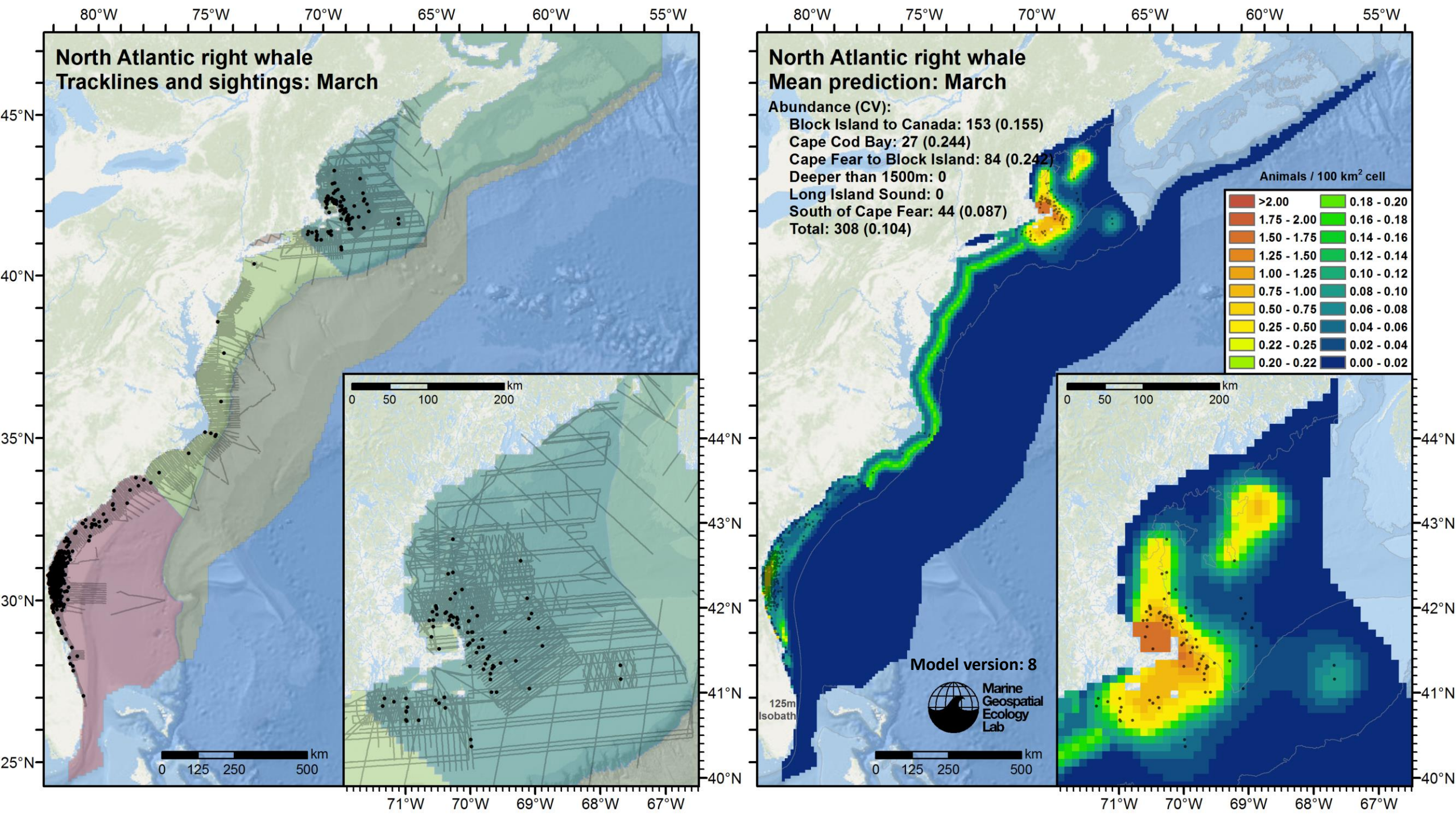

North Atlantic right whale
Tracklines and sightings: October
80°W
75°W
70°W
65°W
60°W
55°W
45°N
40°N
35°N
30°N
25°N
km
0 125 250 500
km
0 50 100 200
71°W
70°W
69°W
68°W
67°W
44°N
43°N
42°N
41°N
40°N
North Atlantic right whale
Mean prediction: October
Abundance (CV):
Block Island to Canada: 98 (0.152)
Deeper than 1500m: 0
Long Island Sound: 0
Nearshore South of Block Island: 7 (0.517)
Offshore South of Block Island: 0
Total: 105 (0.146)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
125m Isobath
Model version: 8
Marine Geospatial Ecology Lab

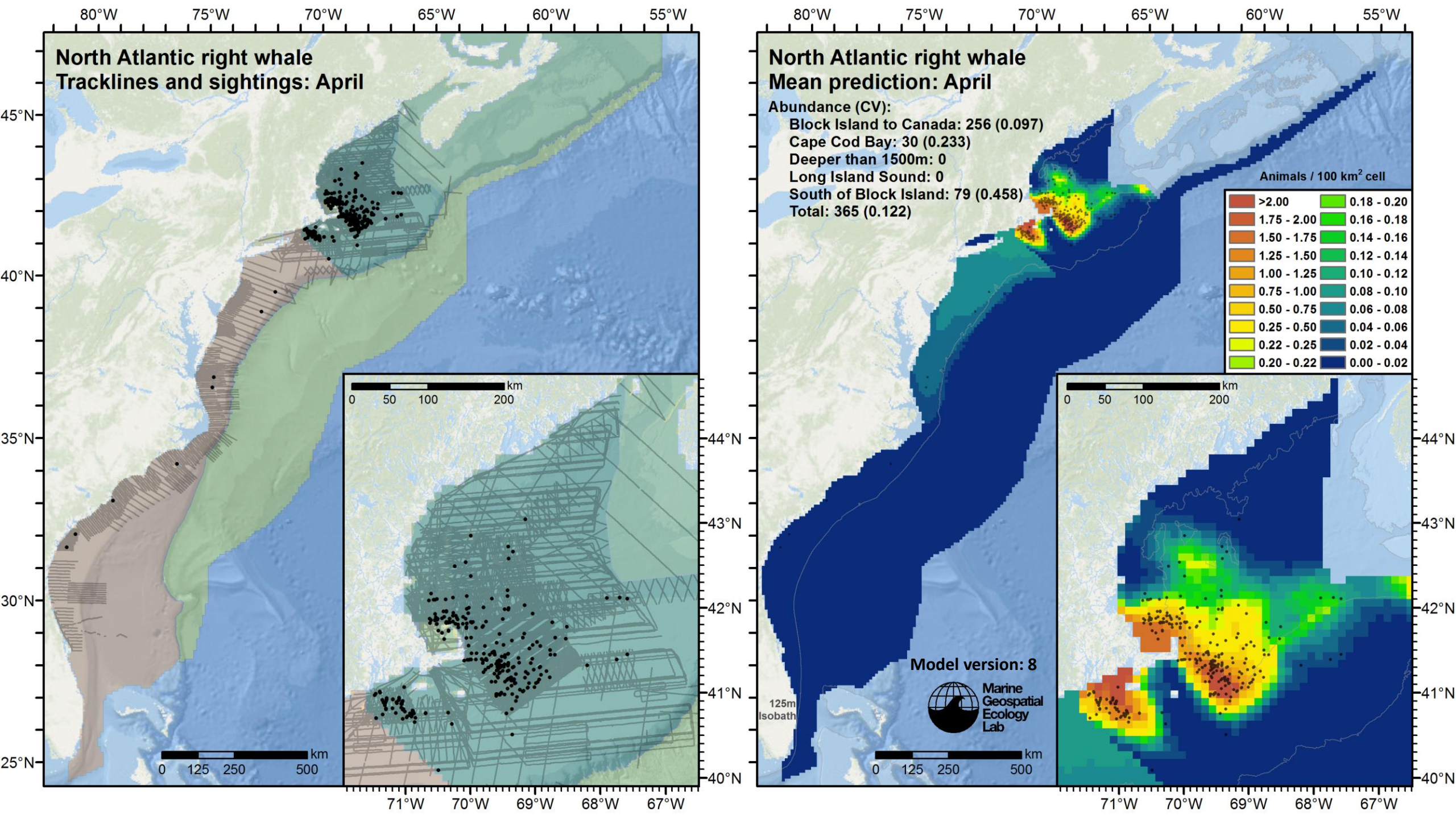

North Atlantic right whale
Tracklines and sightings: November
80°W
75°W
70°W
65°W
60°W
55°W
45°N
40°N
35°N
30°N
25°N
km
0 125 250 500
km
0 50 100 200
71°W
70°W
69°W
68°W
67°W
44°N
43°N
42°N
41°N
40°N
North Atlantic right whale
Mean prediction: November
Abundance (CV):
Block Island to Canada: 136 (0.136)
Deeper than 1500m: 0
Long Island Sound: 0
Nearshore South of Block Island: 7 (0.517)
Offshore South of Block Island: 0
Total: 143 (0.132)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
125m Isobath
Model version: 8
Marine Geospatial Ecology Lab


North Atlantic right whale
Tracklines and sightings: December
80°W
75°W
70°W
65°W
60°W
55°W
45°N
40°N
35°N
30°N
25°N
km
0 125 250 500
km
0 50 100 200
71°W
70°W
69°W
68°W
67°W
44°N
43°N
42°N
41°N
40°N
North Atlantic right whale
Mean prediction: December
Abundance (CV):
Block Island to Canada: 147 (0.158)
Cape Cod Bay: 10 (0.350)
Cape Fear to Block Island: 84 (0.242)
Deeper than 1500m: 0
Long Island Sound: 0
South of Cape Fear: 28 (0.071)
Total: 268 (0.116)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
125m Isobath
Model version: 8
Marine Geospatial Ecology Lab


North Atlantic right whale
Tracklines and sightings: January
North Atlantic right whale
Mean prediction: January
Abundance (CV):
Block Island to Canada: 194 (0.140)
Cape Cod Bay: 10 (0.350)
Cape Fear to Block Island: 84 (0.242)
Deeper than 1500m: 0
Long Island Sound: 0
South of Cape Fear: 56 (0.054)
Total: 344 (0.100)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
Model version: 8
Marine Geospatial Ecology Lab
125m Isobath
km
0 125 250 500
0 50 100 200
80°W 75°W 70°W 65°W 60°W 55°W
45°N 40°N 35°N 30°N 25°N
44°N 43°N 42°N 41°N 40°N
71°W 70°W 69°W 68°W 67°W


North Atlantic right whale
Tracklines and sightings: February
80°W
75°W
70°W
65°W
60°W
55°W
45°N
40°N
35°N
30°N
25°N
km
0 125 250 500
0 50 100 200
71°W
70°W
69°W
68°W
67°W
44°N
43°N
42°N
41°N
40°N
North Atlantic right whale
Mean prediction: February
Abundance (CV):
Block Island to Canada: 139 (0.155)
Cape Cod Bay: 10 (0.245)
Cape Fear to Block Island: 84 (0.242)
Deeper than 1500m: 0
Long Island Sound: 0
South of Cape Fear: 66 (0.061)
Total: 299 (0.100)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
125m Isobath
Model version: 8
Marine Geospatial Ecology Lab


North Atlantic right whale
Tracklines and sightings: March
80°W
75°W
70°W
65°W
60°W
55°W
45°N
40°N
35°N
30°N
25°N
0 125 250 500 km
0 50 100 200 km
71°W
70°W
69°W
68°W
67°W
44°N
43°N
42°N
41°N
40°N
North Atlantic right whale
Mean prediction: March
Abundance (CV):
Block Island to Canada: 153 (0.155)
Cape Cod Bay: 27 (0.244)
Cape Fear to Block Island: 84 (0.242)
Deeper than 1500m: 0
Long Island Sound: 0
South of Cape Fear: 44 (0.087)
Total: 308 (0.104)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
125m Isobath
Model version: 8
Marine Geospatial Ecology Lab


North Atlantic right whale
Tracklines and sightings: April
80°W
75°W
70°W
65°W
60°W
55°W
45°N
40°N
35°N
30°N
25°N
km
0 125 250 500
km
0 50 100 200
71°W
70°W
69°W
68°W
67°W
44°N
43°N
42°N
41°N
40°N
North Atlantic right whale
Mean prediction: April
Abundance (CV):
Block Island to Canada: 256 (0.097)
Cape Cod Bay: 30 (0.233)
Deeper than 1500m: 0
Long Island Sound: 0
South of Block Island: 79 (0.458)
Total: 365 (0.122)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
125m Isobath
Model version: 8
Marine Geospatial Ecology Lab

Plan for the right whale version 9 model

- In 2019, we will start updating all species for the Navy's AFTT Phase IV EIS
- These models due to the Navy in 2021-2022
- As a rapid first run through the modeling process, we will produce a new right whale model, version 9, to be completed October 1, 2019
  - Review with Navy and NARW experts in Oct, present at NARWC, then submit paper

Version 9 model goals:

- Incorporate survey data through the end of 2018
- Build and compare independent "before and after" models (1998-2009 and 2010-2018?) based on when NARW experts believe "things changed"
- To the extent data allow, build a mother-calf pair model

Surveys targeted for the v9 model

We anticipate including most of the following (work is in progress):

- NEFSC / SEFSC AMAPPS II aerial and shipboard surveys, 2016-2018
- NEFSC NARWSS aerial surveys, Jul 2016-Dec 2018
- SEUS NARW aerial surveys, 2016/17 and 2017-18 calving seasons
- UNCW aerial surveys of Navy Norfolk, Hatteras, JAX study areas, 2017
- VA Aquarium aerial surveys outside Chesapeake Bay, 2017
- NE Aquarium aerial surveys of Mass/RI wind energy areas, 2011-2018
- NYS-DEC / TetraTech aerial surveys, 2017-2018
- NYSERDA / Normandeau digital aerial surveys, 2016-2018
- HDR surveys of Navy Hatteras study area, 2018

Longer term objectives (funding needed)

1. Incorporate other sources of right whale observations
   - Systematic visual surveys that did not collect distances to sightings
   - Systematic acoustic surveys
   - Opportunistic sightings
2. Incorporate known population trend (e.g. Pace et al. 2017) as an explicit model offset or nuisance variable
3. Explicitly address fine-scale (day-to-day) and interannual (year-to-year) autocorrelation, to better address clustering of right whales resulting from right whale social behavior and memory
4. Develop system optimized to give up-to-date forecasts in near real time, based on both historical and recent sightings and ocean conditions

For more information

- Following slides give answers to several “frequently asked questions”
- You can download this presentation and GIS files for the right whale v8 model from NOAA (location to be provided)
- Model documentation:
  - v5.4 model: Roberts et al. (2016) https://www.nature.com/articles/srep22615 and supplementary report http://seamap.env.duke.edu/models/Duke-EC-GOM-2015/
  - v7 model: MGEL reports to Navy (provided with v8 downloads)
  - v8 model: This presentation
- I will be at the ALWTRT meeting in Providence next week
- Feel free to email me any questions: jason.roberts@duke.edu

Thanks!

Frequently asked questions

Frequently Asked Question

Is this model appropriate for the ALWTRT's management applications?

Maybe. This is for you, the TRT members, to decide.

The model was originally developed for the Navy's needs in 2015-2017:

- Estimate absolute density (whales / km^2)
- Provide estimates for all grid cells across the U.S. EEZ, with no holes
- Utilize as much data as possible, to maximize confidence and account for variability
- Summarize into monthly maps, to reflect seasonal dynamics in whale movements

Your needs may be similar. But you might have additional requirements:

- Incorporate the very latest survey data available, as of 2019?
- Focus the model on recent years, e.g. after right whale distribution "changed" in 2010?

The v8 model is what we can provide now. I will be at the TRT meeting and happy to answer questions. We have an update planned for Oct. 2019. If you can articulate your requirements we will try to address them for the update.

Frequently Asked Question

How exactly did you fill Cape Cod Bay with Ganley et al.'s (2019) results?

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ENDANGERED SPECIES RESEARCH
Endang Species Res

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What we see is not what there is: estimating North Atlantic right whale *Eubalaena glacialis* local abundance

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ABSTRACT: Aerial surveys can be used to estimate animal abundance, but animals unavailable for detection for portions of the survey can cause biased abundance estimates. Moreover, these biases may be variable owing to changes in behavior. We conducted focal follows to obtain surface and dive times of North Atlantic right whales *Eubalaena glacialis* in Cape Cod Bay (CCB) and measured the aircraft field of view; these metrics were combined to estimate availability and correct monthly abundance estimates from 1998 to 2017 generated via distance sampling methodology. We used a general least squares model to test for trends in abundance. Availability varied with month (0.27–0.85), likely linked to changes in the depth of copepod food resources. Detection probability varied across the years (0.43–0.87). Sightings per unit effort and counts of whales were significant, but downward-biased indicators of abundance and availability caused changes in bias over the season. Estimated abundance in CCB increased during the study period (4.9 whales yr^{-1}), and estimated abundance in peak months increased at a faster rate (10% yr^{-1} for 1998–2017) than for the overall population (2.8% yr^{-1} for 1990–2010). Accurate abundance estimates are necessary to monitor long-term changes in abundance of right whales in CCB, to understand the importance of CCB relative to other areas, and improve management strategies to protect this endangered species from entanglements in fishing gear and ship-strikes. Failing to correct for seasonal variation in availability results in substantial and variable underestimation of abundance.

KEY WORDS: Abundance estimation · Availability bias · Bayesian · Distance sampling · $g(0)$ · Right whales · Transect sampling · Diving

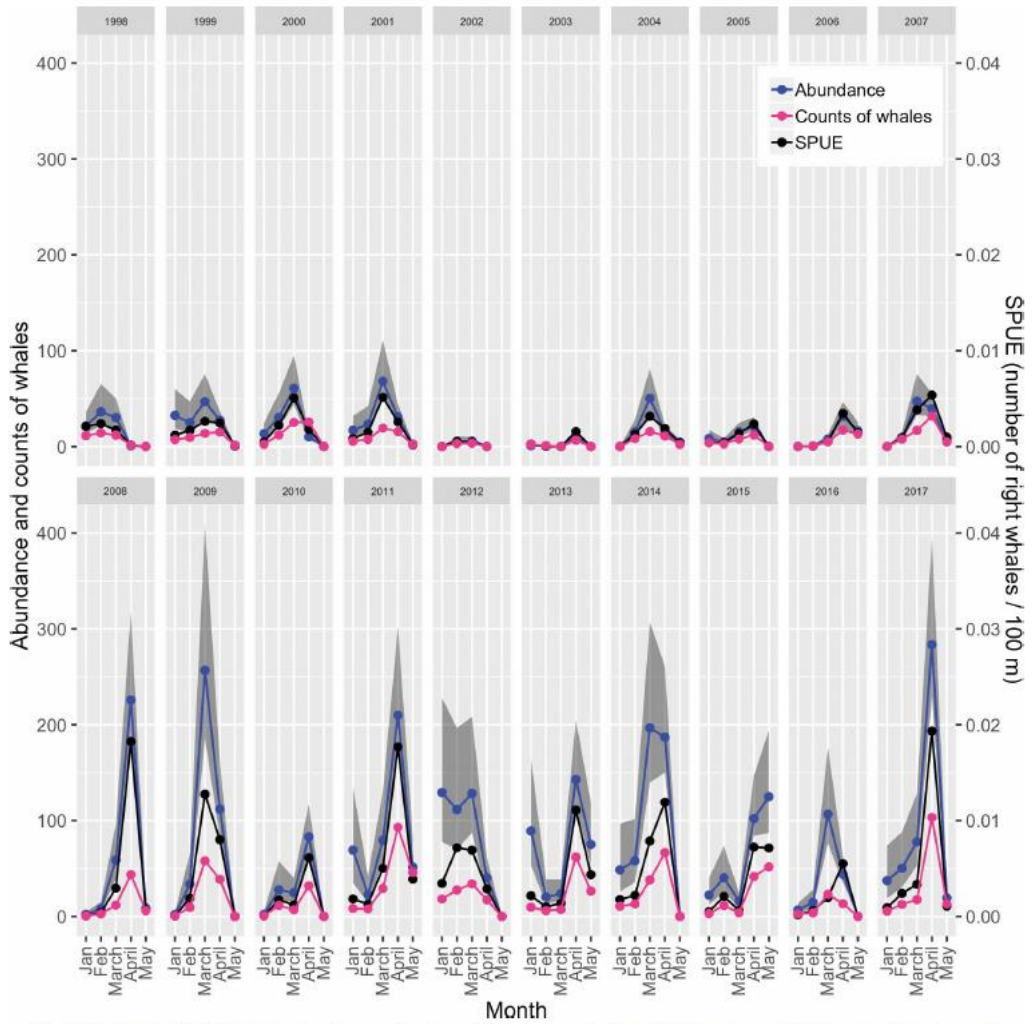


Fig. 6. North Atlantic right whale abundance estimates, sightings per unit effort (SPUE), and counts in Cape Cod Bay by month for each year. Blue points: median of the distribution of bootstrapped abundance; gray shaded regions: 1st and 3rd quartiles of the distribution; black points: SPUE; pink points: counts of right whales divided by the number of surveys in each month. There was no survey effort in May 2002

Cape Cod Bay

- In 2015-2017, we solicited a collaboration with Center for Coastal Studies (CCS), so that their surveys of Cape Cod Bay could be added to our model
- CCS replied positively, but their surveys lacked perpendicular distances to whale sightings, which we needed for our analysis
- They undertook an effort to reconstruct those distances from logged GPS data and then produce abundance and density estimates for CCB
- We left CCB “empty” for Winter and Spring seasons in our v7 model
- Laura Ganley published results in Feb 2019, which we incorporated into v8
  - Rather than incorporate CCS data into our model, we overlaid their results on ours
  - Cape Cod Bay is such a “special place” that it is best modeled separately
    - This may change if robust zooplankton maps become available across the northeast

Incorporation of Ganley et al. (2019) CCB results

Step 1: For our model, Laura Ganley provided:

- Climatological mean abundance and standard error estimates for the 1999-2016 seasons, the period spanned by our model, for 5 months (Jan-May)
- The geographical area those estimates applied to: 4105 km^2

Step 2: I derived mean density estimates and standard errors for each month:

Month	Mean abundance (whales)	SE	Area (km2)	Density (whales/100 km2)	SE
1	23.67	8.29	4105	0.58	0.20
2	25.14	6.16	4105	0.61	0.15
3	66.33	16.18	4105	1.62	0.39
4	71.78	16.73	4105	1.75	0.41
5	16.52	8.20	4105	0.40	0.20

From Laura

I derived

Incorporation of Ganley et al. (2019) CCB results

Step 3: I also needed estimates for December and June:

- For December, I used Ganley's January estimate. Ganley indicated that right whales occasionally showed up in CCB in December. She'll try to include December in her next update.
- For June, I used the density model's prediction.

Month	Mean abundance (whales)	SE	Area (km2)	Density (whales/100 km2)	SE
12				0.58	0.20
1	23.67	8.29	4105	0.58	0.20
2	25.14	6.16	4105	0.61	0.15
3	66.33	16.18	4105	1.62	0.39
4	71.78	16.73	4105	1.75	0.41
5	16.52	8.20	4105	0.40	0.20
6				0.0035	0.0023

Copied

Copied

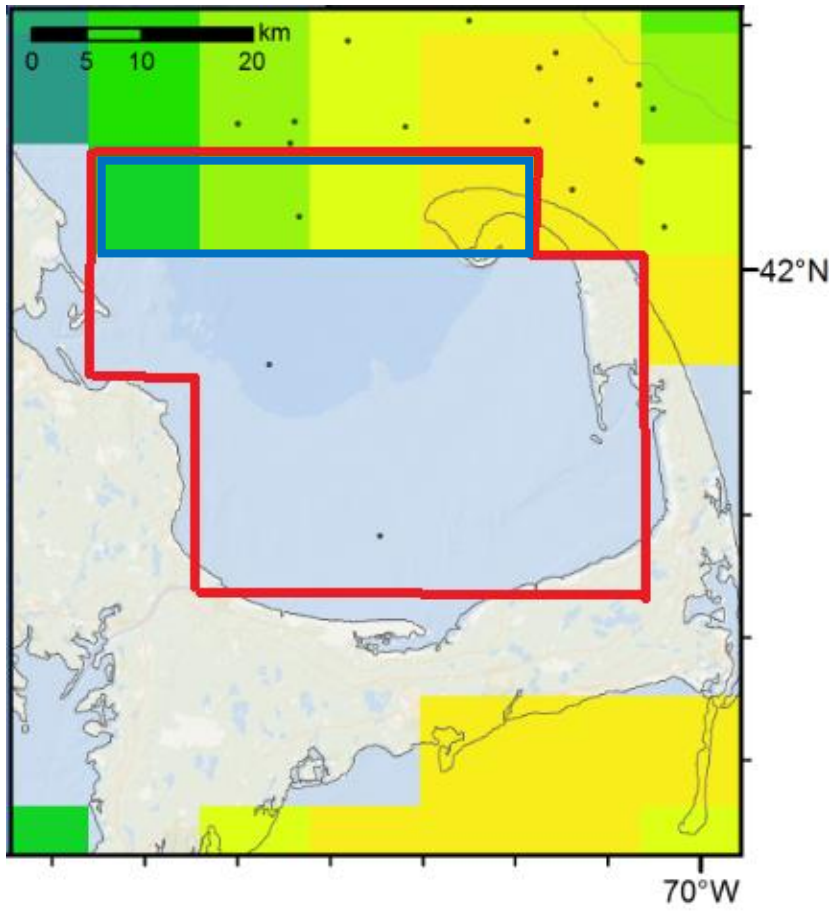
From density model

Incorporation of Ganley et al. (2019) CCB results

Step 4: Together, Ganley and I identified the cells of the density model's grid that best matched the area of CCB surveyed by CCS (red polygon).

For each month, December-June, I set those 17 cells to the monthly density and SE estimates from the previous step. (Each cell received the same value for that month.)

4 cells that were populated with density model predictions in v7 are now populated with Ganley's estimates in v8 (blue polygon).



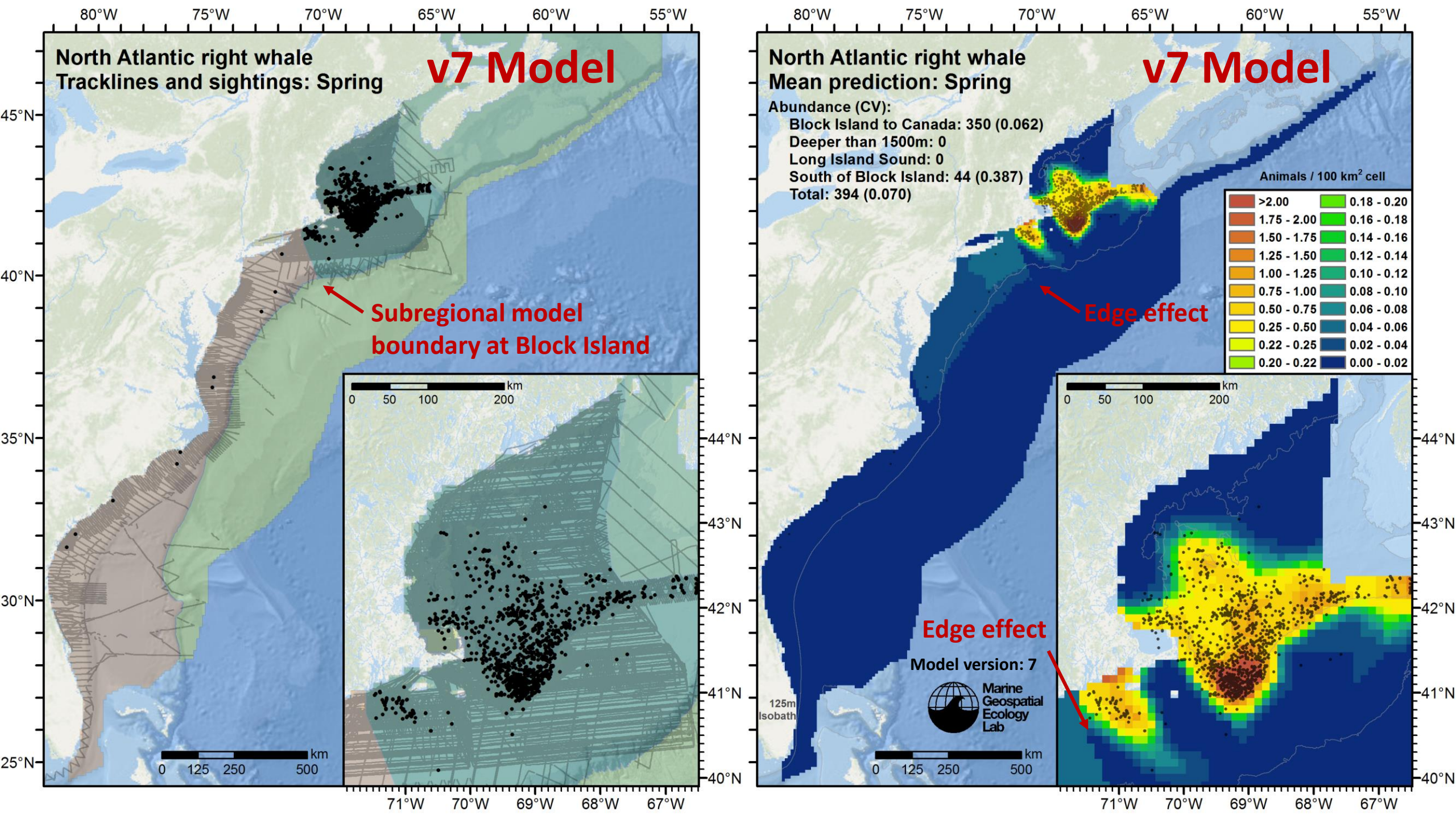
Frequently Asked Question

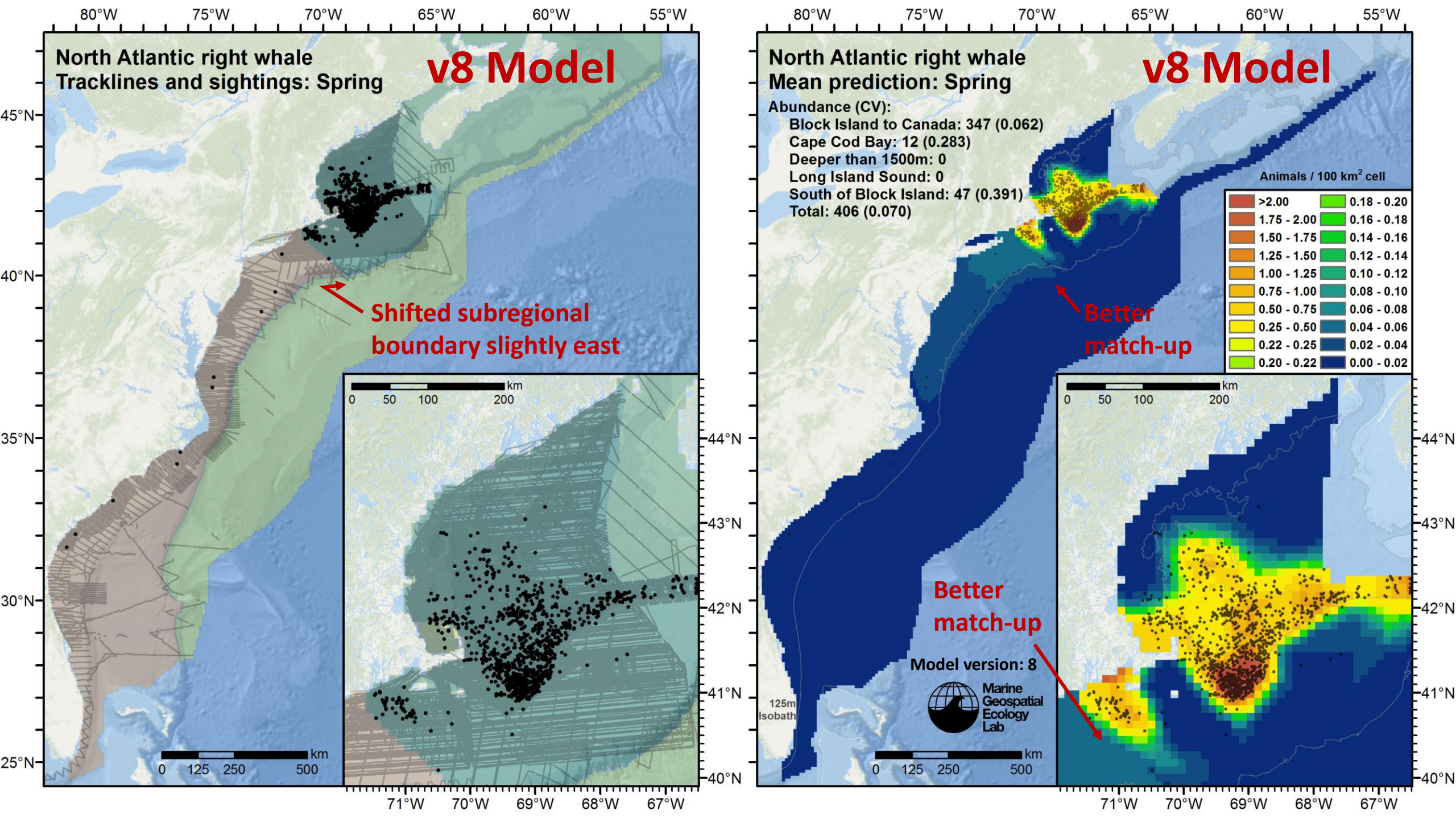
What are the "edge effects" from v7 that were reduced in v8?

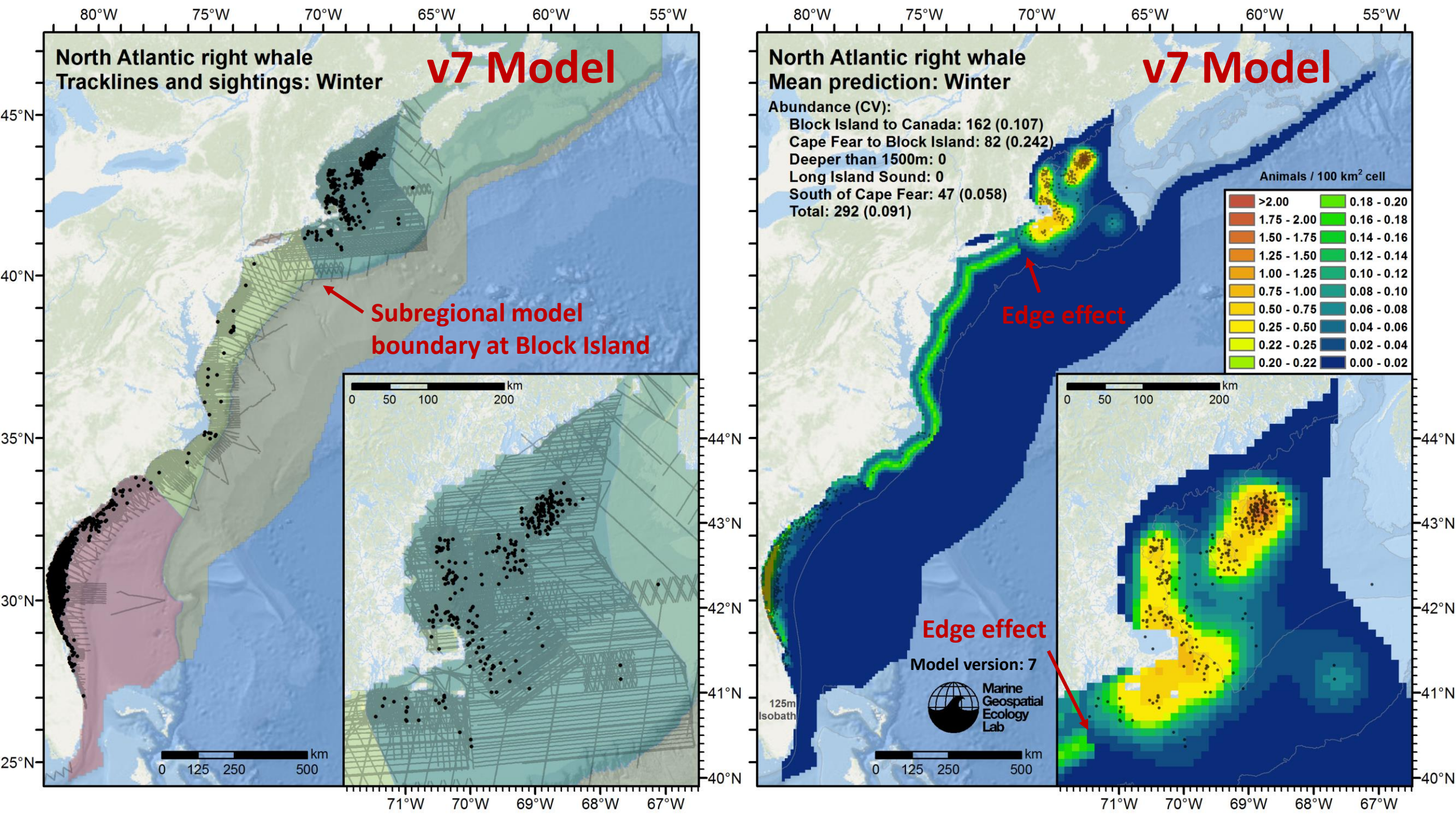
Our modeling approach was to split the study area seasonally and spatially into subregions where we suspect the species exhibits different species-environment relationships, based on the literature and patterns in the data.

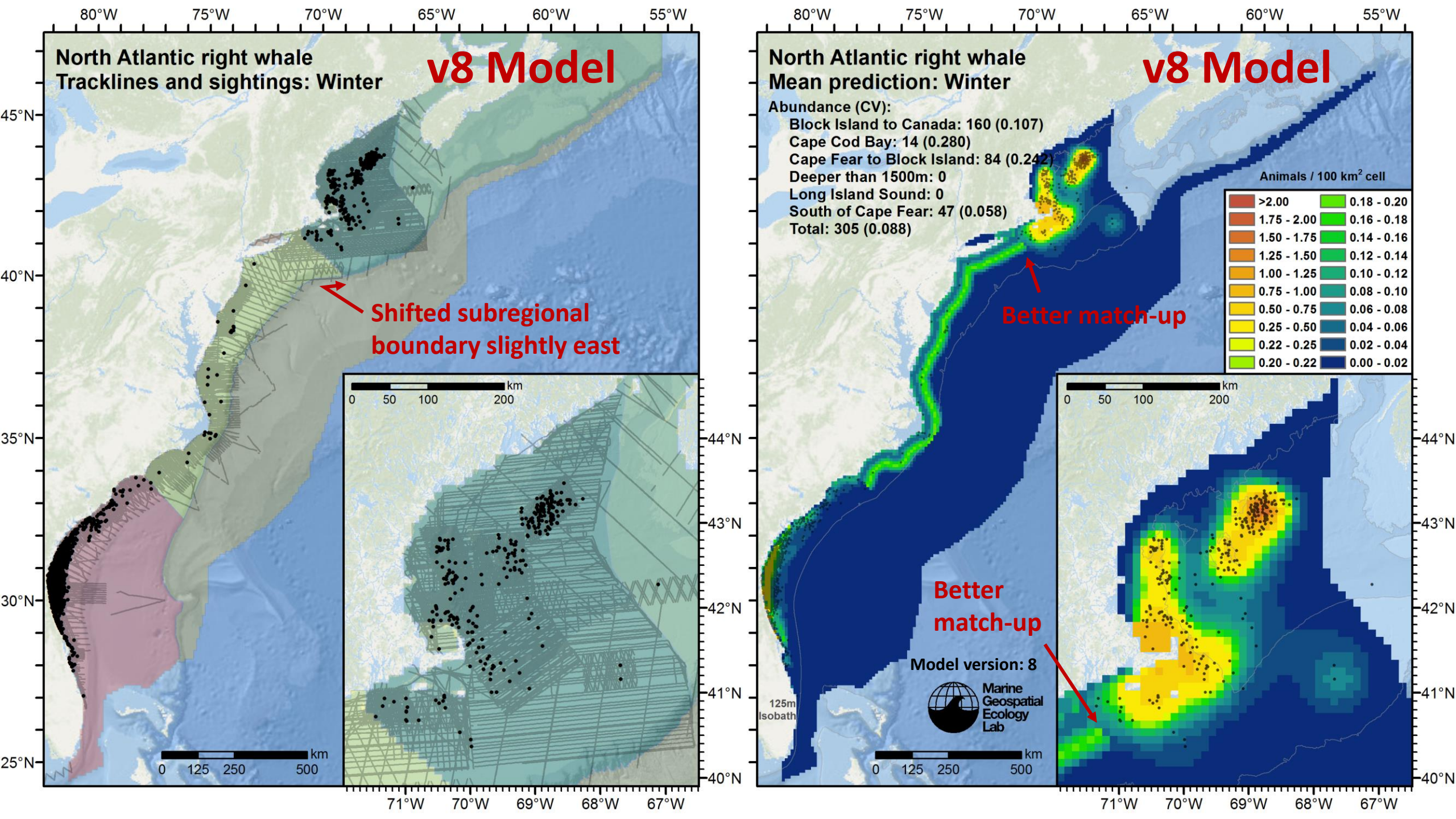
We placed one such split at Block Island:

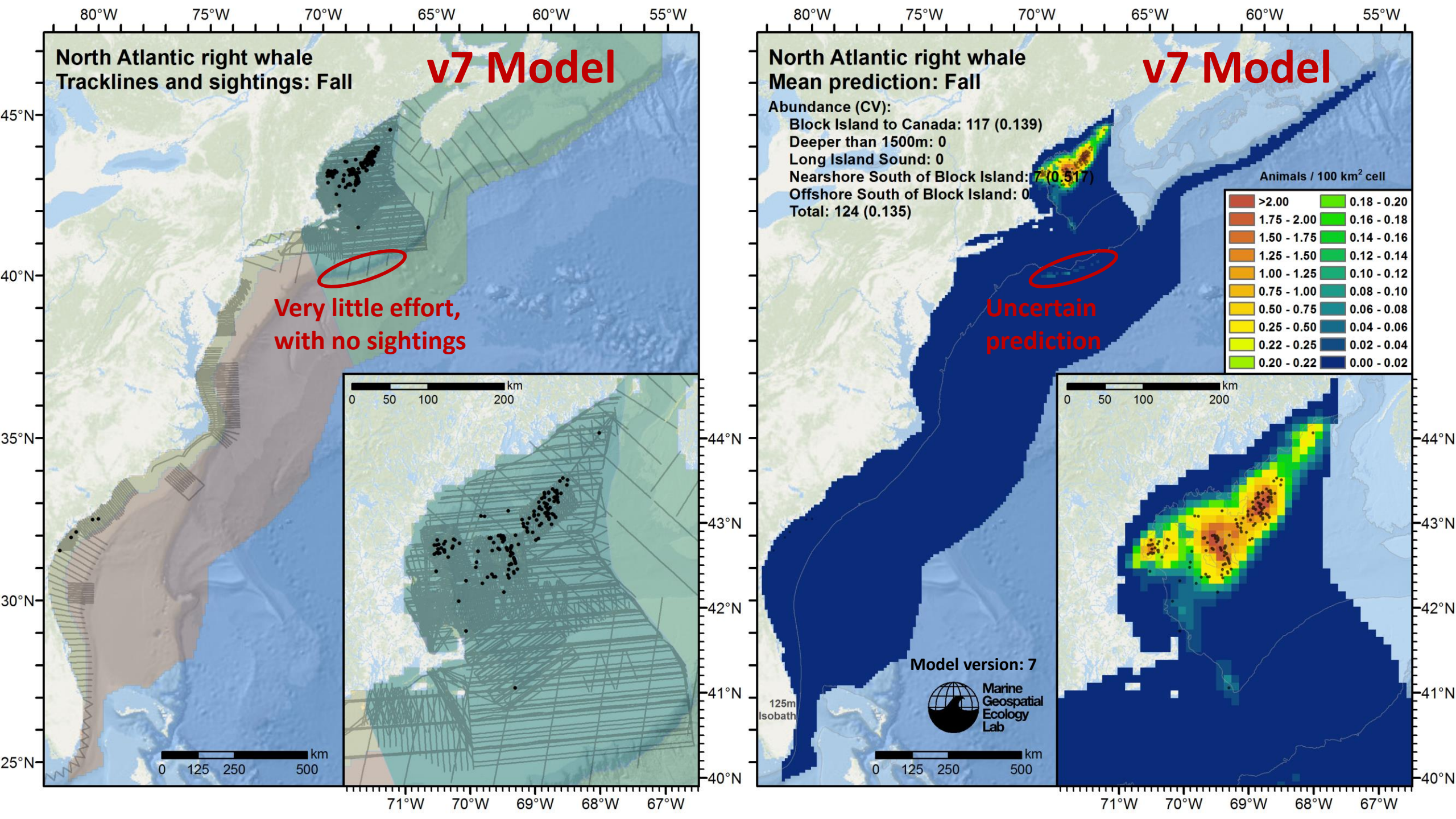
- Aggregations of feeding right whales were observed in multiple years just north of here in Rhode Island Sound
- We were unaware of such regular feeding aggregations south of there
- We split the study area there, to allow models to express different density-to-habitat relationships, in case right whales behaved differently
- The boundary between the subregions produced an edge effect in v7
- In v8, we adjusted this boundary to reduce the edge effect

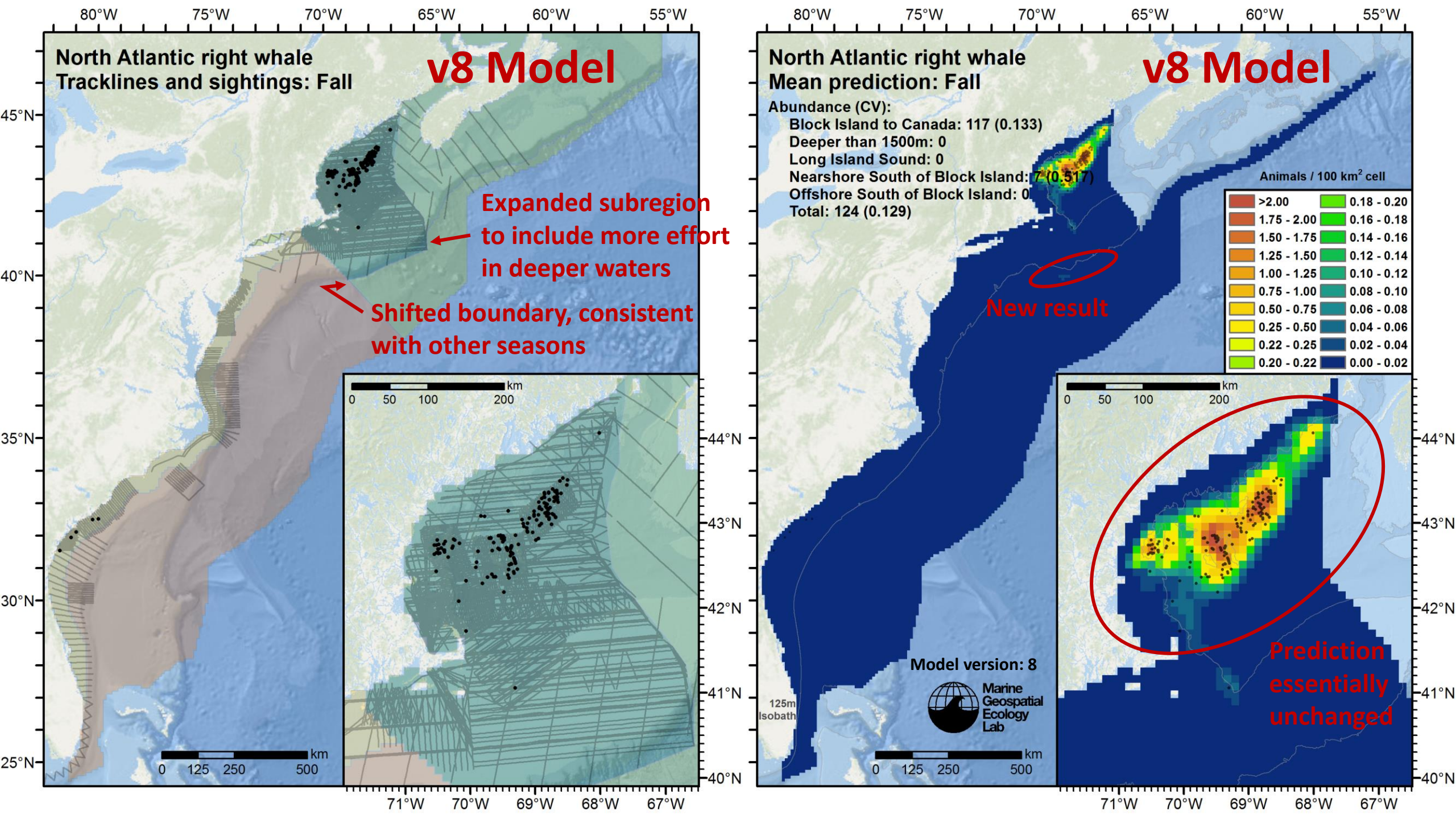

North Atlantic right whale
Tracklines and sightings: Spring
v7 Model
Subregional model boundary at Block Island
km
0 50 100 200
0 125 250 500
80°W 75°W 70°W 65°W 60°W 55°W
45°N 40°N 35°N 30°N 25°N
71°W 70°W 69°W 68°W 67°W
44°N 43°N 42°N 41°N 40°N
North Atlantic right whale
Mean prediction: Spring
v7 Model
Abundance (CV):
Block Island to Canada: 350 (0.062)
Deeper than 1500m: 0
Long Island Sound: 0
South of Block Island: 44 (0.387)
Total: 394 (0.070)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
Edge effect
Edge effect
Model version: 7
Marine Geospatial Ecology Lab
125m Isobath


North Atlantic right whale
Tracklines and sightings: Spring
v8 Model
Shifted subregional boundary slightly east
km
0 50 100 200
0 125 250 500
80°W 75°W 70°W 65°W 60°W 55°W
45°N 40°N 35°N 30°N 25°N
71°W 70°W 69°W 68°W 67°W
44°N 43°N 42°N 41°N 40°N
North Atlantic right whale
Mean prediction: Spring
v8 Model
Abundance (CV):
Block Island to Canada: 347 (0.062)
Cape Cod Bay: 12 (0.283)
Deeper than 1500m: 0
Long Island Sound: 0
South of Block Island: 47 (0.391)
Total: 406 (0.070)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
Better match-up
Better match-up
Model version: 8
Marine Geospatial Ecology Lab
125m Isobath


North Atlantic right whale
Tracklines and sightings: Winter
v7 Model
Subregional model boundary at Block Island
km
0 125 250 500
0 50 100 200
80°W 75°W 70°W 65°W 60°W 55°W
45°N 40°N 35°N 30°N 25°N
71°W 70°W 69°W 68°W 67°W
44°N 43°N 42°N 41°N 40°N
North Atlantic right whale
Mean prediction: Winter
v7 Model
Abundance (CV):
Block Island to Canada: 162 (0.107)
Cape Fear to Block Island: 82 (0.242)
Deeper than 1500m: 0
Long Island Sound: 0
South of Cape Fear: 47 (0.058)
Total: 292 (0.091)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
Edge effect
Edge effect
Model version: 7
Marine Geospatial Ecology Lab
125m Isobath


North Atlantic right whale
Tracklines and sightings: Winter
v8 Model
Shifted subregional boundary slightly east
km
0 50 100 200
0 125 250 500
80°W 75°W 70°W 65°W 60°W 55°W
45°N 40°N 35°N 30°N 25°N
71°W 70°W 69°W 68°W 67°W
44°N 43°N 42°N 41°N 40°N
North Atlantic right whale
Mean prediction: Winter
v8 Model
Abundance (CV):
Block Island to Canada: 160 (0.107)
Cape Cod Bay: 14 (0.280)
Cape Fear to Block Island: 84 (0.242)
Deeper than 1500m: 0
Long Island Sound: 0
South of Cape Fear: 47 (0.058)
Total: 305 (0.088)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
Better match-up
Better match-up
125m Isobath
Model version: 8
Marine Geospatial Ecology Lab


North Atlantic right whale
Tracklines and sightings: Fall
v7 Model
Very little effort,
with no sightings
km
0 125 250 500
0 50 100 200
80°W 75°W 70°W 65°W 60°W 55°W
45°N 40°N 35°N 30°N 25°N
71°W 70°W 69°W 68°W 67°W
44°N 43°N 42°N 41°N 40°N
North Atlantic right whale
Mean prediction: Fall
v7 Model
Abundance (CV):
Block Island to Canada: 117 (0.139)
Deeper than 1500m: 0
Long Island Sound: 0
Nearshore South of Block Island: 7 (0.517)
Offshore South of Block Island: 0
Total: 124 (0.135)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
Uncertain
prediction
125m
Isobath
Model version: 7
Marine
Geospatial
Ecology
Lab


North Atlantic right whale
Tracklines and sightings: Fall
v8 Model
Expanded subregion to include more effort in deeper waters
Shifted boundary, consistent with other seasons
km
0 125 250 500
0 50 100 200
North Atlantic right whale
Mean prediction: Fall
v8 Model
Abundance (CV):
Block Island to Canada: 117 (0.133)
Deeper than 1500m: 0
Long Island Sound: 0
Nearshore South of Block Island: 7 (0.517)
Offshore South of Block Island: 0
Total: 124 (0.129)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
New result
Prediction essentially unchanged
Model version: 8
Marine Geospatial Ecology Lab
125m Isobath
80°W 75°W 70°W 65°W 60°W 55°W
45°N 40°N 35°N 30°N 25°N
44°N 43°N 42°N 41°N 40°N
71°W 70°W 69°W 68°W 67°W

Edge effect in Fall along Georges Bank

The v7 Fall season model predicted a strip of low density along southern Georges Bank, waters 1000-1500m deep, along the model edge (next slide).

High CVs and other diagnostics indicated this was an aberrant prediction. The fitted relationship for the Depth covariate indicated that density increased as depth increased, but data were very sparse at deep depths. To reduce uncertainty at deep depths, we expanded the subregion boundary to encompass the remaining survey effort along deeper areas of Georges Bank.

The resulting model (v8) predicted less density here and CVs improved.

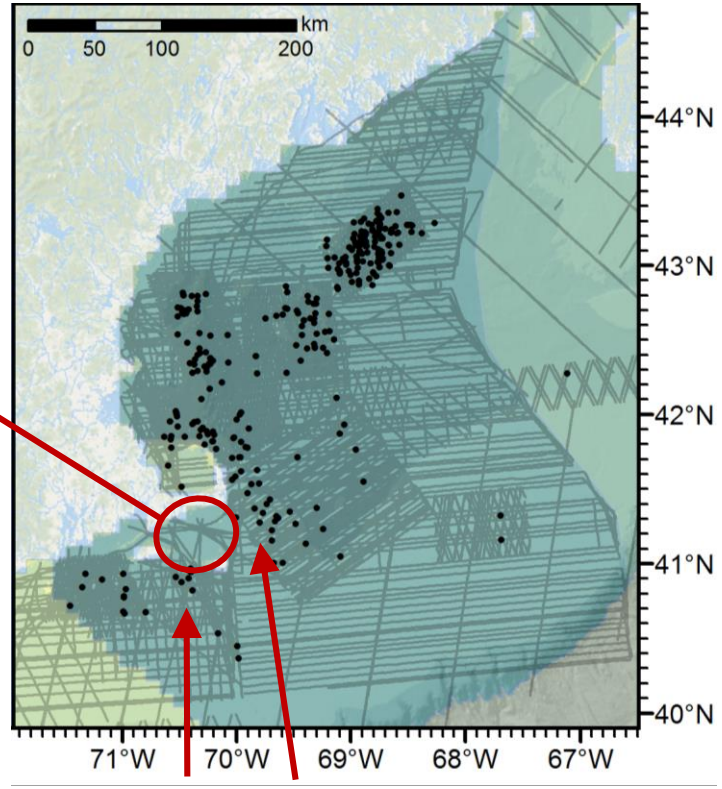
However, we caution that right whales have been observed and acoustically detected in similarly deep waters (albeit more rarely than shallower waters). The best way to improve the model for this region is to conduct additional surveying, or to adjust our methodology to utilize additional classes of data.

Frequently Asked Question

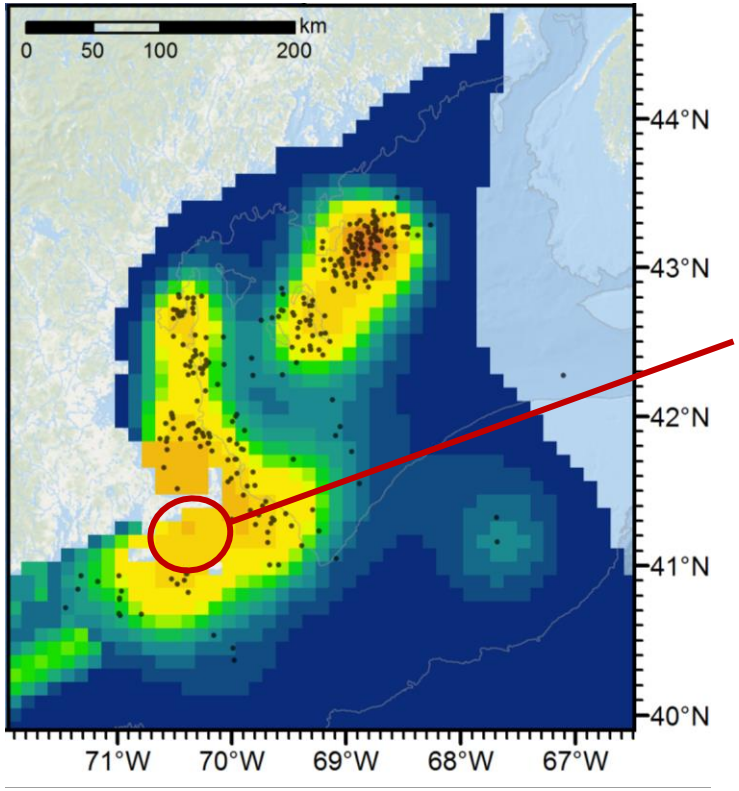
Density predictions were high in Nantucket Sound in winter. Is that realistic?

This resulted from low survey effort in Nantucket Sound itself in winter, along with numerous sightings just outside it, where effort was higher:

Low survey effort inside Nantucket Sound itself



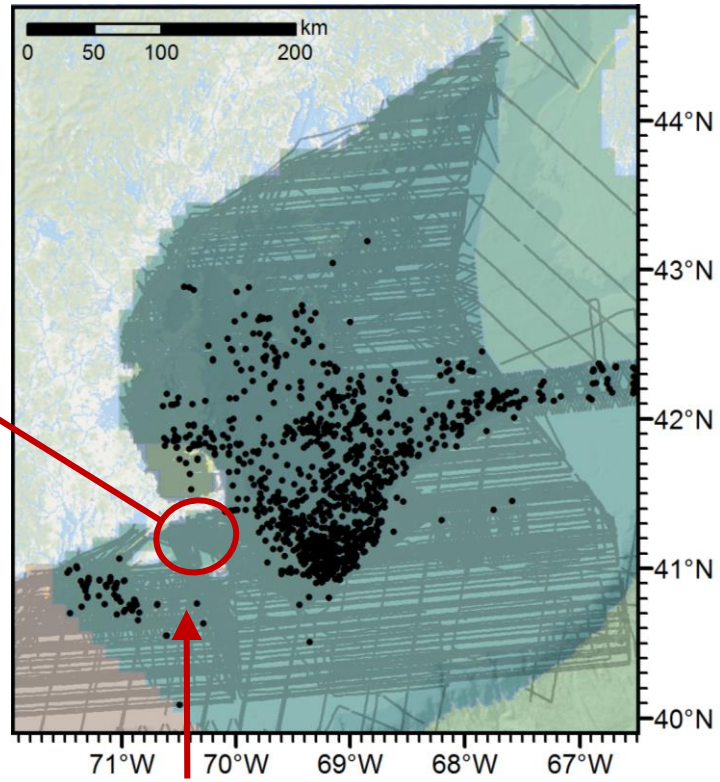
More effort, with sightings, around it



Moderately high density predicted

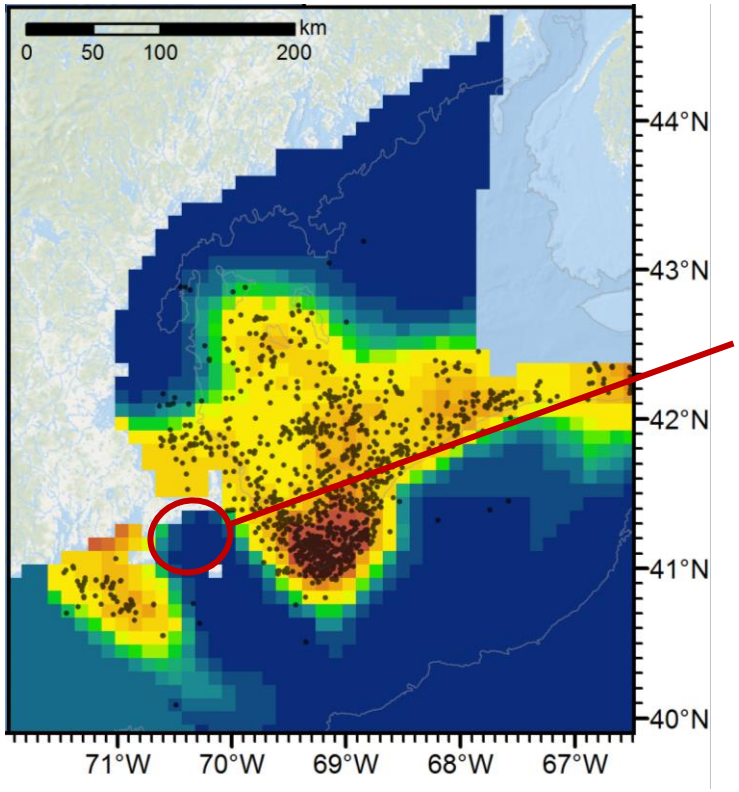
This did not happen in spring, when there was much more survey effort and sightings were farther away (see below).

For v8, we tested several statistical variations (e.g. soap film smoother, more knots) but the high prediction remained. We will look at it again in v9, but ultimately it may remain unless we obtain more survey effort with no sightings.



Much more survey effort in Nantucket Sound in spring

Not as many sightings nearby in this area



Much lower density predicted

Frequently Asked Question

How can densities be derived for inshore areas not included in the model, such as Penobscot Bay or Narragansett Bay?

We excluded many inshore areas because:

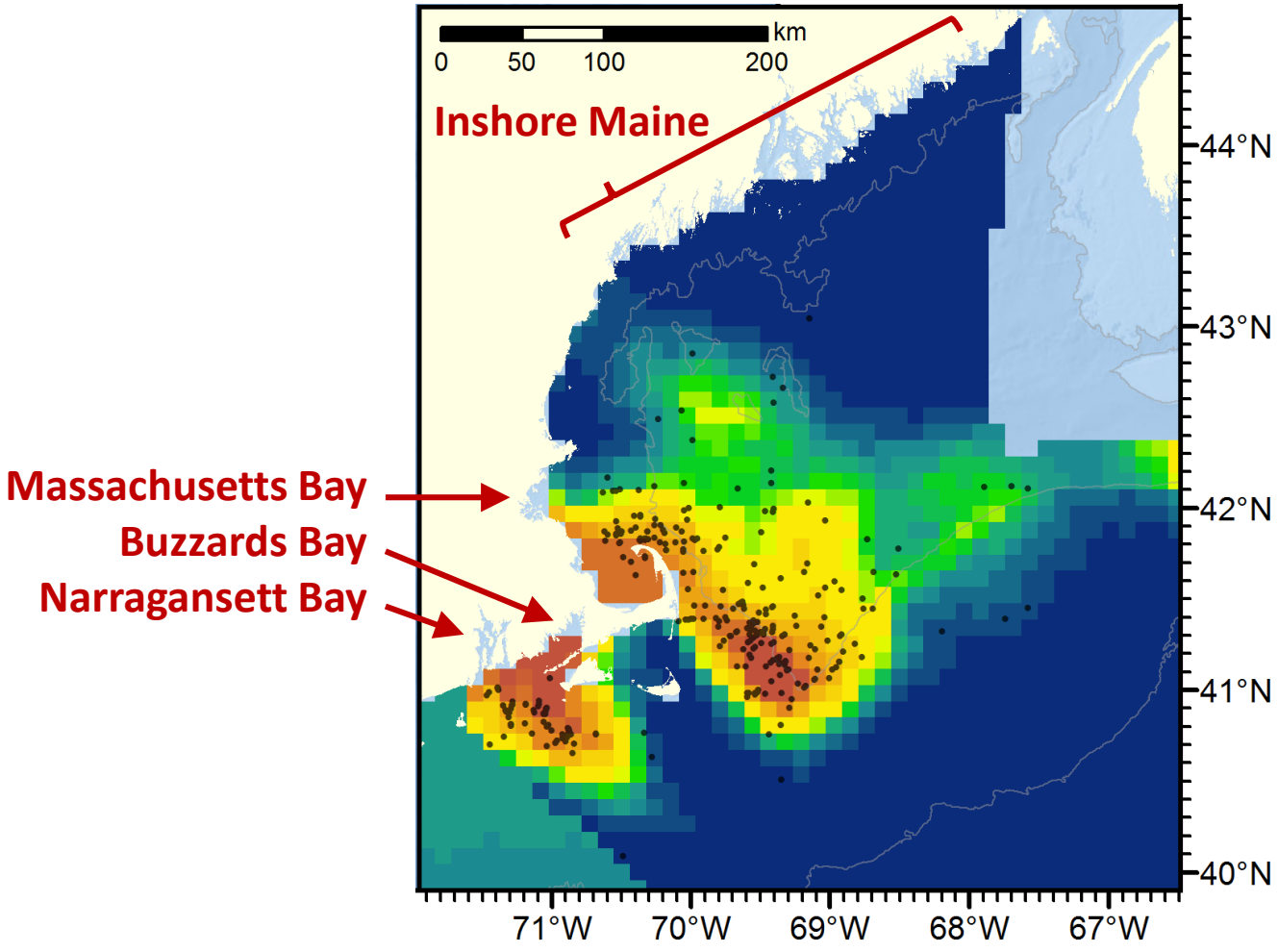
- There were very little survey data covering them, or none at all
- Most of our satellite-based oceanographic covariates did not go so far inshore
- The Navy had limited interest in most inshore areas
  - Those of highest interest were in the southeast or Gulf of Mexico, usually only inhabited by bottlenose dolphins, for which estuary-specific estimates were often available

At this time, our best recommendation would be to spatially extrapolate into inshore areas from cells outside them, in consultation with right whale experts. The results should be interpreted cautiously.

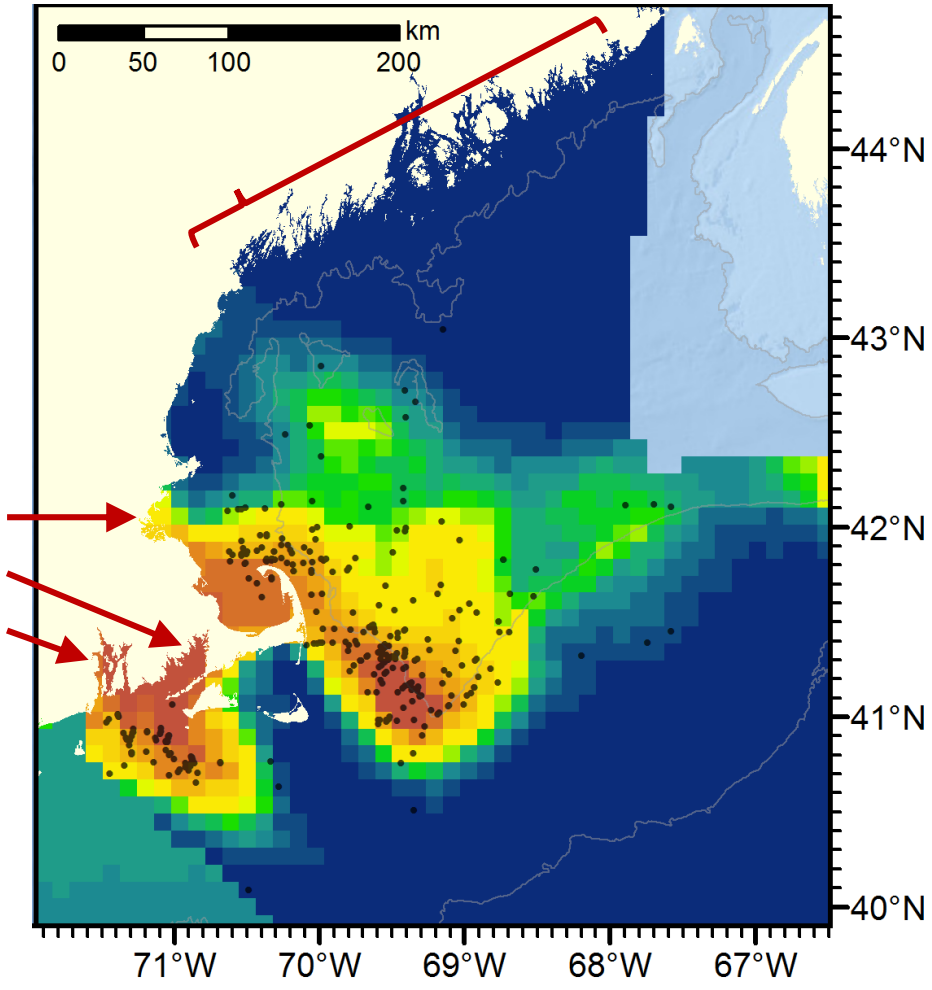
We might be able to provide a better recommendation in the v9 model.

Example month (April) where extrapolations seem easy to accept in some inshore areas (Maine) but require more scrutiny in others (Mass., Rhode Island).

Original April prediction

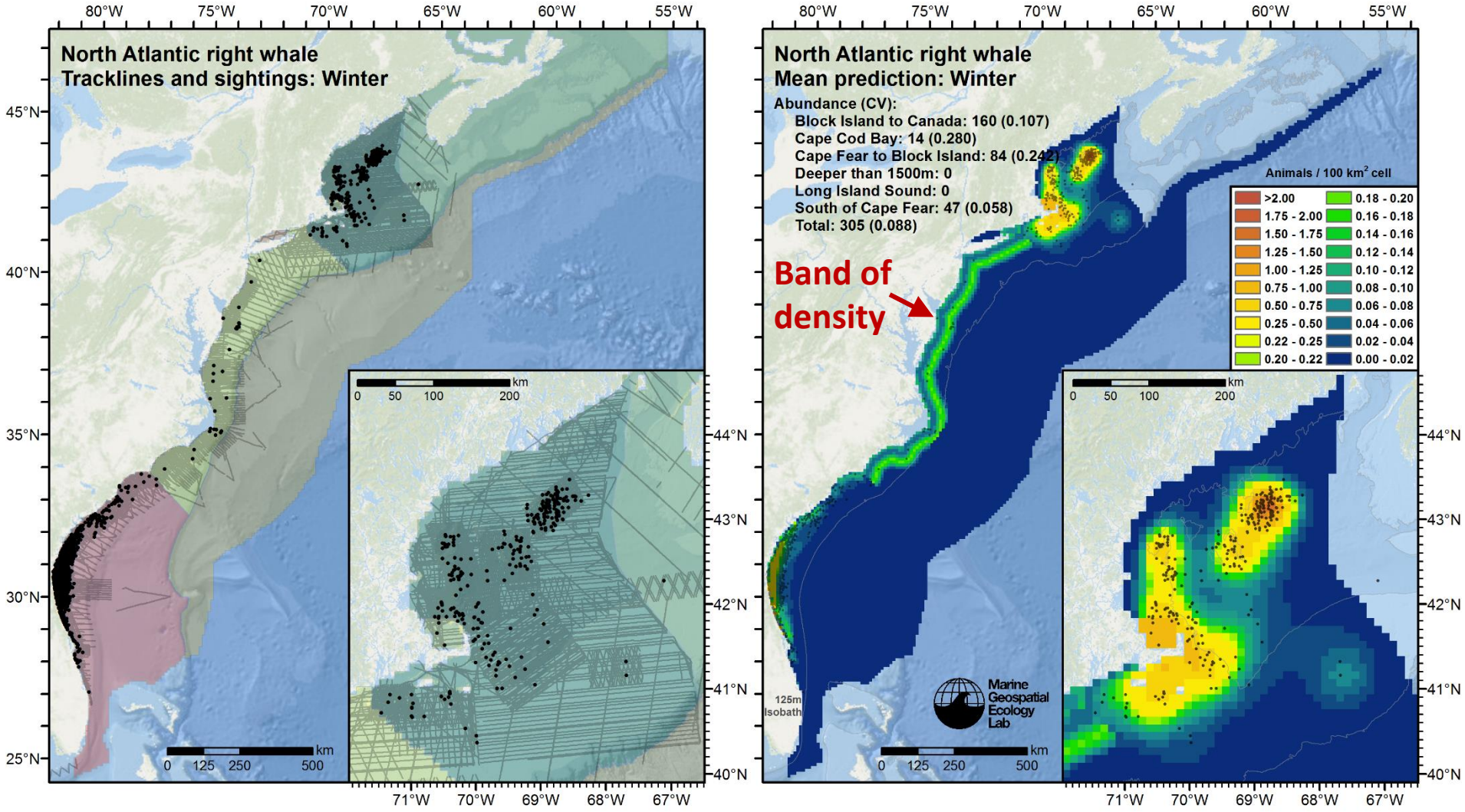


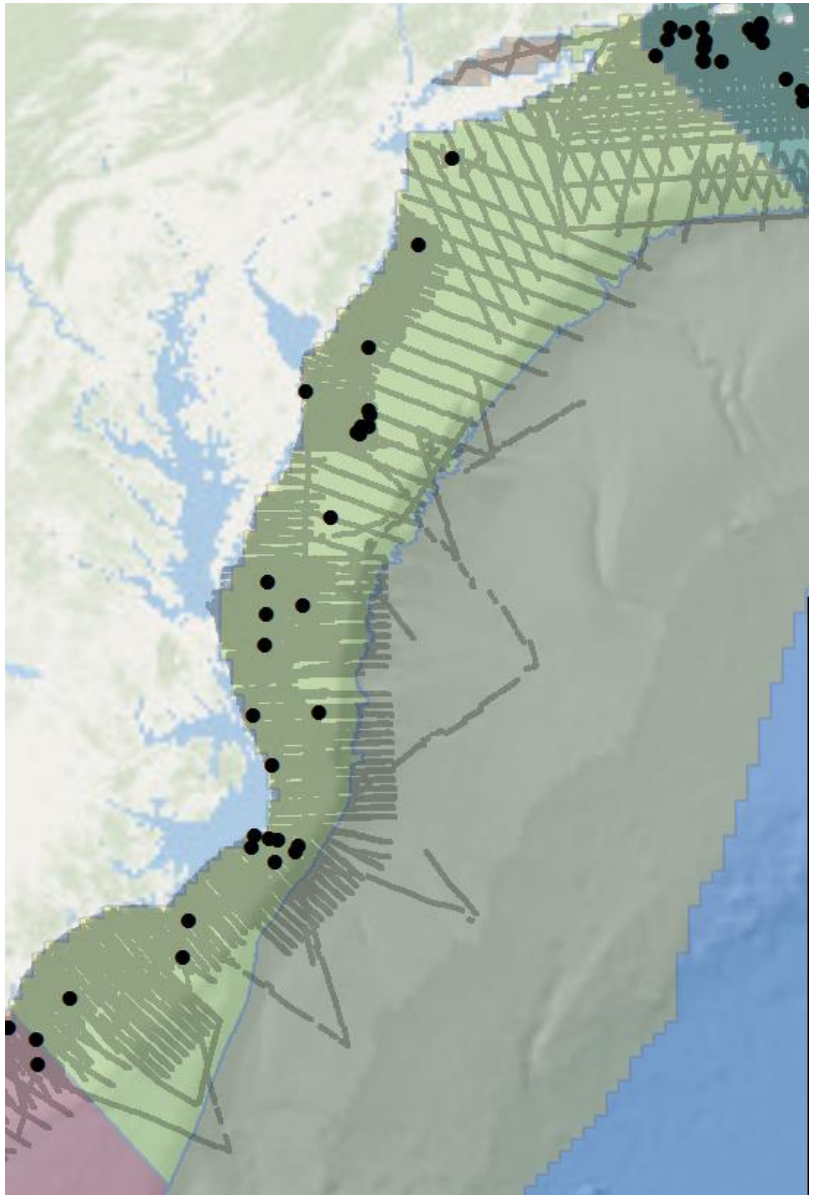
With inshore spatial extrapolation



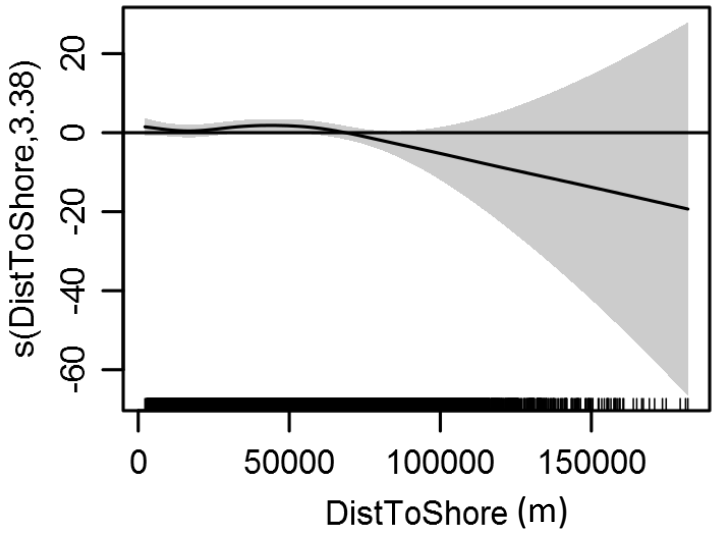
Frequently Asked Question

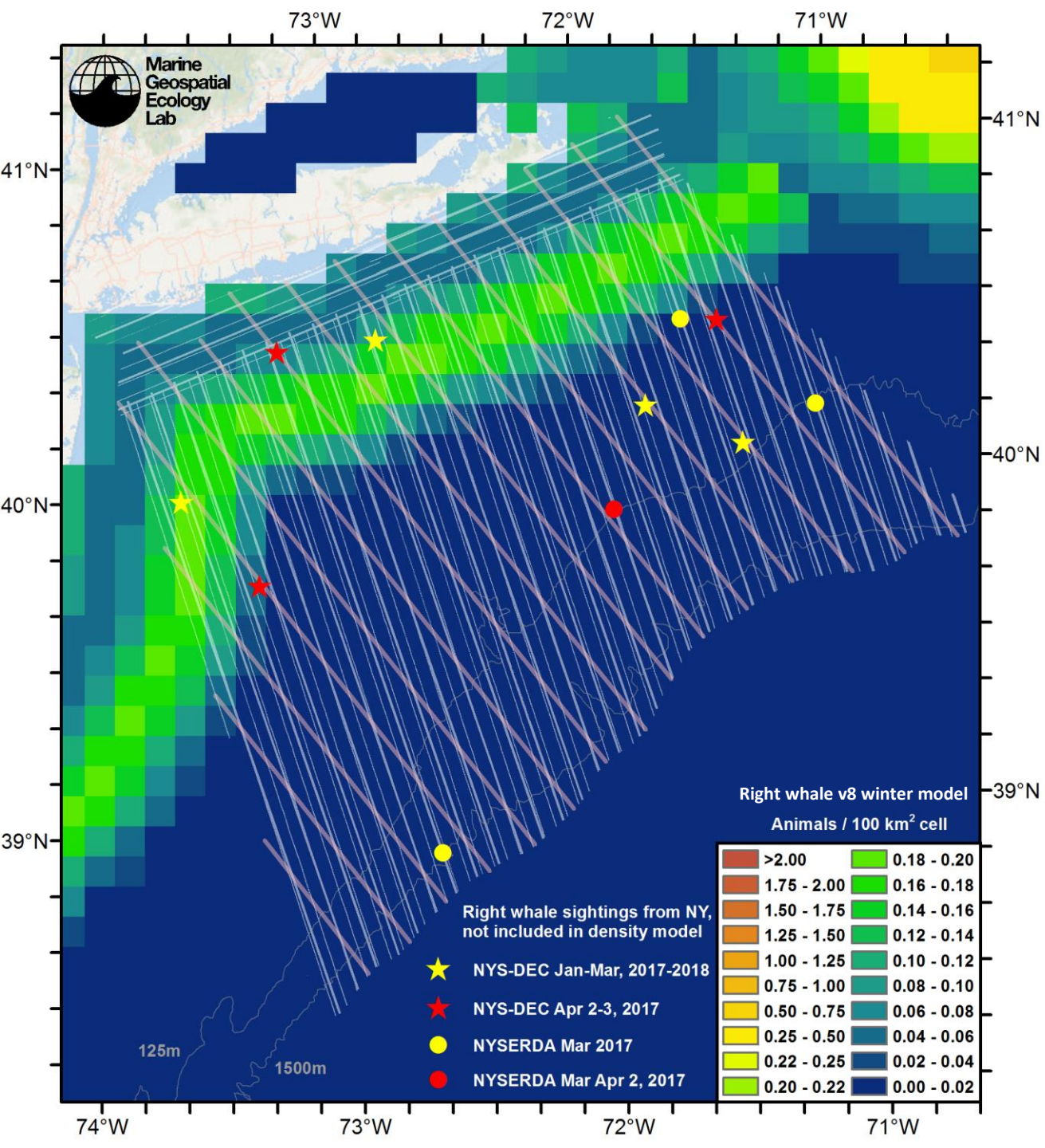
Is the "band" of right whales predicted along the mid-Atlantic in winter realistic? Don't right whales go farther out over the shelf?





In the data available to us for the v7 and v8 models, there were only 28 sightings between Cape Fear and Block Island. This was barely enough to fit a model with a single covariate. We tried many candidates. Most concentrated density close to shore. This was logical, as there was effort across the shelf and the sightings *did occur* on the shoreward side. The ones that did not were either not statistically significant or produced clearly unrealistic patterns. So we selected Distance To Shore as the best model.





We anticipate this could change in the upcoming v9 model, which will include surveys from 2017-2018 in the mid-Atlantic region that reported sightings substantially farther from shore.

Here is one example. Our v8 “winter” model spans December-March. Assuming we use the same definition for v9, the yellow sightings would be incorporated into that model, and the red would be incorporated into the “spring” model.

NEW YORK STATE OF OPPORTUNITY. Department of Environmental Conservation

TETRA TECH

NEW YORK STATE OF OPPORTUNITY. NYSERDA

NORMANDEAU ASSOCIATES ENVIRONMENTAL CONSULTANTS

IEc

2019 ALWTRP Model Updates

Prepared for:

Greater Atlantic Regional Fisheries Office

National Marine Fisheries Service

55 Great Republic Drive

Gloucester, MA 01930

Prepared by:

Industrial Economics, Incorporated

2067 Massachusetts Avenue

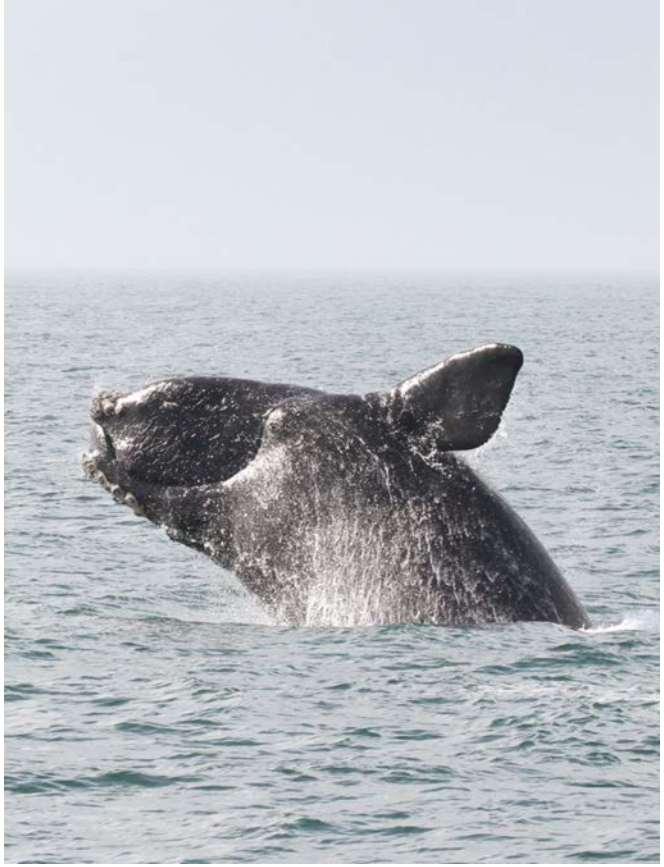
Cambridge, MA 02140

617/354-0074

April 16, 2019

Review: Goals of the Modeling Effort

- Provide members of the ALWTRT with data to build a common understanding of:
  - The seasonal distribution of commercial fishing gear off the Atlantic coast.
  - The seasonal distribution of North Atlantic right whales, humpback whales, and fin whales in these waters.
- Support development of NMFS' vertical line strategy for the ALWTRP.
- Provide analytic support for NMFS' rulemaking process.



North Atlantic right whale *(Eubalaena glacialis)*
Photo: Georgia Department of Natural Resources

Review: Guidelines for Model Design

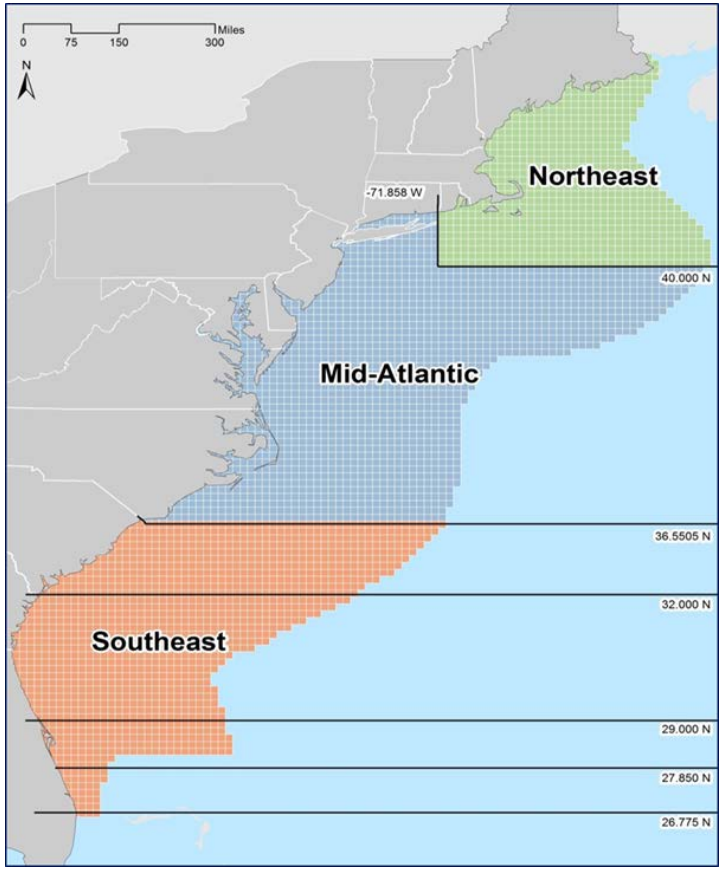
- Design the model with sufficient flexibility to:
  - Incorporate data from disparate sources.
  - Analyze a range of management measures (e.g., closures, gear modification requirements).
- Provide information on protected species and fishing activity in a variety of forms:
  - Maps/animations to illustrate spatial/temporal patterns.
  - Tables and charts to support numerical comparisons.
  - Range of indicators of fishing activity/potential for protected species to encounter commercial fishing gear.
- Maintain an open and transparent development process:
  - Involve the TRT in model design, data collection, and the development of key assumptions.
  - Flexibility to adapt the model to evolve with the TRT's interests and needs.

Review: Development Timeline

2005 – 2010:	Prototype development and data collection. Expanded geographic scope/methods refinement. Module for analysis of management VL scenarios.
2011-2014:	Analysis of TRT proposals. Documentation and peer review. Analysis of proposed and final rule. Draft and Final Environmental Impact Statement.
2014-2015:	Analysis of exemption proposals. Draft and Final Environmental Assessment.
2017-2018:	Transition to a more flexible online interface. Update state and federal data for 2016.
2019:	Update methods for estimating fishing activity. Update state and federal data for 2017. Integrate Duke RW Density model. Integrate NEFSC-developed threat and risk indicators.

Review: Scope

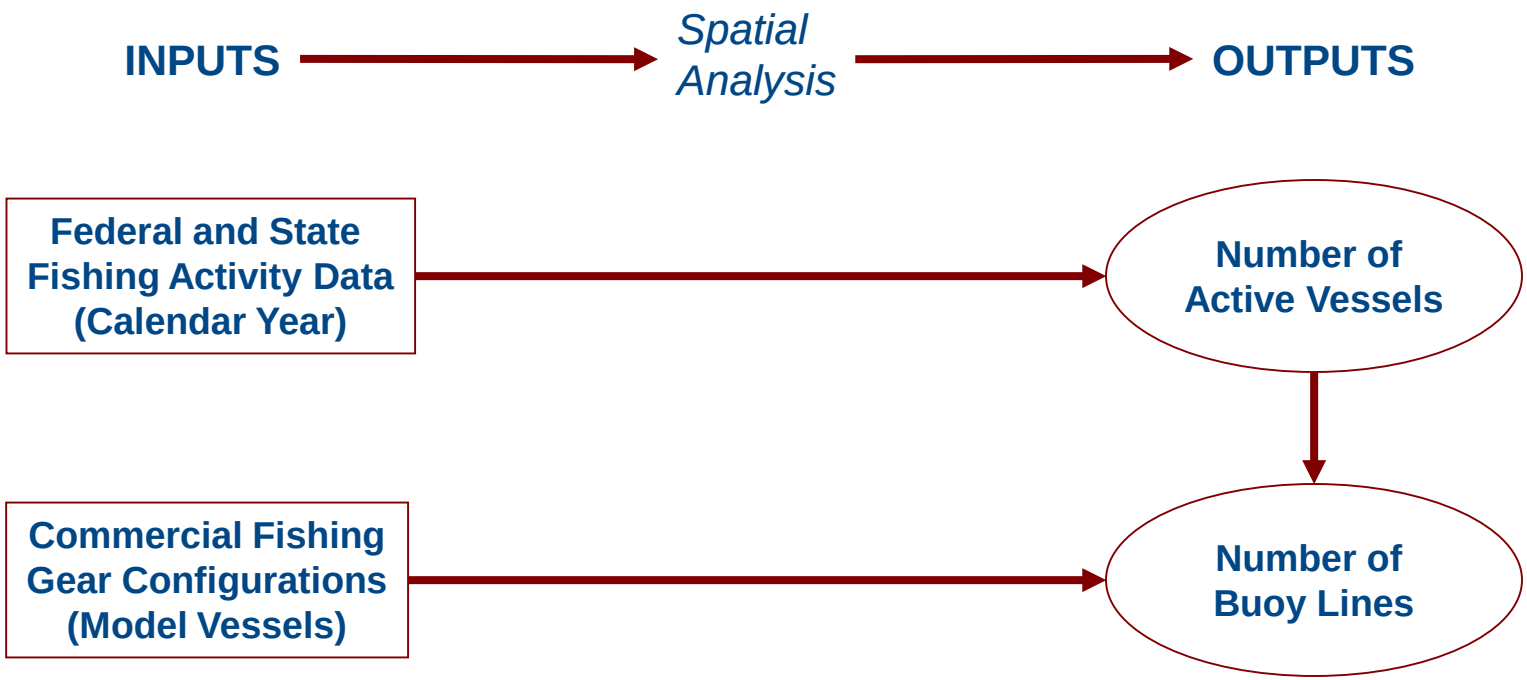
- Software (Updated in 2017):
  - PostGreSQL
  - Pentaho Data Integration
  - Geoserver
- Fisheries:
  - American lobster.
  - Sink and anchored gillnets.
  - Blue crab.
  - Other trap/pot (e.g., black sea bass).
- Protected Species
  - Right Whale
  - Humpback Whale
  - Fin Whale
- Geographic resolution:
  - 1-minute grid cells (analysis/reports).
  - 10-minute grid cells (mapping).
- Temporal resolution: monthly.



Geographic Scope: All waters subject to the requirements of the ALWTRP. Ability to view whale information in Canadian waters if available

Conceptual Overview

Methods and data sources are consistent with previous versions of the model, with improvements to include best available data.



Summary of 2019 Updates

- Improvements to the interface.
  - Provides a more flexible, user friendly approach.
  - Allows for straightforward inclusion of new sources of data (e.g., Duke Right Whale Density model).
- Data and methodological improvements.
  - Updated fishing activity and gear configuration data for 2017.
  - Applied state information in Nearshore waters to improve estimates of the magnitude and location of lobster activity.
  - Refined spatial distributions for offshore lobster vessels.
  - Updated model vessels to reflect the best available information from state fisheries managers.
  - Updated model vessels to reflect 2014/2015 rulemakings.
  - Applied trap and trap/trawl limitations to areas in Maine that are subject to these restrictions.

Data Sources: Vessel Activity

- Federal
  - 2017 Northeast Vessel Trip Report (VTR).
  - 2017 NMFS Permit data (LMA 3 Lobster only).
  - 2017 Southeast Logbook data.
- State
  - Obtained via outreach to state fishery management agency representatives.
  - 2017 data (CT based on 2016 data).
  - Includes waters designated as exempt and non-exempt from the 2014/2015 vertical line rulemaking.
  - Sources vary by state (e.g., trip reports, monthly catch reports, permit data, dealer reports, and surveys).
  - Typically indicates location by state management zone.

Updates: Vessel Activity

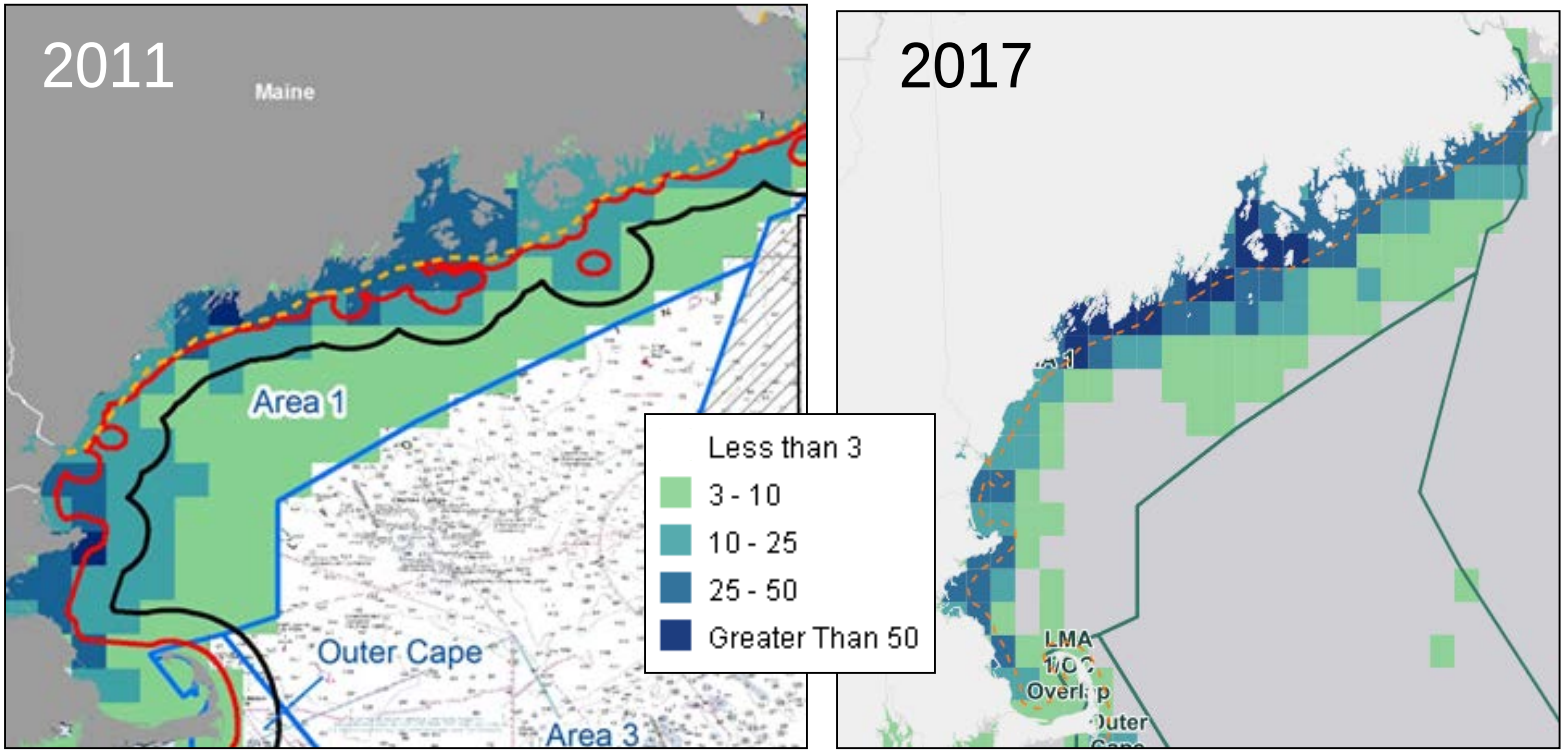
- Worked with the ME, MA, NH, and RI fisheries management representatives to address lack of VTR reporting in the federal lobster fishery.
- The model previously used permit and VTR data as proxies to estimate the number of non-reporting vessels engaged in lobstering each month within each LMA.
- State fisheries managers felt strongly that this approach did not adequately represent the location and magnitude of vessel activity in nearshore waters.
- Based on their recommendation, the model now applies state data on the activity and location of vessels that hold federal permits (but do not report to VTR) in the nearshore areas.

Updates: Vessel Activity

- To avoid double-counting vessels in Maine state and nearshore waters, we omit the use of VTR in those areas.
- In Northeast offshore waters, the model continues to use permit and VTR data to estimate unreported activity by vessels holding Federal lobster permits.
  - Previous approach distributed the activity of these vessels equally across all of LMA 3.
  - The model now distributes their activity to each of the offshore NMFS statistical areas in proportion to the distribution of trips reported by lobster vessels that submit VTRs.

Updates: Vessel Activity

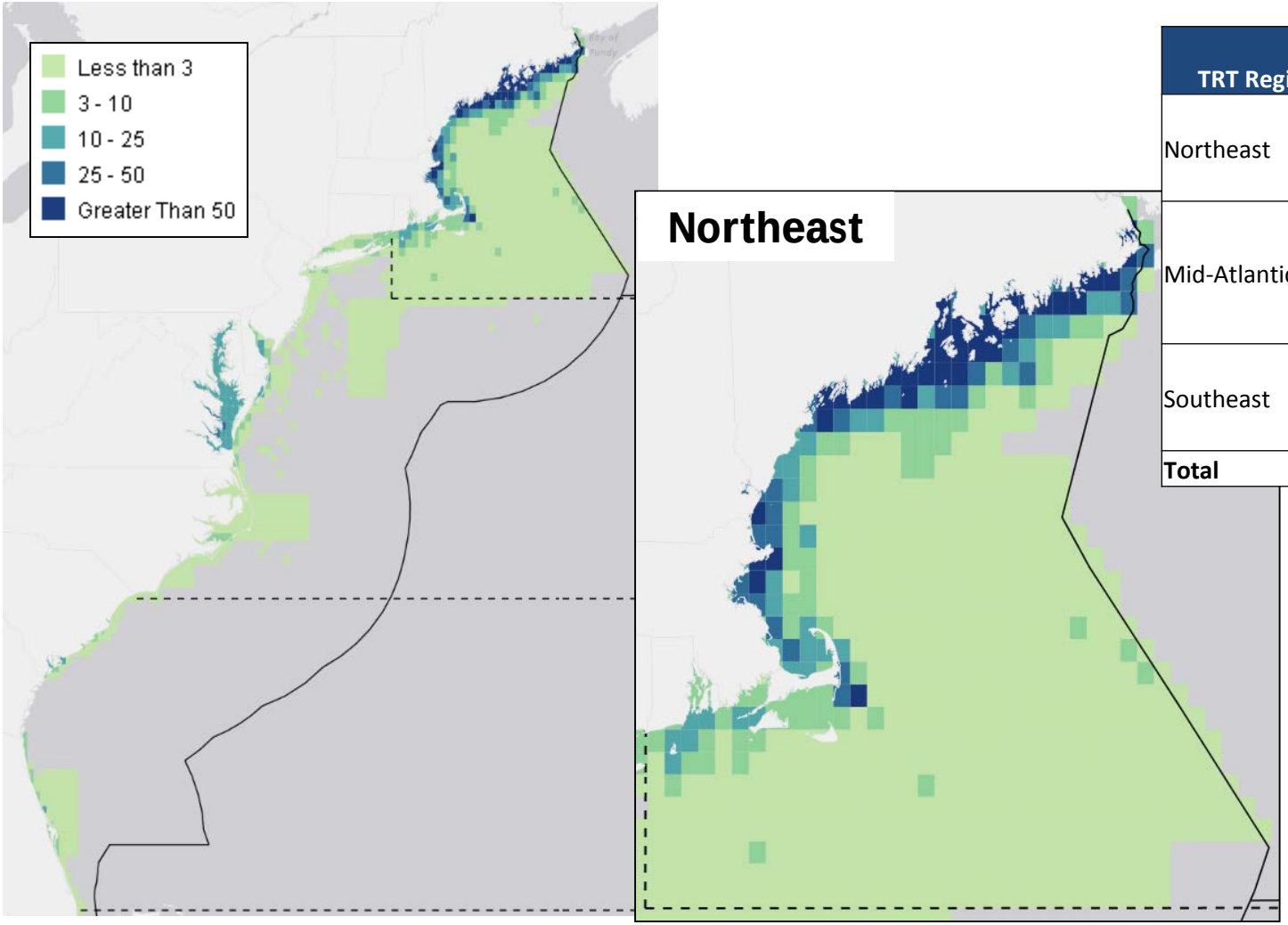
- Outcome: Improved estimates of the magnitude and location of activity in nearshore waters, particularly LMA 1.



Estimated Number of Active Vessels ~ All Fisheries (Monthly Average)

2017 Draft Example Results: Vessel Activity

Estimated Number of FTE Active Vessels | September | All Fisheries | All Waters



TRT Region	Fishery	# FTE Active Vessels
Northeast	Lobster trap/pot	5,199
	Sink Gillnet	148
	Other trap/pot	123
Mid-Atlantic	Lobster trap/pot	131
	Sink Gillnet	302
	Other trap/pot	128
	Blue crab pot	1,166
Southeast	Sink Gillnet	10
	Other trap/pot	0
	Blue crab pot	222
Total		**7,430**

Data Sources: Model Vessel Gear Configurations

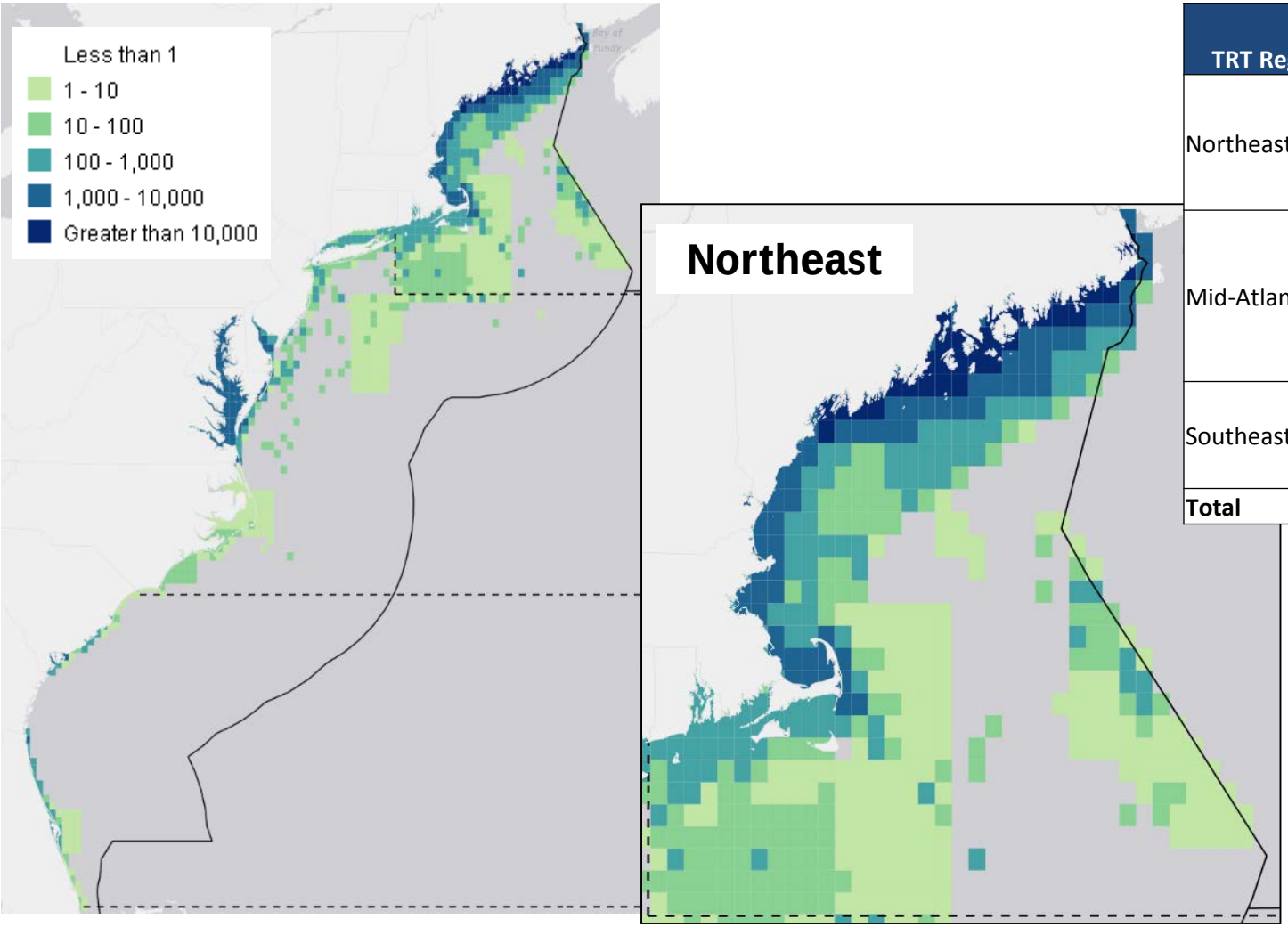
- Federal waters:
  - For Nearshore lobster and other trap/pot, apply ME, MA, and RI data, where available.
  - For Nearshore blue crab, apply data for nearest states.
  - Northeast Domestic Observer Program (gillnet).
  - Best professional judgments of NMFS gear team.
- State waters:
  - Best available information from each state fishery management agency for 2017 (CT based on 2016 data).
  - ME, NH, MA, RI provided review and comment on the 2017 update to the lobster fishery.

Updates: Model Vessel Gear Configurations

- Updated model vessels to reflect the best available information from state fisheries managers.
- Over the last several years, Maine instituted trap and trawl-length maximums in specific locations along the coast. The model now incorporates these regions and applies the maximums that Maine has specified in characterizing activity within them.
- We assume that all model vessels will conform to the minimum trap-per-trawl requirements imposed by the 2014 vertical line rule and subsequent amendments.
  - For example, available data show a proportion of vessels fishing singles in state waters, which is allowed in the exempted area but prohibited in non-exempt waters. In the non-exempt share of the state zones, we assume this proportion of vessels will fish doubles, as allowed by the Plan.

2017 Draft Example Results: Buoy Lines

Estimated Number of Buoy Lines| September | All Fisheries | All Waters



TRT Region	Fishery	# Buoy Lines
Northeast	Lobster trap/pot	912,300
	Sink Gillnet	4,400
	Other trap/pot	3,800
Mid-Atlantic	Lobster trap/pot	8,500
	Sink Gillnet	2,000
	Other trap/pot	11,000
	Blue crab pot	255,600
Southeast	Sink Gillnet	100
	Other trap/pot	0
	Blue crab pot	22,600
Total		**1,220,200**

Integrating New Information

- Platform updates allow for the presentation and integration of new and emerging data. Latest version includes:
  - Duke Right Whale Density model (Roberts et al.)
  - Threat Score (NEFSC)
  - Risk Score (NEFSC)
- Model interface will allow for interactive viewing of 2017 baseline information at the April 2019 TRT meeting, as needed.

IEc

North Atlantic Right Whale *(Eubalaena glacialis)*
Credit: Georgia Department of Natural Resources (GADNR), Permit 15488

Decision Support Tool

Contributions from Burton Shank, Doug Sigourney
Danielle Cholewiak, Josh Hatch- NEFSC

Jason Roberts-Duke

Neal Etre-IEC

Presented by Sean Hayes NEFSC

- Presentation for Atlantic Large Whale TRT April 16, 2019

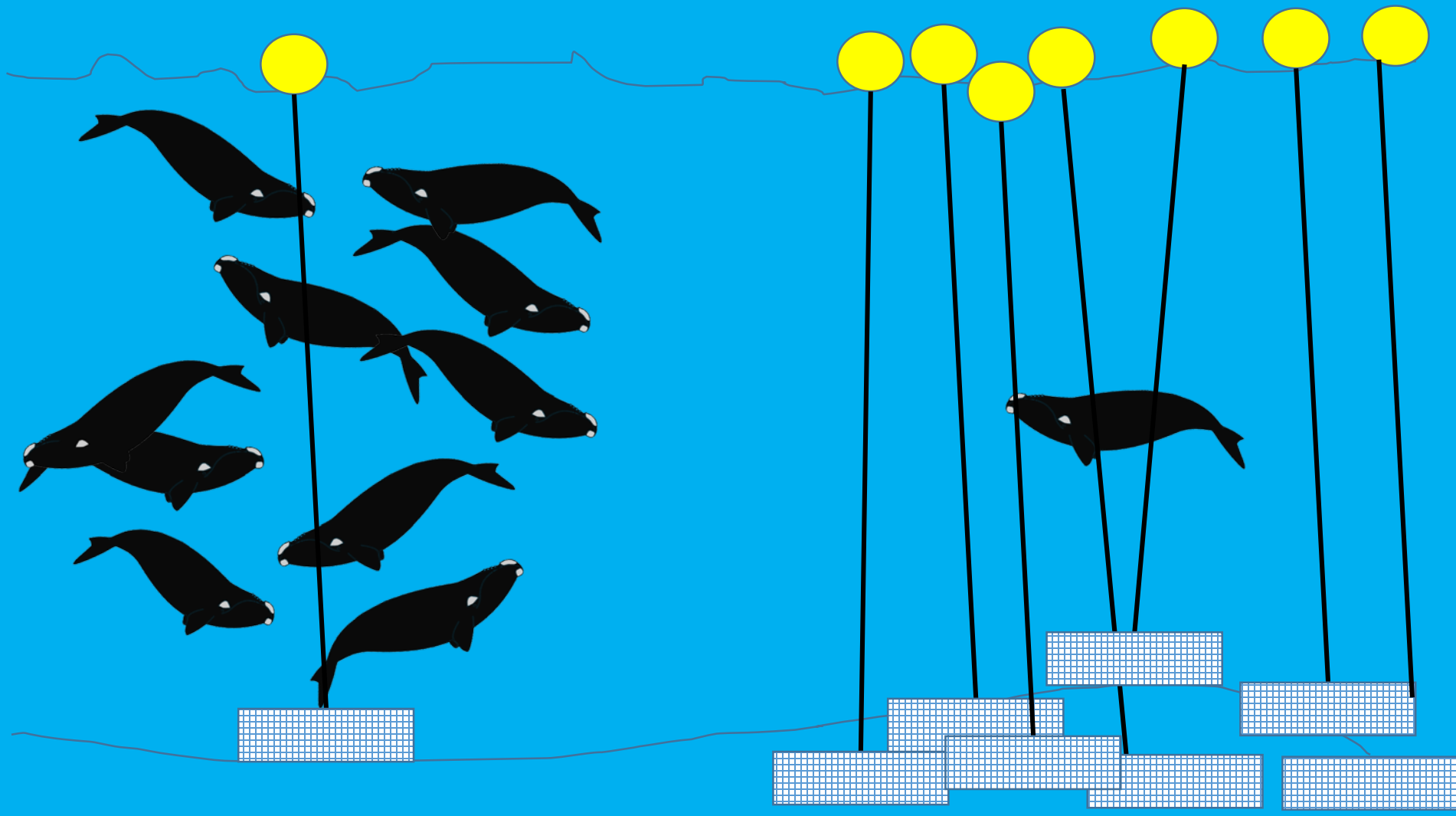
Risk = likelihood x severity

Likelihood

- # of lines/density
- # whales/density
- Encounter rate- unknown

- Severity
  - Serious Injury/Mortality (MMPA charge)
  - Sublethal

What has More Risk?



Tools to reduce risk

- Closures
- Trap/line reductions
- Lighter gear (weak rope, sleeves etc.)
- Line cutters
- Buoyless (acoustic or timer release etc)

How to compare?

Things we explored..

- Management Strategy Evaluation (MSE)
- Marxan- TNC
- Modeling encounter rates?

Feasible…

- Co-occurrence- IEC- where are whales and gear?

Next steps..

- Relative Risk Units- Farmer et al. 2016

$$Risk = Whales \ * Gear\ density \ * \boldsymbol{severity}$$

- Calculated for each month and area
- Summed across all months and locations

Farmer, N. A., T. A. Gowan, J. R. Powell, and B. J. Zoodsma. 2016. Evaluation of Alternatives to Winter Closure of Black Sea Bass Pot Gear: Projected Impacts on Catch and Risk of Entanglement with North Atlantic Right Whales Eubalaena glacialis. Marine and Coastal Fisheries 8(1):202-221.

$$Risk = Whales * Gear\ density * severity$$

Month	grid area	line type	Whale density	Gear Density	severity	Risk
January	533	medium	2	40	7	560
		heavy	2	60	10	1280
					total risk for Area 533 in January	**1760**
					TRT 60% reduction goal	**704**

(all numbers just for example only- not real values)

$$Risk = Whales * Gear\ density * severity$$

tentative solution- use lighter gear with lower severity score

Month	grid area	line type	Whale density	Gear Density	severity	Risk
January	533	Light	2	40	3.5	280
		Light	2	60	3.5	420
					total risk for Area 533 in January	**700**
					TRT 60% reduction goal	**704**

Goal reached

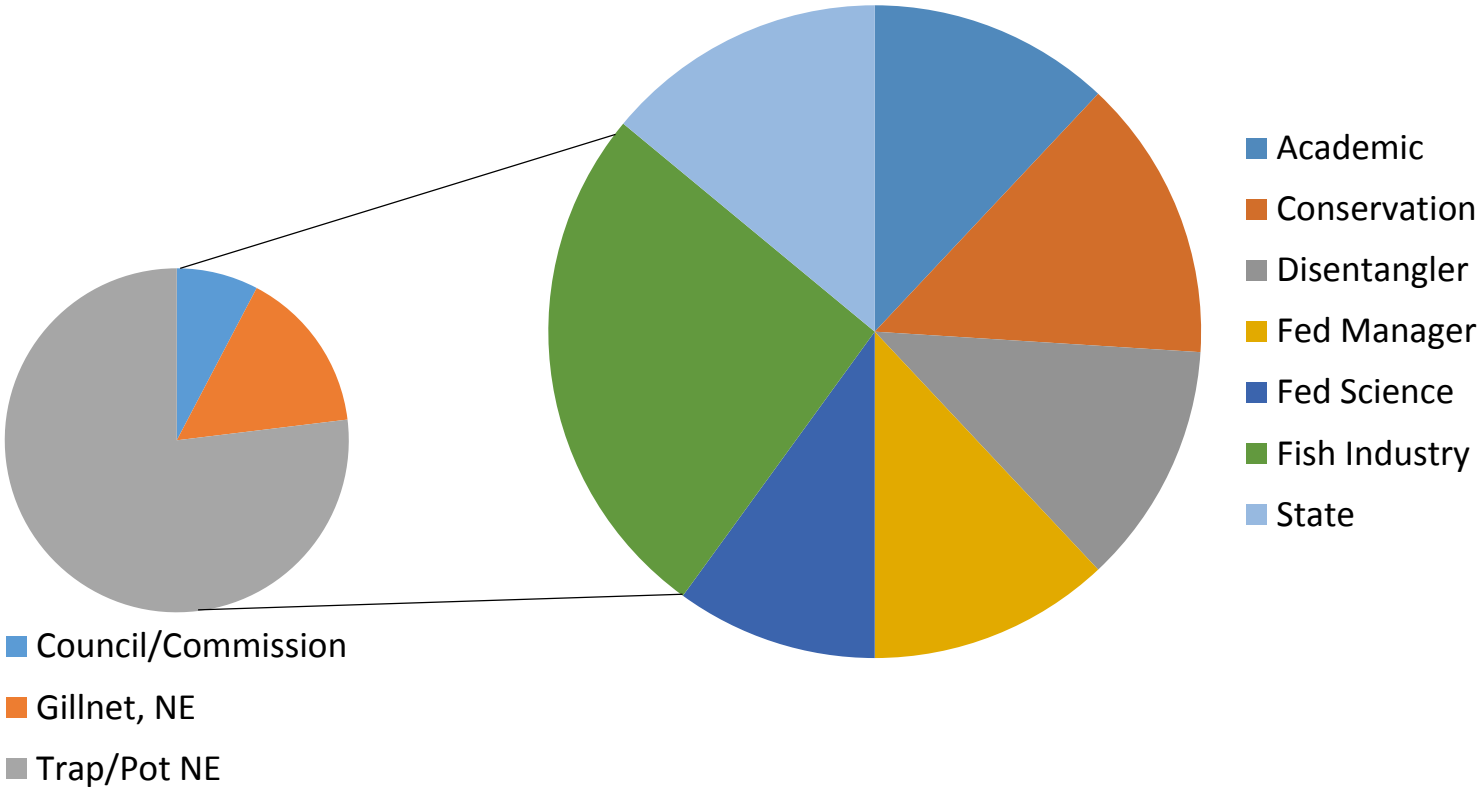
Severity- Poll informed TRT members and agency staff

- Provided list of gear types
  - 3/8” line with 1-3 traps
  - 5/8” line with >40 traps
- Score relative Risk severity scale 0-10
- Provided list of ‘risk modifiers’
  - Acoustic release- %time in water
  - Timer release- %time in water
  - Line cutters, sleeves, 1700lb rope (relative risk 0-10)

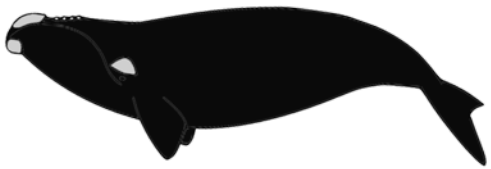
$$Risk = Whales * Gear\ density * severity$$

Preliminary poll results

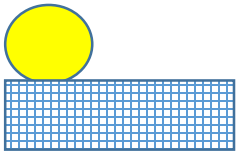
50 responses, some responses left some cells blank



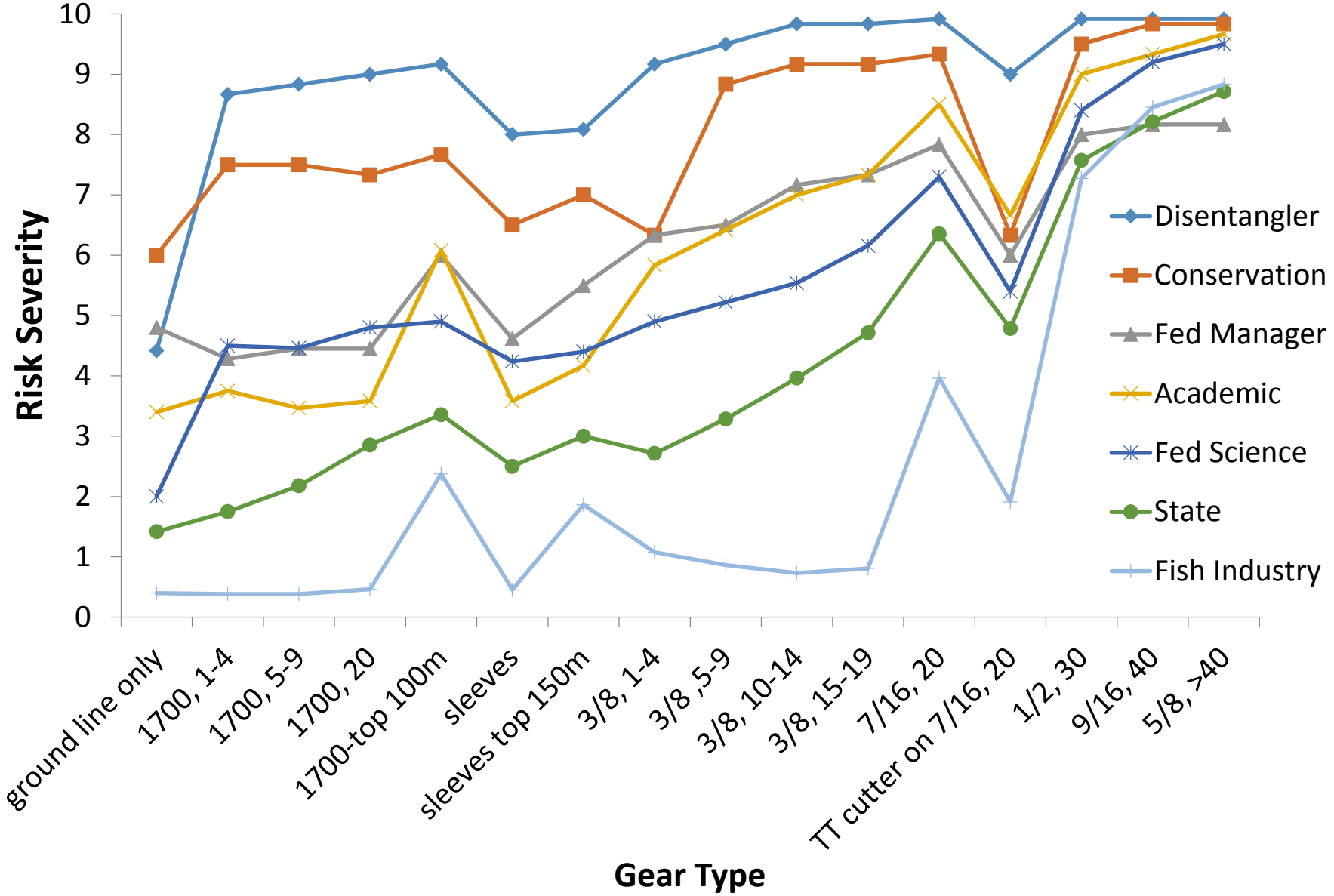
Buoyless results



Gear	% Time in water column	Credible interval
Timed release PopUp Inshore	48	(33-63%)
Time-release PopUp Offshore	54	(38-67%)
Acoustic recall PopUp	12	(6-20%)



Preliminary poll results



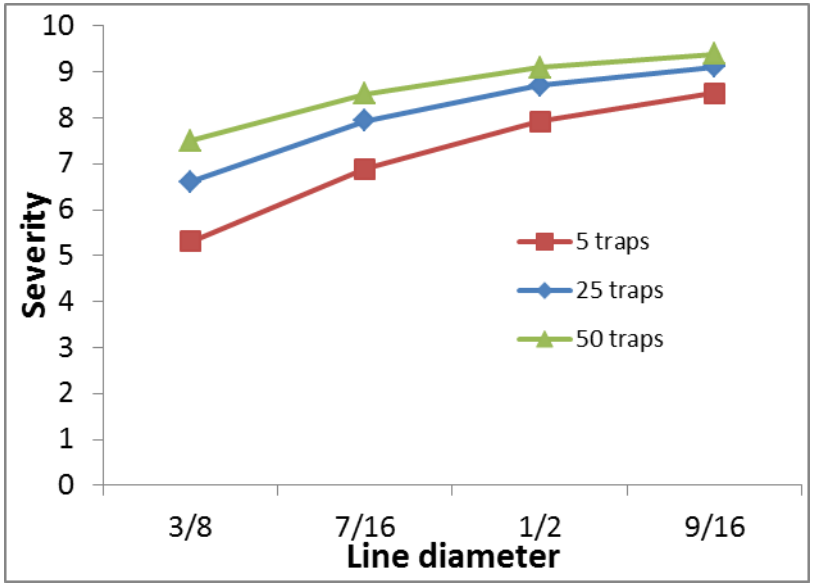
Poll means and ranking by gear type

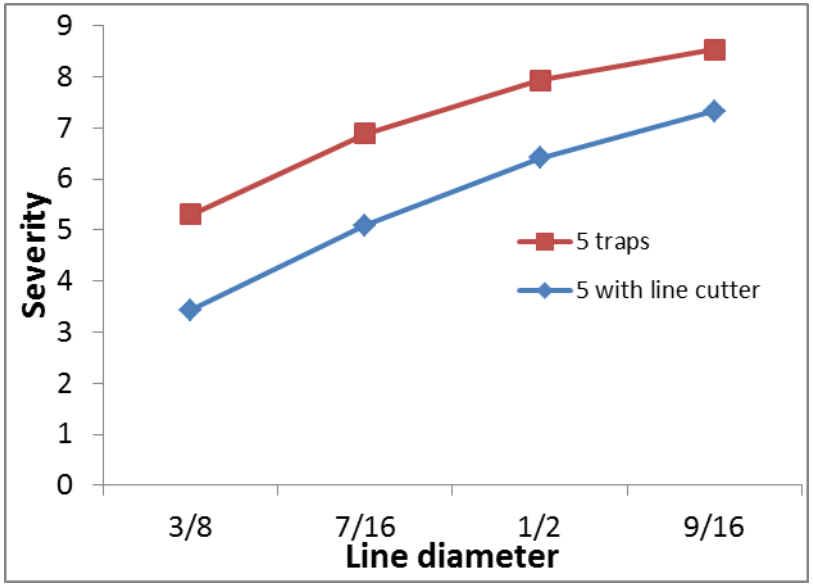
(range 0= no gear, 10 greatest risk)

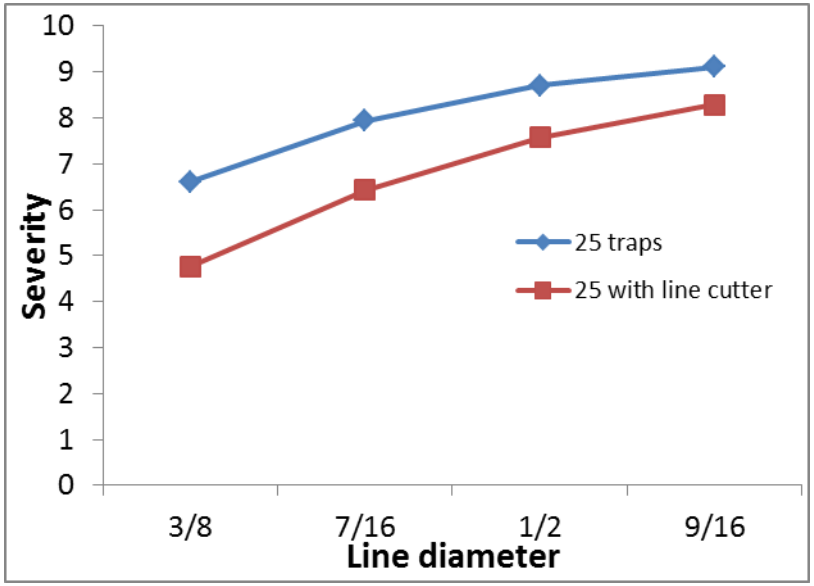
Gear Type	Raw Means	Mean risk score by caucus	*Baysien 'means'
ground line only	2.9	3.2	3.8
sleeves	3.8	4.3	4.2
1700lb, 1-4 traps	3.8	4.4	4.8
1700lb , 5-9	3.8	4.5	4.9
1700lb , 20	4.0	4.6	5.0
sleeves top 150m	4.5	4.9	5.4
3/8 line, 1-4 traps	4.6	5.2	5.2
1700lb -top 100m	5.2	5.6	5.9
TT cutter on 7/16, 20	5.3	5.7	6.1
3/8 line ,5-9 traps	5.1	5.8	5.5
3/8 line, 10-14	5.4	6.2	5.9
3/8 line, 15-19	5.6	6.5	6.2
7/16 line, 20	7.1	7.6	7.7
1/2 line, 30	8.4	8.5	8.8
9/16 line, 40	8.9	9.0	9.3
5/8 line, >40	9.2	9.2	9.7

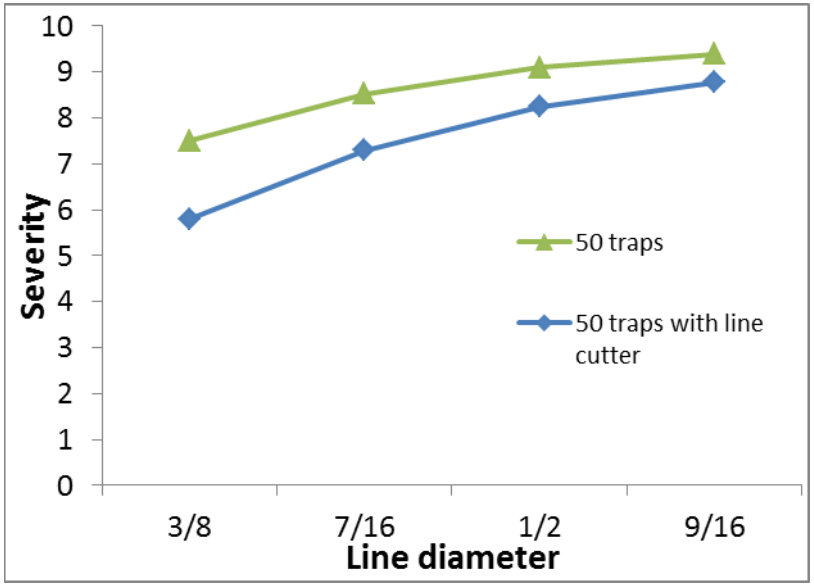
*Baysien means subject to final model run with specific parameters

Effect of trawl length and TT line cutter





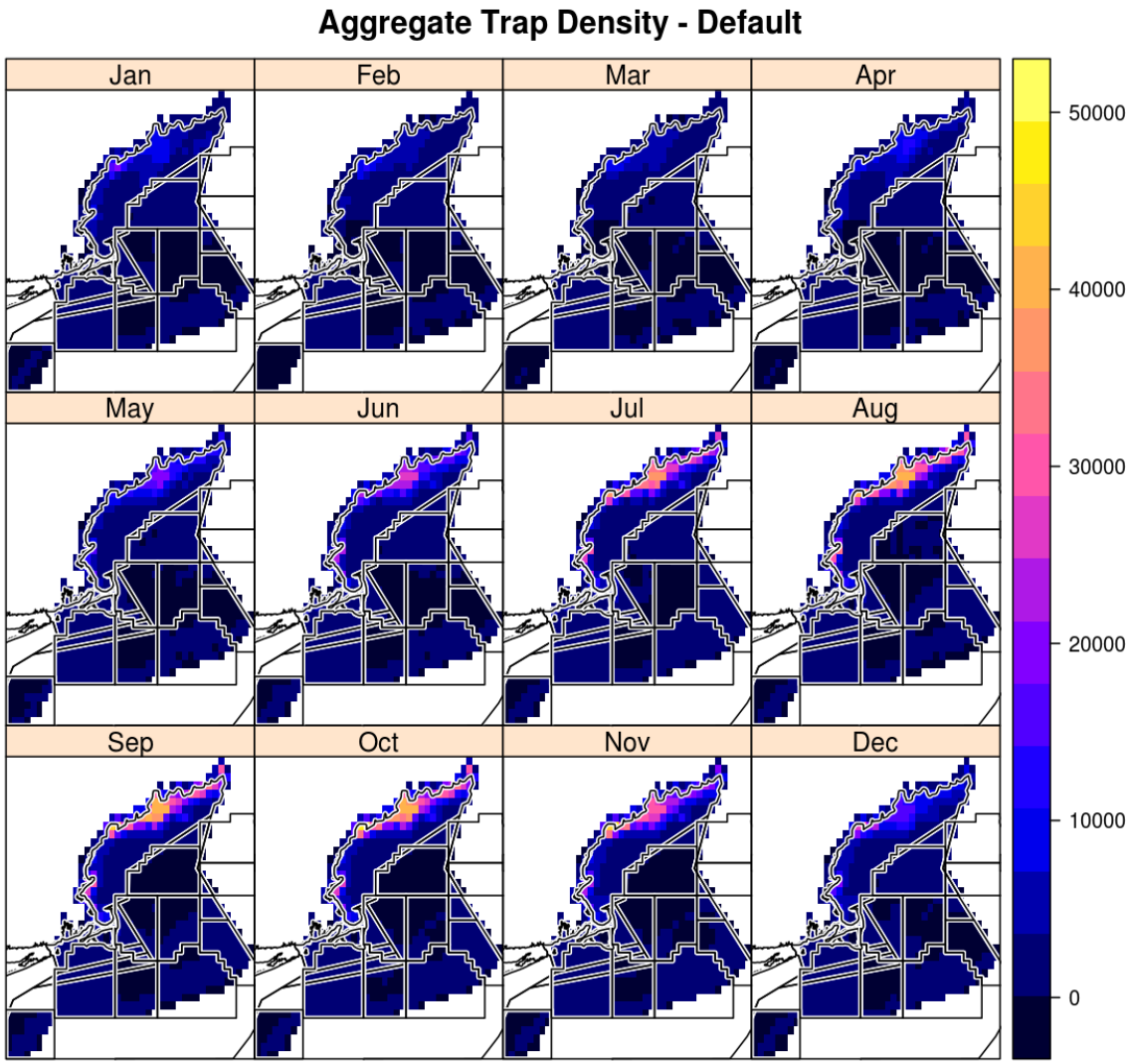




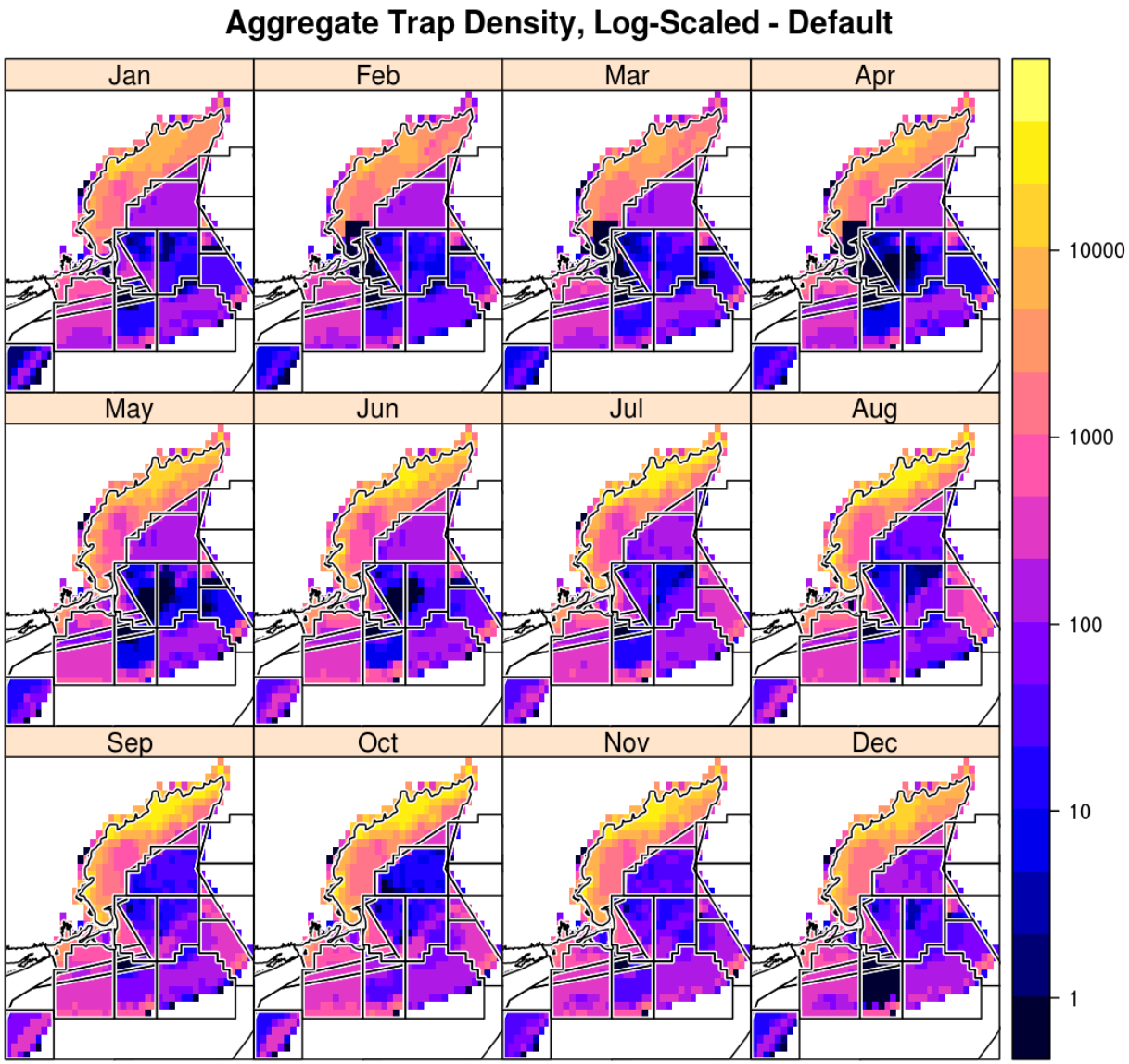
The Space Time continuum of whales and gear

Improved information

- Improved gear knowledge-
  - IEC model results and data sets
  - Observer data
  - VTR data
  - Data Contributions from ME
- Improved whale distribution
  - NARW density models- habitat affiliations- Roberts et al
  - Not in model- but available for key areas
    - Acoustic detections and recent Aerial survey observations



$$Risk = Whales * Gear\ density * severity$$



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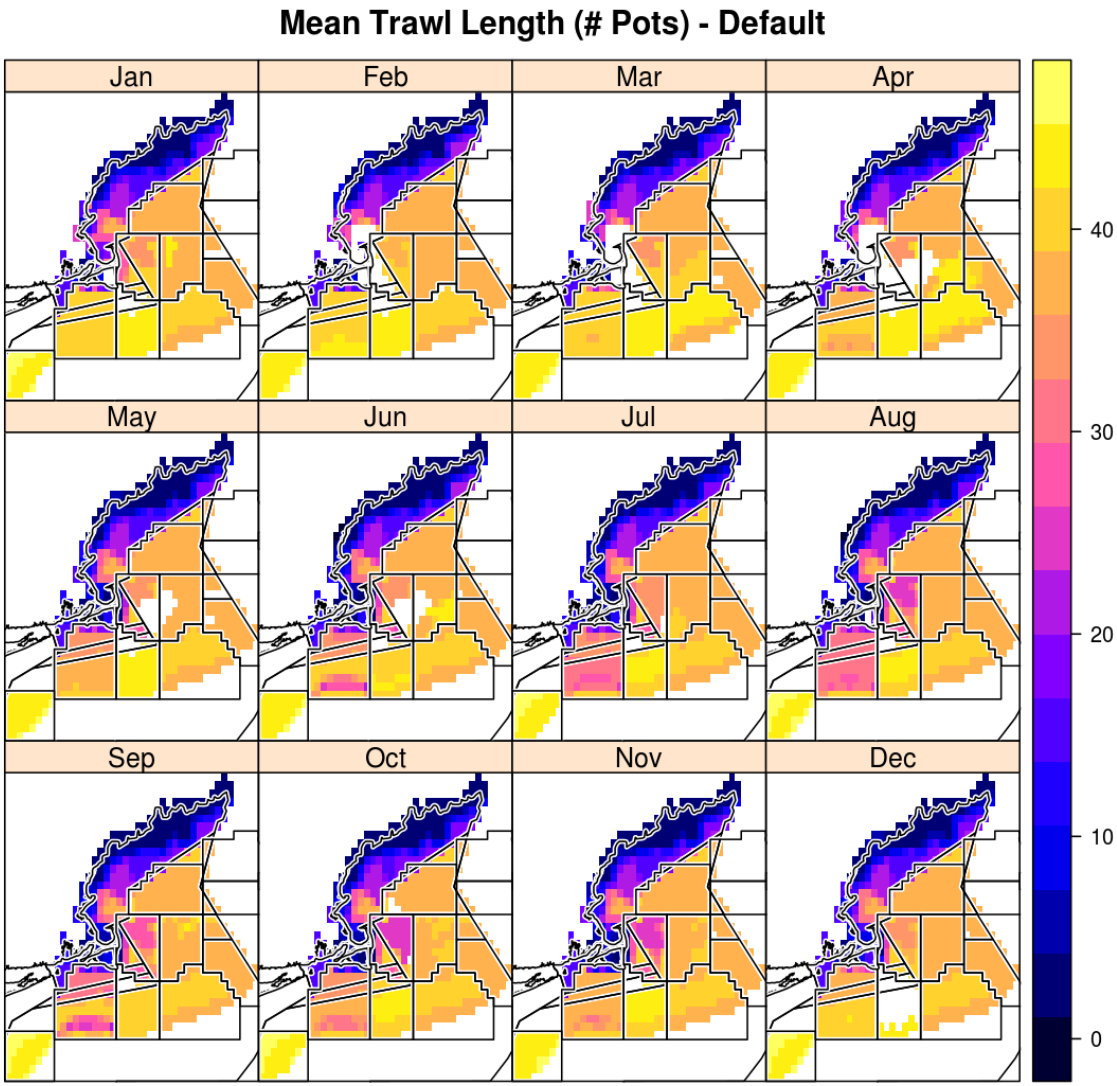

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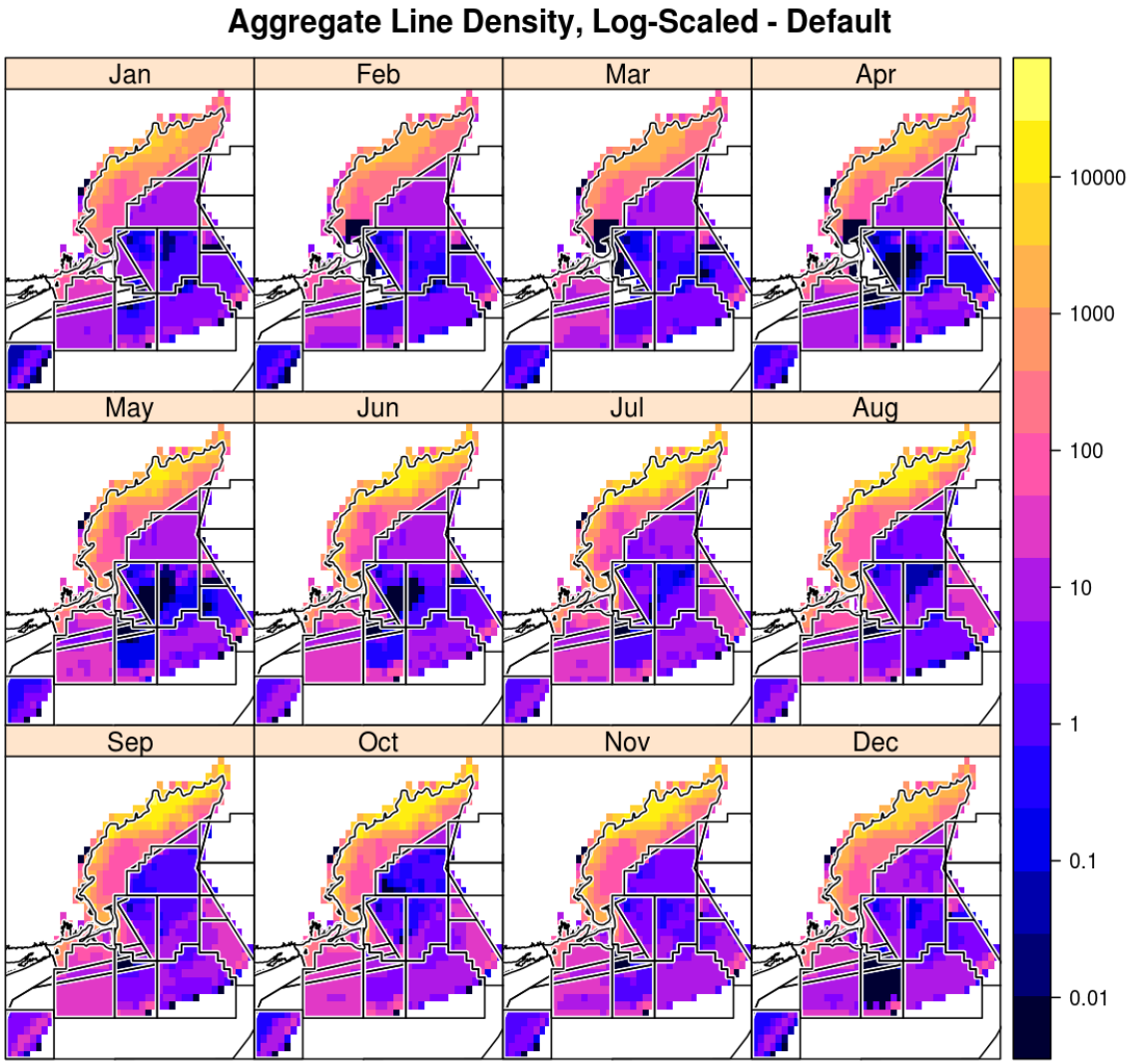

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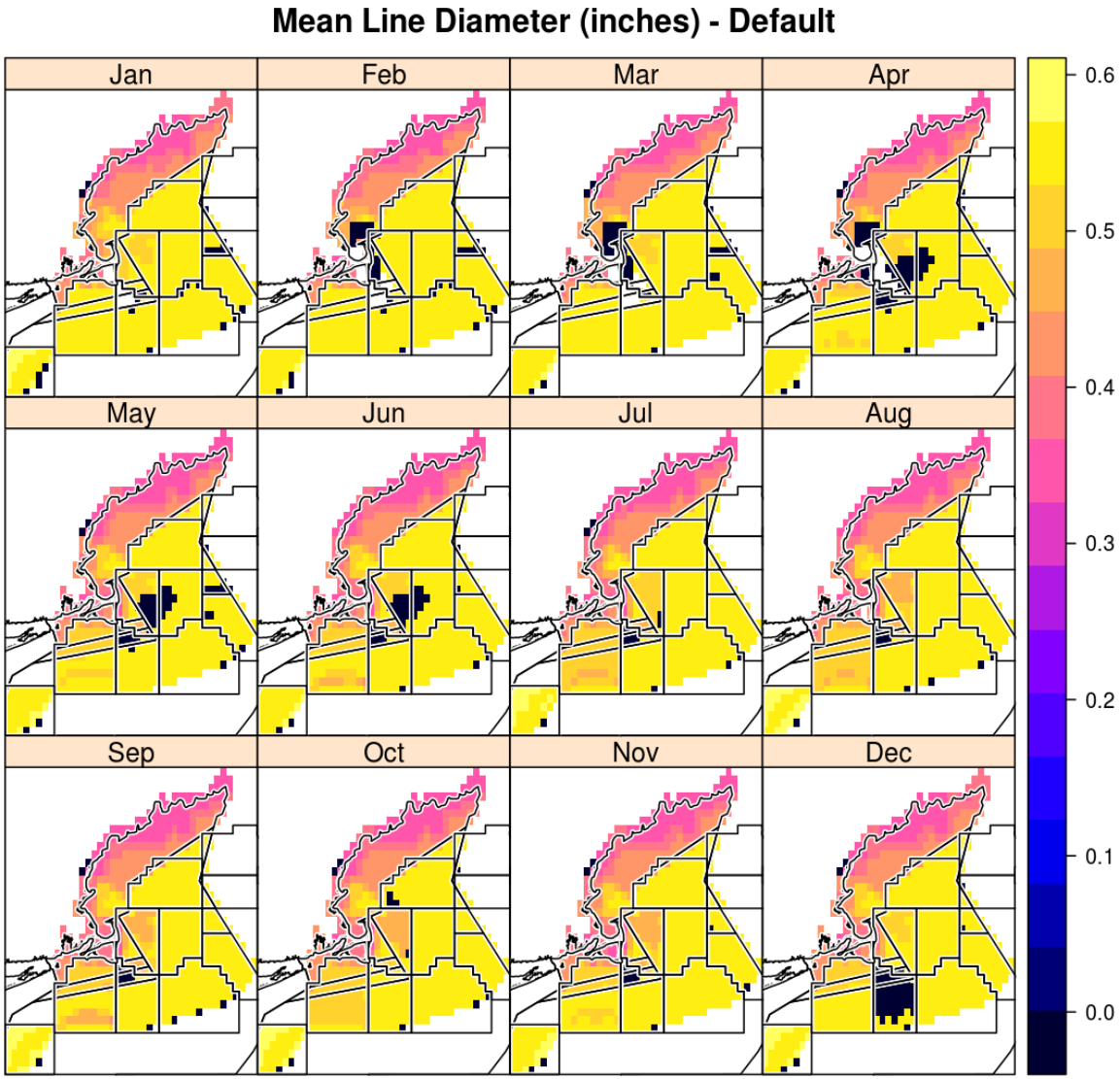

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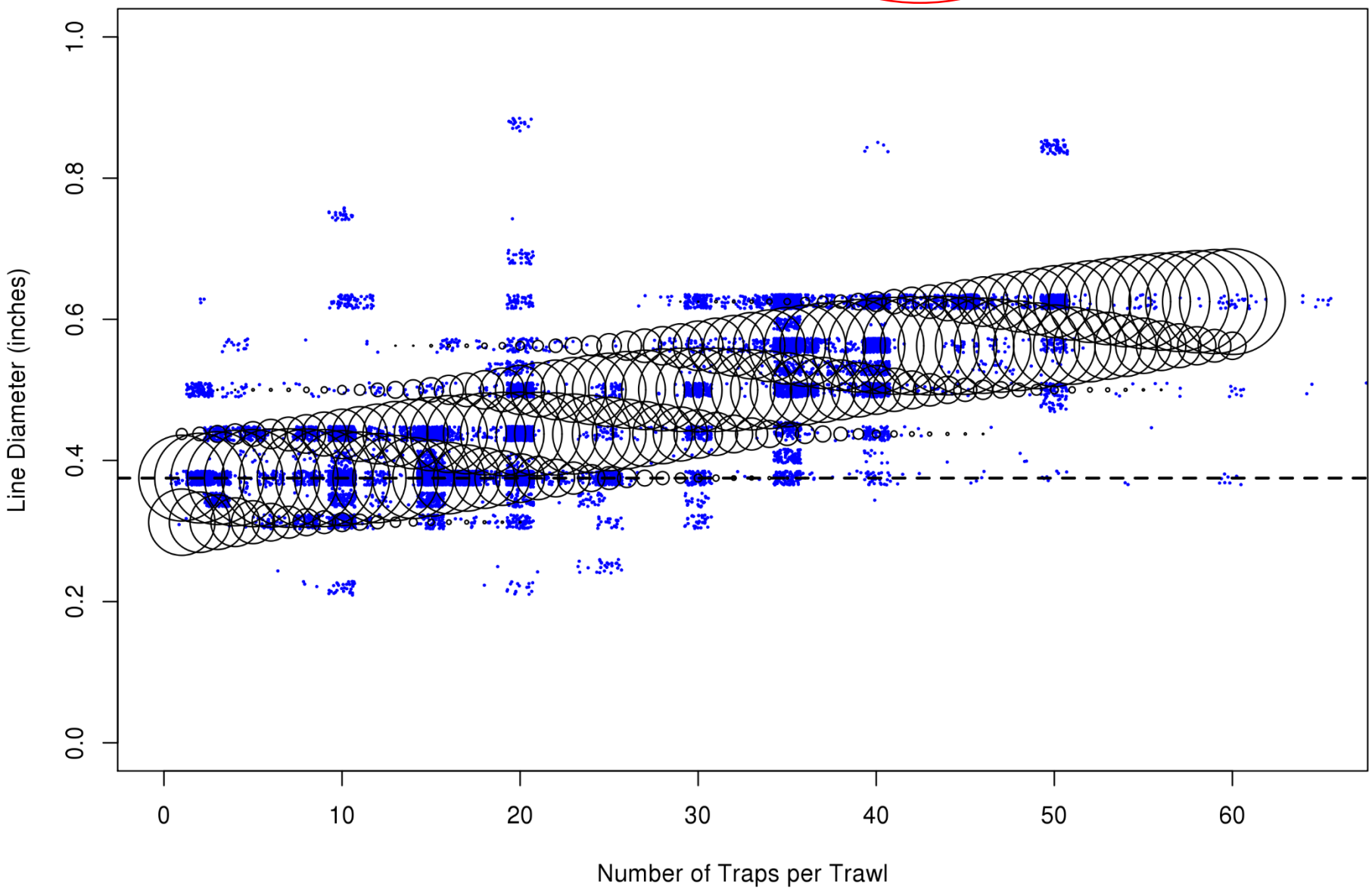
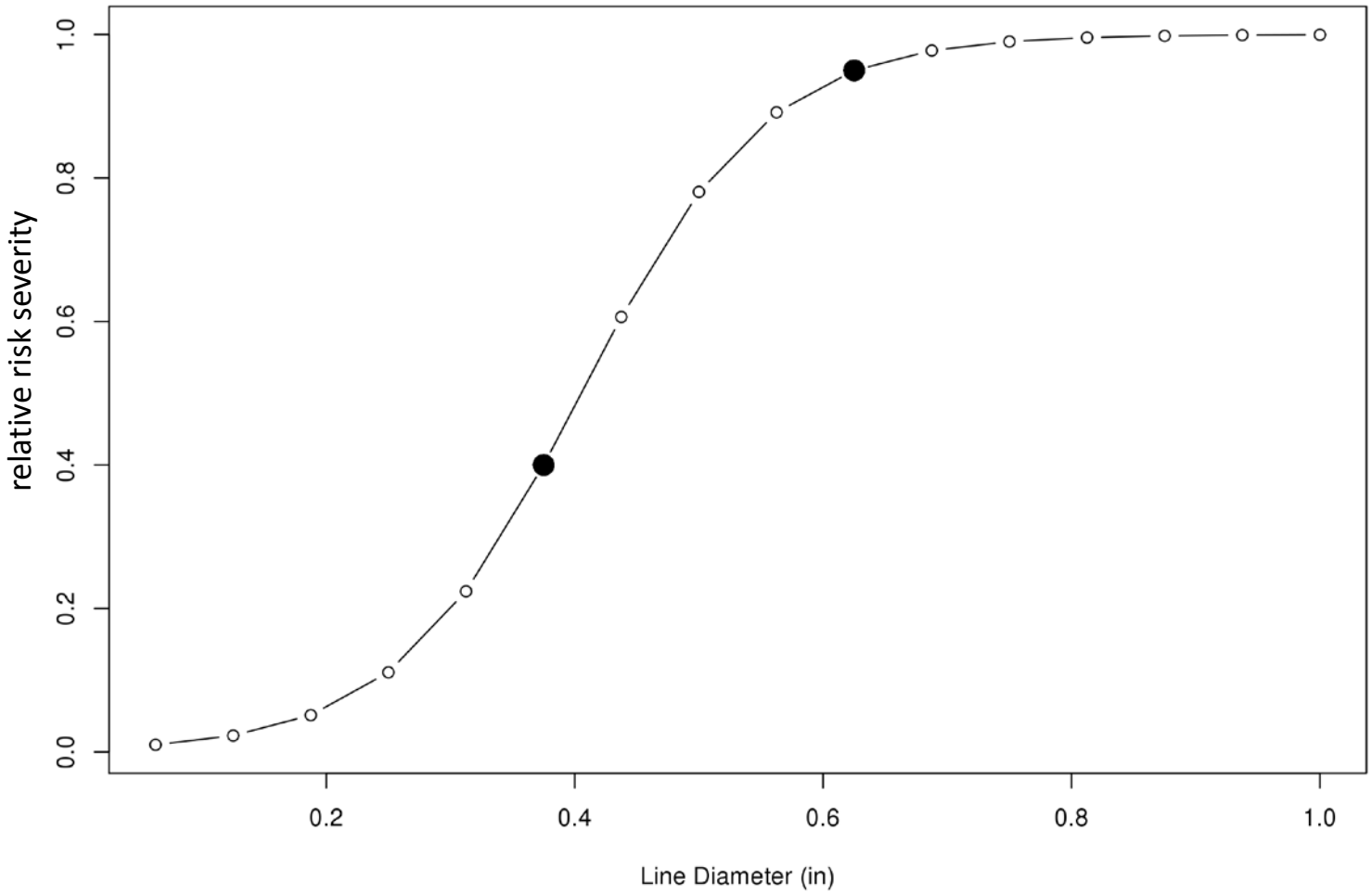
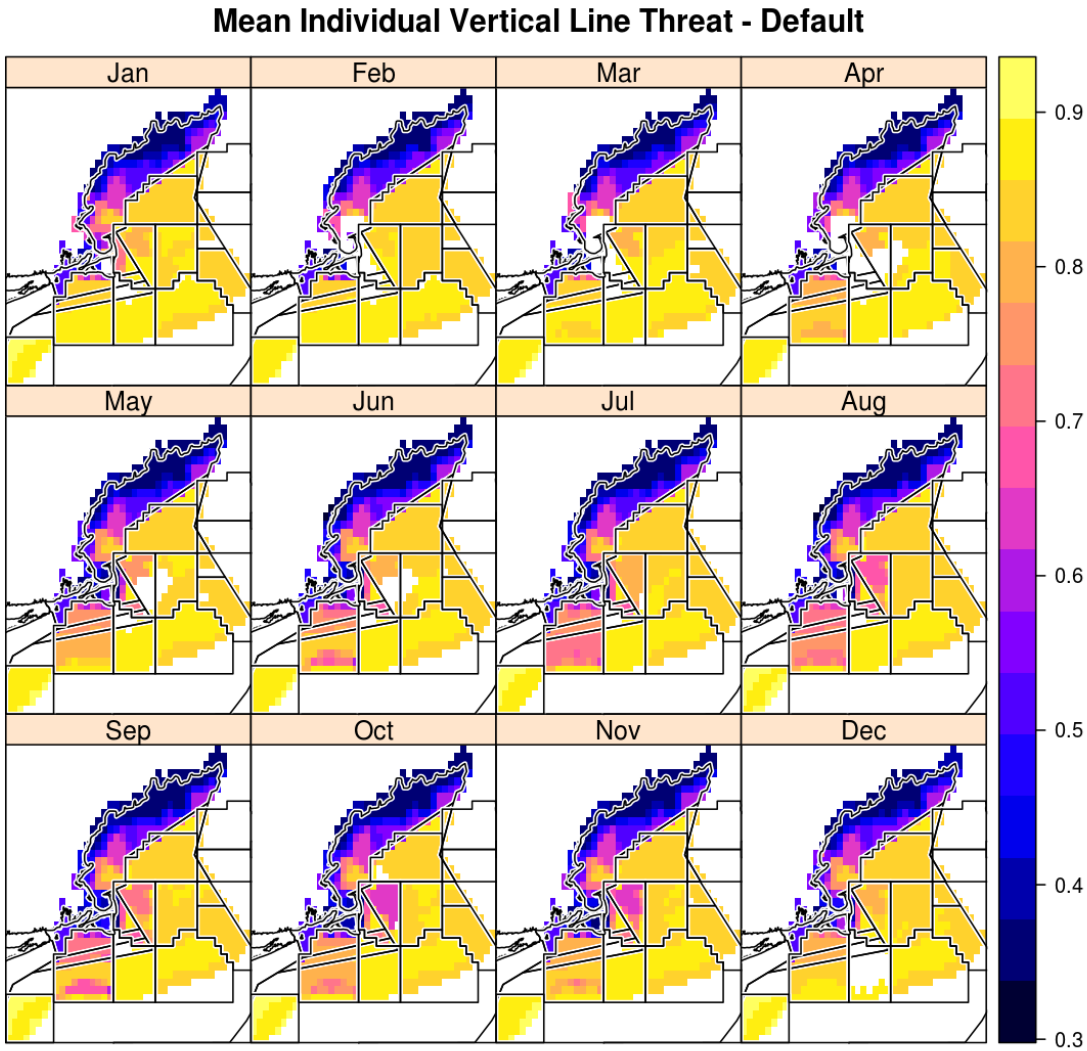


Example modeled relationship between vertical line diameter and relative risk severity

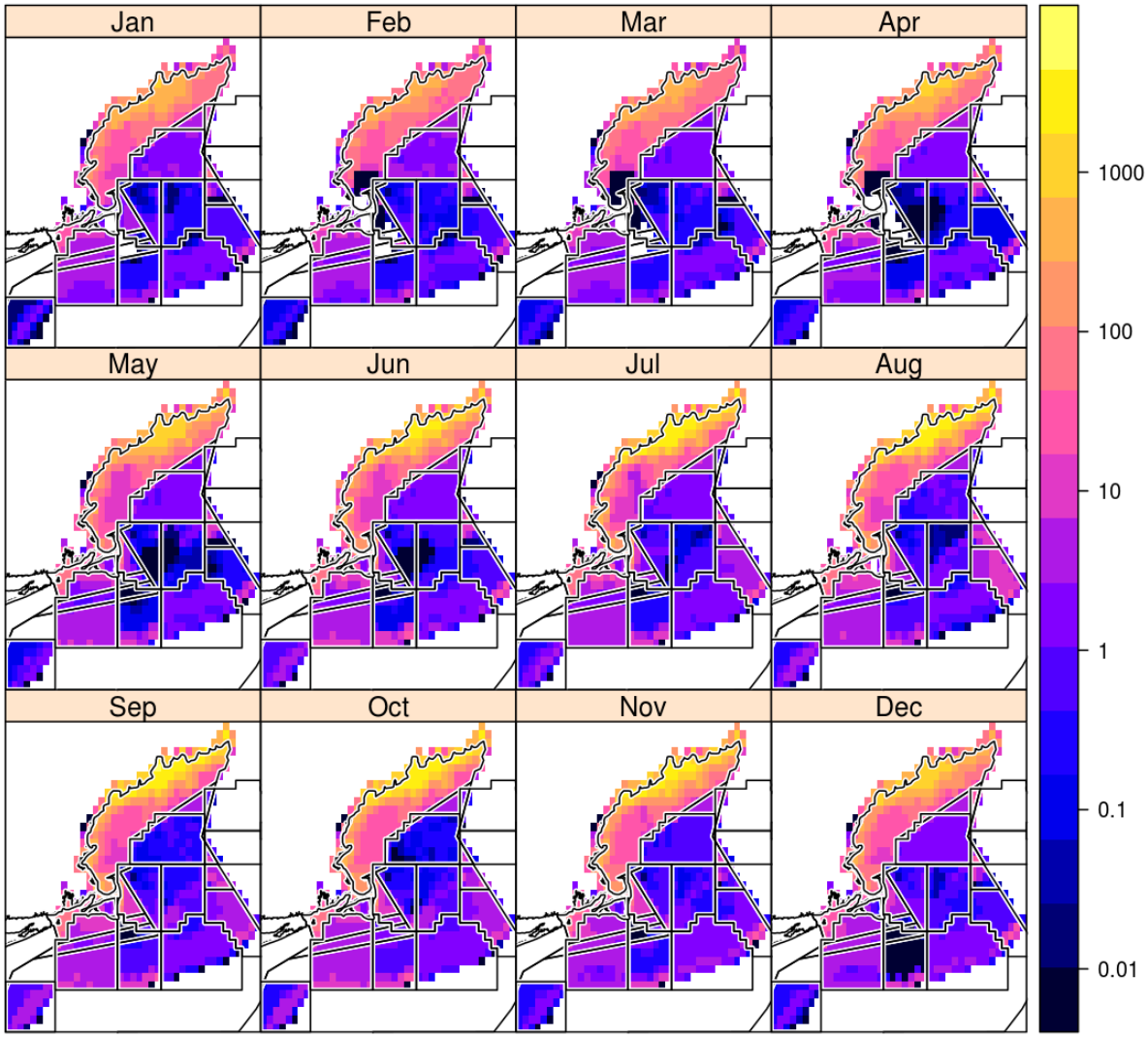


$$Risk = Whales \ * Gear\ density * severity$$

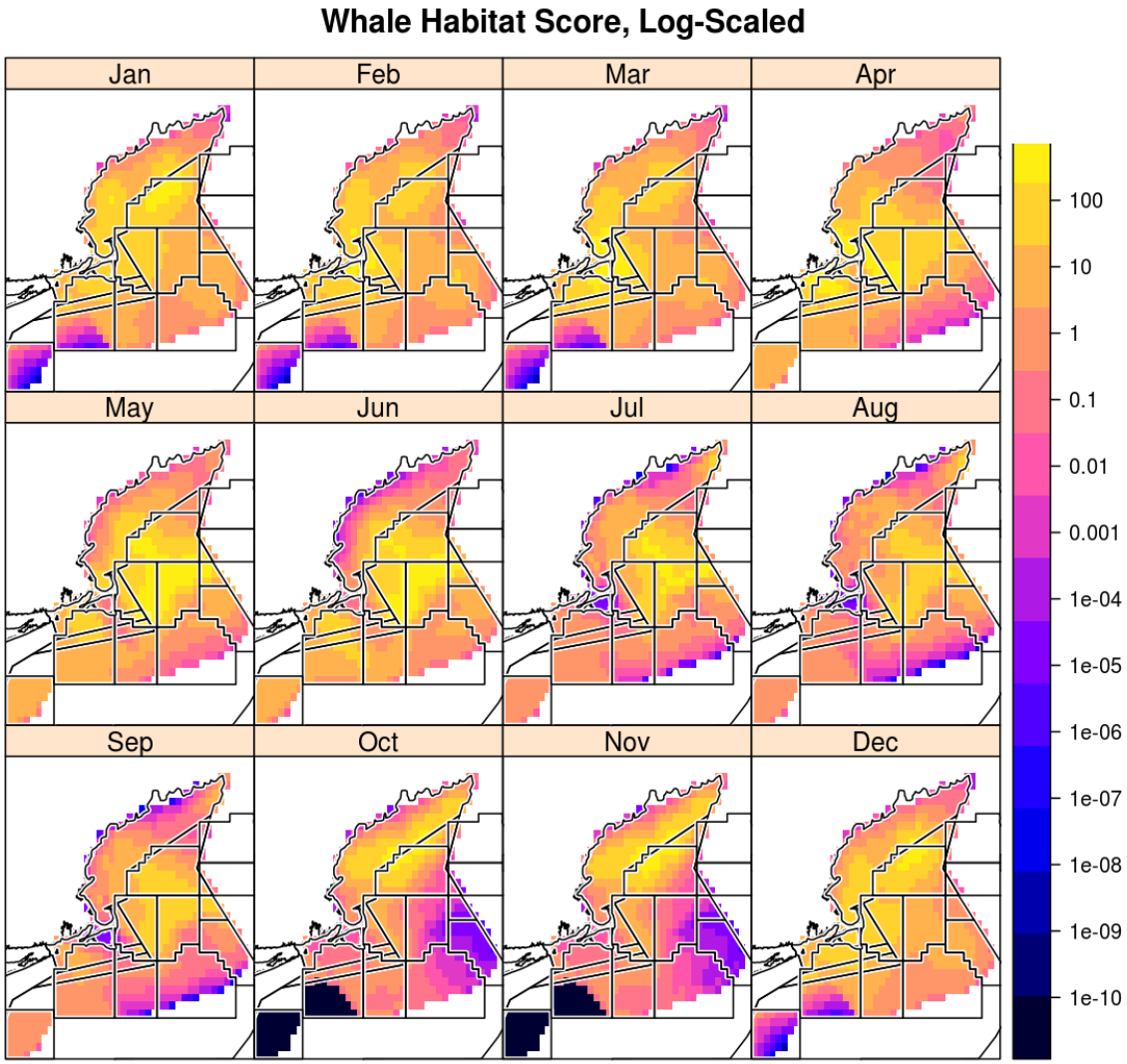


$$Risk = Whales * Gear\ density * severity$$

Aggregate Line Threat Score (Line Threat X Line Density), Log-Scaled - Default



$$Risk = Whales * Gear\ density * severity$$



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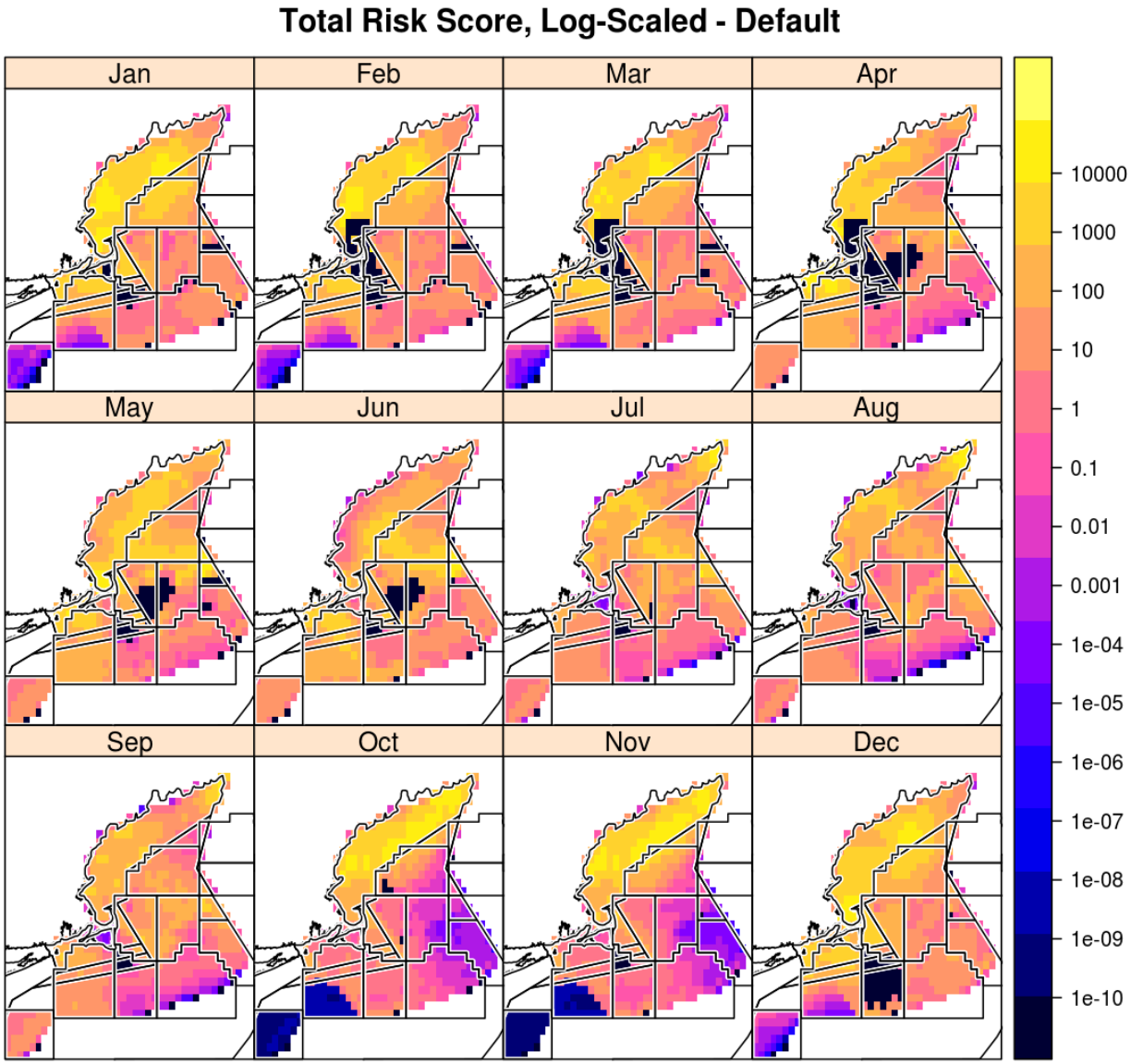


Relative Risk

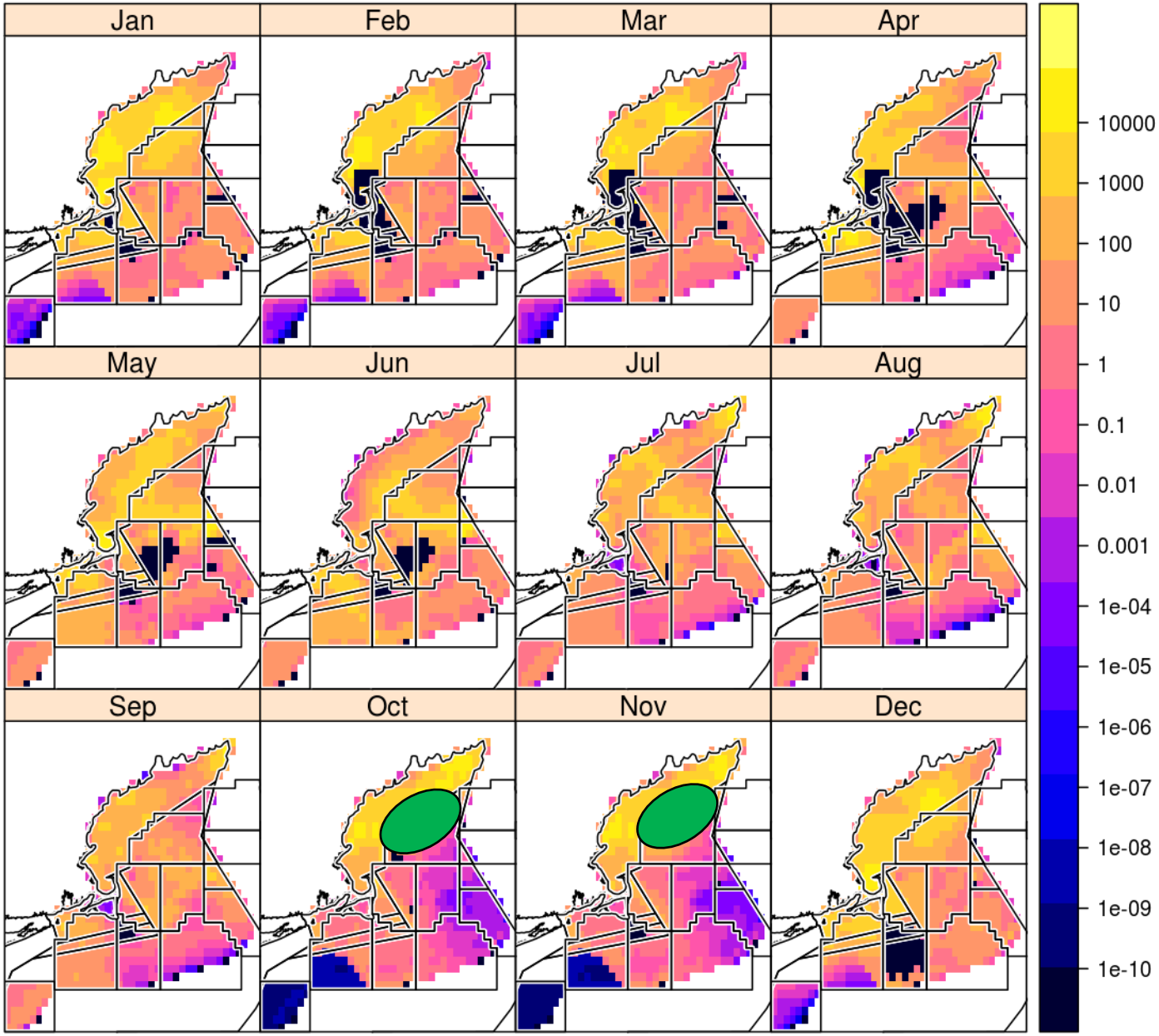
	Variable	Month	Default
40	RelativeRisk	1	850757.2
41	RelativeRisk	2	480243.2
42	RelativeRisk	3	408800.9
43	RelativeRisk	4	727481.4
44	RelativeRisk	5	661472.5
45	RelativeRisk	6	246594.6
46	RelativeRisk	7	238812.2
47	RelativeRisk	8	300872.2
48	RelativeRisk	9	104023.2
49	RelativeRisk	10	960176.7
50	RelativeRisk	11	1172830.2
51	RelativeRisk	12	827609.5
52	RelativeRisk	Total	6979673.9

Current Risk		6,979,674
Goal	60%	2,791,870
	80%	1,395,935

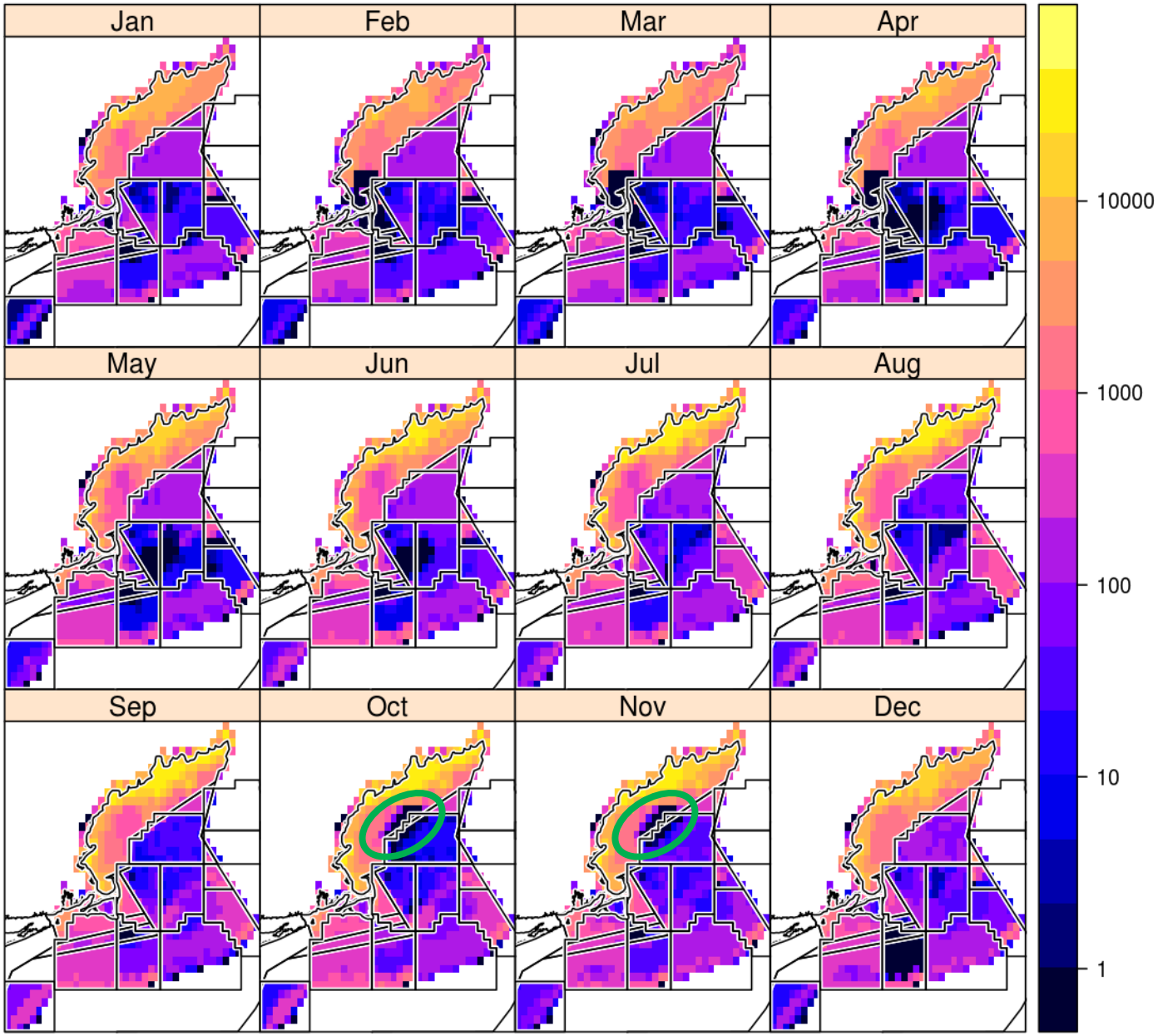
$$Risk = Whales * Gear\ density * severity$$

Example closure scenario

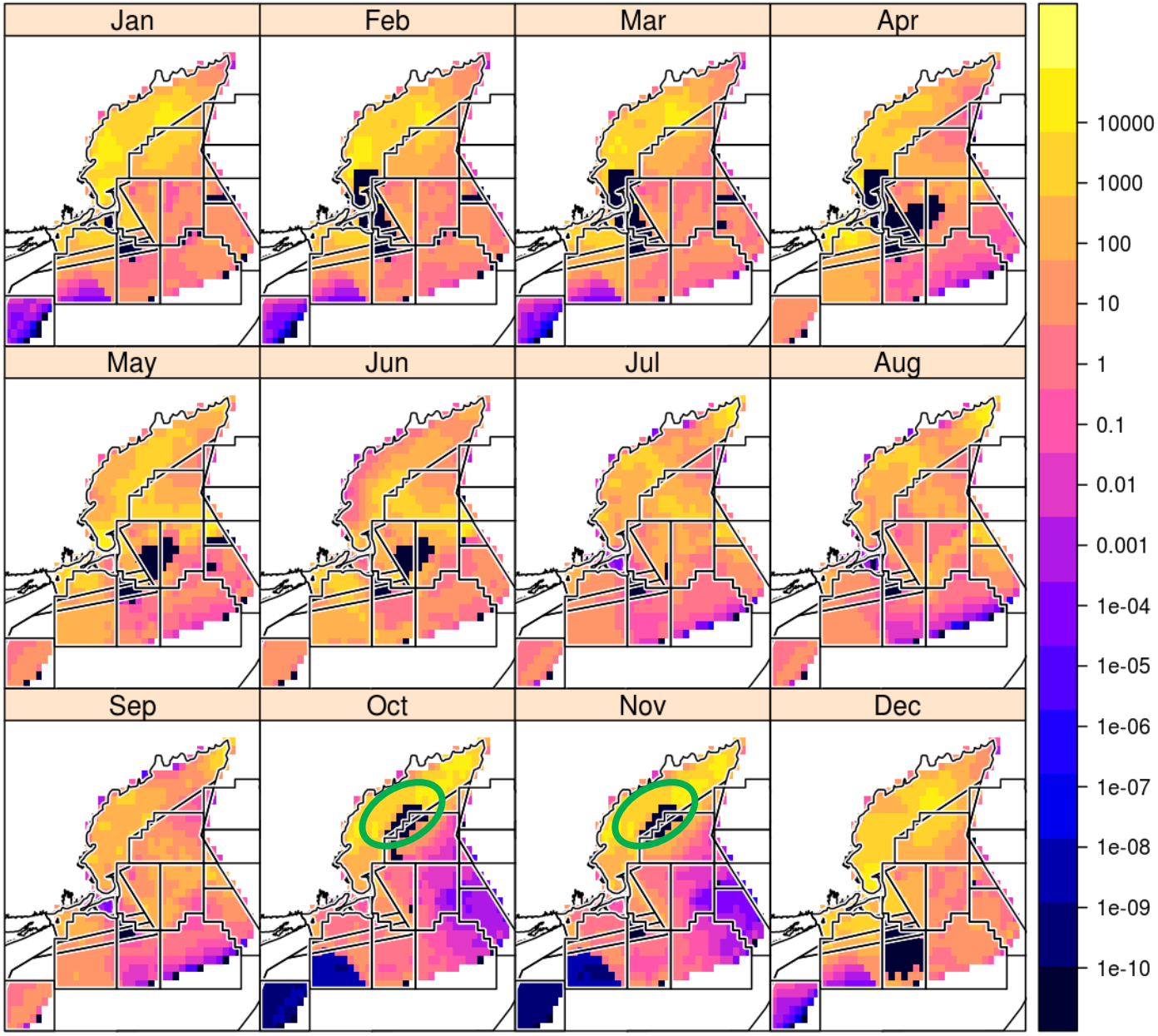
Total Risk Score, Log-Scaled - Default



Aggregate Trap Density, Log-Scaled - Scenario



Total Risk Score, Log-Scaled - Default



Trap Numbers

	Variable	Month	Default	Scenario	Change
1	TrapsFished	1	788532.0	788532.0	1.0000000
2	TrapsFished	2	536218.4	536218.4	1.0000000
3	TrapsFished	3	524014.1	524014.1	1.0000000
4	TrapsFished	4	739229.2	739229.2	1.0000000
5	TrapsFished	5	1090979.1	1090979.1	1.0000000
6	TrapsFished	6	1485203.4	1485203.4	1.0000000
7	TrapsFished	7	1921503.8	1921503.8	1.0000000
8	TrapsFished	8	2124201.3	2124201.3	1.0000000
9	TrapsFished	9	2152331.2	2152331.2	1.0000000
10	TrapsFished	10	2171781.2	2137022.5	0.9839953
11	TrapsFished	11	1810620.4	1773237.4	0.9793535
12	TrapsFished	12	1171224.0	1171224.0	1.0000000
13	TrapsFished	Total	16515837.9	16443696.2	0.9956320

<1% trap reduction

Total Trawls

	Variable	Month	Default	Scenario	Change
14	Trawls	1	152697.70	152697.70	1.0000000
15	Trawls	2	97742.35	97742.35	1.0000000
16	Trawls	3	96938.60	96938.60	1.0000000
17	Trawls	4	182147.06	182147.06	1.0000000
18	Trawls	5	338355.28	338355.28	1.0000000
19	Trawls	6	521224.71	521224.71	1.0000000
20	Trawls	7	764735.53	764735.53	1.0000000
21	Trawls	8	853819.40	853819.40	1.0000000
22	Trawls	9	830436.36	830436.36	1.0000000
23	Trawls	10	798160.28	796174.15	0.9975116
24	Trawls	11	585919.86	583726.55	0.9962566
25	Trawls	12	280951.24	280951.24	1.0000000
26	Trawls	Total	5503128.38	5498948.94	0.9992405

<0.1% trawl reduction

Total Vertical Line

	Variable	Month	Default	Scenario	Change
27	VerticalLines	1	187301.3	187301.3	1.0000000
28	VerticalLines	2	120795.8	120795.8	1.0000000
29	VerticalLines	3	119028.9	119028.9	1.0000000
30	VerticalLines	4	210195.9	210195.9	1.0000000
31	VerticalLines	5	373807.0	373807.0	1.0000000
32	VerticalLines	6	568879.1	568879.1	1.0000000
33	VerticalLines	7	821544.1	821544.1	1.0000000
34	VerticalLines	8	914007.2	914007.2	1.0000000
35	VerticalLines	9	893679.6	893679.6	1.0000000
36	VerticalLines	10	866479.4	862507.1	0.9954156
37	VerticalLines	11	650196.3	645809.7	0.9932534
38	VerticalLines	12	328702.0	328702.0	1.0000000
39	VerticalLines	Total	6054616.8	6046257.9	0.9986194

<0.2% line reduction

Relative Risk

	Variable	Month	Default	Scenario	Change
40	RelativeRisk	1	850757.2	850757.2	1.0000000
41	RelativeRisk	2	480243.2	480243.2	1.0000000
42	RelativeRisk	3	408800.9	408800.9	1.0000000
43	RelativeRisk	4	727481.4	727481.4	1.0000000
44	RelativeRisk	5	661472.5	661472.5	1.0000000
45	RelativeRisk	6	246594.6	246594.6	1.0000000
46	RelativeRisk	7	238812.2	238812.2	1.0000000
47	RelativeRisk	8	300872.2	300872.2	1.0000000
48	RelativeRisk	9	104023.2	104023.2	1.0000000
49	RelativeRisk	10	960176.7	697549.6	0.7264804
50	RelativeRisk	11	1172830.2	780127.6	0.6651667
51	RelativeRisk	12	827609.5	827609.5	1.0000000
52	RelativeRisk	Total	6979673.9	6324344.1	0.9061088

9.4% risk reduction

Note- not a closure example from TRT

- this example focuses on a strategic closure in a high risk area
- Assumes ‘high accuracy’ in model that is intentionally relative
- Assumes all gear pulled out of water
- not a preferred solution over time as fisheries and whales move.

More complex scenarios

- Remember this simple formula

$$Risk = Whales \ * Gear\ density \ * severity$$

- Closures where gear is displaced?
  - Risk in closed area goes to 0, apply formula to adjacent areas- if whale density is less, risk can still go down.
- 30% line reduction with fixed trawl length (fewer traps)-
  - gear density (and risk) reduced 30%
  - Line reduction with trawling up- can reduce risk- but must adjust for trawling up risk
- Apply some severity modifier- sleeves, time-tension cutter, 1700lb rope etc.

What is next?

- Apply new severity scores from poll to tool
- Score the TRT scenarios
- Provide trained model operators to TRT breakout groups
- TRT works to build strawman solution

In collaboration with survey programs and scientists from:

Should your logo be here? My apologies! Please email me!

Primary funding for modeling from:

Additional funding from:

How this project got started

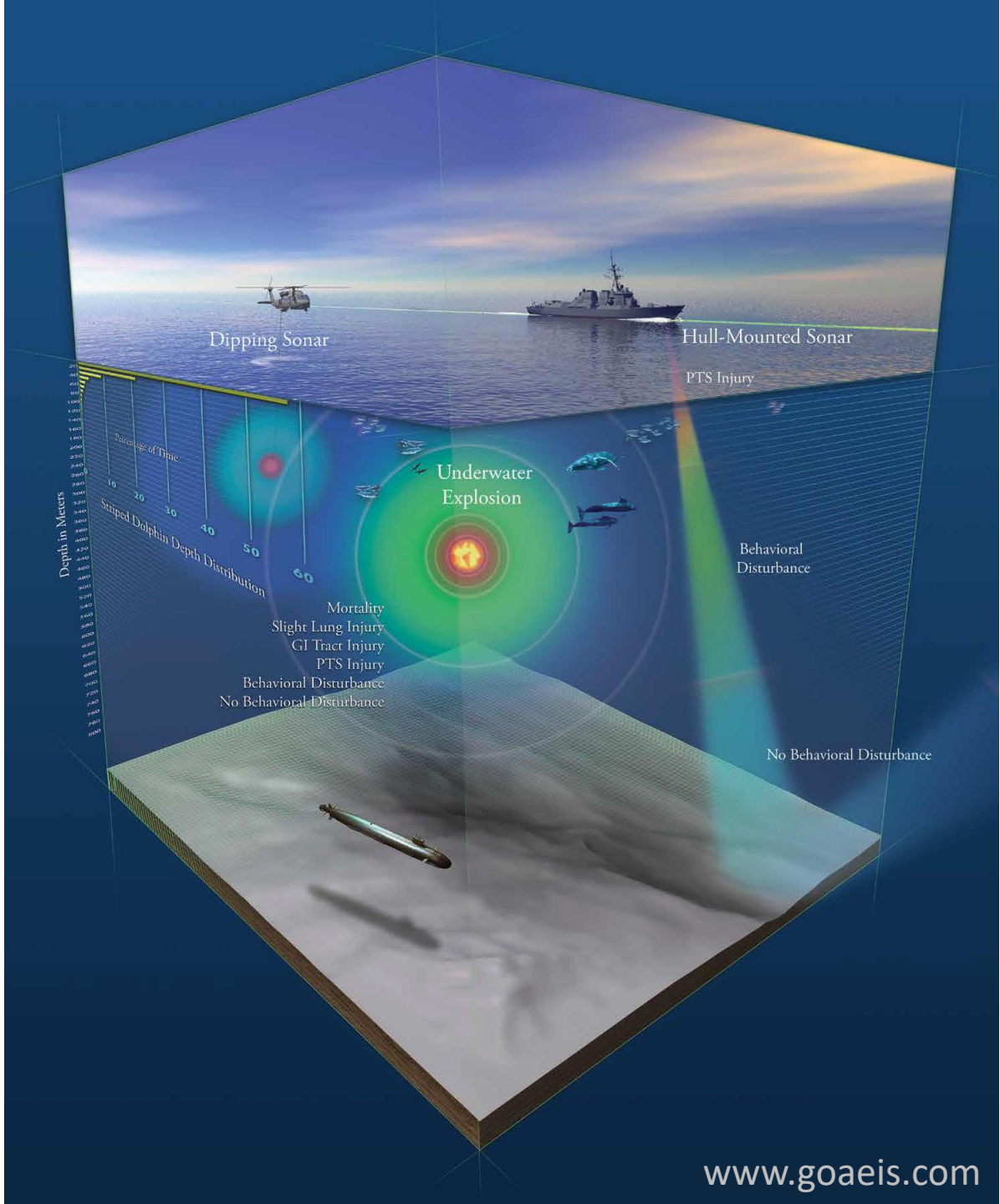
The Navy encounters marine mammals…

Photo: nbcnews.com

Navy MMPA compliance

- Every 7 years*, the Navy must obtain a Letter of Authorization permitting the “take” of marine mammal during training and testing activities
- The permit must estimate the *number of individual animals* of each mammal stock that would be taken

*Prior to 2018, Letters of Authorization lasted 5 years



www.goaeis.com

Navy Acoustic Effects Model (NAEMO)

NAVSEA WARFARE CENTERS NEWPORT

Inputs

Navy Activity Information

Sound Propagation Modeling

Population Density Maps

Exposure History of Each Simulated Individual Animal

Criteria Thresholds Applied

Estimated Number of Exposures

Results Database

Post Analysis Evaluation

Requested Takes

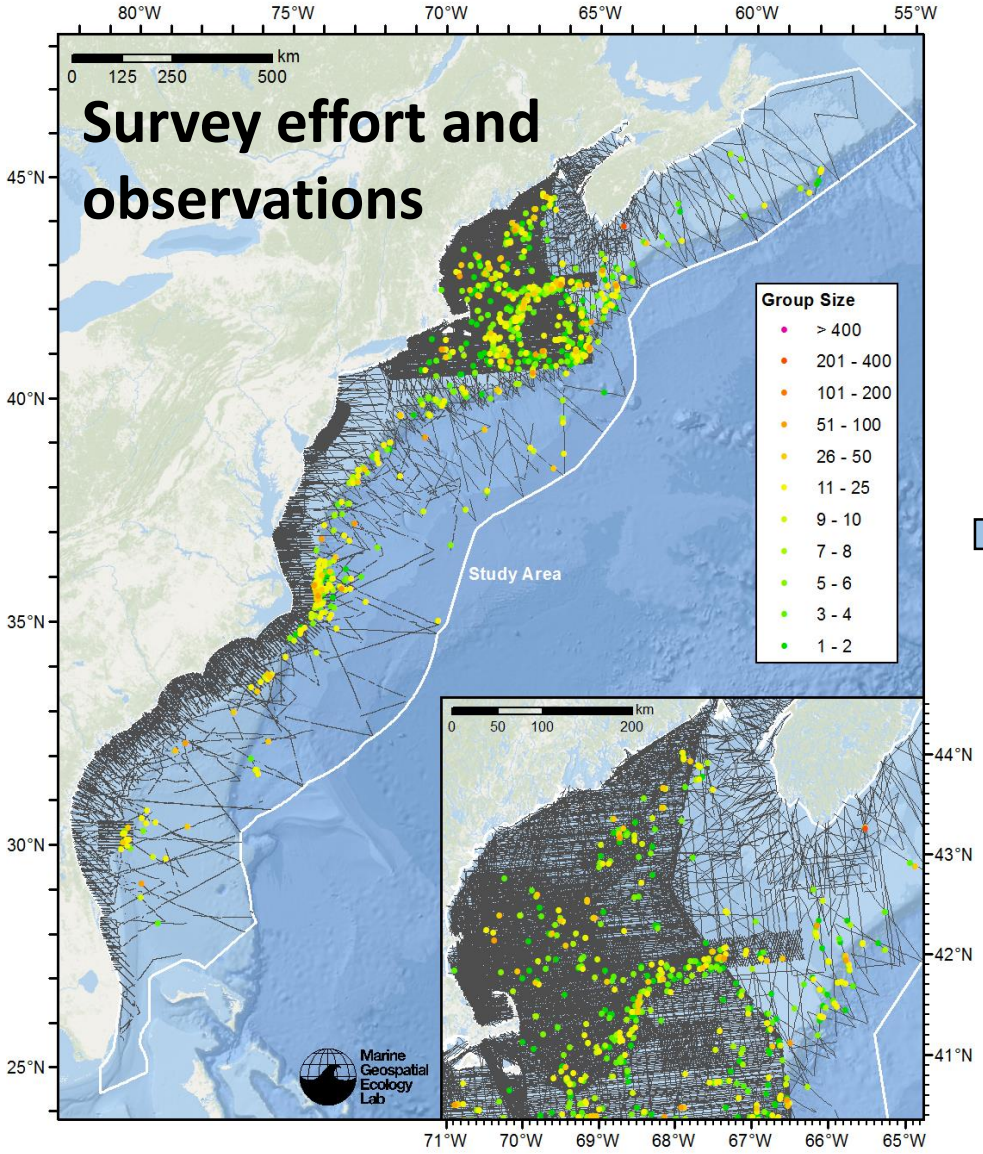
MMPA Request / ESA Consult

Density = *number of individuals per square kilometer*

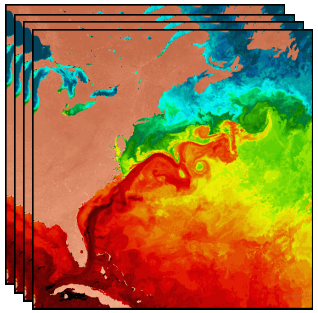
This is where we come in…

UNCLASSIFIED

Density modeling



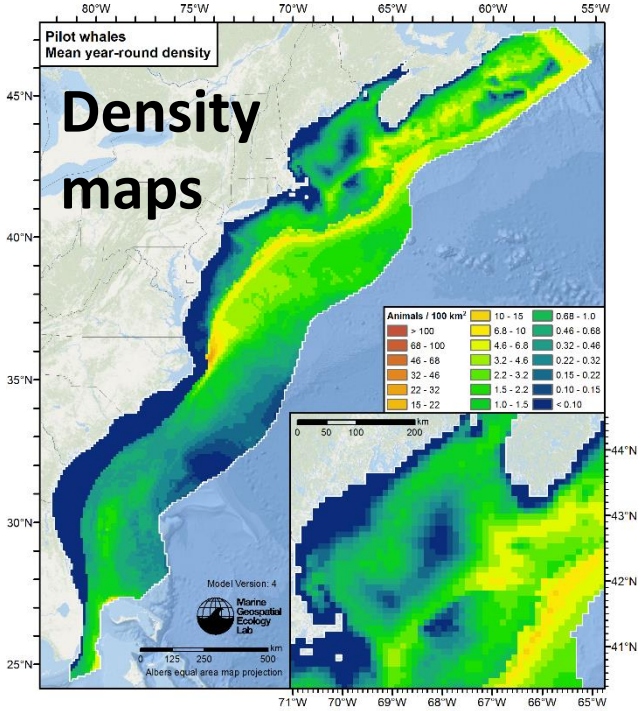
Oceanographic maps

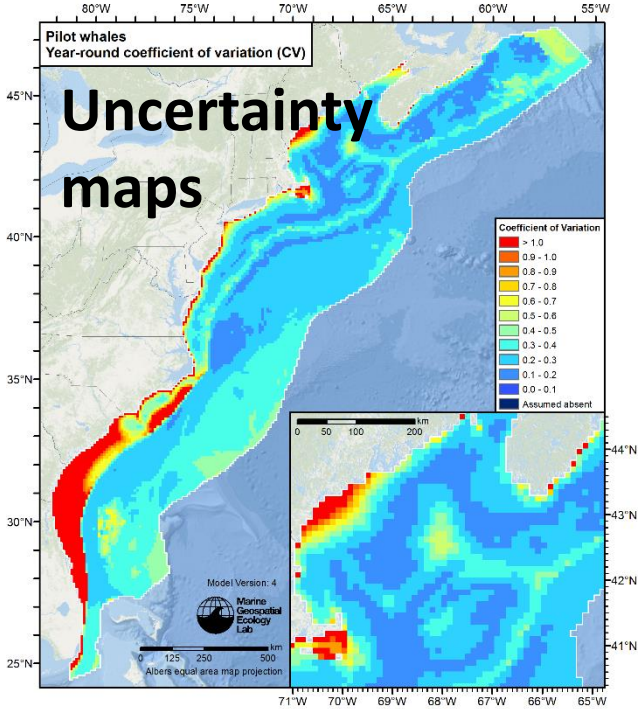


Statistical models

The models relate density (animals / km^2) to ocean conditions known to correlate with species' habitats

From the resulting statistical relationships, we can then predict densities, given maps of conditions





A critical problem:
The farther away they are,
the lower the chance you'll detect them
?
Photo: Scott and Mary Flanders

Shipboard observers

Photo: NOAA

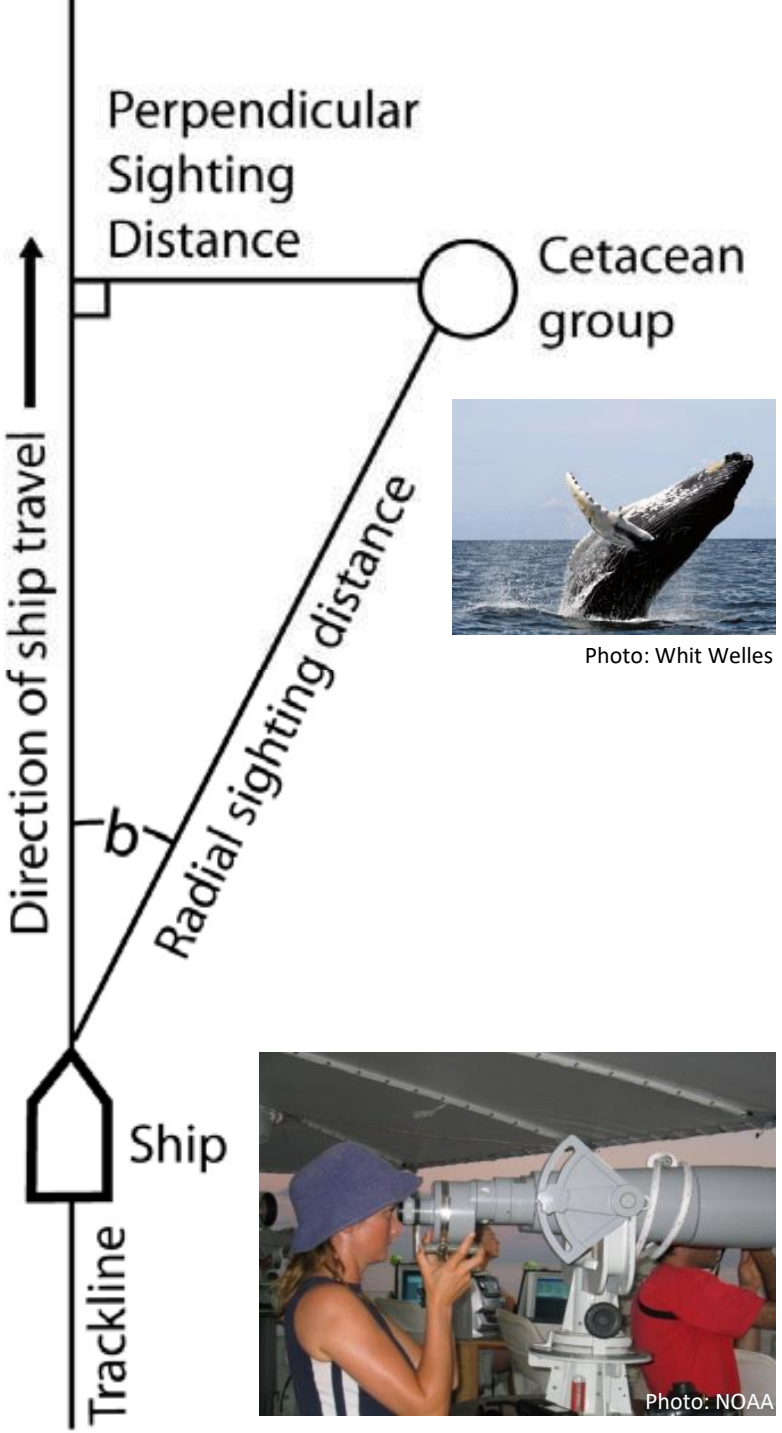


Photo: Whit Welles

Photo: NOAA

Aerial observers

Photo: C. Khan

Photo: C. Khan

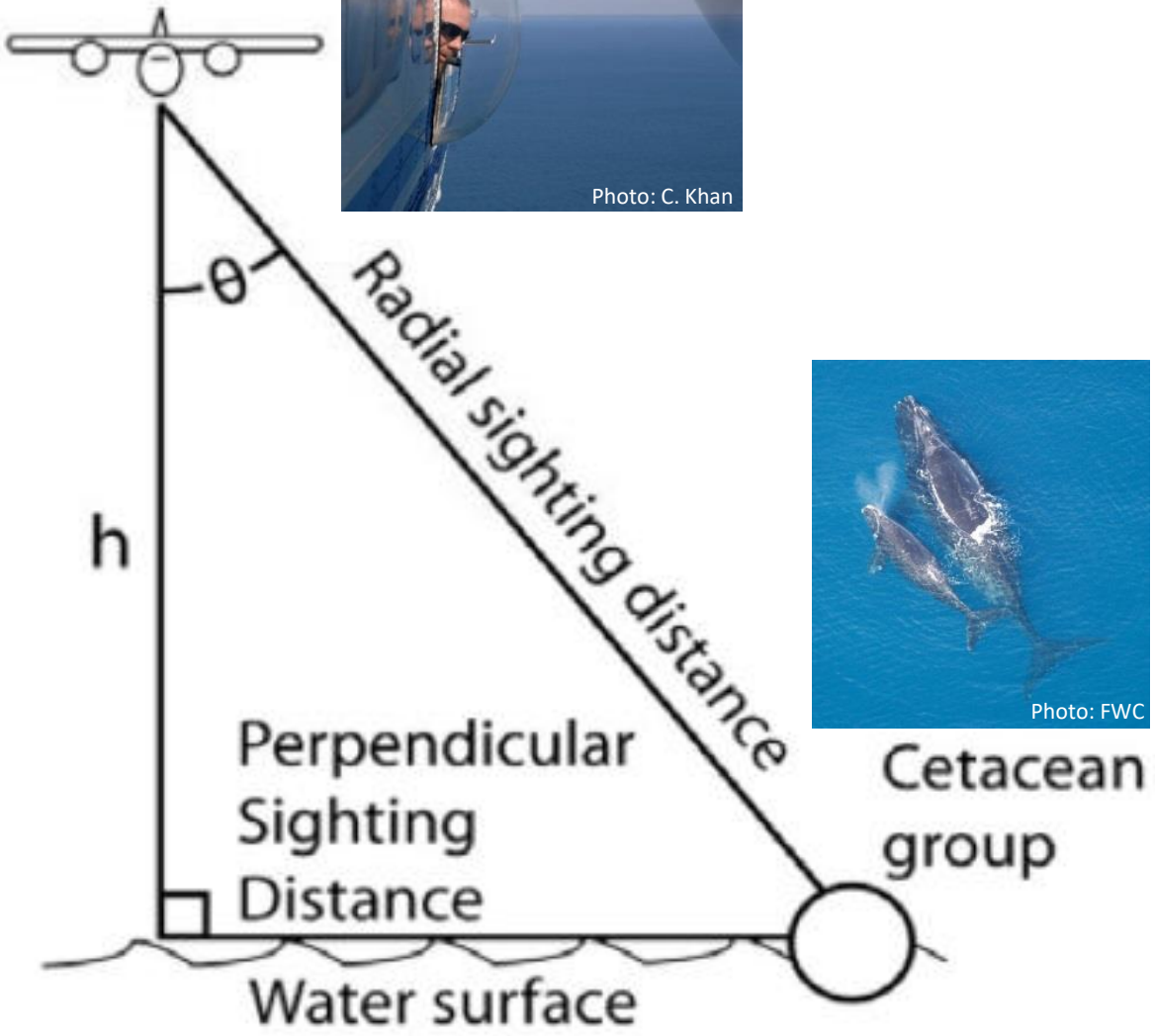
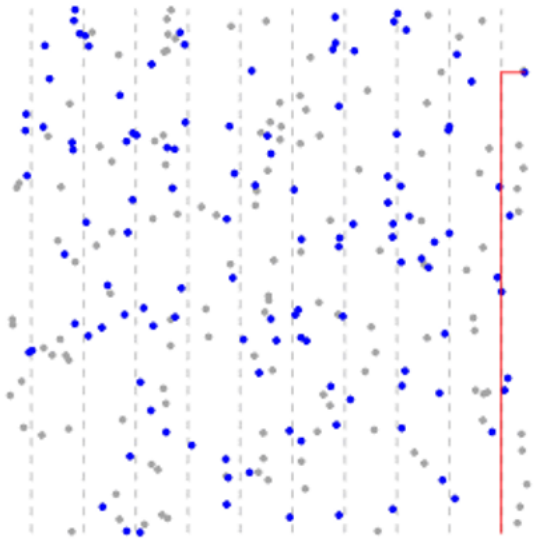


Photo: FWC

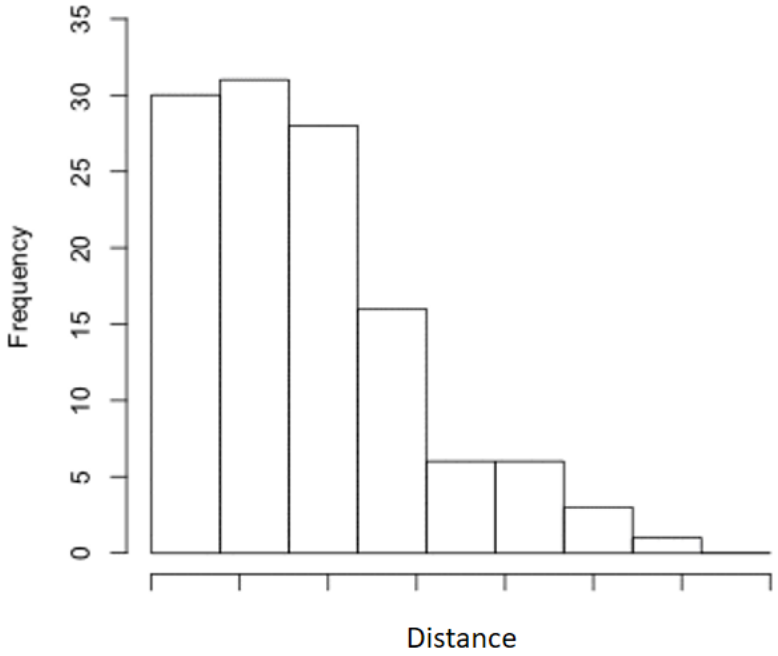
Modeling detectability

Cetacean sightings

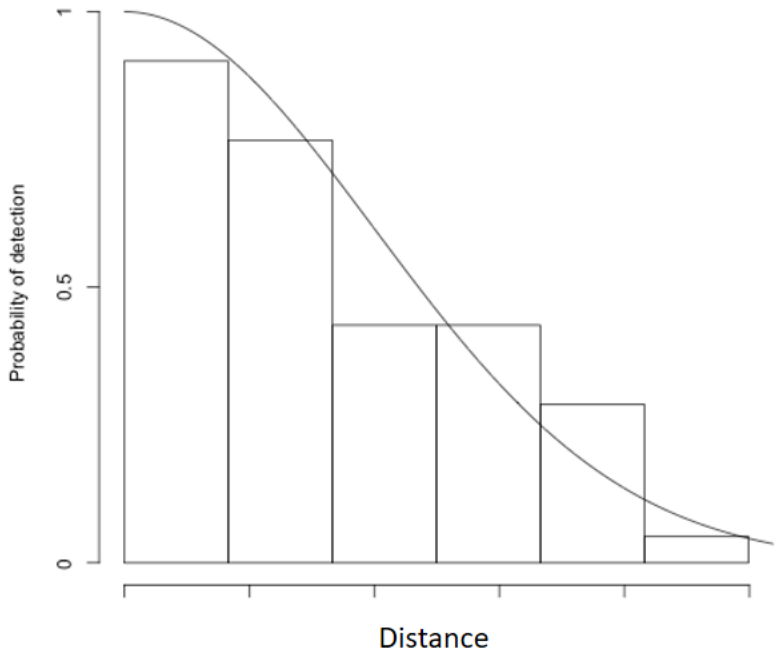


- Vessel trackline
- Cetacean sighted by observers
- Cetacean missed by observers

Histogram of observed distances



Detection function

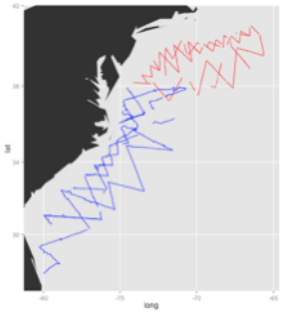


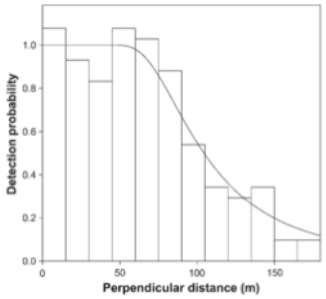
Figures: David L. Miller

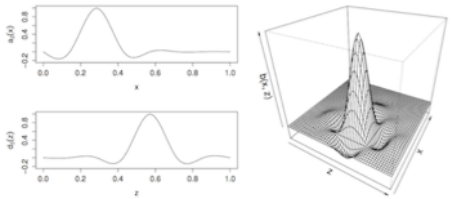
This technique is called “distance sampling”

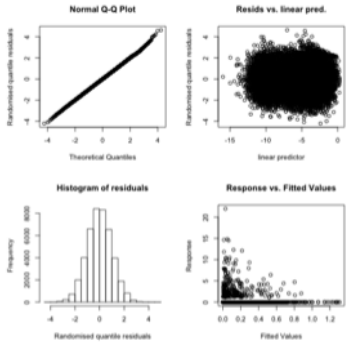
Density surface modeling (DSM)

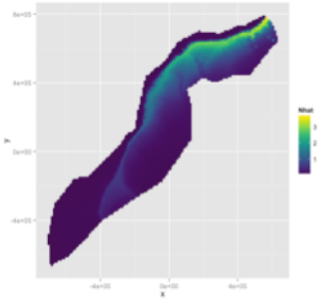
(Hedley and Buckland 2004; Thomas et al. 2010; Miller et al. 2013)











Line transects → Detectability → Spatial model (GAM) ⇄ Model checking/ criticism → Predictions

Oceanographic data → Spatial model (GAM)

Oceanographic data → Predictions

Stage 1

Stage 2

Adapted from figure by David L. Miller

Important limitations of our current approach

1. We can only utilize line transect surveys, and they must be preplanned and laid out systematically (not directed to known animals)

2. We can only utilize surveys that collected distances to animals, so that detectability can be modeled

3. We cannot directly utilize opportunistic sightings, acoustic detections, or other data not conforming to 1 and 2 above

These limitations may be overcome with additional R&D work.
(More on that later…)

Project timeline

2015-2016

Version 5.6

- First model
- Used by Navy for AFTT Phase III EIS and LOA
- Published in Roberts et al. 2016

2017

Version 7

- Incorporated AMAPPS and SEUS NARW surveys
- Released to Navy and NMFS
- Used by NMFS for Atlantic G&G IHA permitting

April 2019

Version 8

- Prepared in time for ALWTRT meeting
- Used same surveys and GAMs as v7
- Filled CCB with Ganley et al. 2019 abundance est.
- Reduced minor edge effects from v7

Presented today

October 2019

Version 9

- Will add surveys from 2017-2018
- Will fit and compare models of recent period (2010-2018?) to older period (1998-2010?)

Surveys used in the v7 and v8 right whale models

Platform	Provider	Program	Survey Effort (1000 km) Extant	Added	Total	% Increase
Aerial	NEFSC	Marine mammal abundance surveys	70	41	112	59
		NARWSS harbor porpoise survey	6		6	
		NARWSS right whale surveys	432	87	520	20
	NJDEP	New Jersey Ecological Baseline Study	11		11	
	SEFSC	Marine mammal abundance surveys	43	66	108	154
	SEUS NARW	FWRI surveys		521	521	
		NEAq surveys		237	237	
		SSA surveys (Skymaster)		279	279	
		SSA surveys (Twin Otter)		291	291	
	UNCW	Cape Hatteras Navy Surveys	19	16	35	86
		Jacksonville Navy Surveys	65	22	87	34
		Marine mammal surveys, 2002	18		18	
		Norfolk Canyon Navy Surveys		12	12	
		Onslow Bay Navy Surveys	49		49	
		Right whale surveys, 2005-2008	114		114	
	VAMSC	MD Wind Energy Area surveys		16	16	
		VA Wind Energy Area surveys	17	5	21	28
	All		844	1591	2435	189
Shipboard	NEFSC	Marine mammal abundance surveys	16	12	28	76
	NJDEP	New Jersey Ecological Baseline Study	14		14	
	SEFSC	Marine mammal abundance surveys	28	15	43	52
	All		58	27	85	47

AMAPPS

Used in v7

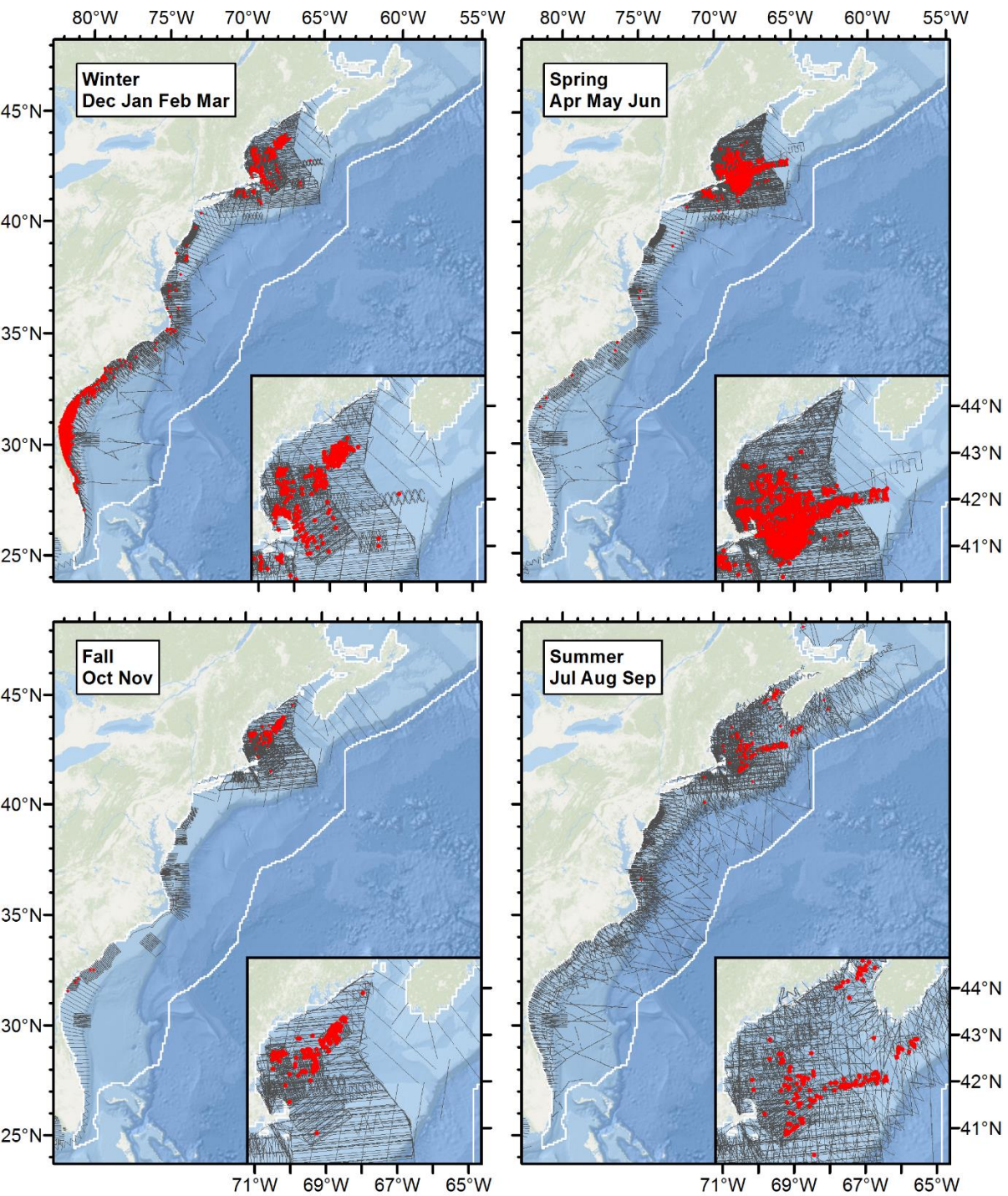
Added for v8

Used in v8

The surveys used in v8, and the v8 model itself, presented today, spanned 1998-2016

Temporal dynamics

- To allow species-environment relationships to vary seasonally and regionally, we split the year into seasons and study area into subregions, based on known right whale ecology, and modeled each independently
  - E.g. whales on the calving groups differ from those overwintering in the northeast
- We compared models that climatological estimates (long term averages) to contemporaneous estimates (resolved to the year and day) of oceanographic covariates
  - Usually climatological covariates performed better
- Based on requests from the Navy and other potential users, we summarized the results into monthly averages:
  - 12 density maps, giving average conditions over the modeled period 1998-2016
  - Uncertainty represented as 12 maps of the coefficient of variation of the GAM



Seasons used in v7 and v8

Winter (December-March)

- Defined as these months because right whales usually known to be present on the calving grounds

Spring (April-June)

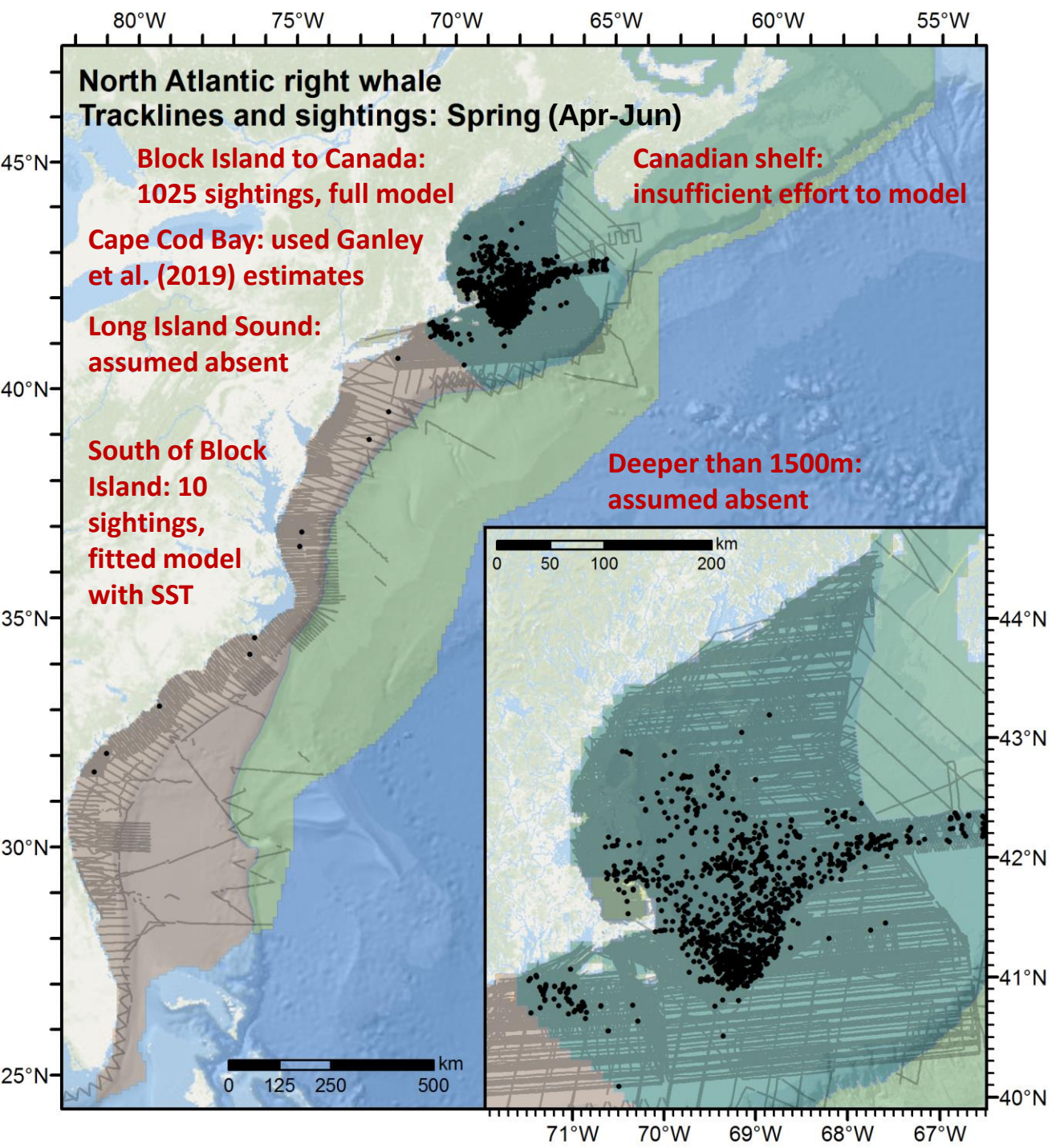
- Most whales found north of New York
- Whales moved from CCB, across GSC, to Geo. Bank
- In July, big drop in sightings in GSC

Summer (July-September)

- Only months with substantial survey effort in Canada (at least from surveys used in this analysis)

Fall (October-November)

- Large numbers of sightings in western Gulf of Maine
- First sightings south of Cape Hatteras (but very few)
- Caution urged: relatively sparse effort everywhere

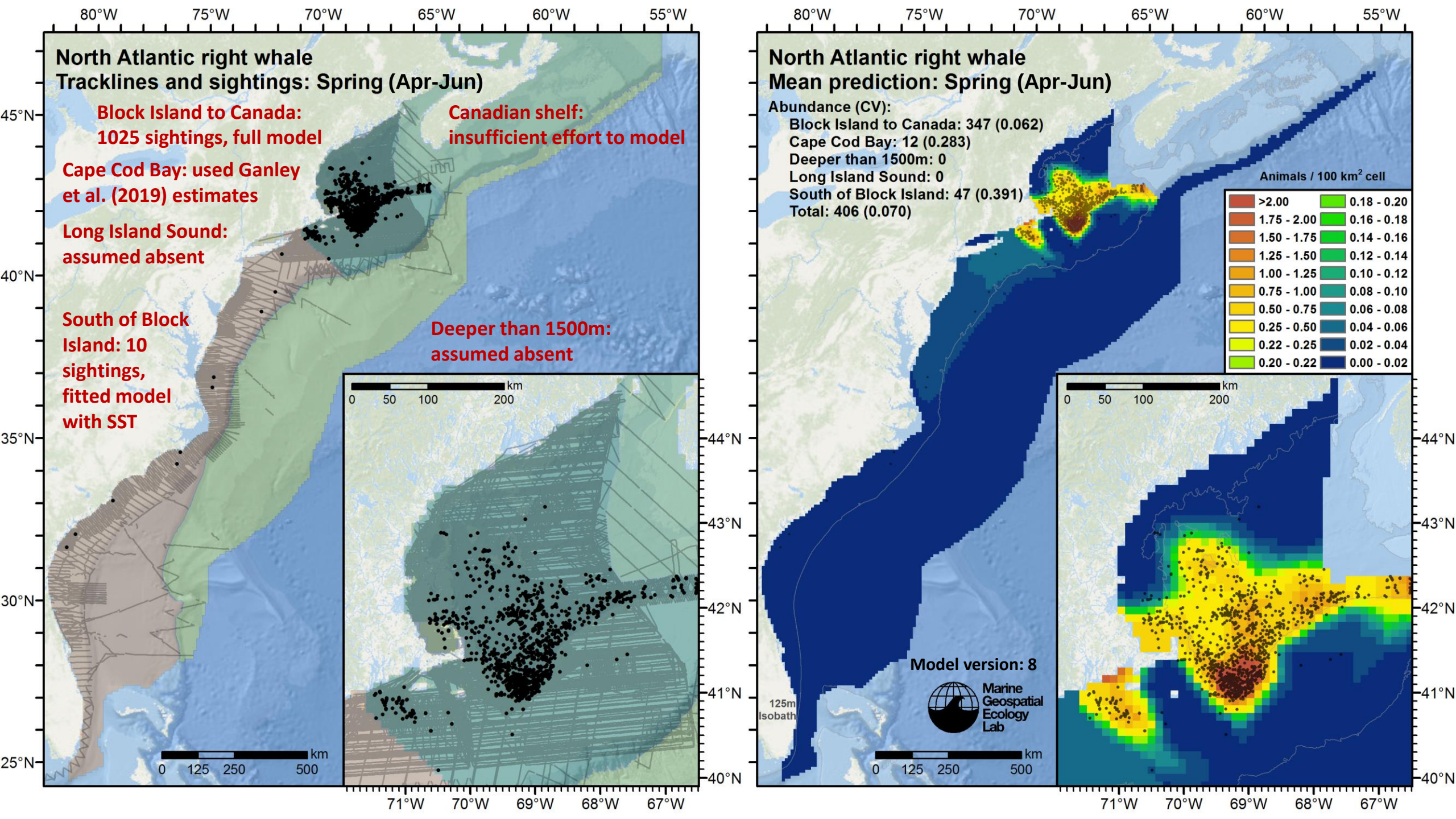


Lets look at each season…

- We'll cycle through: Spring, Summer, Fall, Winter
- Left side is a schematic showing how we split the season into subregions

← Here is the Spring schematic

- Right side (not shown yet) is a map of estimated density, averaged over all years and months of the season


North Atlantic right whale
Tracklines and sightings: Spring (Apr-Jun)
Block Island to Canada:
1025 sightings, full model
Canadian shelf:
insufficient effort to model
Cape Cod Bay: used Ganley et al. (2019) estimates
Long Island Sound:
assumed absent
South of Block Island: 10 sightings, fitted model with SST
Deeper than 1500m:
assumed absent
km
0 125 250 500
0 50 100 200
80°W 75°W 70°W 65°W 60°W 55°W
45°N 40°N 35°N 30°N 25°N
44°N 43°N 42°N 41°N 40°N
71°W 70°W 69°W 68°W 67°W
North Atlantic right whale
Mean prediction: Spring (Apr-Jun)
Abundance (CV):
Block Island to Canada: 347 (0.062)
Cape Cod Bay: 12 (0.283)
Deeper than 1500m: 0
Long Island Sound: 0
South of Block Island: 47 (0.391)
Total: 406 (0.070)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
125m Isobath
Model version: 8
Marine Geospatial Ecology Lab

Density color scale

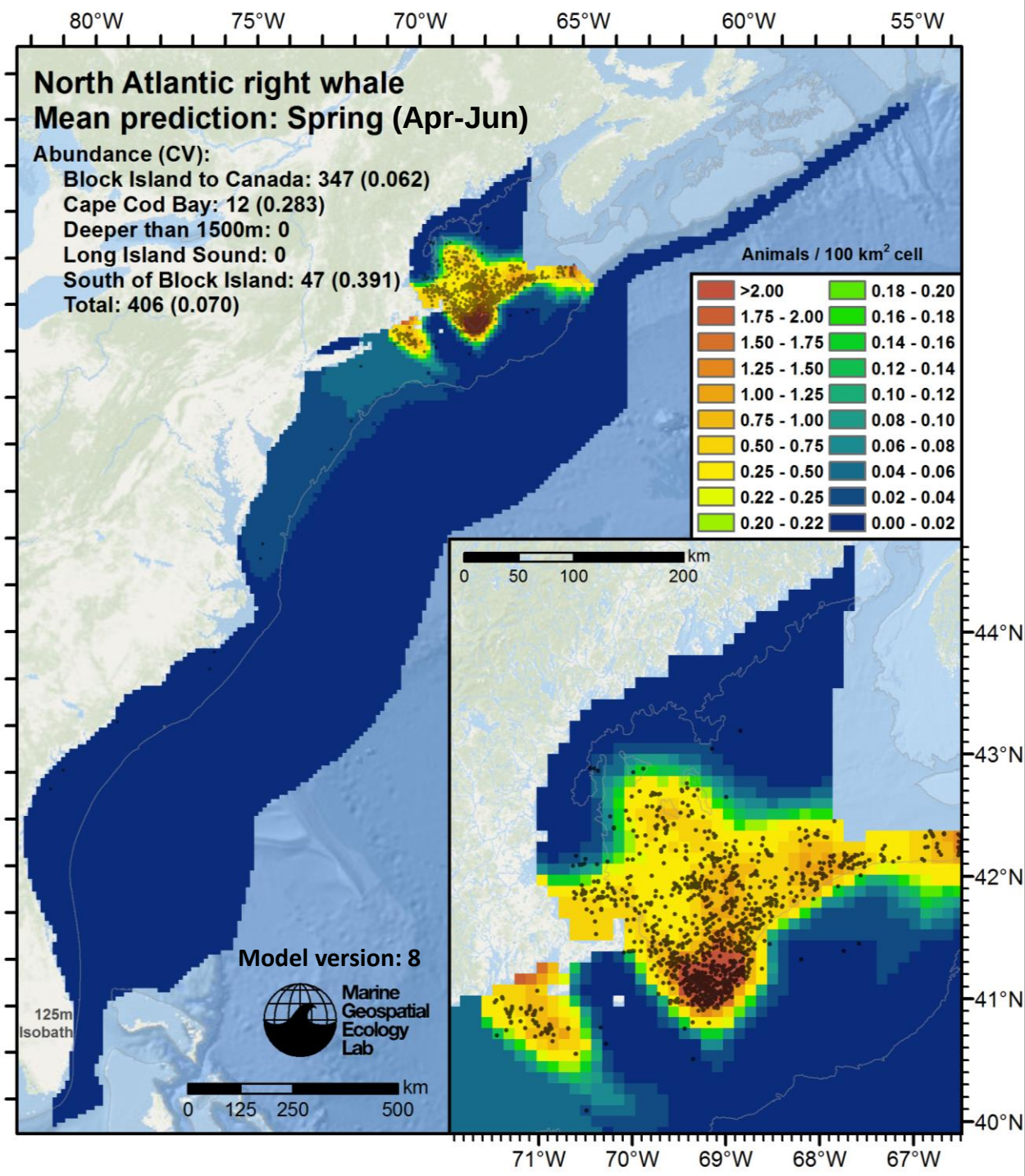
High density range, increments by 0.25

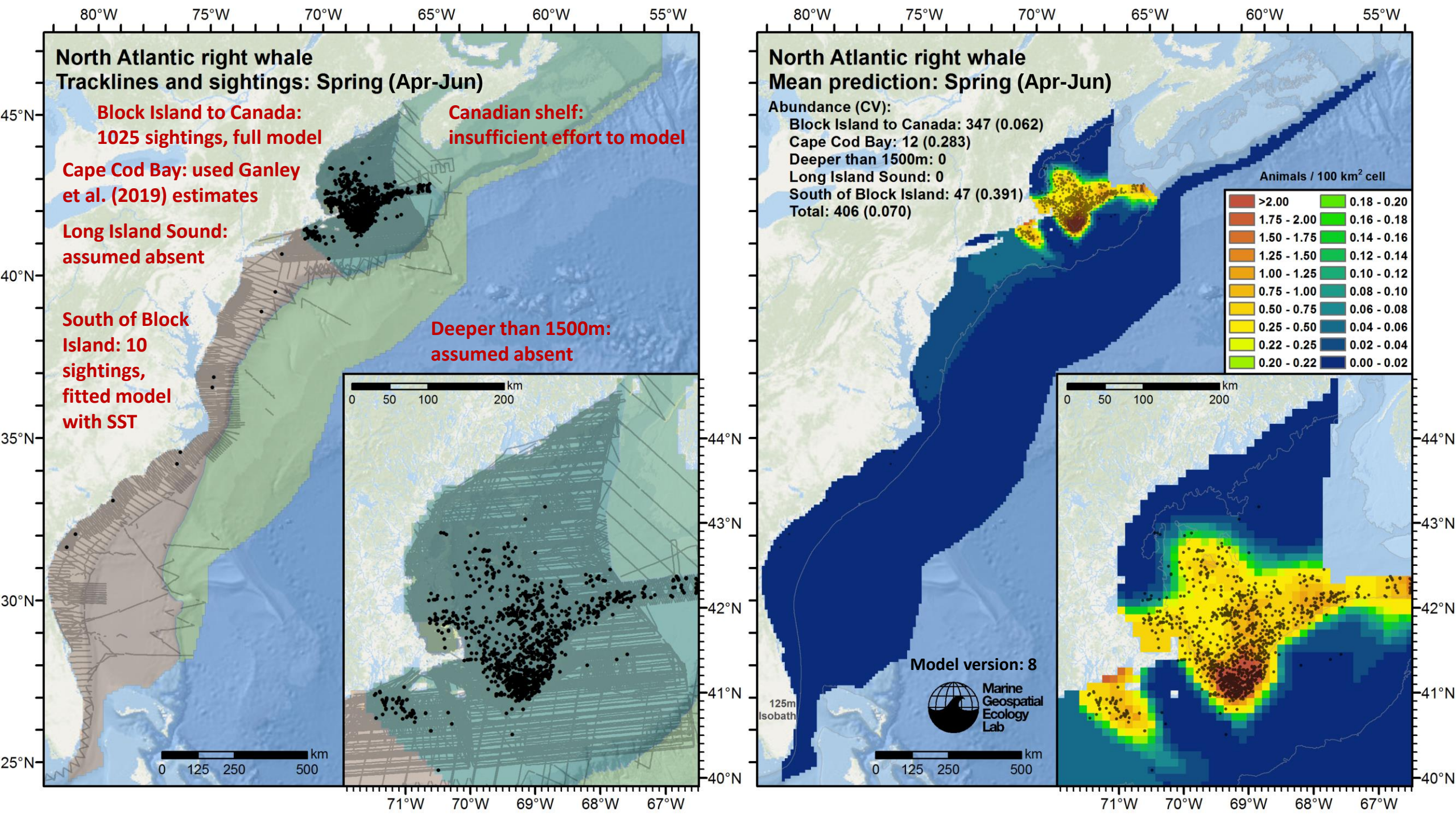
Bright yellow → separates two ranges

Low density range, increments by 0.02

- >2.00
- 1.75 - 2.00
- 1.50 - 1.75
- 1.25 - 1.50
- 1.00 - 1.25
- 0.75 - 1.00
- 0.50 - 0.75
- 0.25 - 0.50
- 0.22 - 0.25
- 0.20 - 0.22
- 0.18 - 0.20
- 0.16 - 0.18
- 0.14 - 0.16
- 0.12 - 0.14
- 0.10 - 0.12
- 0.08 - 0.10
- 0.06 - 0.08
- 0.04 - 0.06
- 0.02 - 0.04
- 0.00 - 0.02

All right whale density maps in this presentation are shown with this scale

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Tracklines and sightings: Spring (Apr-Jun)
Block Island to Canada:
1025 sightings, full model
Canadian shelf:
insufficient effort to model
Cape Cod Bay: used Ganley et al. (2019) estimates
Long Island Sound:
assumed absent
South of Block Island: 10 sightings, fitted model with SST
Deeper than 1500m:
assumed absent
km
0 125 250 500
0 50 100 200
80°W 75°W 70°W 65°W 60°W 55°W
45°N 40°N 35°N 30°N 25°N
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71°W 70°W 69°W 68°W 67°W
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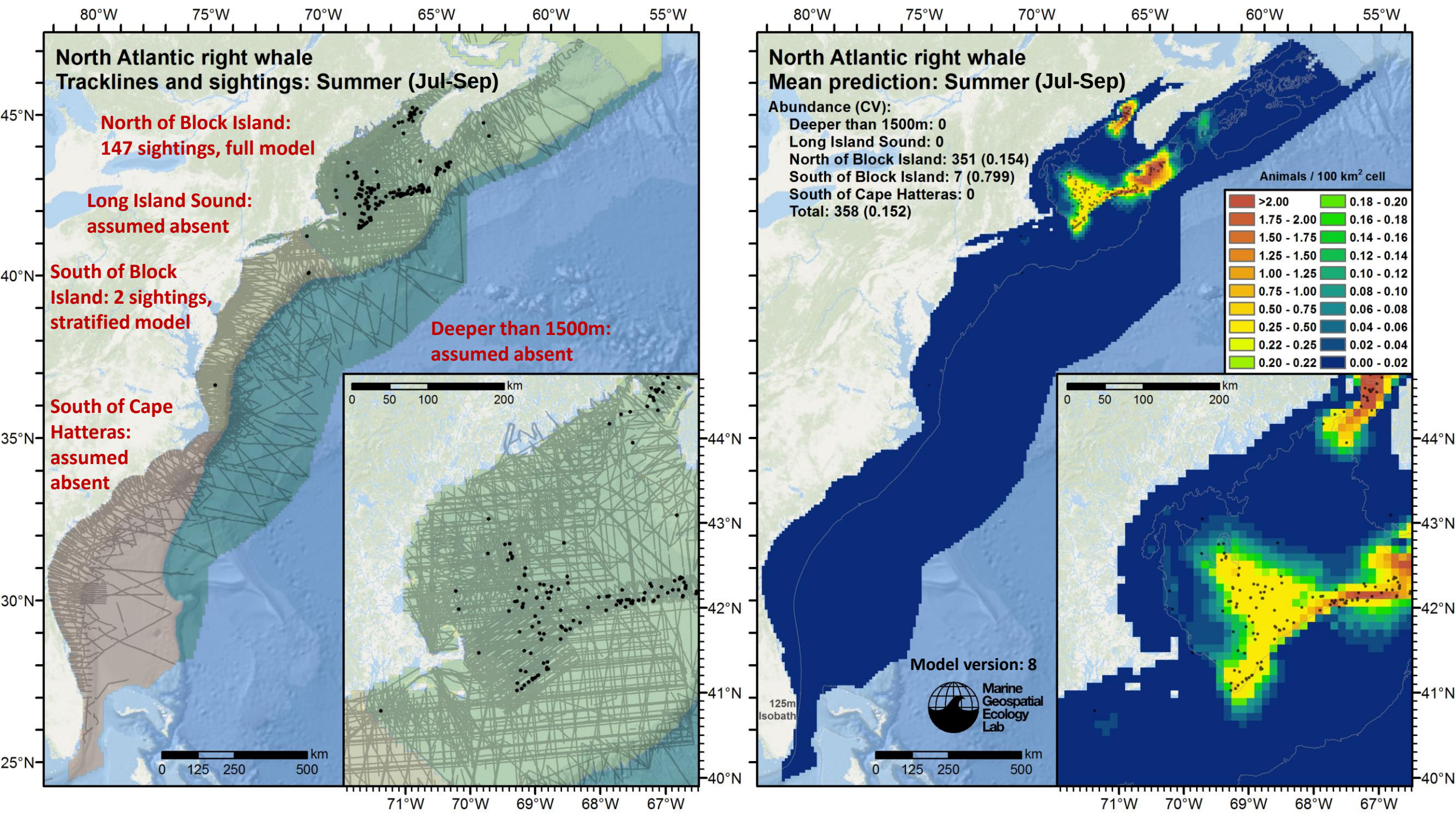
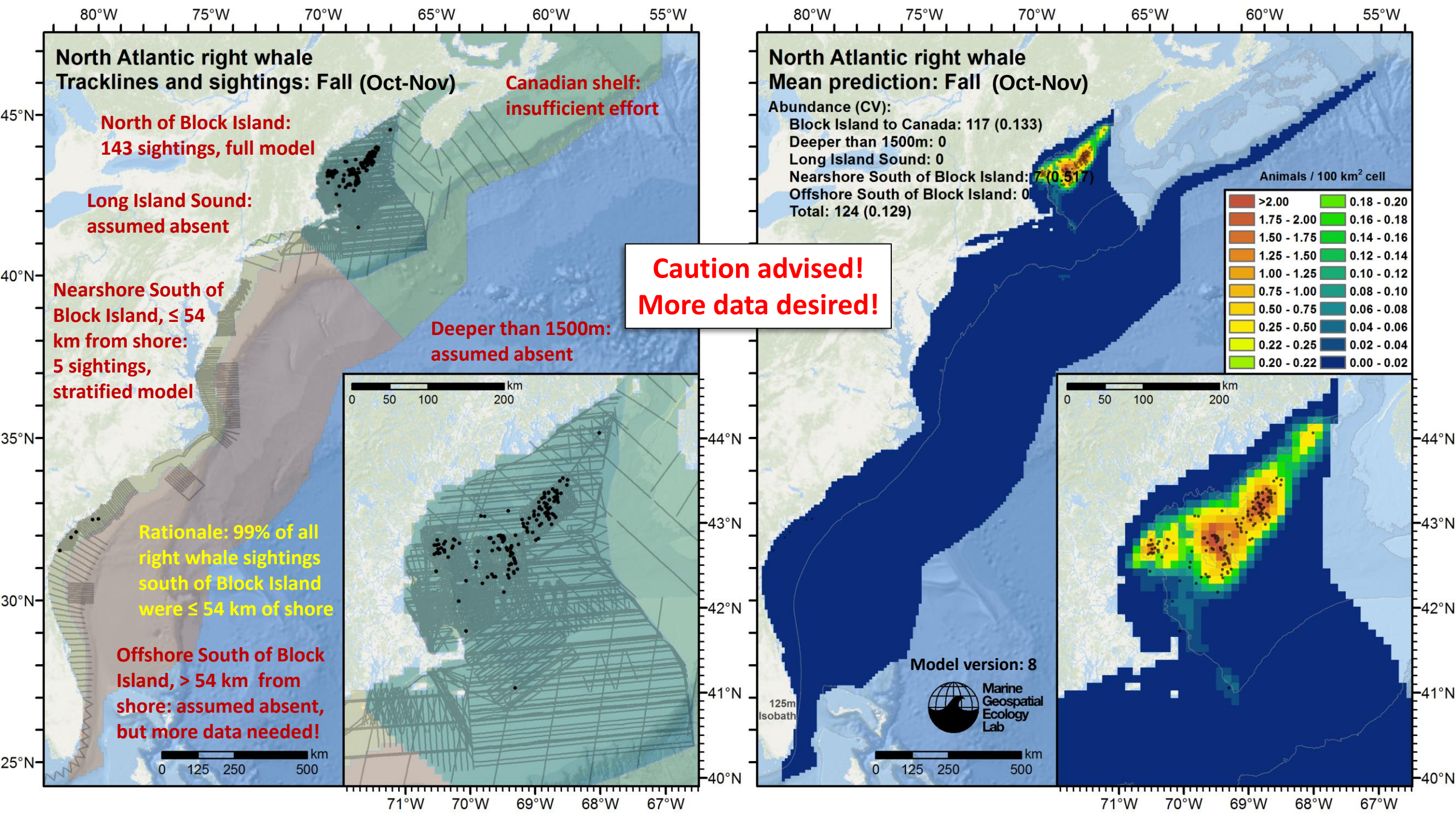
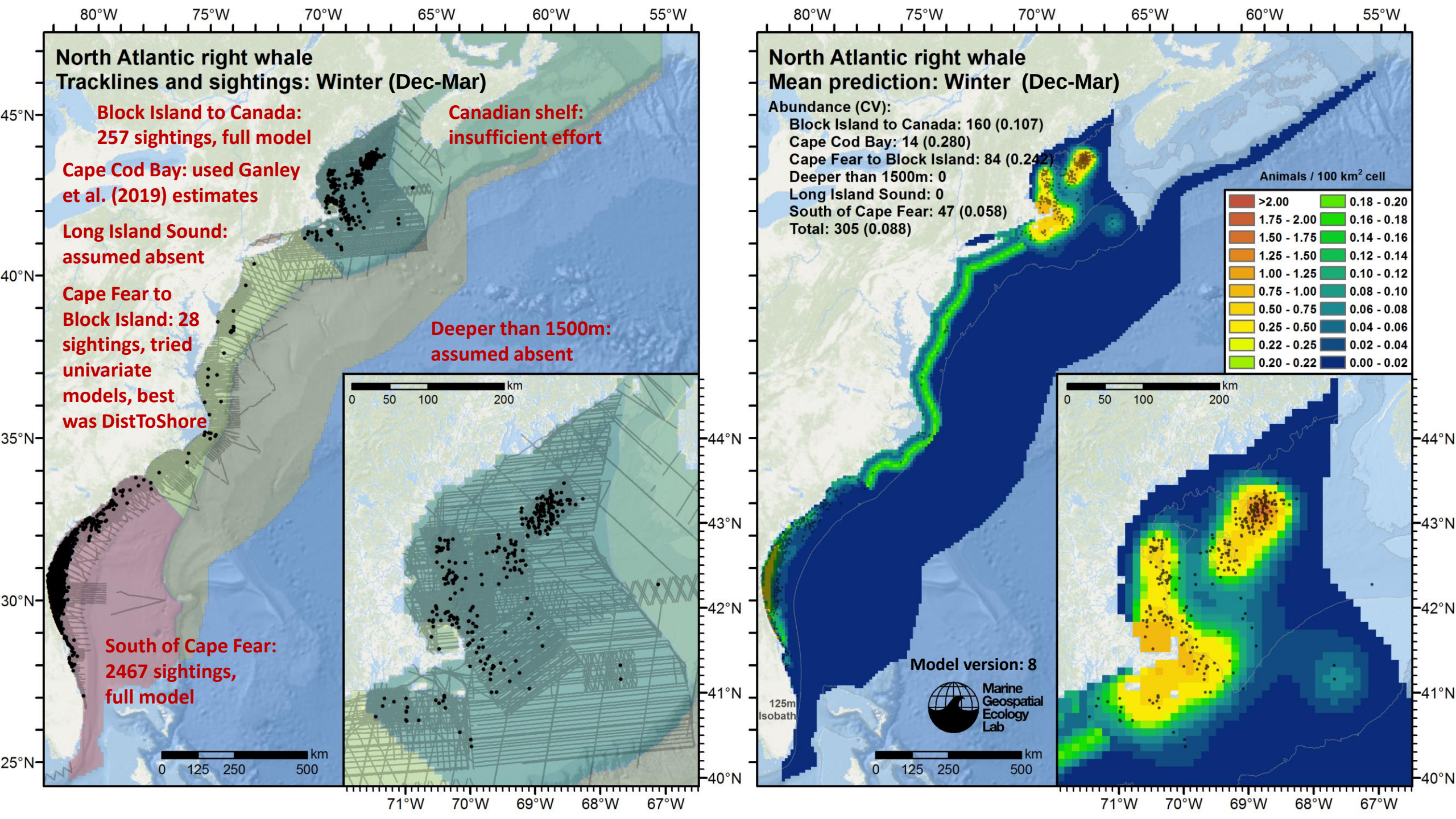
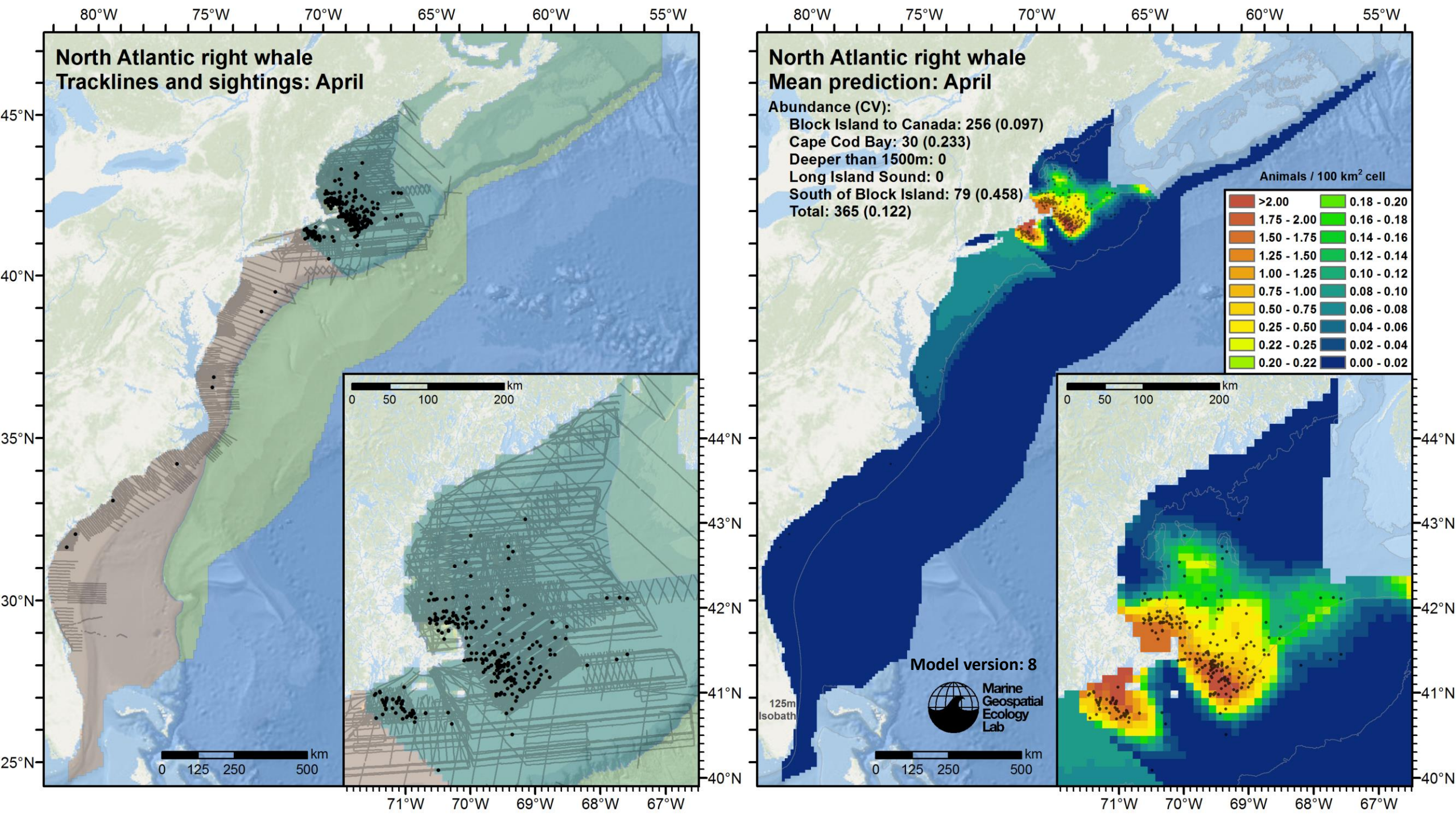
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
125m Isobath
Model version: 8
Marine Geospatial Ecology Lab

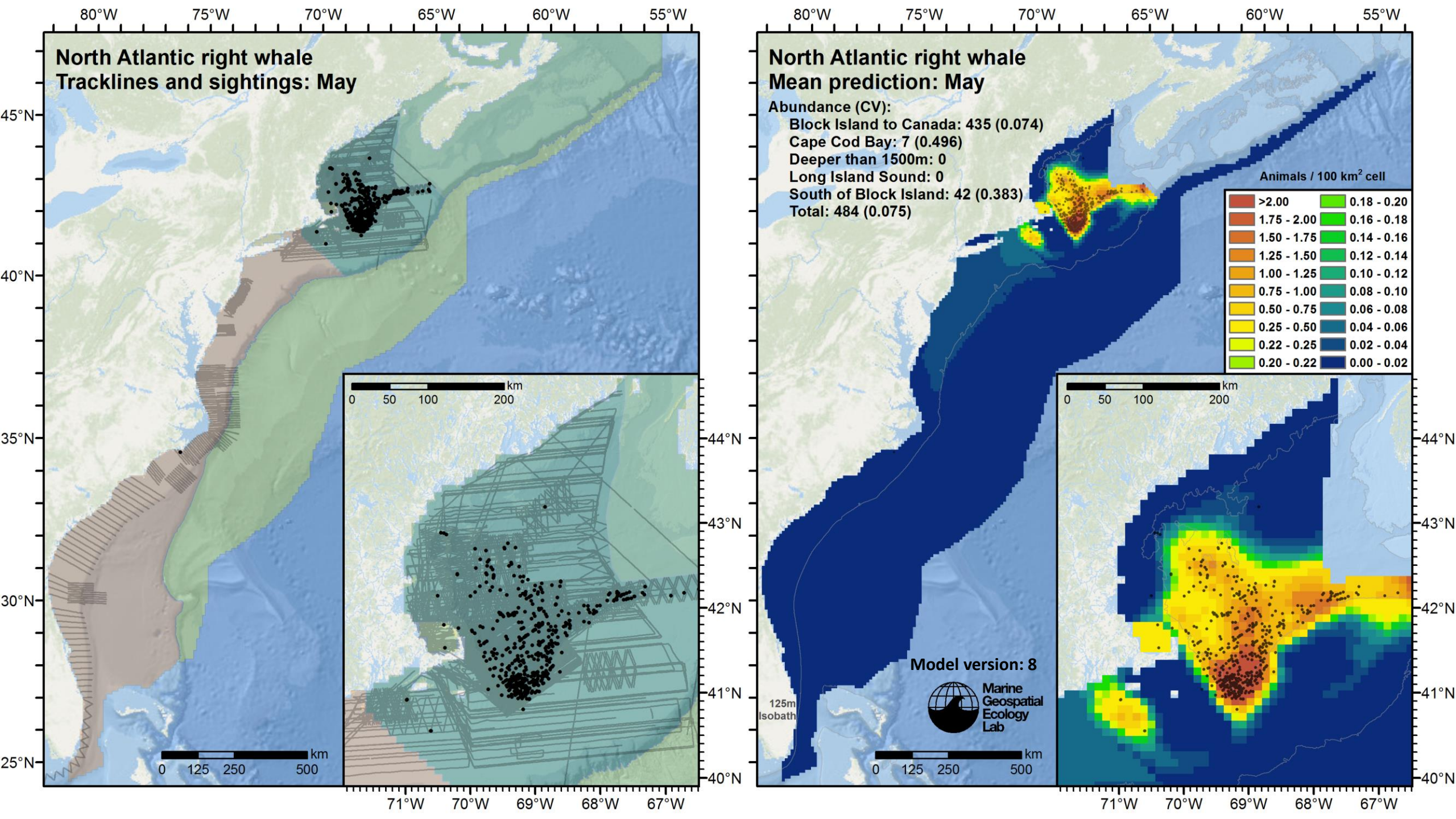

North Atlantic right whale
Tracklines and sightings: Summer (Jul-Sep)
North of Block Island:
147 sightings, full model
Long Island Sound:
assumed absent
South of Block
Island: 2 sightings,
stratified model
Deeper than 1500m:
assumed absent
South of Cape
Hatteras:
assumed
absent
km
0 125 250 500
0 50 100 200
80°W 75°W 70°W 65°W 60°W 55°W
45°N 40°N 35°N 30°N 25°N
44°N 43°N 42°N 41°N 40°N
71°W 70°W 69°W 68°W 67°W
North Atlantic right whale
Mean prediction: Summer (Jul-Sep)
Abundance (CV):
Deeper than 1500m: 0
Long Island Sound: 0
North of Block Island: 351 (0.154)
South of Block Island: 7 (0.799)
South of Cape Hatteras: 0
Total: 358 (0.152)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
125m
Isobath
Model version: 8
Marine
Geospatial
Ecology
Lab

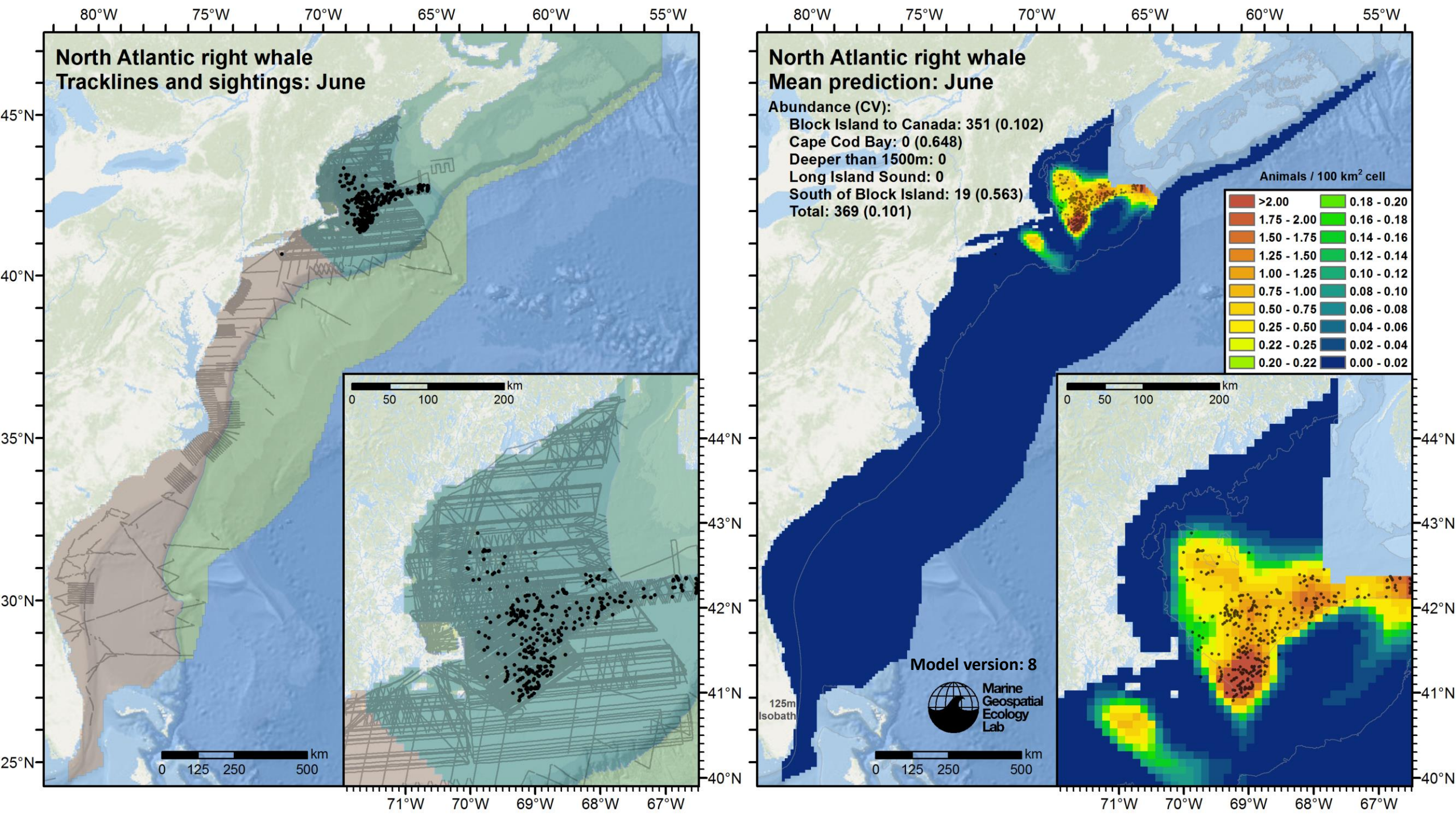

North Atlantic right whale
Tracklines and sightings: Fall (Oct-Nov)
Canadian shelf: insufficient effort
North of Block Island: 143 sightings, full model
Long Island Sound: assumed absent
Nearshore South of Block Island, ≤ 54 km from shore: 5 sightings, stratified model
Deeper than 1500m: assumed absent
Rationale: 99% of all right whale sightings south of Block Island were ≤ 54 km of shore
Offshore South of Block Island, > 54 km from shore: assumed absent, but more data needed!
Caution advised!
More data desired!
North Atlantic right whale
Mean prediction: Fall (Oct-Nov)
Abundance (CV):
Block Island to Canada: 117 (0.133)
Deeper than 1500m: 0
Long Island Sound: 0
Nearshore South of Block Island: 7 (0.517)
Offshore South of Block Island: 0
Total: 124 (0.129)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
Model version: 8
Marine Geospatial Ecology Lab
125m Isobath
km
0 125 250 500
0 50 100 200
80°W 75°W 70°W 65°W 60°W 55°W
45°N 40°N 35°N 30°N 25°N
44°N 43°N 42°N 41°N 40°N
71°W 70°W 69°W 68°W 67°W

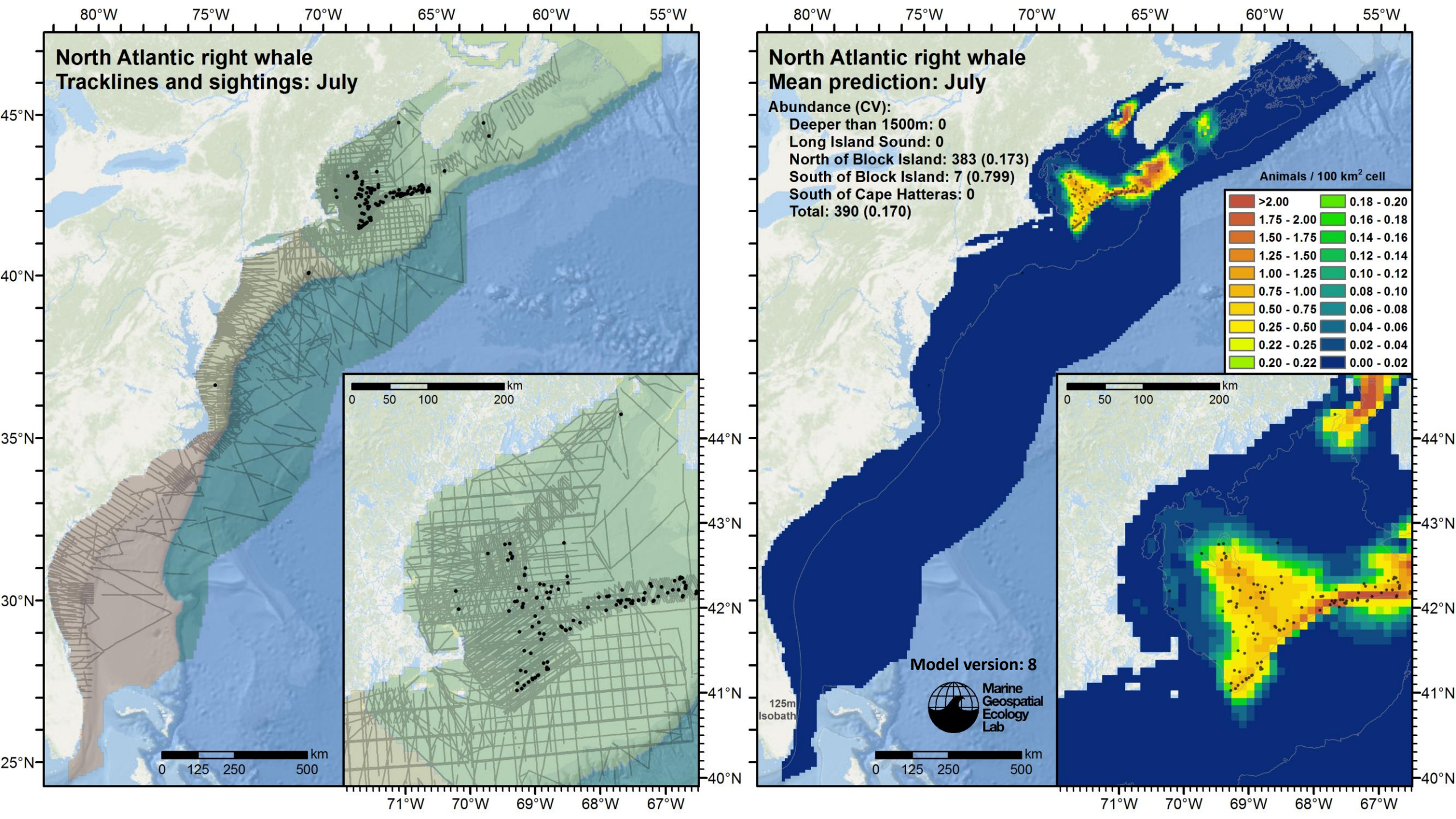

North Atlantic right whale
Tracklines and sightings: Winter (Dec-Mar)
Block Island to Canada: 257 sightings, full model
Canadian shelf: insufficient effort
Cape Cod Bay: used Ganley et al. (2019) estimates
Long Island Sound: assumed absent
Cape Fear to Block Island: 28 sightings, tried univariate models, best was DistToShore
Deeper than 1500m: assumed absent
South of Cape Fear: 2467 sightings, full model
km
0 125 250 500
0 50 100 200
80°W 75°W 70°W 65°W 60°W 55°W
45°N 40°N 35°N 30°N 25°N
44°N 43°N 42°N 41°N 40°N
71°W 70°W 69°W 68°W 67°W
North Atlantic right whale
Mean prediction: Winter (Dec-Mar)
Abundance (CV):
Block Island to Canada: 160 (0.107)
Cape Cod Bay: 14 (0.280)
Cape Fear to Block Island: 84 (0.242)
Deeper than 1500m: 0
Long Island Sound: 0
South of Cape Fear: 47 (0.058)
Total: 305 (0.088)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
125m Isobath
Model version: 8
Marine Geospatial Ecology Lab

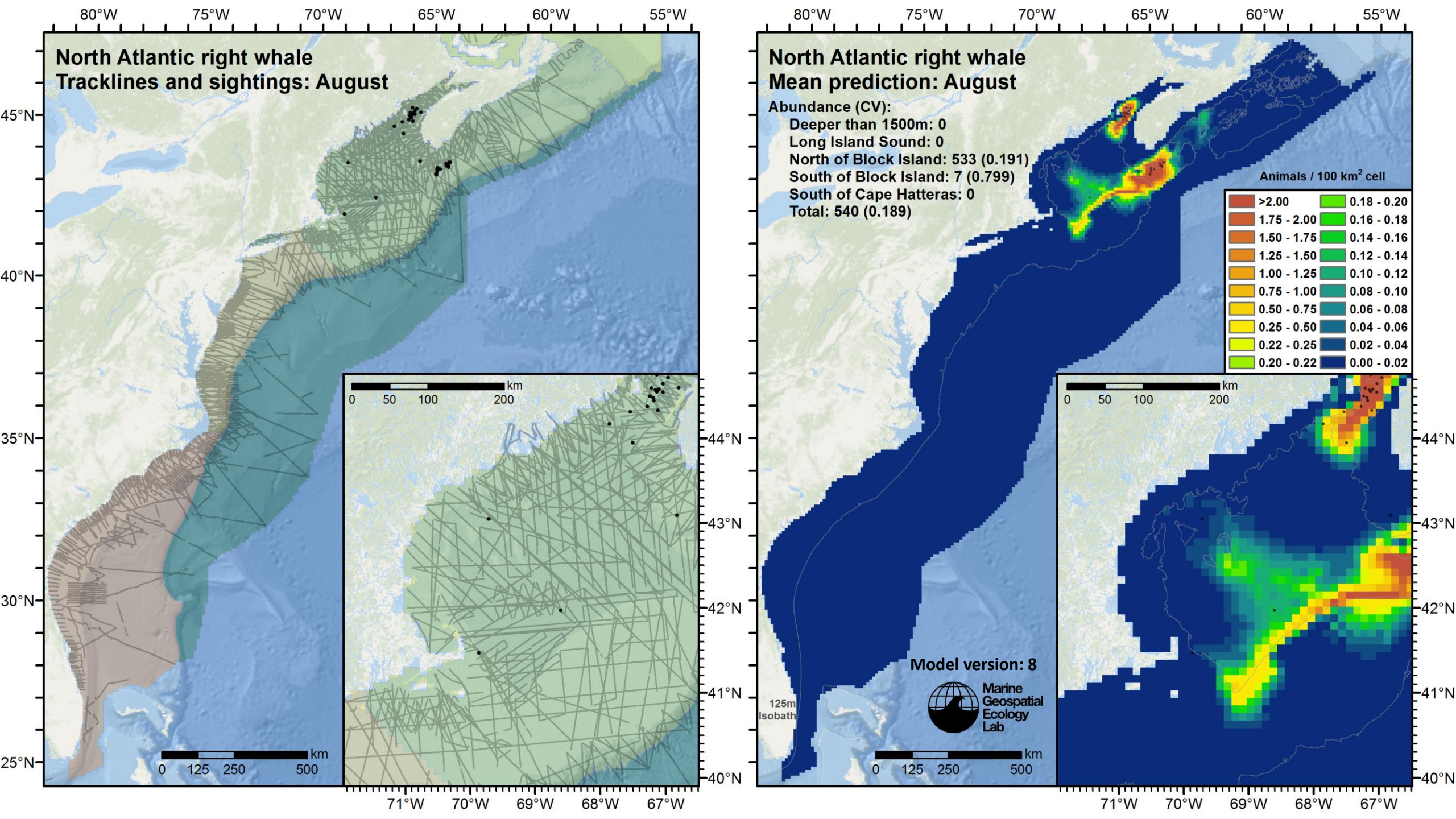
Monthly predictions

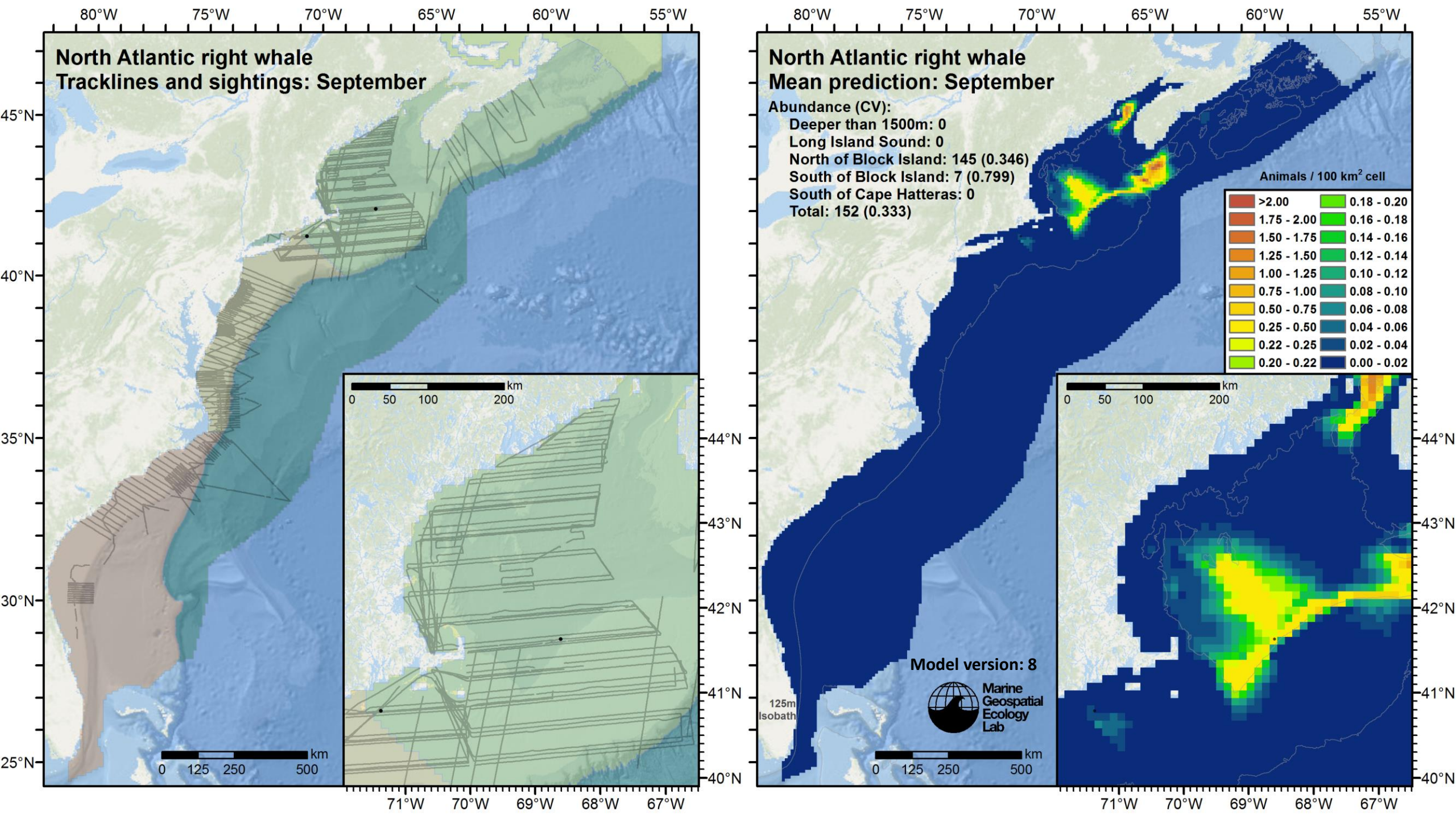

North Atlantic right whale
Tracklines and sightings: April
80°W
75°W
70°W
65°W
60°W
55°W
45°N
40°N
35°N
30°N
25°N
km
0 125 250 500
km
0 50 100 200
71°W
70°W
69°W
68°W
67°W
44°N
43°N
42°N
41°N
40°N
North Atlantic right whale
Mean prediction: April
Abundance (CV):
Block Island to Canada: 256 (0.097)
Cape Cod Bay: 30 (0.233)
Deeper than 1500m: 0
Long Island Sound: 0
South of Block Island: 79 (0.458)
Total: 365 (0.122)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
125m Isobath
Model version: 8
Marine Geospatial Ecology Lab

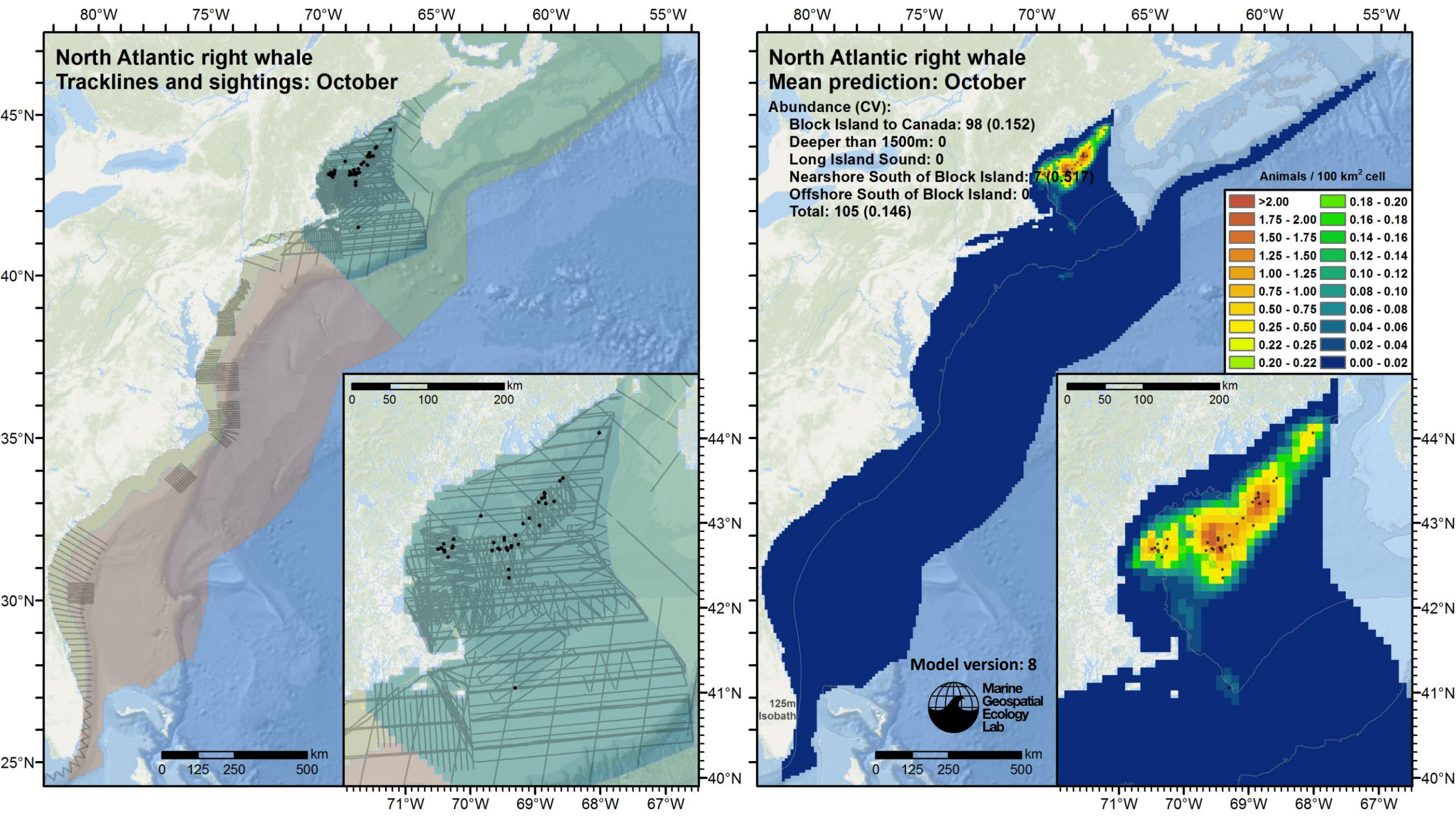

North Atlantic right whale
Tracklines and sightings: May
North Atlantic right whale
Mean prediction: May
Abundance (CV):
Block Island to Canada: 435 (0.074)
Cape Cod Bay: 7 (0.496)
Deeper than 1500m: 0
Long Island Sound: 0
South of Block Island: 42 (0.383)
Total: 484 (0.075)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
Model version: 8
Marine Geospatial Ecology Lab
125m Isobath
km
0 125 250 500
0 50 100 200
80°W 75°W 70°W 65°W 60°W 55°W
45°N 40°N 35°N 30°N 25°N
44°N 43°N 42°N 41°N 40°N
71°W 70°W 69°W 68°W 67°W

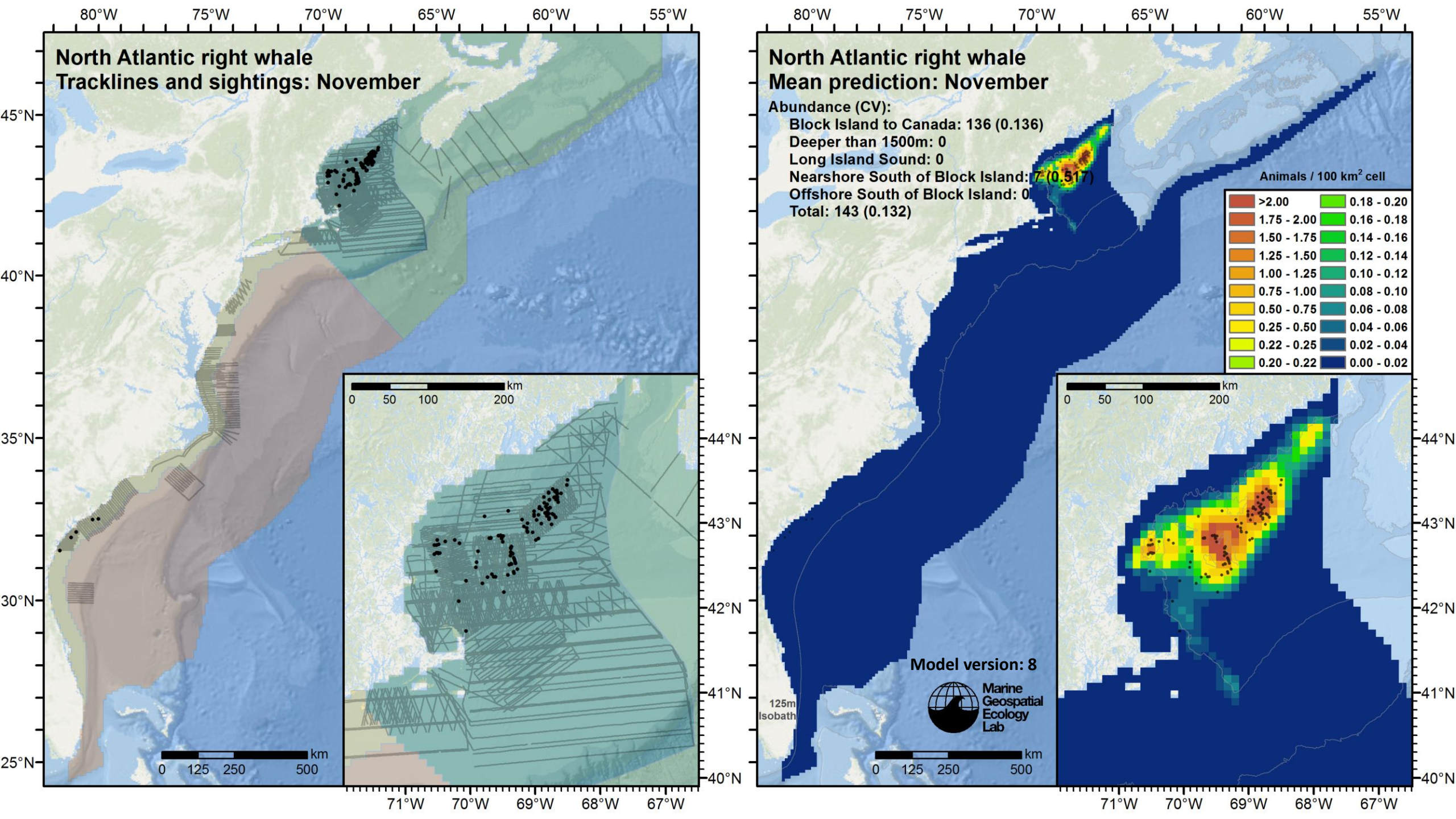

North Atlantic right whale
Tracklines and sightings: June
80°W
75°W
70°W
65°W
60°W
55°W
45°N
40°N
35°N
30°N
25°N
0 125 250 500 km
0 50 100 200 km
44°N
43°N
42°N
41°N
40°N
71°W
70°W
69°W
68°W
67°W
North Atlantic right whale
Mean prediction: June
Abundance (CV):
Block Island to Canada: 351 (0.102)
Cape Cod Bay: 0 (0.648)
Deeper than 1500m: 0
Long Island Sound: 0
South of Block Island: 19 (0.563)
Total: 369 (0.101)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
125m Isobath
Model version: 8
Marine Geospatial Ecology Lab

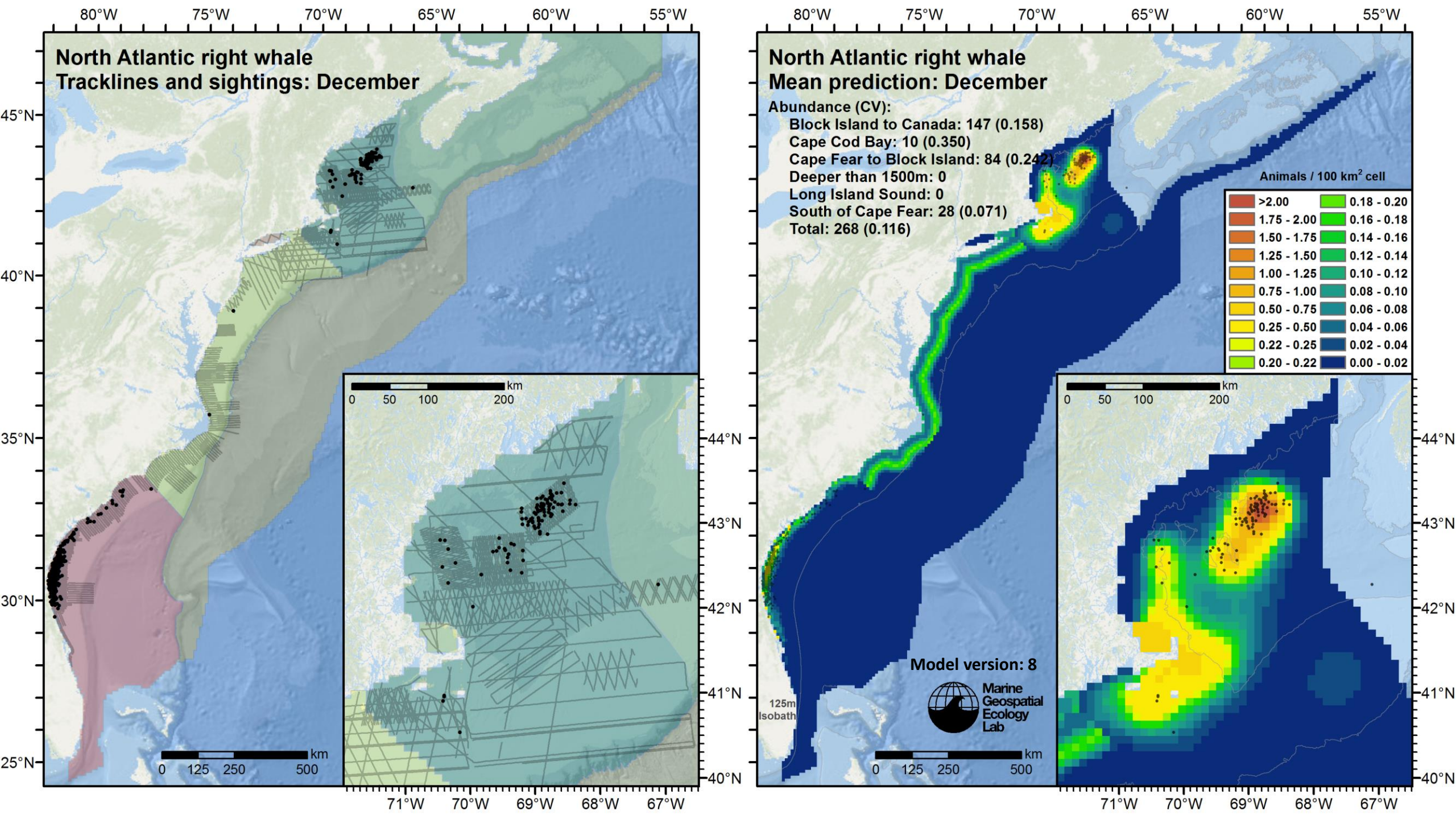

North Atlantic right whale
Tracklines and sightings: July
80°W
75°W
70°W
65°W
60°W
55°W
45°N
40°N
35°N
30°N
25°N
km
0 125 250 500
km
0 50 100 200
44°N
43°N
42°N
41°N
40°N
71°W
70°W
69°W
68°W
67°W
North Atlantic right whale
Mean prediction: July
Abundance (CV):
Deeper than 1500m: 0
Long Island Sound: 0
North of Block Island: 383 (0.173)
South of Block Island: 7 (0.799)
South of Cape Hatteras: 0
Total: 390 (0.170)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
125m Isobath
Model version: 8
Marine Geospatial Ecology Lab

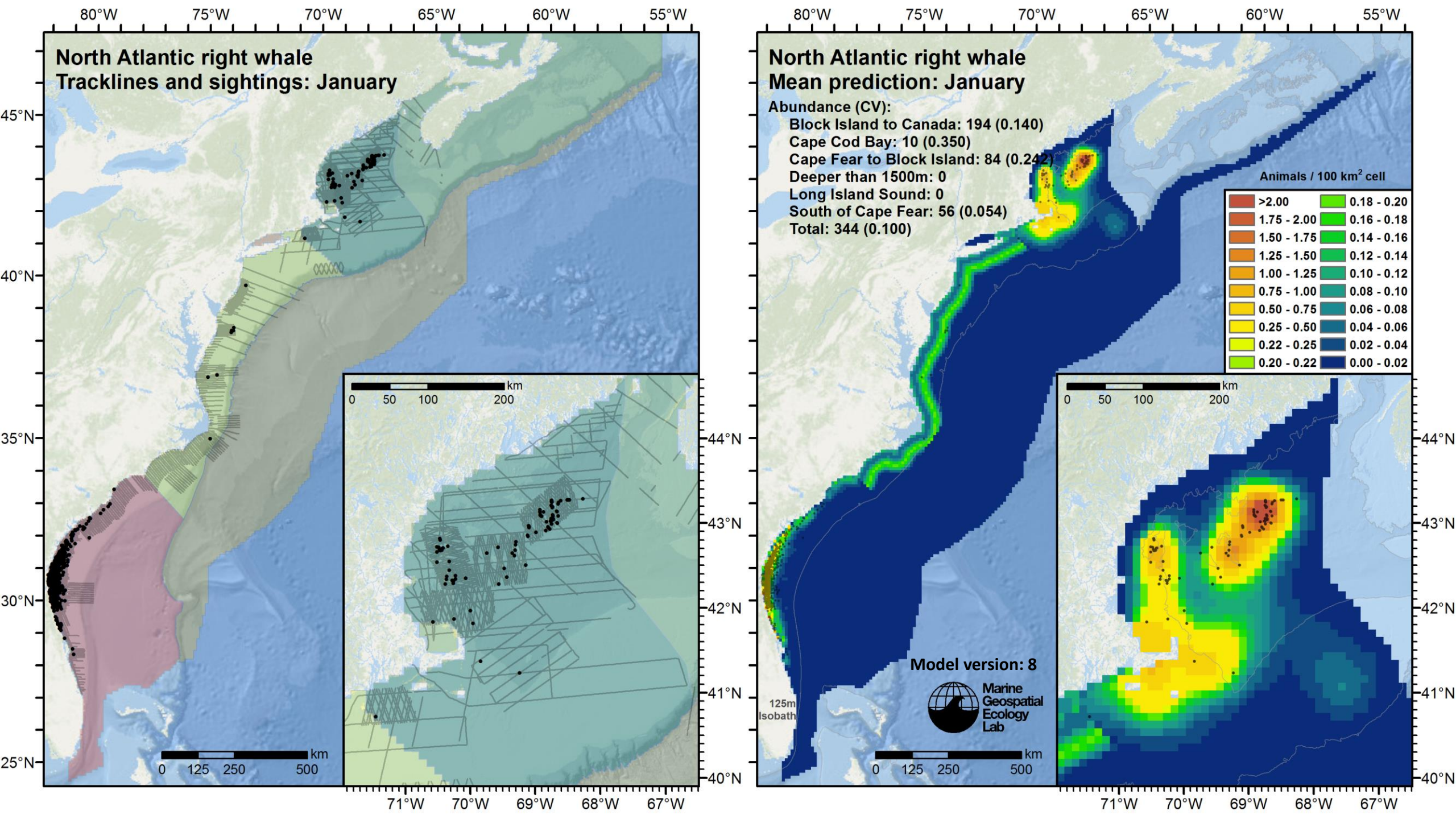

North Atlantic right whale
Tracklines and sightings: August
80°W
75°W
70°W
65°W
60°W
55°W
45°N
40°N
35°N
30°N
25°N
0 125 250 500 km
0 50 100 200 km
71°W
70°W
69°W
68°W
67°W
44°N
43°N
42°N
41°N
40°N
North Atlantic right whale
Mean prediction: August
Abundance (CV):
Deeper than 1500m: 0
Long Island Sound: 0
North of Block Island: 533 (0.191)
South of Block Island: 7 (0.799)
South of Cape Hatteras: 0
Total: 540 (0.189)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
125m Isobath
Model version: 8
Marine Geospatial Ecology Lab

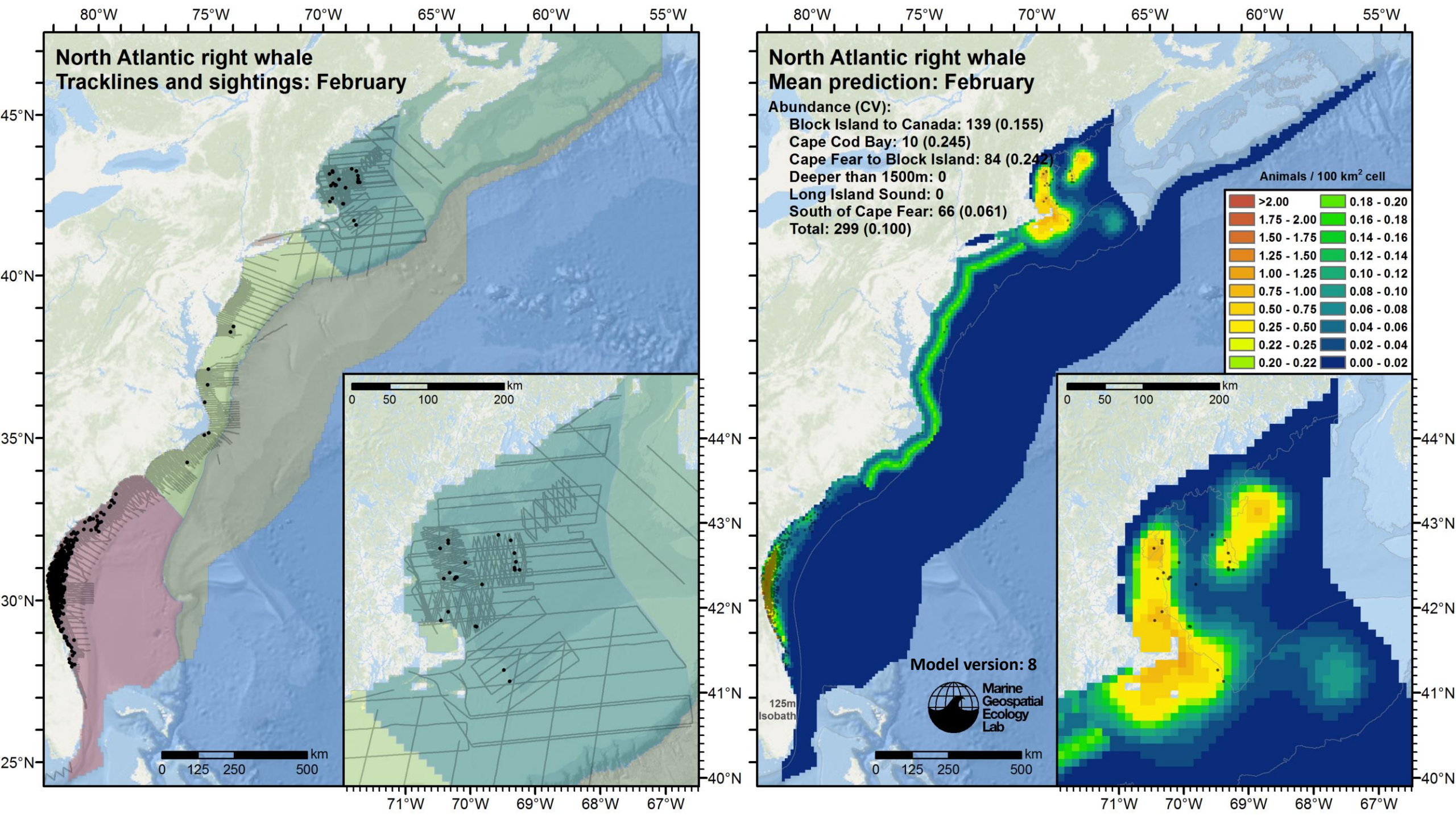

North Atlantic right whale
Tracklines and sightings: September
80°W
75°W
70°W
65°W
60°W
55°W
45°N
40°N
35°N
30°N
25°N
km
0 125 250 500
km
0 50 100 200
71°W
70°W
69°W
68°W
67°W
44°N
43°N
42°N
41°N
40°N
North Atlantic right whale
Mean prediction: September
Abundance (CV):
Deeper than 1500m: 0
Long Island Sound: 0
North of Block Island: 145 (0.346)
South of Block Island: 7 (0.799)
South of Cape Hatteras: 0
Total: 152 (0.333)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
125m Isobath
Model version: 8
Marine Geospatial Ecology Lab

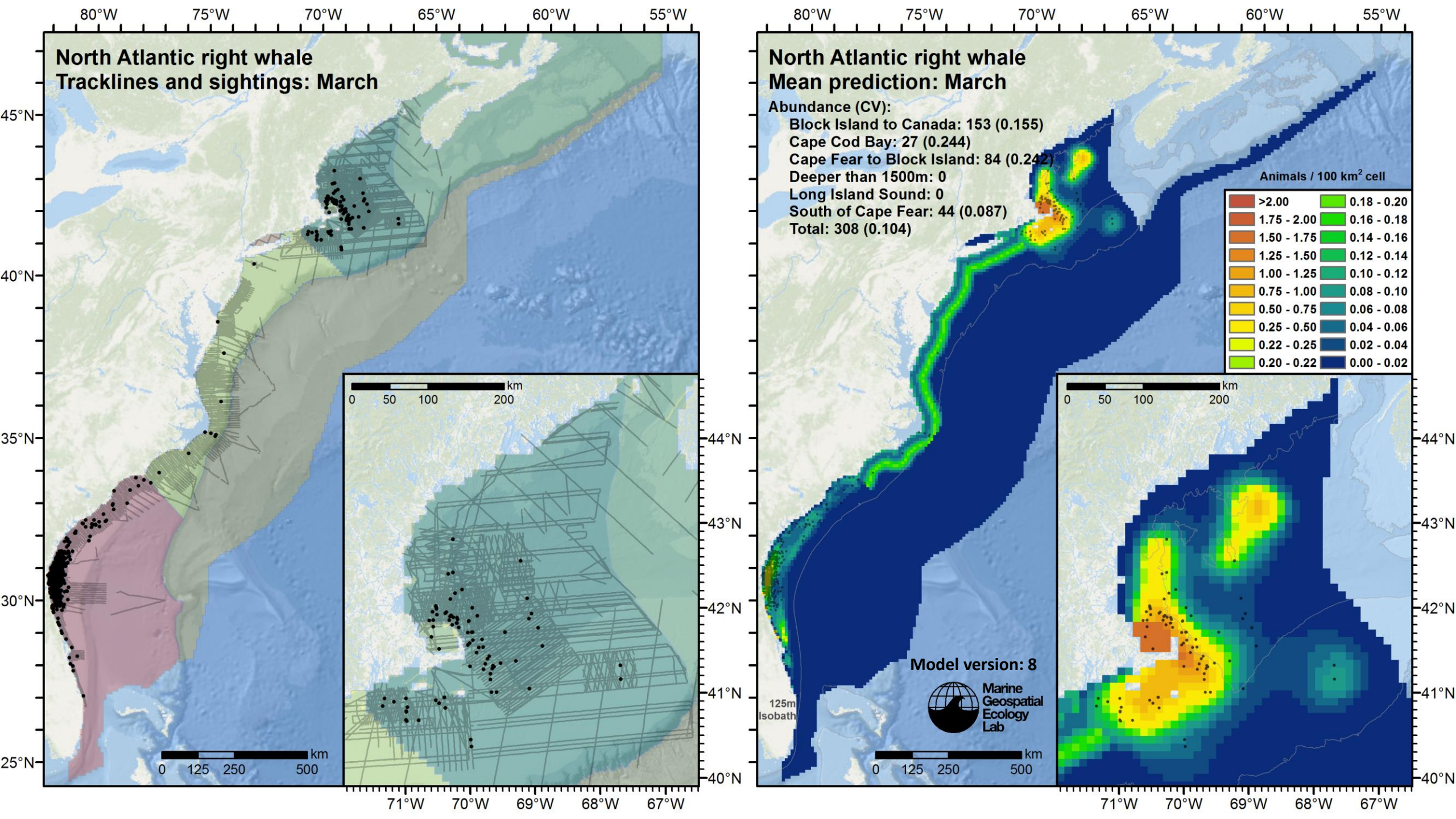

North Atlantic right whale
Tracklines and sightings: October
80°W
75°W
70°W
65°W
60°W
55°W
45°N
40°N
35°N
30°N
25°N
km
0 125 250 500
km
0 50 100 200
71°W
70°W
69°W
68°W
67°W
44°N
43°N
42°N
41°N
40°N
North Atlantic right whale
Mean prediction: October
Abundance (CV):
Block Island to Canada: 98 (0.152)
Deeper than 1500m: 0
Long Island Sound: 0
Nearshore South of Block Island: 7 (0.517)
Offshore South of Block Island: 0
Total: 105 (0.146)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
125m Isobath
Model version: 8
Marine Geospatial Ecology Lab

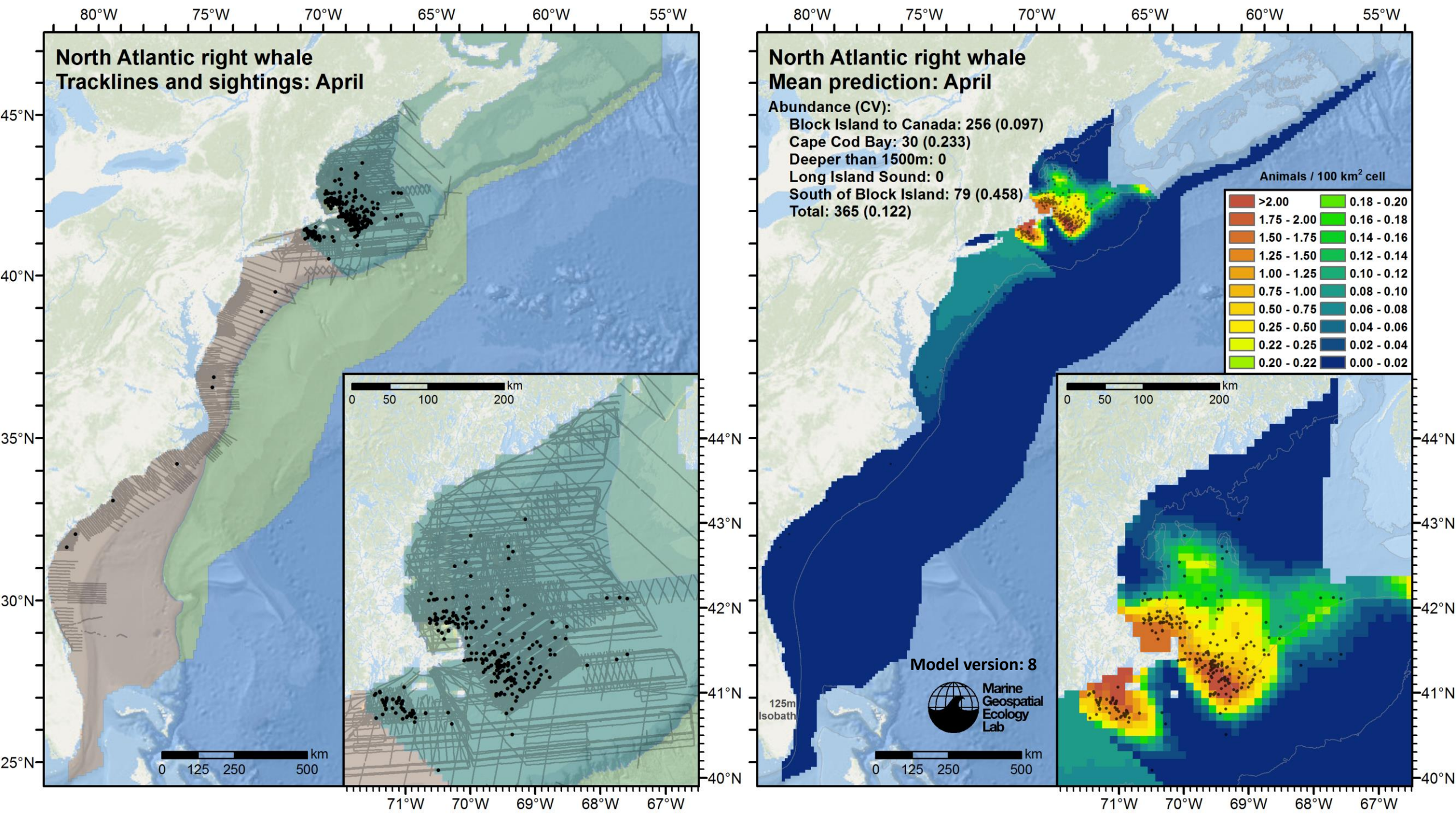

North Atlantic right whale
Tracklines and sightings: November
80°W
75°W
70°W
65°W
60°W
55°W
45°N
40°N
35°N
30°N
25°N
km
0 125 250 500
km
0 50 100 200
71°W
70°W
69°W
68°W
67°W
44°N
43°N
42°N
41°N
40°N
North Atlantic right whale
Mean prediction: November
Abundance (CV):
Block Island to Canada: 136 (0.136)
Deeper than 1500m: 0
Long Island Sound: 0
Nearshore South of Block Island: 7 (0.517)
Offshore South of Block Island: 0
Total: 143 (0.132)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
125m Isobath
Model version: 8
Marine Geospatial Ecology Lab


North Atlantic right whale
Tracklines and sightings: December
80°W
75°W
70°W
65°W
60°W
55°W
45°N
40°N
35°N
30°N
25°N
km
0 125 250 500
km
0 50 100 200
71°W
70°W
69°W
68°W
67°W
44°N
43°N
42°N
41°N
40°N
North Atlantic right whale
Mean prediction: December
Abundance (CV):
Block Island to Canada: 147 (0.158)
Cape Cod Bay: 10 (0.350)
Cape Fear to Block Island: 84 (0.242)
Deeper than 1500m: 0
Long Island Sound: 0
South of Cape Fear: 28 (0.071)
Total: 268 (0.116)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
125m Isobath
Model version: 8
Marine Geospatial Ecology Lab


North Atlantic right whale
Tracklines and sightings: January
North Atlantic right whale
Mean prediction: January
Abundance (CV):
Block Island to Canada: 194 (0.140)
Cape Cod Bay: 10 (0.350)
Cape Fear to Block Island: 84 (0.242)
Deeper than 1500m: 0
Long Island Sound: 0
South of Cape Fear: 56 (0.054)
Total: 344 (0.100)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
Model version: 8
Marine Geospatial Ecology Lab
125m Isobath
km
0 125 250 500
0 50 100 200
80°W 75°W 70°W 65°W 60°W 55°W
45°N 40°N 35°N 30°N 25°N
44°N 43°N 42°N 41°N 40°N
71°W 70°W 69°W 68°W 67°W


North Atlantic right whale
Tracklines and sightings: February
80°W
75°W
70°W
65°W
60°W
55°W
45°N
40°N
35°N
30°N
25°N
km
0 125 250 500
0 50 100 200
71°W
70°W
69°W
68°W
67°W
44°N
43°N
42°N
41°N
40°N
North Atlantic right whale
Mean prediction: February
Abundance (CV):
Block Island to Canada: 139 (0.155)
Cape Cod Bay: 10 (0.245)
Cape Fear to Block Island: 84 (0.242)
Deeper than 1500m: 0
Long Island Sound: 0
South of Cape Fear: 66 (0.061)
Total: 299 (0.100)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
125m Isobath
Model version: 8
Marine Geospatial Ecology Lab


North Atlantic right whale
Tracklines and sightings: March
80°W
75°W
70°W
65°W
60°W
55°W
45°N
40°N
35°N
30°N
25°N
0 125 250 500 km
0 50 100 200 km
71°W
70°W
69°W
68°W
67°W
44°N
43°N
42°N
41°N
40°N
North Atlantic right whale
Mean prediction: March
Abundance (CV):
Block Island to Canada: 153 (0.155)
Cape Cod Bay: 27 (0.244)
Cape Fear to Block Island: 84 (0.242)
Deeper than 1500m: 0
Long Island Sound: 0
South of Cape Fear: 44 (0.087)
Total: 308 (0.104)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
125m Isobath
Model version: 8
Marine Geospatial Ecology Lab


North Atlantic right whale
Tracklines and sightings: April
80°W
75°W
70°W
65°W
60°W
55°W
45°N
40°N
35°N
30°N
25°N
km
0 125 250 500
km
0 50 100 200
71°W
70°W
69°W
68°W
67°W
44°N
43°N
42°N
41°N
40°N
North Atlantic right whale
Mean prediction: April
Abundance (CV):
Block Island to Canada: 256 (0.097)
Cape Cod Bay: 30 (0.233)
Deeper than 1500m: 0
Long Island Sound: 0
South of Block Island: 79 (0.458)
Total: 365 (0.122)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
125m Isobath
Model version: 8
Marine Geospatial Ecology Lab

Plan for the right whale version 9 model

- In 2019, we will start updating all species for the Navy's AFTT Phase IV EIS
- These models due to the Navy in 2021-2022
- As a rapid first run through the modeling process, we will produce a new right whale model, version 9, to be completed October 1, 2019
  - Review with Navy and NARW experts in Oct, present at NARWC, then submit paper

Version 9 model goals:

- Incorporate survey data through the end of 2018
- Build and compare independent "before and after" models (1998-2009 and 2010-2018?) based on when NARW experts believe "things changed"
- To the extent data allow, build a mother-calf pair model

Surveys targeted for the v9 model

We anticipate including most of the following (work is in progress):

- NEFSC / SEFSC AMAPPS II aerial and shipboard surveys, 2016-2018
- NEFSC NARWSS aerial surveys, Jul 2016-Dec 2018
- SEUS NARW aerial surveys, 2016/17 and 2017-18 calving seasons
- UNCW aerial surveys of Navy Norfolk, Hatteras, JAX study areas, 2017
- VA Aquarium aerial surveys outside Chesapeake Bay, 2017
- NE Aquarium aerial surveys of Mass/RI wind energy areas, 2011-2018
- NYS-DEC / TetraTech aerial surveys, 2017-2018
- NYSERDA / Normandeau digital aerial surveys, 2016-2018
- HDR surveys of Navy Hatteras study area, 2018

Longer term objectives (funding needed)

1. Incorporate other sources of right whale observations
   - Systematic visual surveys that did not collect distances to sightings
   - Systematic acoustic surveys
   - Opportunistic sightings
2. Incorporate known population trend (e.g. Pace et al. 2017) as an explicit model offset or nuisance variable
3. Explicitly address fine-scale (day-to-day) and interannual (year-to-year) autocorrelation, to better address clustering of right whales resulting from right whale social behavior and memory
4. Develop system optimized to give up-to-date forecasts in near real time, based on both historical and recent sightings and ocean conditions

For more information

- Following slides give answers to several “frequently asked questions”
- You can download this presentation and GIS files for the right whale v8 model from NOAA (location to be provided)
- Model documentation:
  - v5.4 model: Roberts et al. (2016) https://www.nature.com/articles/srep22615 and supplementary report http://seamap.env.duke.edu/models/Duke-EC-GOM-2015/
  - v7 model: MGEL reports to Navy (provided with v8 downloads)
  - v8 model: This presentation
- I will be at the ALWTRT meeting in Providence next week
- Feel free to email me any questions: jason.roberts@duke.edu

Thanks!

Frequently asked questions

Frequently Asked Question

Is this model appropriate for the ALWTRT's management applications?

Maybe. This is for you, the TRT members, to decide.

The model was originally developed for the Navy's needs in 2015-2017:

- Estimate absolute density (whales / km^2)
- Provide estimates for all grid cells across the U.S. EEZ, with no holes
- Utilize as much data as possible, to maximize confidence and account for variability
- Summarize into monthly maps, to reflect seasonal dynamics in whale movements

Your needs may be similar. But you might have additional requirements:

- Incorporate the very latest survey data available, as of 2019?
- Focus the model on recent years, e.g. after right whale distribution "changed" in 2010?

The v8 model is what we can provide now. I will be at the TRT meeting and happy to answer questions. We have an update planned for Oct. 2019. If you can articulate your requirements we will try to address them for the update.

Frequently Asked Question

How exactly did you fill Cape Cod Bay with Ganley et al.'s (2019) results?

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ENDANGERED SPECIES RESEARCH
Endang Species Res

Published February 28

OPEN ACCESS

What we see is not what there is: estimating North Atlantic right whale *Eubalaena glacialis* local abundance

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ABSTRACT: Aerial surveys can be used to estimate animal abundance, but animals unavailable for detection for portions of the survey can cause biased abundance estimates. Moreover, these biases may be variable owing to changes in behavior. We conducted focal follows to obtain surface and dive times of North Atlantic right whales *Eubalaena glacialis* in Cape Cod Bay (CCB) and measured the aircraft field of view; these metrics were combined to estimate availability and correct monthly abundance estimates from 1998 to 2017 generated via distance sampling methodology. We used a general least squares model to test for trends in abundance. Availability varied with month (0.27–0.85), likely linked to changes in the depth of copepod food resources. Detection probability varied across the years (0.43–0.87). Sightings per unit effort and counts of whales were significant, but downward-biased indicators of abundance and availability caused changes in bias over the season. Estimated abundance in CCB increased during the study period (4.9 whales yr^{-1}), and estimated abundance in peak months increased at a faster rate (10% yr^{-1} for 1998–2017) than for the overall population (2.8% yr^{-1} for 1990–2010). Accurate abundance estimates are necessary to monitor long-term changes in abundance of right whales in CCB, to understand the importance of CCB relative to other areas, and improve management strategies to protect this endangered species from entanglements in fishing gear and ship-strikes. Failing to correct for seasonal variation in availability results in substantial and variable underestimation of abundance.

KEY WORDS: Abundance estimation · Availability bias · Bayesian · Distance sampling · $g(0)$ · Right whales · Transect sampling · Diving

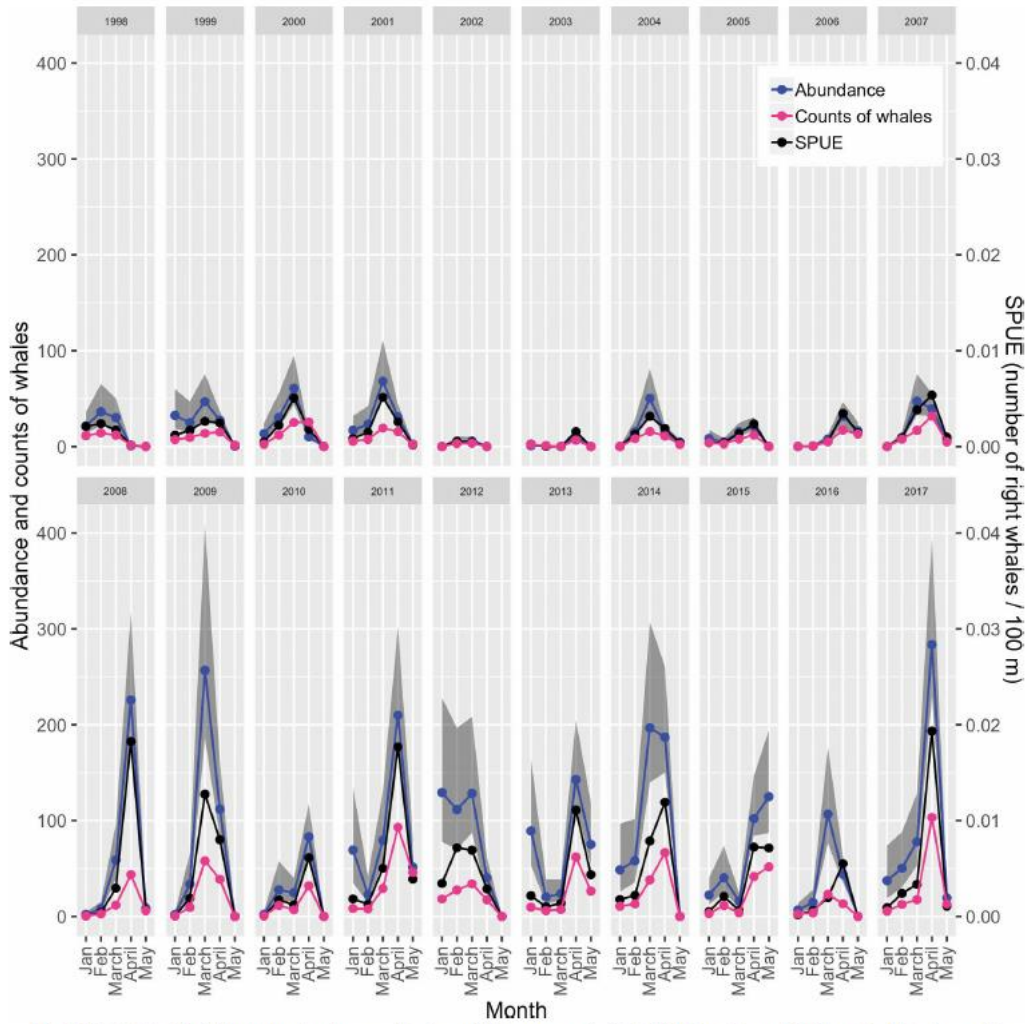


Fig. 6. North Atlantic right whale abundance estimates, sightings per unit effort (SPUE), and counts in Cape Cod Bay by month for each year. Blue points: median of the distribution of bootstrapped abundance; gray shaded regions: 1st and 3rd quartiles of the distribution; black points: SPUE; pink points: counts of right whales divided by the number of surveys in each month. There was no survey effort in May 2002

Cape Cod Bay

- In 2015-2017, we solicited a collaboration with Center for Coastal Studies (CCS), so that their surveys of Cape Cod Bay could be added to our model
- CCS replied positively, but their surveys lacked perpendicular distances to whale sightings, which we needed for our analysis
- They undertook an effort to reconstruct those distances from logged GPS data and then produce abundance and density estimates for CCB
- We left CCB “empty” for Winter and Spring seasons in our v7 model
- Laura Ganley published results in Feb 2019, which we incorporated into v8
  - Rather than incorporate CCS data into our model, we overlaid their results on ours
  - Cape Cod Bay is such a “special place” that it is best modeled separately
    - This may change if robust zooplankton maps become available across the northeast

Incorporation of Ganley et al. (2019) CCB results

Step 1: For our model, Laura Ganley provided:

- Climatological mean abundance and standard error estimates for the 1999-2016 seasons, the period spanned by our model, for 5 months (Jan-May)
- The geographical area those estimates applied to: 4105 km^2

Step 2: I derived mean density estimates and standard errors for each month:

Month	Mean abundance (whales)	SE	Area (km2)	Density (whales/100 km2)	SE
1	23.67	8.29	4105	0.58	0.20
2	25.14	6.16	4105	0.61	0.15
3	66.33	16.18	4105	1.62	0.39
4	71.78	16.73	4105	1.75	0.41
5	16.52	8.20	4105	0.40	0.20

From Laura

I derived

Incorporation of Ganley et al. (2019) CCB results

Step 3: I also needed estimates for December and June:

- For December, I used Ganley's January estimate. Ganley indicated that right whales occasionally showed up in CCB in December. She'll try to include December in her next update.
- For June, I used the density model's prediction.

Month	Mean abundance (whales)	SE	Area (km2)	Density (whales/100 km2)	SE
12				0.58	0.20
1	23.67	8.29	4105	0.58	0.20
2	25.14	6.16	4105	0.61	0.15
3	66.33	16.18	4105	1.62	0.39
4	71.78	16.73	4105	1.75	0.41
5	16.52	8.20	4105	0.40	0.20
6				0.0035	0.0023

Copied

Copied

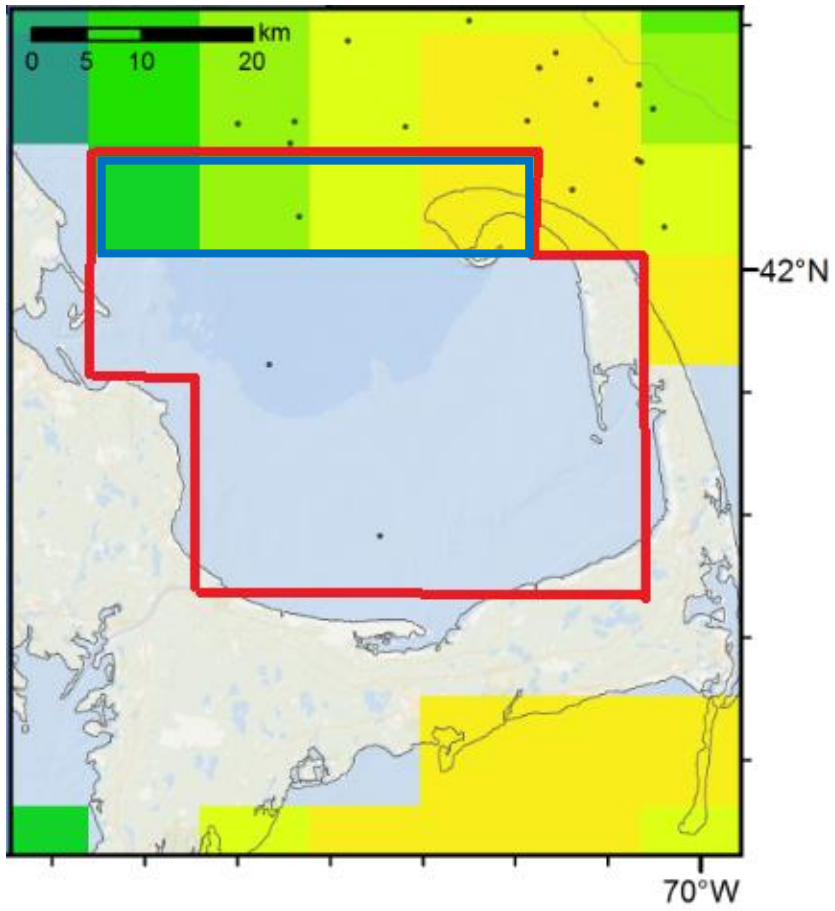
From density model

Incorporation of Ganley et al. (2019) CCB results

Step 4: Together, Ganley and I identified the cells of the density model's grid that best matched the area of CCB surveyed by CCS (red polygon).

For each month, December-June, I set those 17 cells to the monthly density and SE estimates from the previous step. (Each cell received the same value for that month.)

4 cells that were populated with density model predictions in v7 are now populated with Ganley's estimates in v8 (blue polygon).



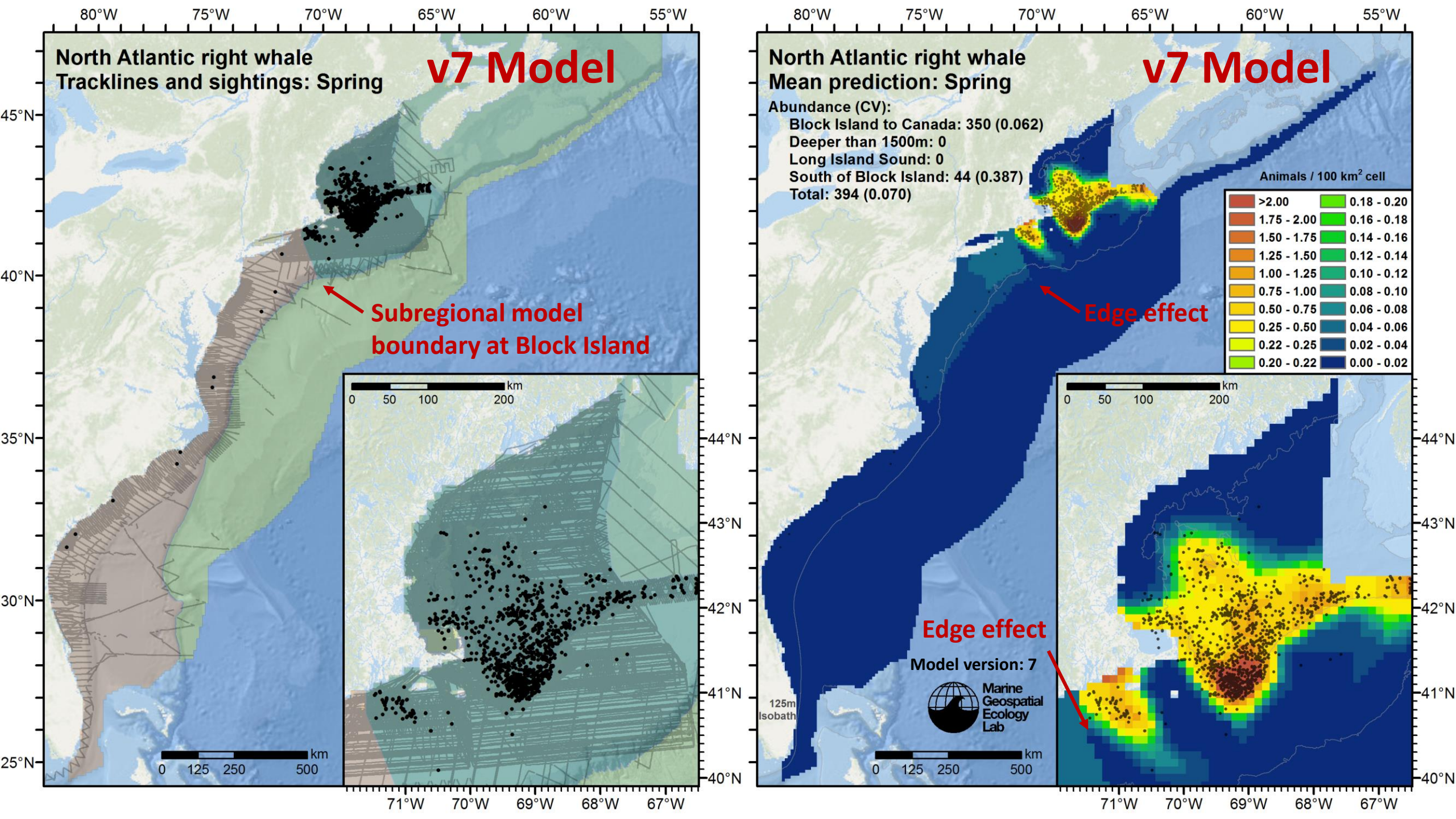
Frequently Asked Question

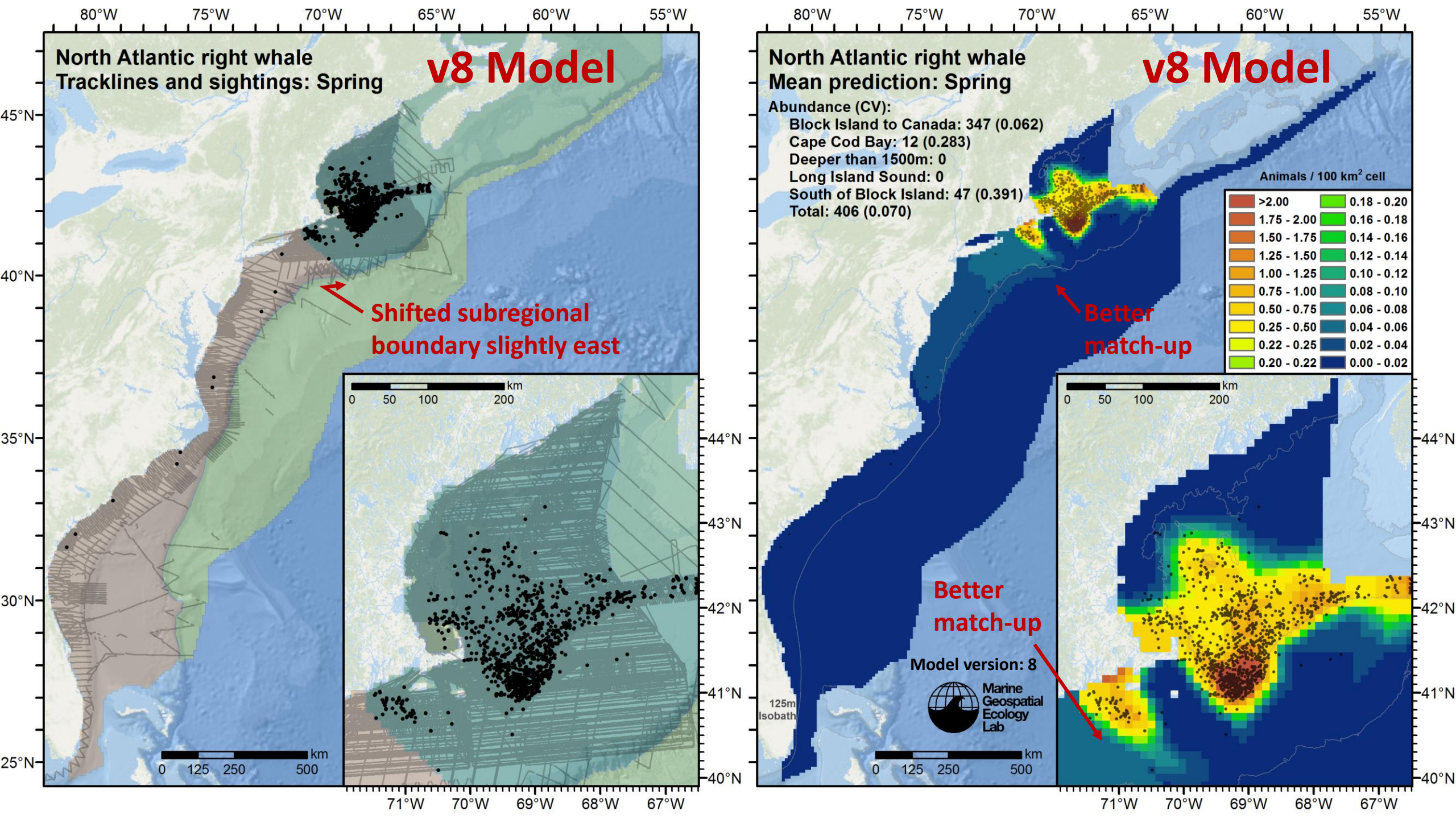
What are the "edge effects" from v7 that were reduced in v8?

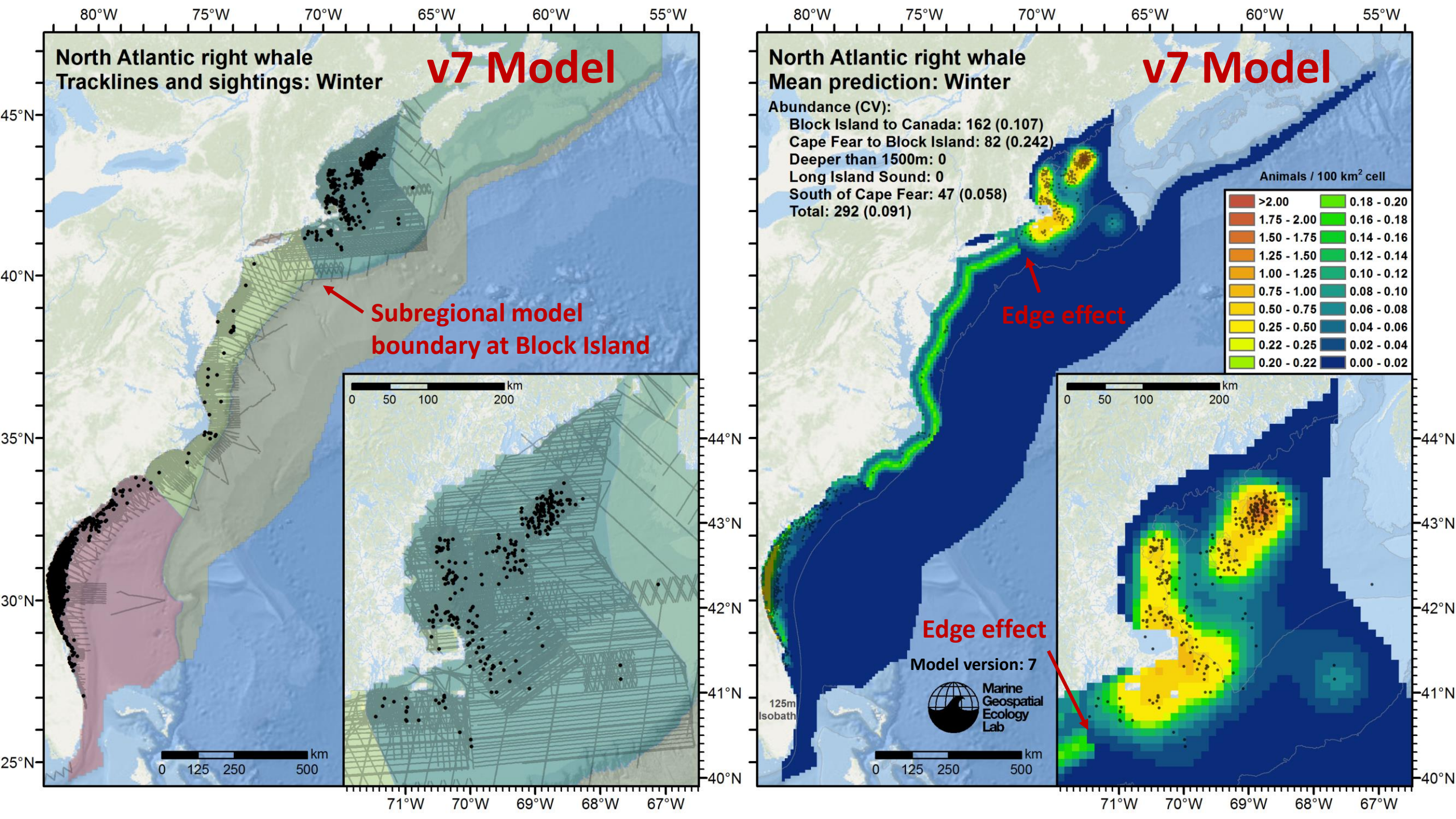
Our modeling approach was to split the study area seasonally and spatially into subregions where we suspect the species exhibits different species-environment relationships, based on the literature and patterns in the data.

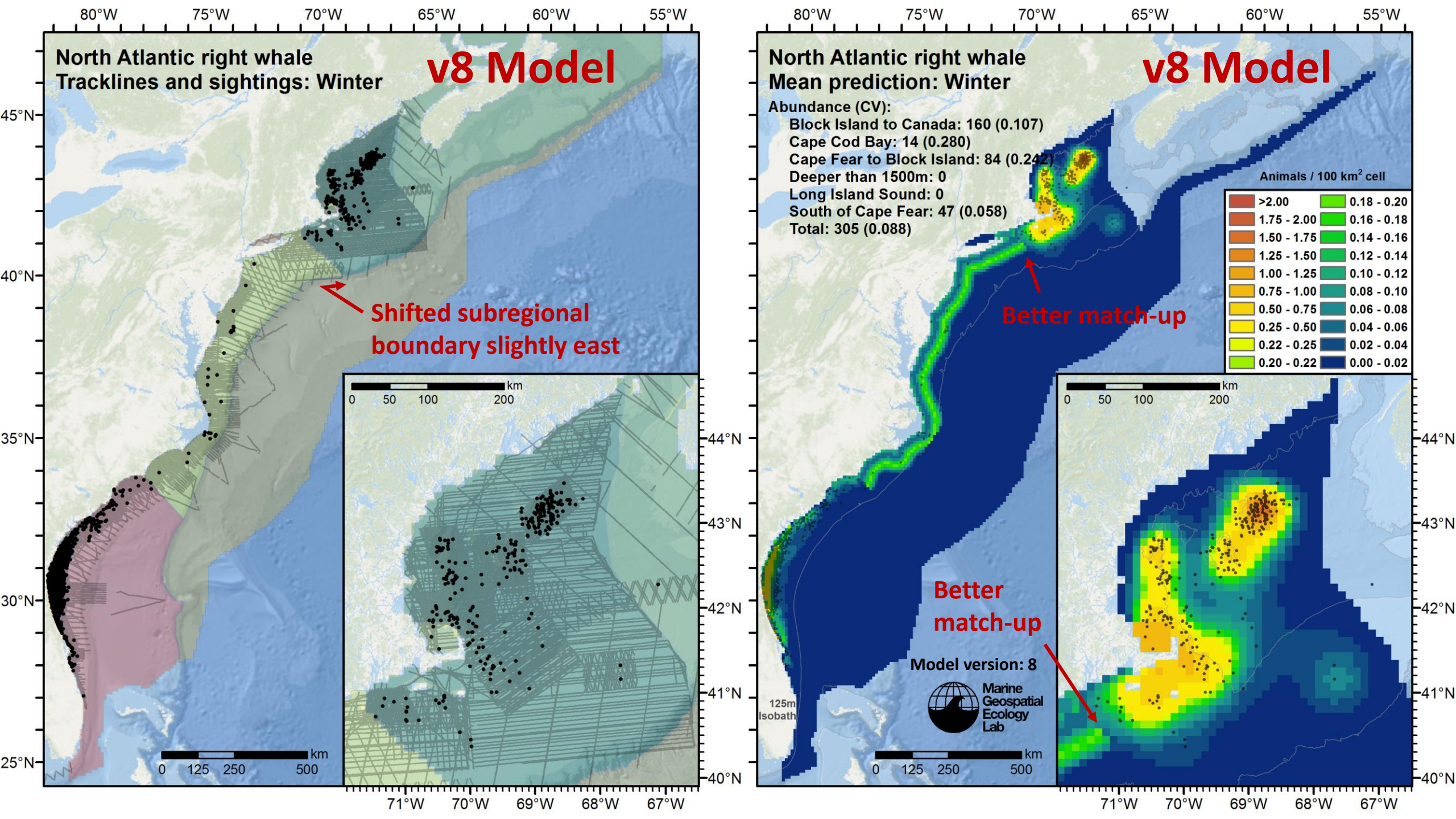
We placed one such split at Block Island:

- Aggregations of feeding right whales were observed in multiple years just north of here in Rhode Island Sound
- We were unaware of such regular feeding aggregations south of there
- We split the study area there, to allow models to express different density-to-habitat relationships, in case right whales behaved differently
- The boundary between the subregions produced an edge effect in v7
- In v8, we adjusted this boundary to reduce the edge effect


North Atlantic right whale
Tracklines and sightings: Spring
v7 Model
Subregional model boundary at Block Island
km
0 50 100 200
0 125 250 500
80°W 75°W 70°W 65°W 60°W 55°W
45°N 40°N 35°N 30°N 25°N
71°W 70°W 69°W 68°W 67°W
44°N 43°N 42°N 41°N 40°N
North Atlantic right whale
Mean prediction: Spring
v7 Model
Abundance (CV):
Block Island to Canada: 350 (0.062)
Deeper than 1500m: 0
Long Island Sound: 0
South of Block Island: 44 (0.387)
Total: 394 (0.070)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
Edge effect
Edge effect
Model version: 7
Marine Geospatial Ecology Lab
125m Isobath


North Atlantic right whale
Tracklines and sightings: Spring
v8 Model
Shifted subregional boundary slightly east
km
0 50 100 200
0 125 250 500
80°W 75°W 70°W 65°W 60°W 55°W
45°N 40°N 35°N 30°N 25°N
71°W 70°W 69°W 68°W 67°W
44°N 43°N 42°N 41°N 40°N
North Atlantic right whale
Mean prediction: Spring
v8 Model
Abundance (CV):
Block Island to Canada: 347 (0.062)
Cape Cod Bay: 12 (0.283)
Deeper than 1500m: 0
Long Island Sound: 0
South of Block Island: 47 (0.391)
Total: 406 (0.070)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
Better match-up
Better match-up
Model version: 8
Marine Geospatial Ecology Lab
125m Isobath


North Atlantic right whale
Tracklines and sightings: Winter
v7 Model
Subregional model boundary at Block Island
km
0 125 250 500
0 50 100 200
80°W 75°W 70°W 65°W 60°W 55°W
45°N 40°N 35°N 30°N 25°N
71°W 70°W 69°W 68°W 67°W
44°N 43°N 42°N 41°N 40°N
North Atlantic right whale
Mean prediction: Winter
v7 Model
Abundance (CV):
Block Island to Canada: 162 (0.107)
Cape Fear to Block Island: 82 (0.242)
Deeper than 1500m: 0
Long Island Sound: 0
South of Cape Fear: 47 (0.058)
Total: 292 (0.091)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
Edge effect
Edge effect
Model version: 7
Marine Geospatial Ecology Lab
125m Isobath


North Atlantic right whale
Tracklines and sightings: Winter
v8 Model
Shifted subregional boundary slightly east
km
0 50 100 200
0 125 250 500
80°W 75°W 70°W 65°W 60°W 55°W
45°N 40°N 35°N 30°N 25°N
71°W 70°W 69°W 68°W 67°W
44°N 43°N 42°N 41°N 40°N
North Atlantic right whale
Mean prediction: Winter
v8 Model
Abundance (CV):
Block Island to Canada: 160 (0.107)
Cape Cod Bay: 14 (0.280)
Cape Fear to Block Island: 84 (0.242)
Deeper than 1500m: 0
Long Island Sound: 0
South of Cape Fear: 47 (0.058)
Total: 305 (0.088)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
Better match-up
Better match-up
125m Isobath
Model version: 8
Marine Geospatial Ecology Lab

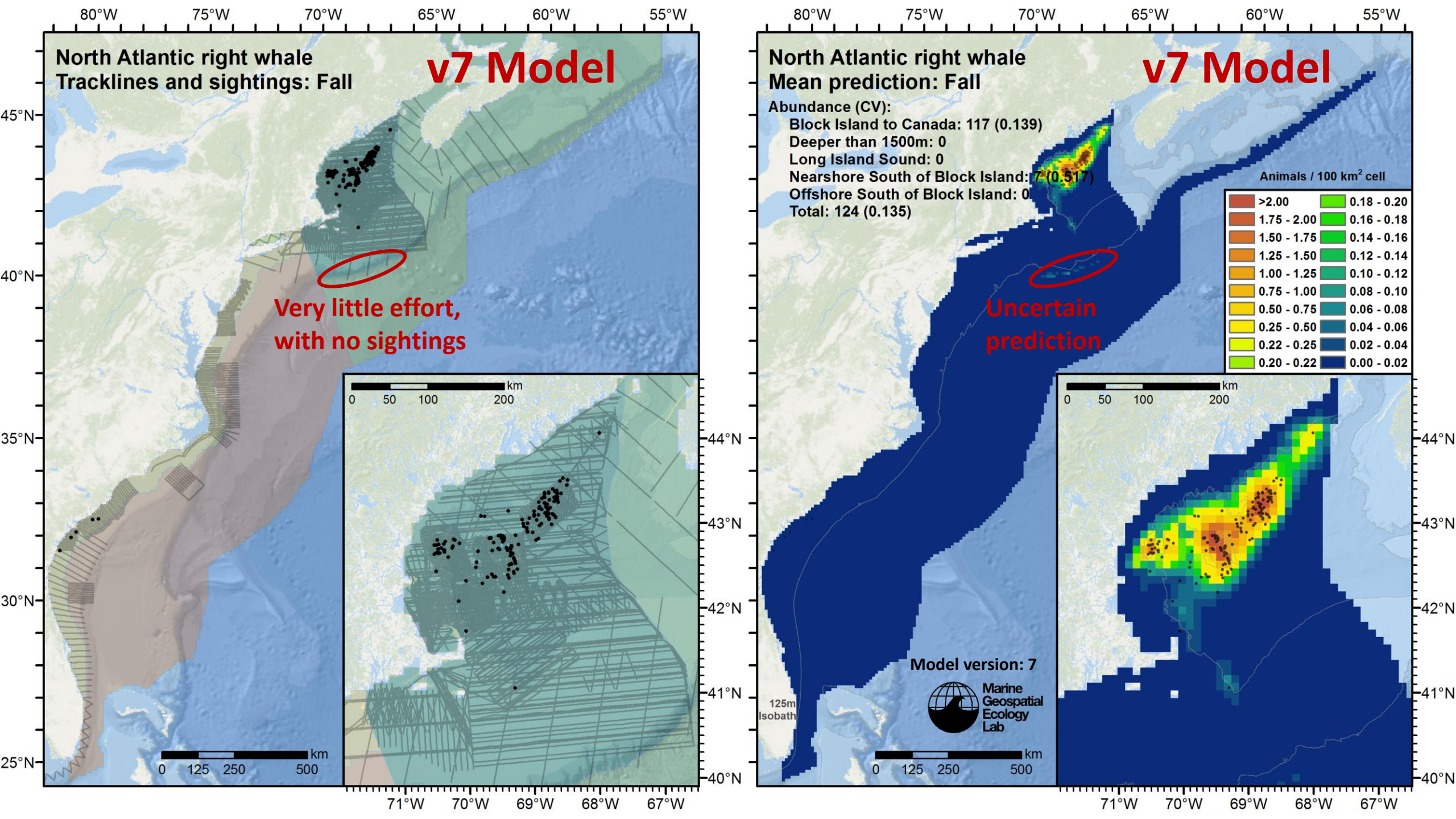
Edge effect in Fall along Georges Bank

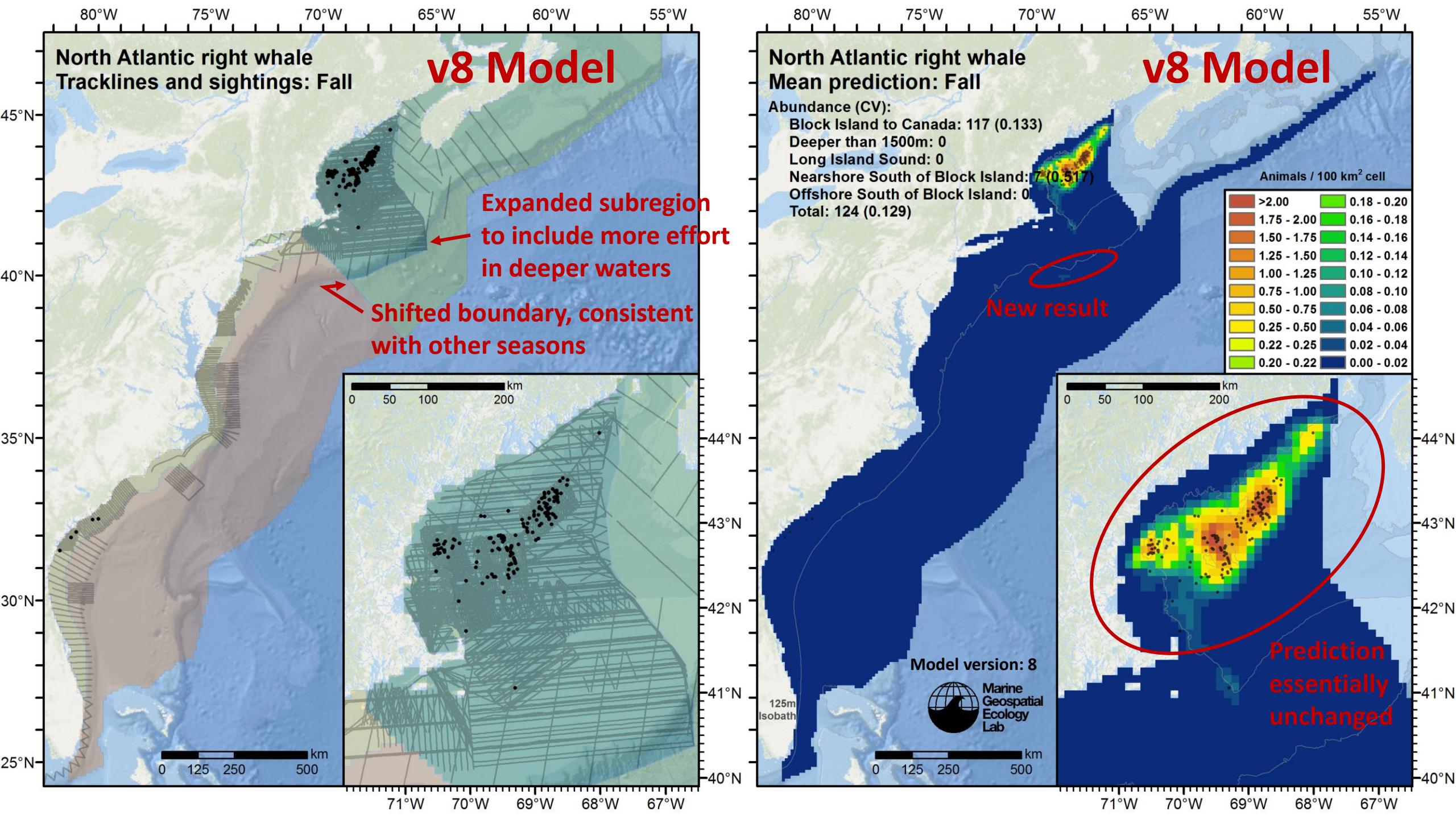
The v7 Fall season model predicted a strip of low density along southern Georges Bank, waters 1000-1500m deep, along the model edge (next slide).

High CVs and other diagnostics indicated this was an aberrant prediction. The fitted relationship for the Depth covariate indicated that density increased as depth increased, but data were very sparse at deep depths. To reduce uncertainty at deep depths, we expanded the subregion boundary to encompass the remaining survey effort along deeper areas of Georges Bank.

The resulting model (v8) predicted less density here and CVs improved.

However, we caution that right whales have been observed and acoustically detected in similarly deep waters (albeit more rarely than shallower waters). The best way to improve the model for this region is to conduct additional surveying, or to adjust our methodology to utilize additional classes of data.


North Atlantic right whale
Tracklines and sightings: Fall
v7 Model
Very little effort,
with no sightings
km
0 125 250 500
0 50 100 200
80°W 75°W 70°W 65°W 60°W 55°W
45°N 40°N 35°N 30°N 25°N
71°W 70°W 69°W 68°W 67°W
44°N 43°N 42°N 41°N 40°N
North Atlantic right whale
Mean prediction: Fall
v7 Model
Abundance (CV):
Block Island to Canada: 117 (0.139)
Deeper than 1500m: 0
Long Island Sound: 0
Nearshore South of Block Island: 7 (0.517)
Offshore South of Block Island: 0
Total: 124 (0.135)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
Uncertain
prediction
125m
Isobath
Model version: 7
Marine
Geospatial
Ecology
Lab

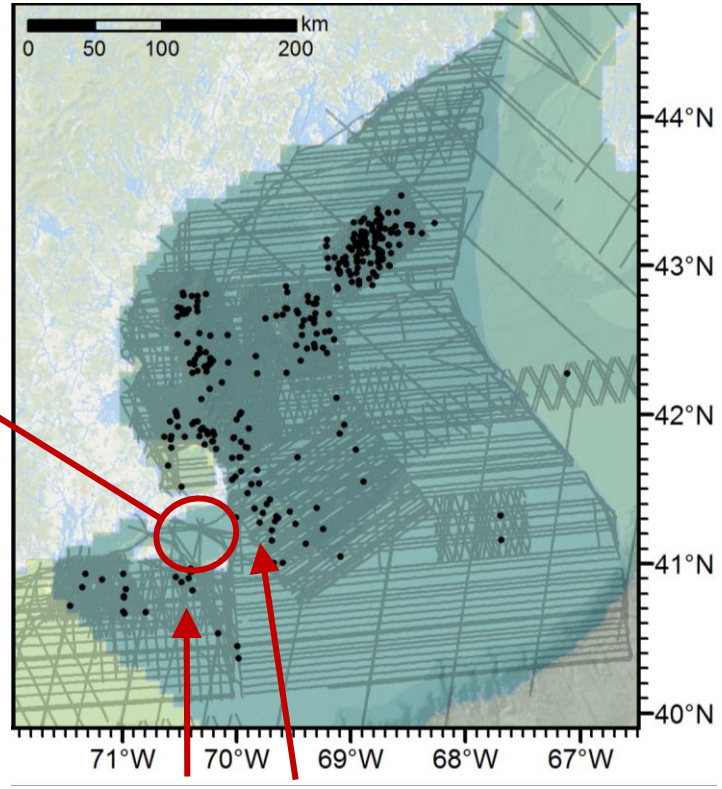

North Atlantic right whale
Tracklines and sightings: Fall
v8 Model
Expanded subregion to include more effort in deeper waters
Shifted boundary, consistent with other seasons
km
0 125 250 500
0 50 100 200
North Atlantic right whale
Mean prediction: Fall
v8 Model
Abundance (CV):
Block Island to Canada: 117 (0.133)
Deeper than 1500m: 0
Long Island Sound: 0
Nearshore South of Block Island: 7 (0.517)
Offshore South of Block Island: 0
Total: 124 (0.129)
Animals / 100 km² cell
>2.00
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
0.22 - 0.25
0.20 - 0.22
0.18 - 0.20
0.16 - 0.18
0.14 - 0.16
0.12 - 0.14
0.10 - 0.12
0.08 - 0.10
0.06 - 0.08
0.04 - 0.06
0.02 - 0.04
0.00 - 0.02
New result
Prediction essentially unchanged
Model version: 8
Marine Geospatial Ecology Lab
125m Isobath
80°W 75°W 70°W 65°W 60°W 55°W
45°N 40°N 35°N 30°N 25°N
44°N 43°N 42°N 41°N 40°N
71°W 70°W 69°W 68°W 67°W

Frequently Asked Question

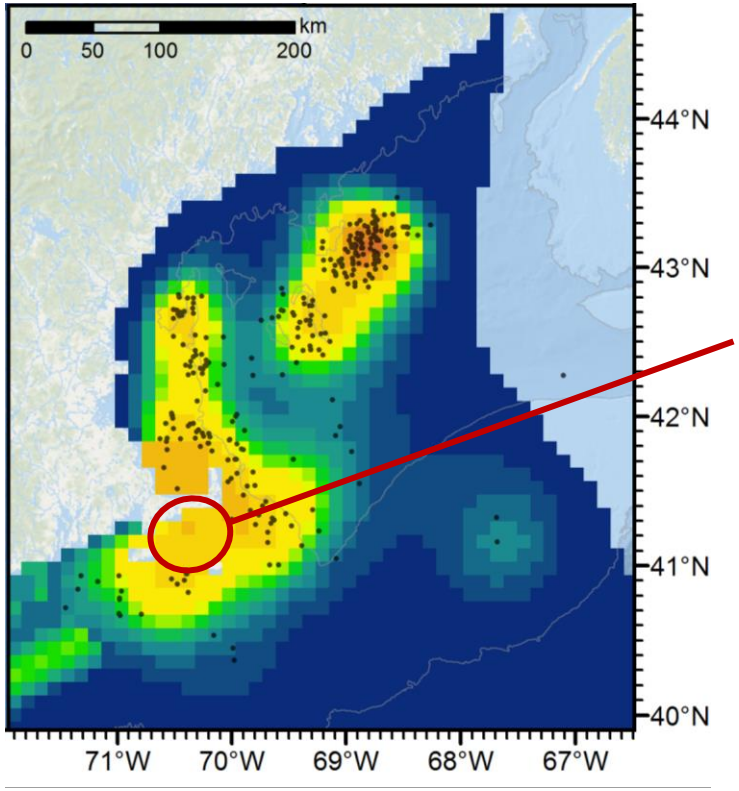
Density predictions were high in Nantucket Sound in winter. Is that realistic?

This resulted from low survey effort in Nantucket Sound itself in winter, along with numerous sightings just outside it, where effort was higher:

Low survey effort inside Nantucket Sound itself



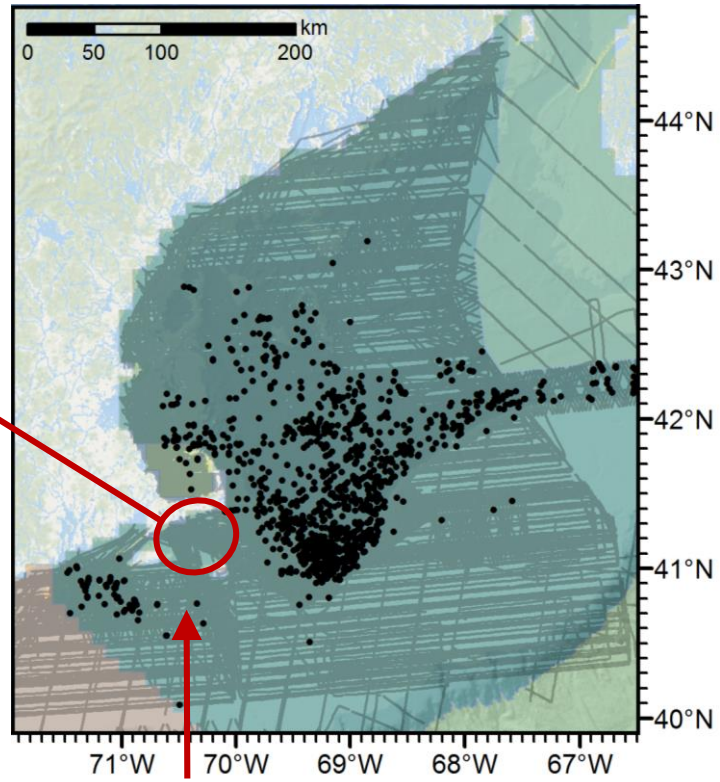
More effort, with sightings, around it



Moderately high density predicted

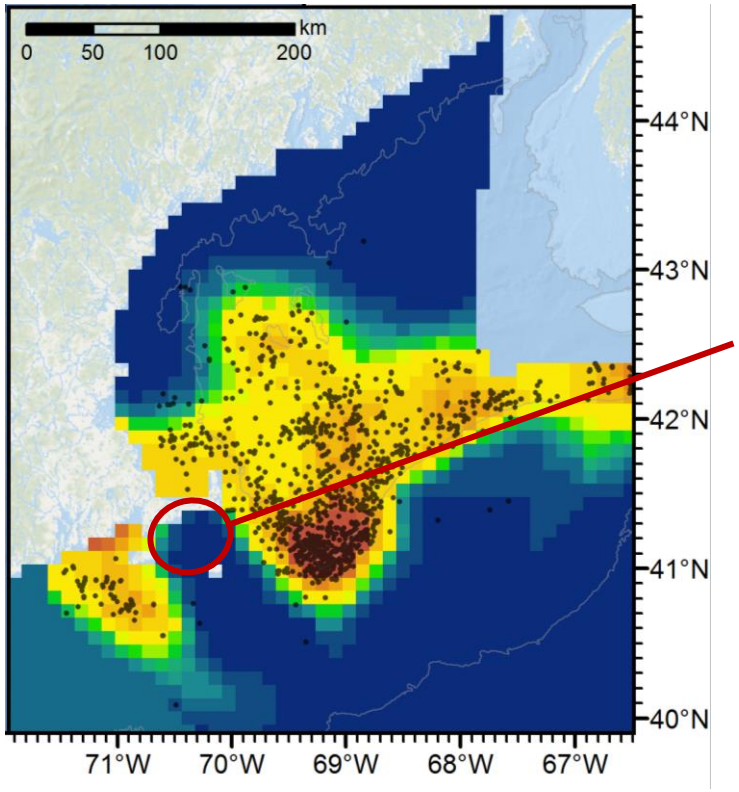
This did not happen in spring, when there was much more survey effort and sightings were farther away (see below).

For v8, we tested several statistical variations (e.g. soap film smoother, more knots) but the high prediction remained. We will look at it again in v9, but ultimately it may remain unless we obtain more survey effort with no sightings.



Much more survey effort in Nantucket Sound in spring

Not as many sightings nearby in this area



Much lower density predicted

Frequently Asked Question

How can densities be derived for inshore areas not included in the model, such as Penobscot Bay or Narragansett Bay?

We excluded many inshore areas because:

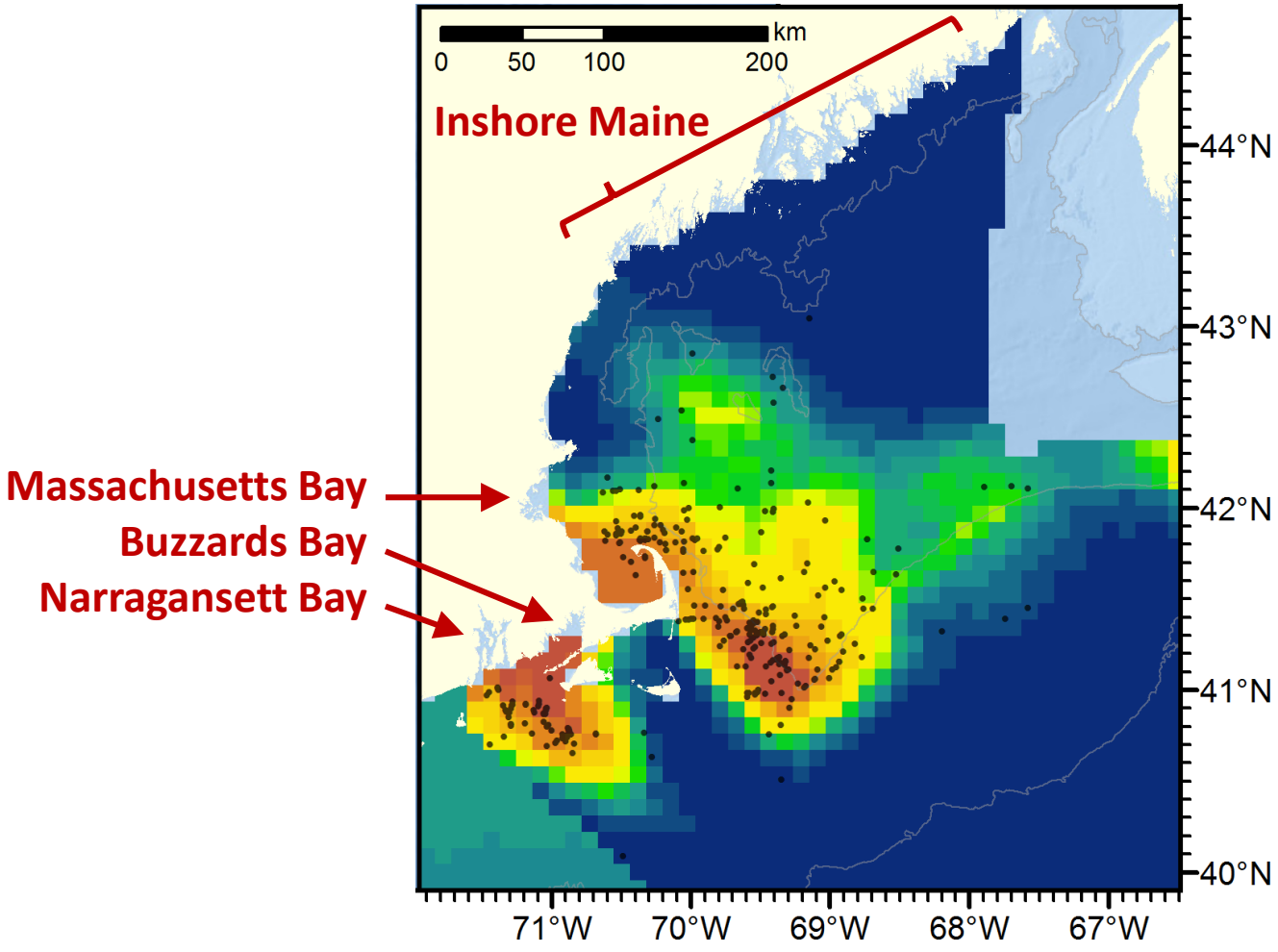
- There were very little survey data covering them, or none at all
- Most of our satellite-based oceanographic covariates did not go so far inshore
- The Navy had limited interest in most inshore areas
  - Those of highest interest were in the southeast or Gulf of Mexico, usually only inhabited by bottlenose dolphins, for which estuary-specific estimates were often available

At this time, our best recommendation would be to spatially extrapolate into inshore areas from cells outside them, in consultation with right whale experts. The results should be interpreted cautiously.

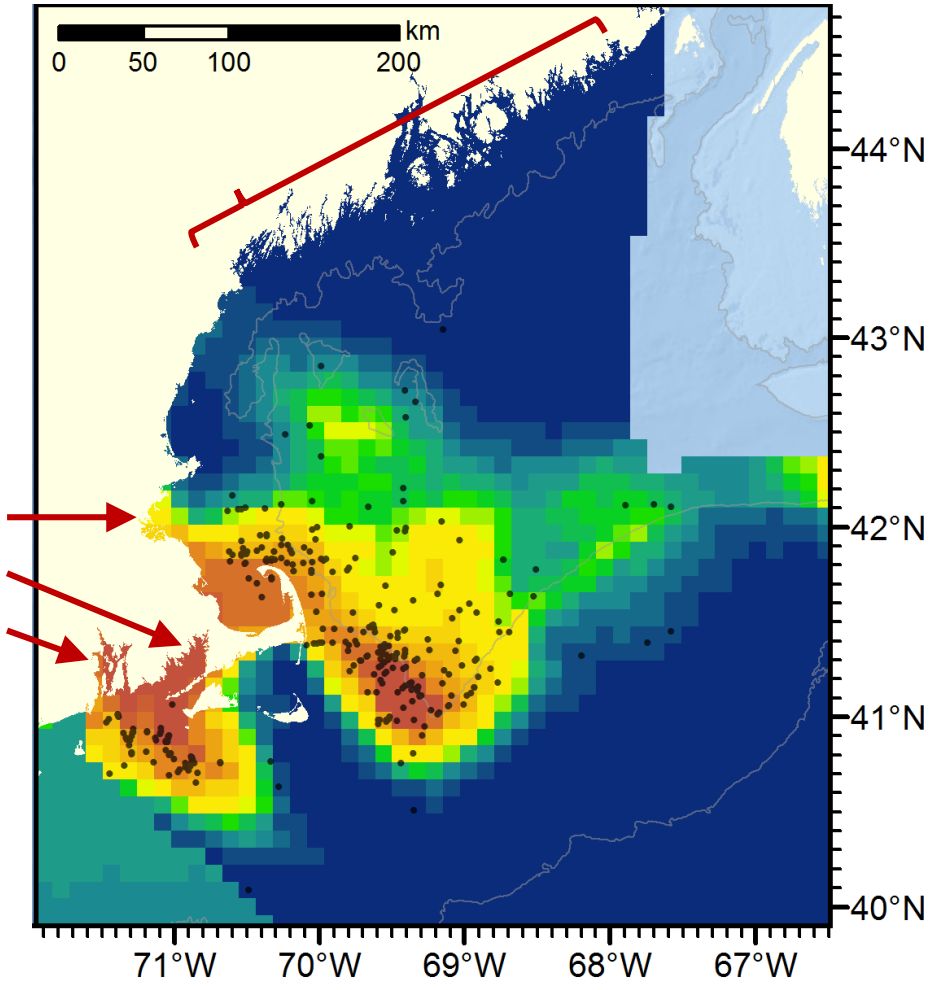
We might be able to provide a better recommendation in the v9 model.

Example month (April) where extrapolations seem easy to accept in some inshore areas (Maine) but require more scrutiny in others (Mass., Rhode Island).

Original April prediction

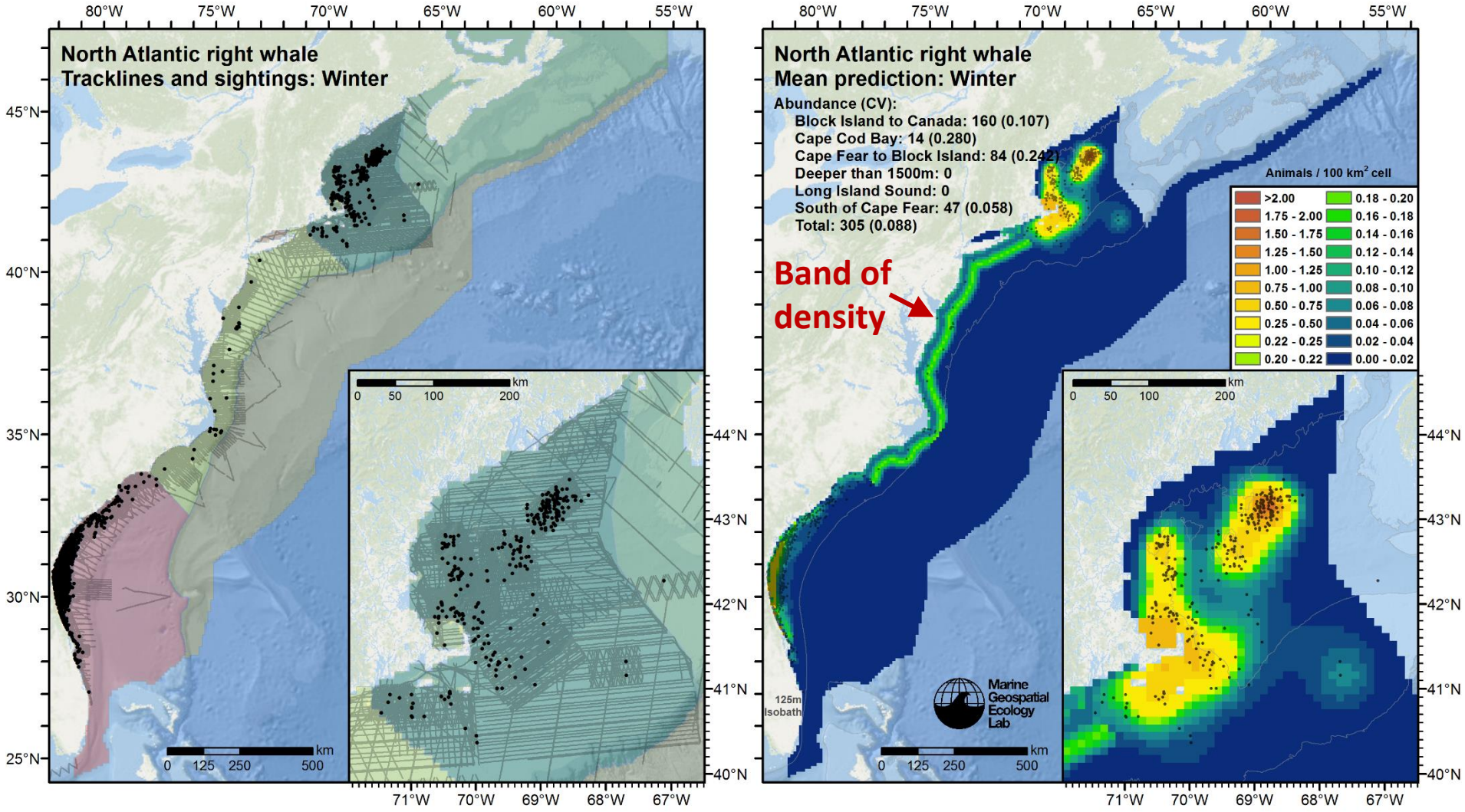


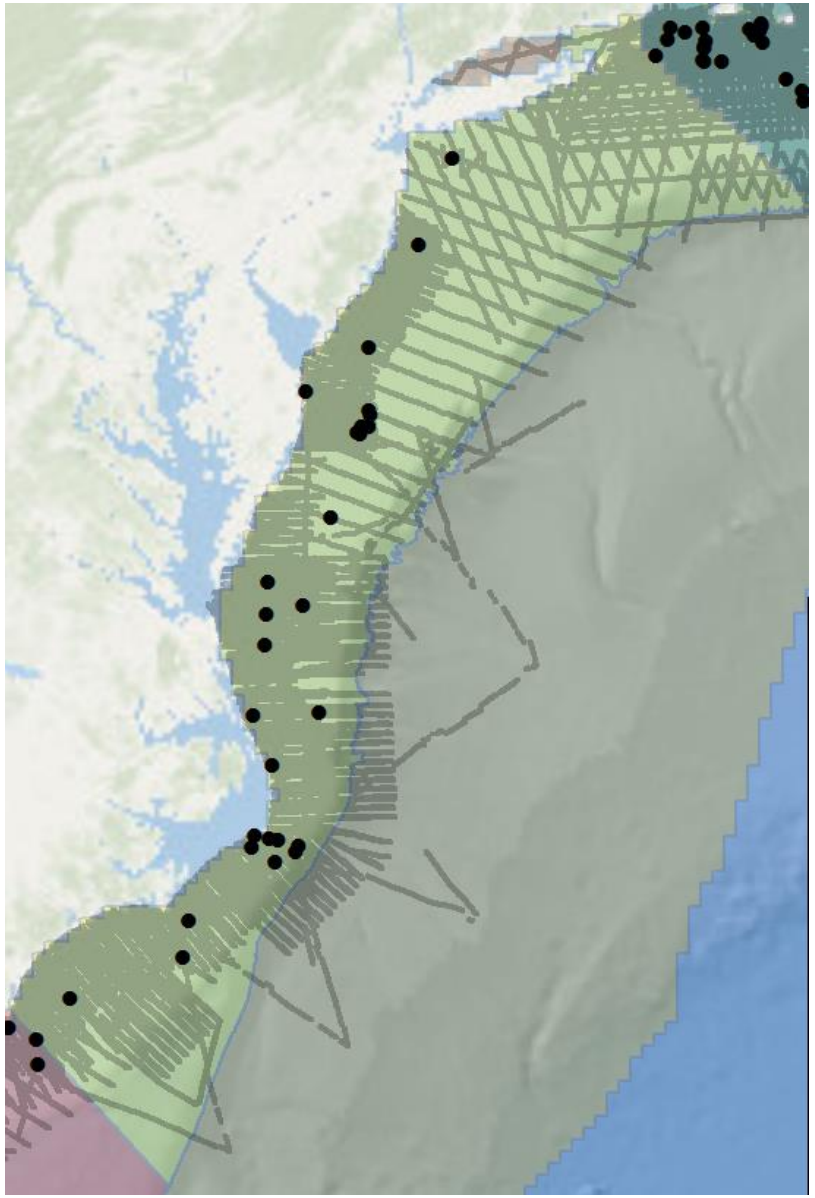
With inshore spatial extrapolation



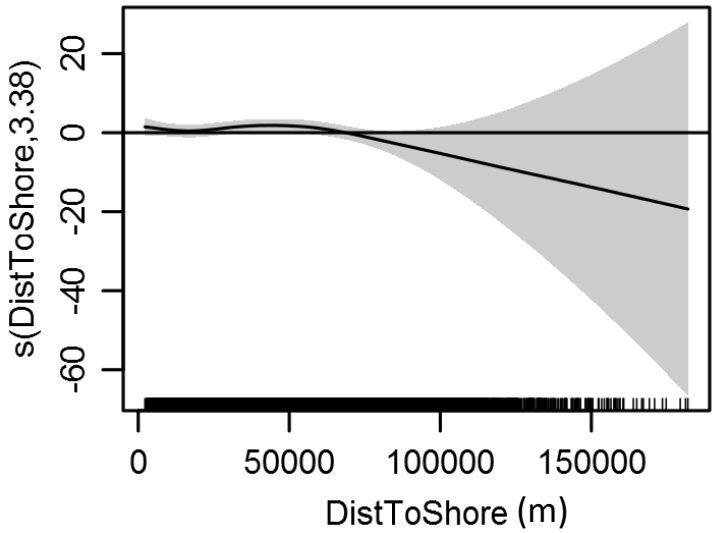
Frequently Asked Question

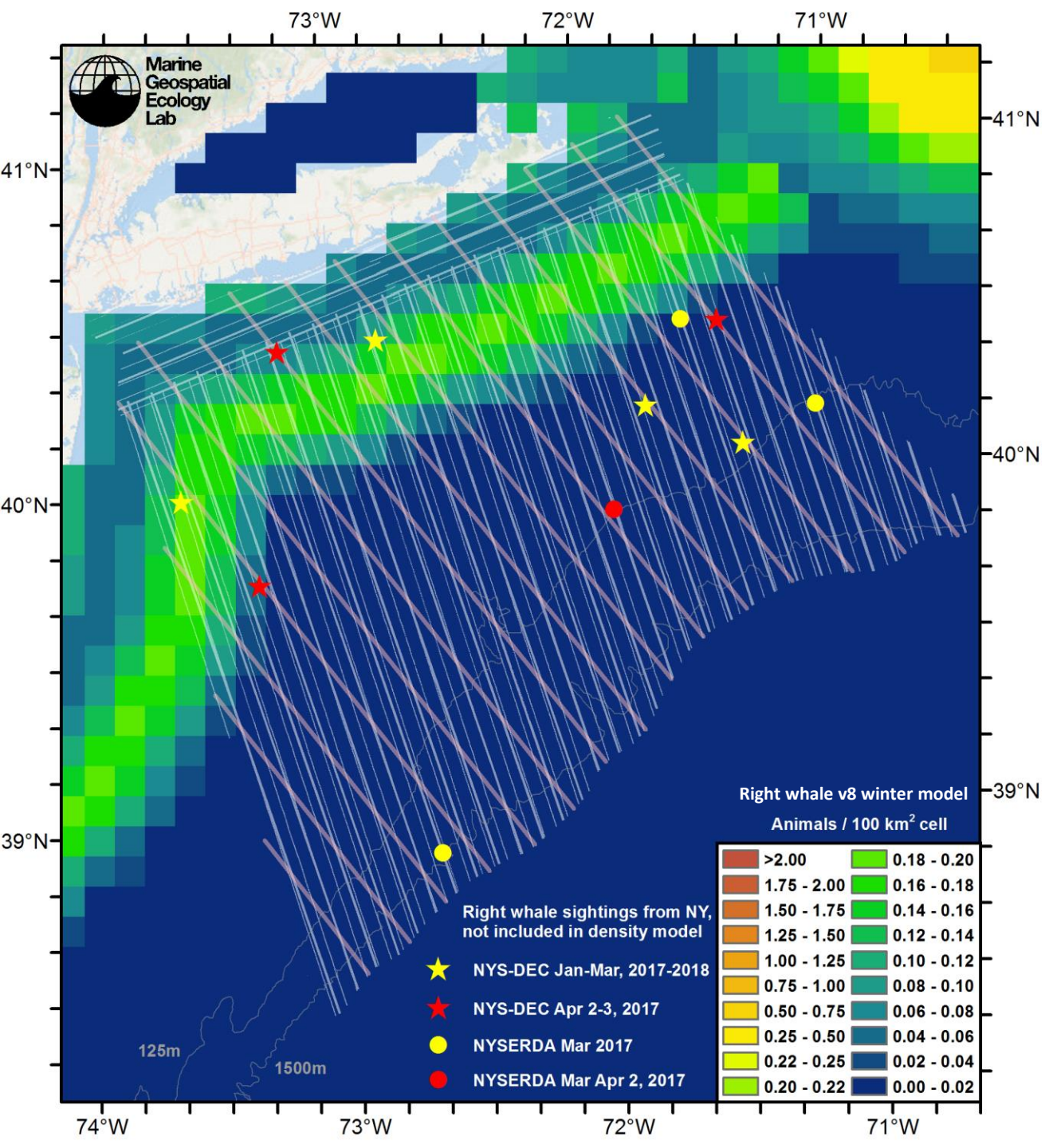
Is the "band" of right whales predicted along the mid-Atlantic in winter realistic? Don't right whales go farther out over the shelf?





In the data available to us for the v7 and v8 models, there were only 28 sightings between Cape Fear and Block Island. This was barely enough to fit a model with a single covariate. We tried many candidates. Most concentrated density close to shore. This was logical, as there was effort across the shelf and the sightings *did occur* on the shoreward side. The ones that did not were either not statistically significant or produced clearly unrealistic patterns. So we selected Distance To Shore as the best model.





We anticipate this could change in the upcoming v9 model, which will include surveys from 2017-2018 in the mid-Atlantic region that reported sightings substantially farther from shore.

Here is one example. Our v8 “winter” model spans December-March. Assuming we use the same definition for v9, the yellow sightings would be incorporated into that model, and the red would be incorporated into the “spring” model.

NEW YORK STATE OF OPPORTUNITY. Department of Environmental Conservation

TETRA TECH

NEW YORK STATE OF OPPORTUNITY. NYSERDA

NORMANDEAU ASSOCIATES ENVIRONMENTAL CONSULTANTS

IEc

2019 ALWTRP Model Updates

Prepared for:

Greater Atlantic Regional Fisheries Office

National Marine Fisheries Service

55 Great Republic Drive

Gloucester, MA 01930

Prepared by:

Industrial Economics, Incorporated

2067 Massachusetts Avenue

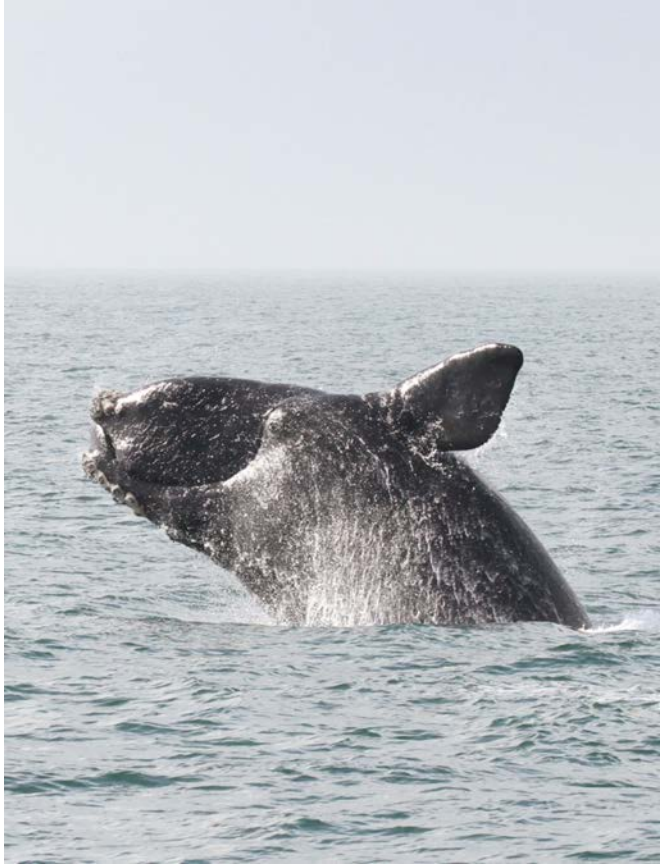
Cambridge, MA 02140

617/354-0074

April 16, 2019

Review: Goals of the Modeling Effort

- Provide members of the ALWTRT with data to build a common understanding of:
  - The seasonal distribution of commercial fishing gear off the Atlantic coast.
  - The seasonal distribution of North Atlantic right whales, humpback whales, and fin whales in these waters.
- Support development of NMFS' vertical line strategy for the ALWTRP.
- Provide analytic support for NMFS' rulemaking process.



North Atlantic right whale *(Eubalaena glacialis)*
Photo: Georgia Department of Natural Resources

Review: Guidelines for Model Design

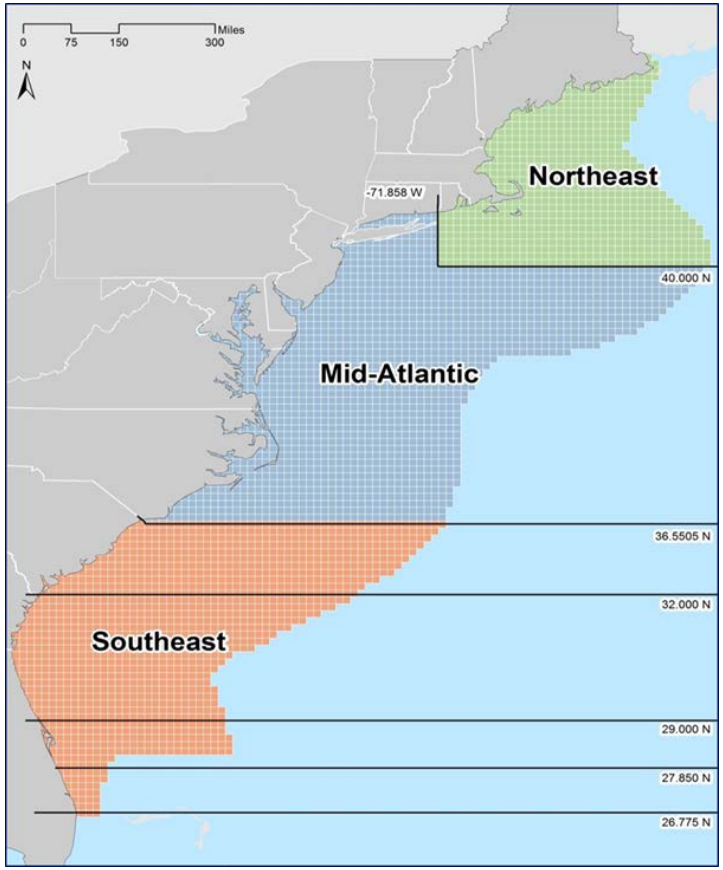
- Design the model with sufficient flexibility to:
  - Incorporate data from disparate sources.
  - Analyze a range of management measures (e.g., closures, gear modification requirements).
- Provide information on protected species and fishing activity in a variety of forms:
  - Maps/animations to illustrate spatial/temporal patterns.
  - Tables and charts to support numerical comparisons.
  - Range of indicators of fishing activity/potential for protected species to encounter commercial fishing gear.
- Maintain an open and transparent development process:
  - Involve the TRT in model design, data collection, and the development of key assumptions.
  - Flexibility to adapt the model to evolve with the TRT's interests and needs.

Review: Development Timeline

2005 – 2010:	Prototype development and data collection. Expanded geographic scope/methods refinement. Module for analysis of management VL scenarios.
2011-2014:	Analysis of TRT proposals. Documentation and peer review. Analysis of proposed and final rule. Draft and Final Environmental Impact Statement.
2014-2015:	Analysis of exemption proposals. Draft and Final Environmental Assessment.
2017-2018:	Transition to a more flexible online interface. Update state and federal data for 2016.
2019:	Update methods for estimating fishing activity. Update state and federal data for 2017. Integrate Duke RW Density model. Integrate NEFSC-developed threat and risk indicators.

Review: Scope

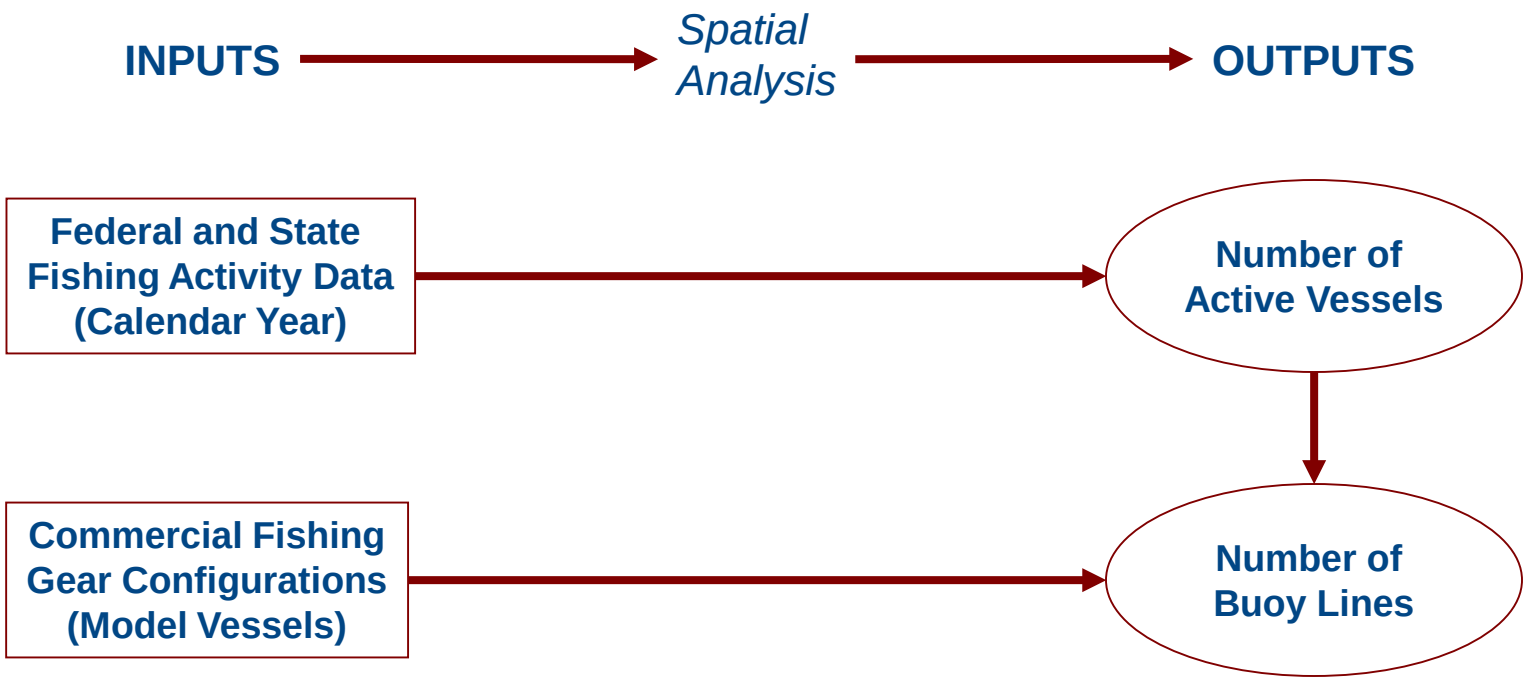
- Software (Updated in 2017):
  - PostGreSQL
  - Pentaho Data Integration
  - Geoserver
- Fisheries:
  - American lobster.
  - Sink and anchored gillnets.
  - Blue crab.
  - Other trap/pot (e.g., black sea bass).
- Protected Species
  - Right Whale
  - Humpback Whale
  - Fin Whale
- Geographic resolution:
  - 1-minute grid cells (analysis/reports).
  - 10-minute grid cells (mapping).
- Temporal resolution: monthly.



Geographic Scope: All waters subject to the requirements of the ALWTRP. Ability to view whale information in Canadian waters if available

Conceptual Overview

Methods and data sources are consistent with previous versions of the model, with improvements to include best available data.



Summary of 2019 Updates

- Improvements to the interface.
  - Provides a more flexible, user friendly approach.
  - Allows for straightforward inclusion of new sources of data (e.g., Duke Right Whale Density model).
- Data and methodological improvements.
  - Updated fishing activity and gear configuration data for 2017.
  - Applied state information in Nearshore waters to improve estimates of the magnitude and location of lobster activity.
  - Refined spatial distributions for offshore lobster vessels.
  - Updated model vessels to reflect the best available information from state fisheries managers.
  - Updated model vessels to reflect 2014/2015 rulemakings.
  - Applied trap and trap/trawl limitations to areas in Maine that are subject to these restrictions.

Data Sources: Vessel Activity

- Federal
  - 2017 Northeast Vessel Trip Report (VTR).
  - 2017 NMFS Permit data (LMA 3 Lobster only).
  - 2017 Southeast Logbook data.
- State
  - Obtained via outreach to state fishery management agency representatives.
  - 2017 data (CT based on 2016 data).
  - Includes waters designated as exempt and non-exempt from the 2014/2015 vertical line rulemaking.
  - Sources vary by state (e.g., trip reports, monthly catch reports, permit data, dealer reports, and surveys).
  - Typically indicates location by state management zone.

Updates: Vessel Activity

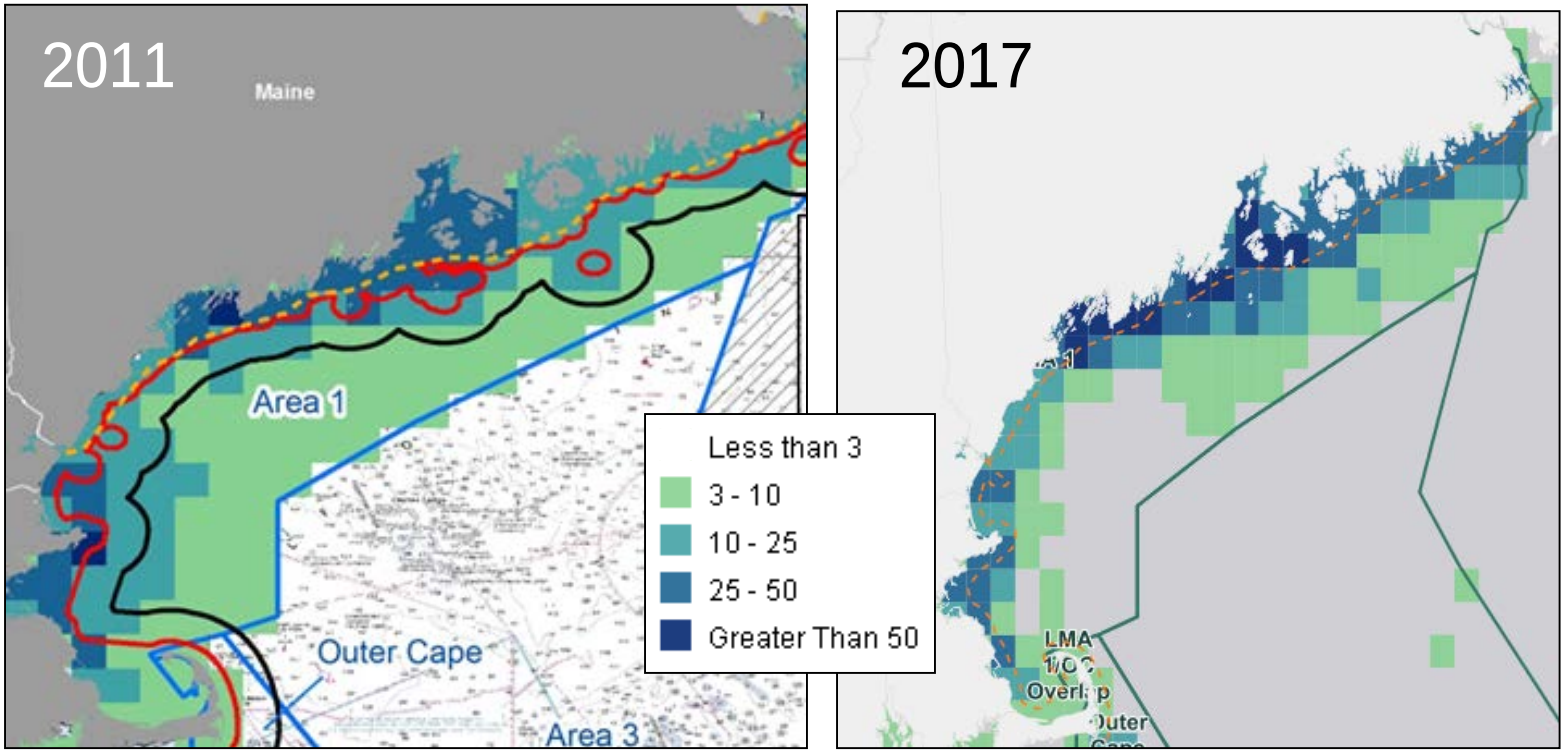
- Worked with the ME, MA, NH, and RI fisheries management representatives to address lack of VTR reporting in the federal lobster fishery.
- The model previously used permit and VTR data as proxies to estimate the number of non-reporting vessels engaged in lobstering each month within each LMA.
- State fisheries managers felt strongly that this approach did not adequately represent the location and magnitude of vessel activity in nearshore waters.
- Based on their recommendation, the model now applies state data on the activity and location of vessels that hold federal permits (but do not report to VTR) in the nearshore areas.

Updates: Vessel Activity

- To avoid double-counting vessels in Maine state and nearshore waters, we omit the use of VTR in those areas.
- In Northeast offshore waters, the model continues to use permit and VTR data to estimate unreported activity by vessels holding Federal lobster permits.
  - Previous approach distributed the activity of these vessels equally across all of LMA 3.
  - The model now distributes their activity to each of the offshore NMFS statistical areas in proportion to the distribution of trips reported by lobster vessels that submit VTRs.

Updates: Vessel Activity

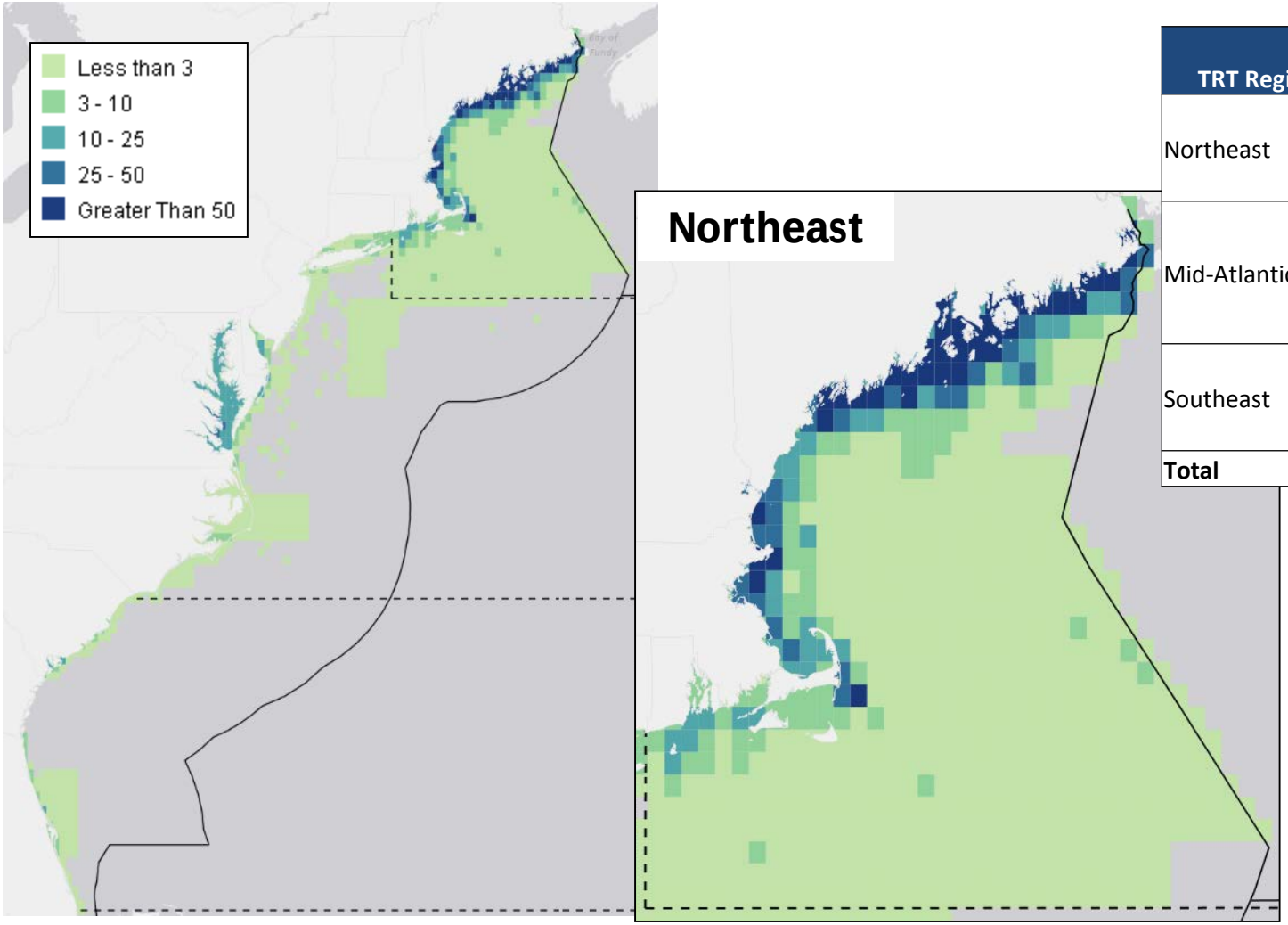
- Outcome: Improved estimates of the magnitude and location of activity in nearshore waters, particularly LMA 1.



Estimated Number of Active Vessels ~ All Fisheries (Monthly Average)

2017 Draft Example Results: Vessel Activity

Estimated Number of FTE Active Vessels | September | All Fisheries | All Waters



TRT Region	Fishery	# FTE Active Vessels
Northeast	Lobster trap/pot	5,199
	Sink Gillnet	148
	Other trap/pot	123
Mid-Atlantic	Lobster trap/pot	131
	Sink Gillnet	302
	Other trap/pot	128
	Blue crab pot	1,166
Southeast	Sink Gillnet	10
	Other trap/pot	0
	Blue crab pot	222
Total		**7,430**

Data Sources: Model Vessel Gear Configurations

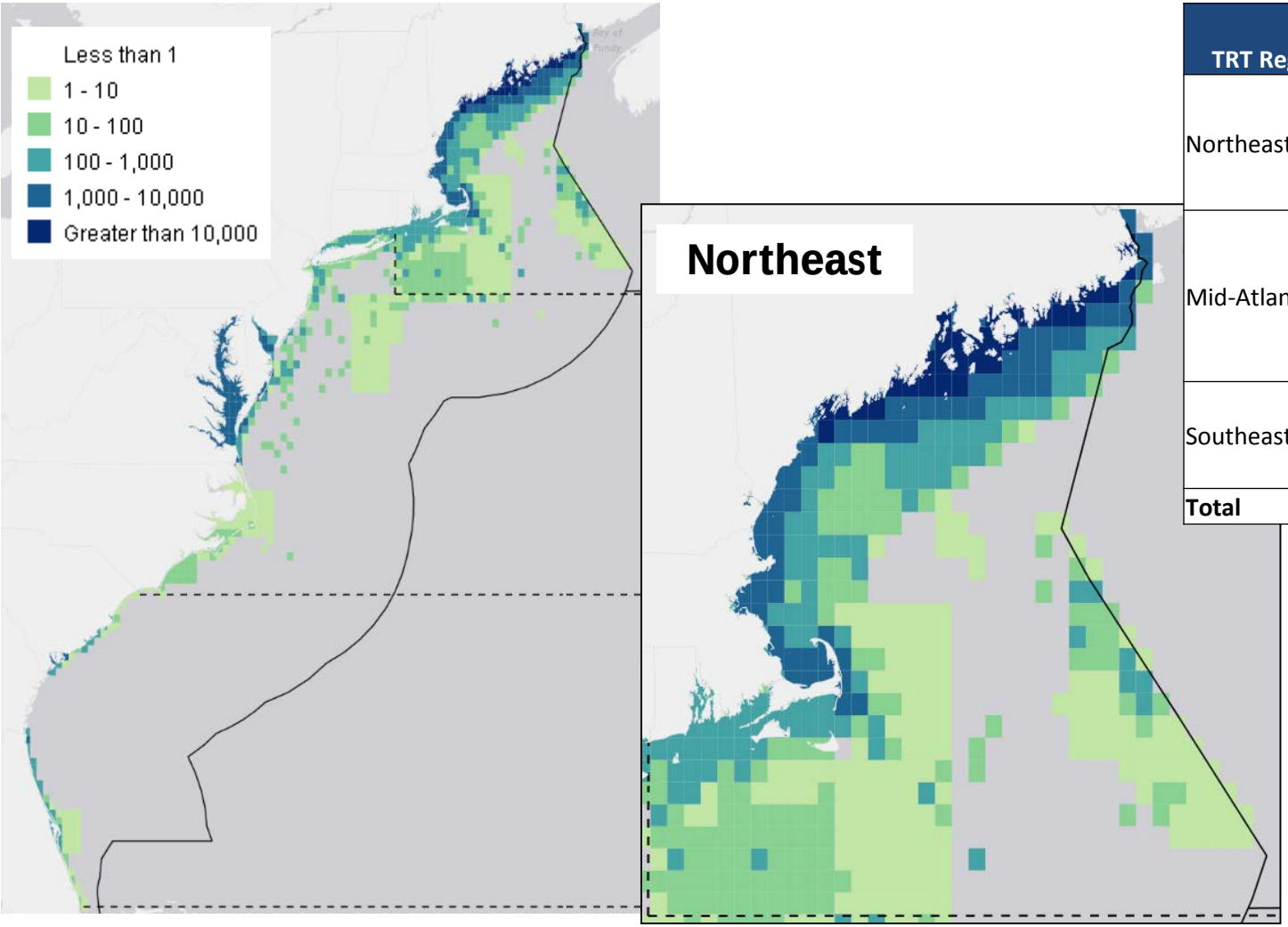
- Federal waters:
  - For Nearshore lobster and other trap/pot, apply ME, MA, and RI data, where available.
  - For Nearshore blue crab, apply data for nearest states.
  - Northeast Domestic Observer Program (gillnet).
  - Best professional judgments of NMFS gear team.
- State waters:
  - Best available information from each state fishery management agency for 2017 (CT based on 2016 data).
  - ME, NH, MA, RI provided review and comment on the 2017 update to the lobster fishery.

Updates: Model Vessel Gear Configurations

- Updated model vessels to reflect the best available information from state fisheries managers.
- Over the last several years, Maine instituted trap and trawl-length maximums in specific locations along the coast. The model now incorporates these regions and applies the maximums that Maine has specified in characterizing activity within them.
- We assume that all model vessels will conform to the minimum trap-per-trawl requirements imposed by the 2014 vertical line rule and subsequent amendments.
  - For example, available data show a proportion of vessels fishing singles in state waters, which is allowed in the exempted area but prohibited in non-exempt waters. In the non-exempt share of the state zones, we assume this proportion of vessels will fish doubles, as allowed by the Plan.

2017 Draft Example Results: Buoy Lines

Estimated Number of Buoy Lines| September | All Fisheries | All Waters



TRT Region	Fishery	# Buoy Lines
Northeast	Lobster trap/pot	912,300
	Sink Gillnet	4,400
	Other trap/pot	3,800
Mid-Atlantic	Lobster trap/pot	8,500
	Sink Gillnet	2,000
	Other trap/pot	11,000
	Blue crab pot	255,600
Southeast	Sink Gillnet	100
	Other trap/pot	0
	Blue crab pot	22,600
Total		**1,220,200**

Integrating New Information

- Platform updates allow for the presentation and integration of new and emerging data. Latest version includes:
  - Duke Right Whale Density model (Roberts et al.)
  - Threat Score (NEFSC)
  - Risk Score (NEFSC)
- Model interface will allow for interactive viewing of 2017 baseline information at the April 2019 TRT meeting, as needed.

IEc

North Atlantic Right Whale *(Eubalaena glacialis)*
Credit: Georgia Department of Natural Resources (GADNR), Permit 15488

Decision Support Tool

Contributions from Burton Shank, Doug Sigourney
Danielle Cholewiak, Josh Hatch- NEFSC

Jason Roberts-Duke

Neal Etre-IEC

Presented by Sean Hayes NEFSC

- Presentation for Atlantic Large Whale TRT April 16, 2019

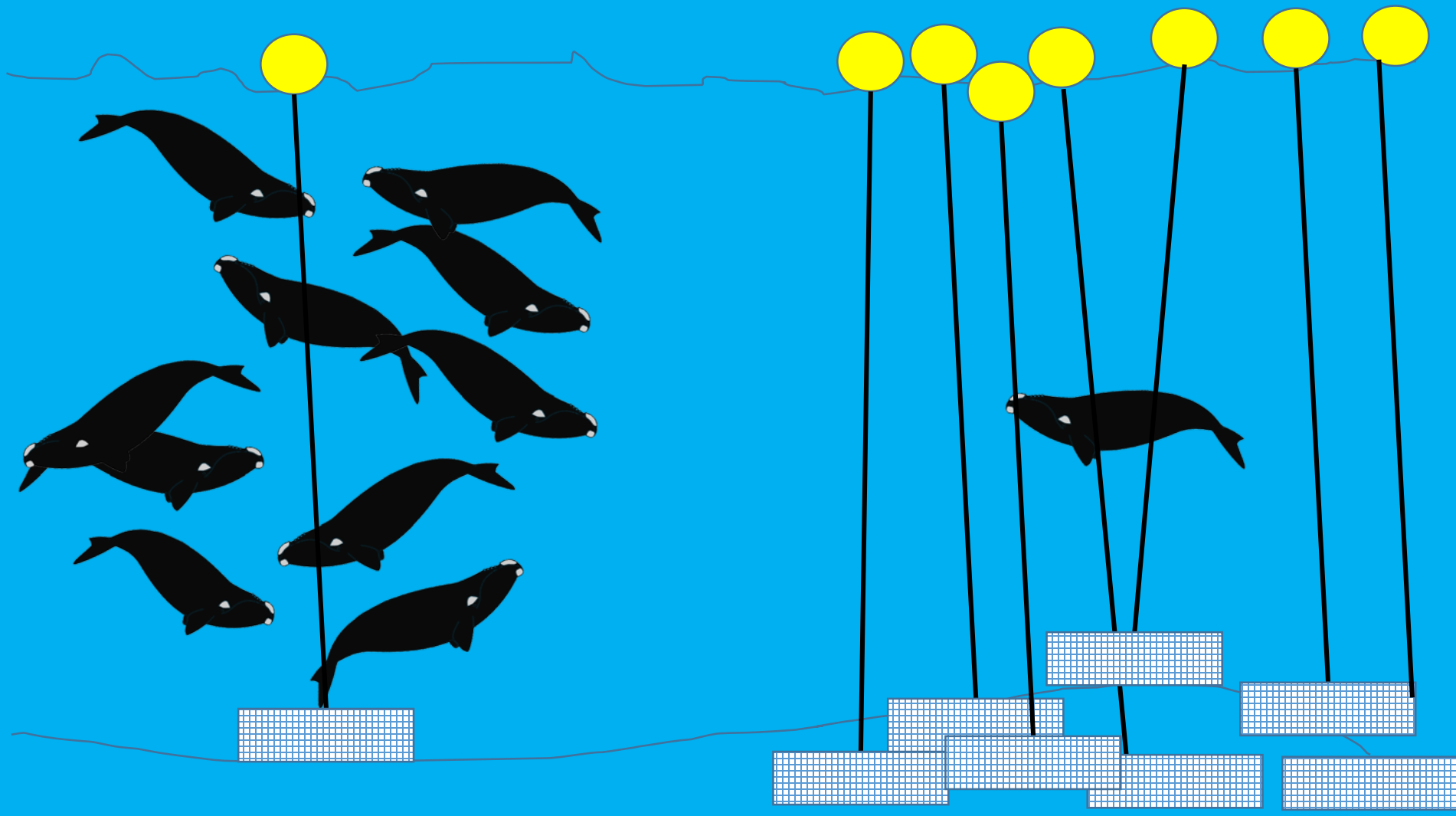
Risk = likelihood x severity

Likelihood

- # of lines/density
- # whales/density
- Encounter rate- unknown

- Severity
  - Serious Injury/Mortality (MMPA charge)
  - Sublethal

What has More Risk?



Tools to reduce risk

- Closures
- Trap/line reductions
- Lighter gear (weak rope, sleeves etc.)
- Line cutters
- Buoyless (acoustic or timer release etc)

How to compare?

Things we explored..

- Management Strategy Evaluation (MSE)
- Marxan- TNC
- Modeling encounter rates?

Feasible…

- Co-occurrence- IEC- where are whales and gear?

Next steps..

- Relative Risk Units- Farmer et al. 2016

$$Risk = Whales \ * Gear\ density \ * \boldsymbol{severity}$$

- Calculated for each month and area
- Summed across all months and locations

Farmer, N. A., T. A. Gowan, J. R. Powell, and B. J. Zoodsma. 2016. Evaluation of Alternatives to Winter Closure of Black Sea Bass Pot Gear: Projected Impacts on Catch and Risk of Entanglement with North Atlantic Right Whales Eubalaena glacialis. Marine and Coastal Fisheries 8(1):202-221.

$$Risk = Whales * Gear\ density * severity$$

Month	grid area	line type	Whale density	Gear Density	severity	Risk
January	533	medium	2	40	7	560
		heavy	2	60	10	1280
					total risk for Area 533 in January	**1760**
					TRT 60% reduction goal	**704**

(all numbers just for example only- not real values)

$$Risk = Whales * Gear\ density * severity$$

tentative solution- use lighter gear with lower severity score

Month	grid area	line type	Whale density	Gear Density	severity	Risk
January	533	Light	2	40	3.5	280
		Light	2	60	3.5	420
					total risk for Area 533 in January	**700**
					TRT 60% reduction goal	**704**

Goal reached

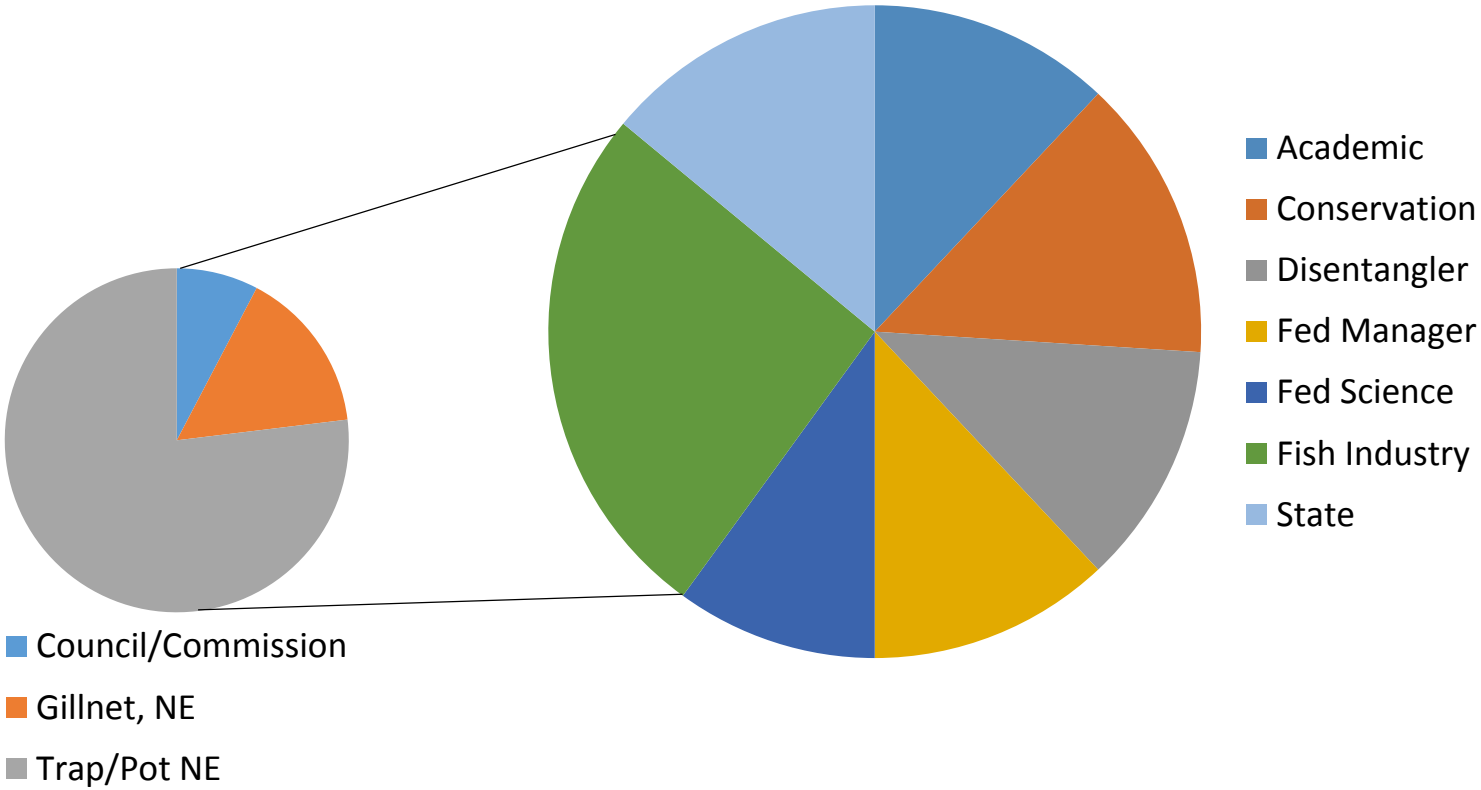
Severity- Poll informed TRT members and agency staff

- Provided list of gear types
  - 3/8” line with 1-3 traps
  - 5/8” line with >40 traps
- Score relative Risk severity scale 0-10
- Provided list of ‘risk modifiers’
  - Acoustic release- %time in water
  - Timer release- %time in water
  - Line cutters, sleeves, 1700lb rope (relative risk 0-10)

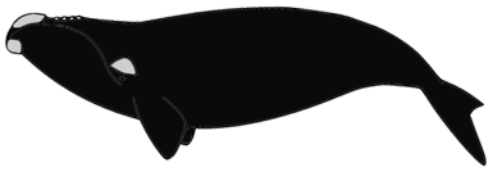
$$Risk = Whales * Gear\ density * severity$$

Preliminary poll results

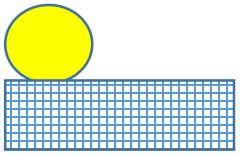
50 responses, some responses left some cells blank



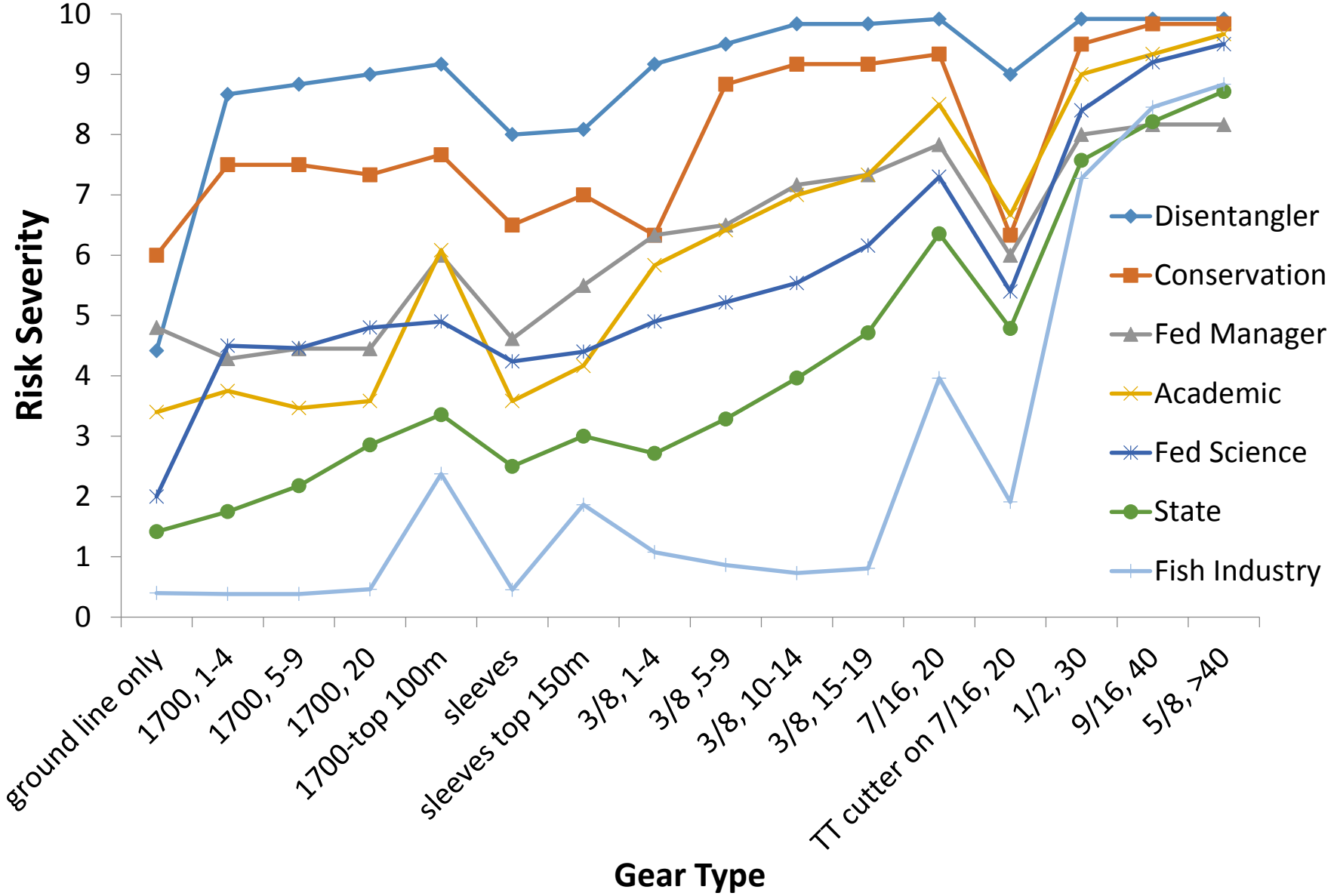
Buoyless results



Gear	% Time in water column	Credible interval
Timed release PopUp Inshore	48	(33-63%)
Time-release PopUp Offshore	54	(38-67%)
Acoustic recall PopUp	12	(6-20%)



Preliminary poll results



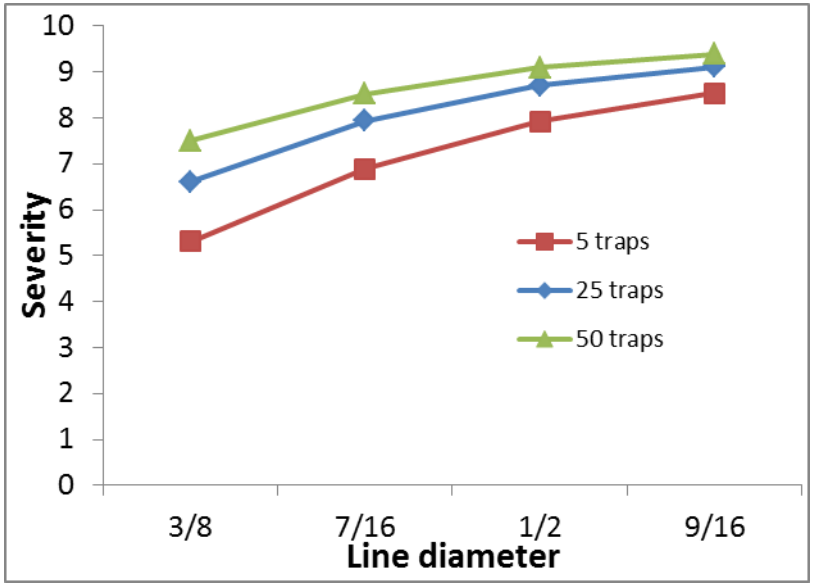
Poll means and ranking by gear type

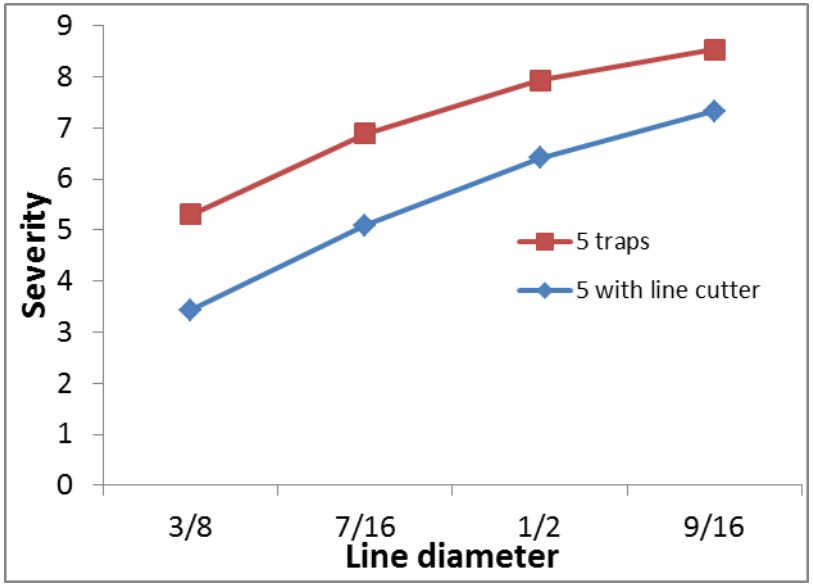
(range 0= no gear, 10 greatest risk)

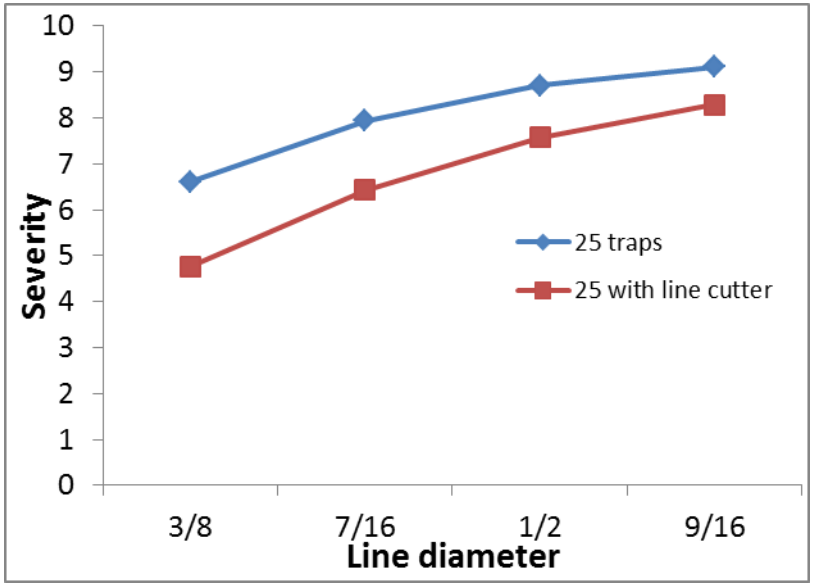
Gear Type	Raw Means	Mean risk score by caucus	*Baysien 'means'
ground line only	2.9	3.2	3.8
sleeves	3.8	4.3	4.2
1700lb, 1-4 traps	3.8	4.4	4.8
1700lb , 5-9	3.8	4.5	4.9
1700lb , 20	4.0	4.6	5.0
sleeves top 150m	4.5	4.9	5.4
3/8 line, 1-4 traps	4.6	5.2	5.2
1700lb -top 100m	5.2	5.6	5.9
TT cutter on 7/16, 20	5.3	5.7	6.1
3/8 line ,5-9 traps	5.1	5.8	5.5
3/8 line, 10-14	5.4	6.2	5.9
3/8 line, 15-19	5.6	6.5	6.2
7/16 line, 20	7.1	7.6	7.7
1/2 line, 30	8.4	8.5	8.8
9/16 line, 40	8.9	9.0	9.3
5/8 line, >40	9.2	9.2	9.7

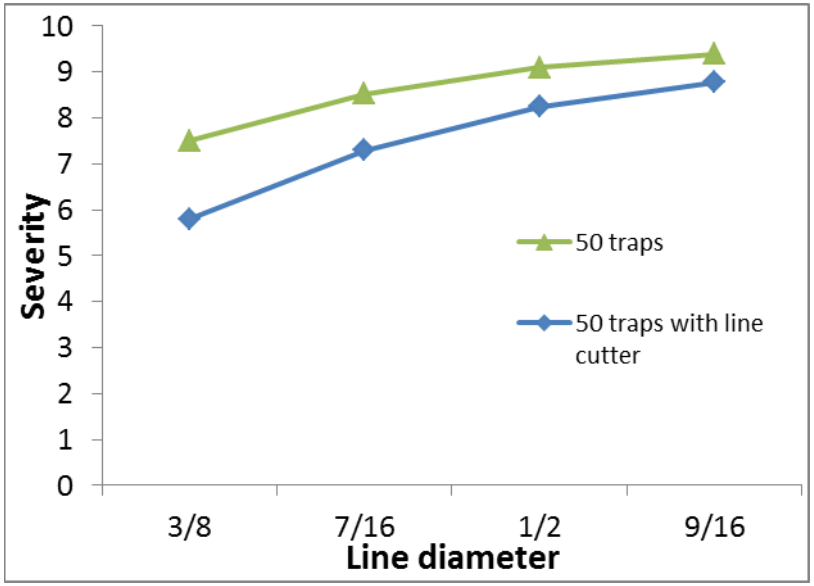
*Baysien means subject to final model run with specific parameters

Effect of trawl length and TT line cutter





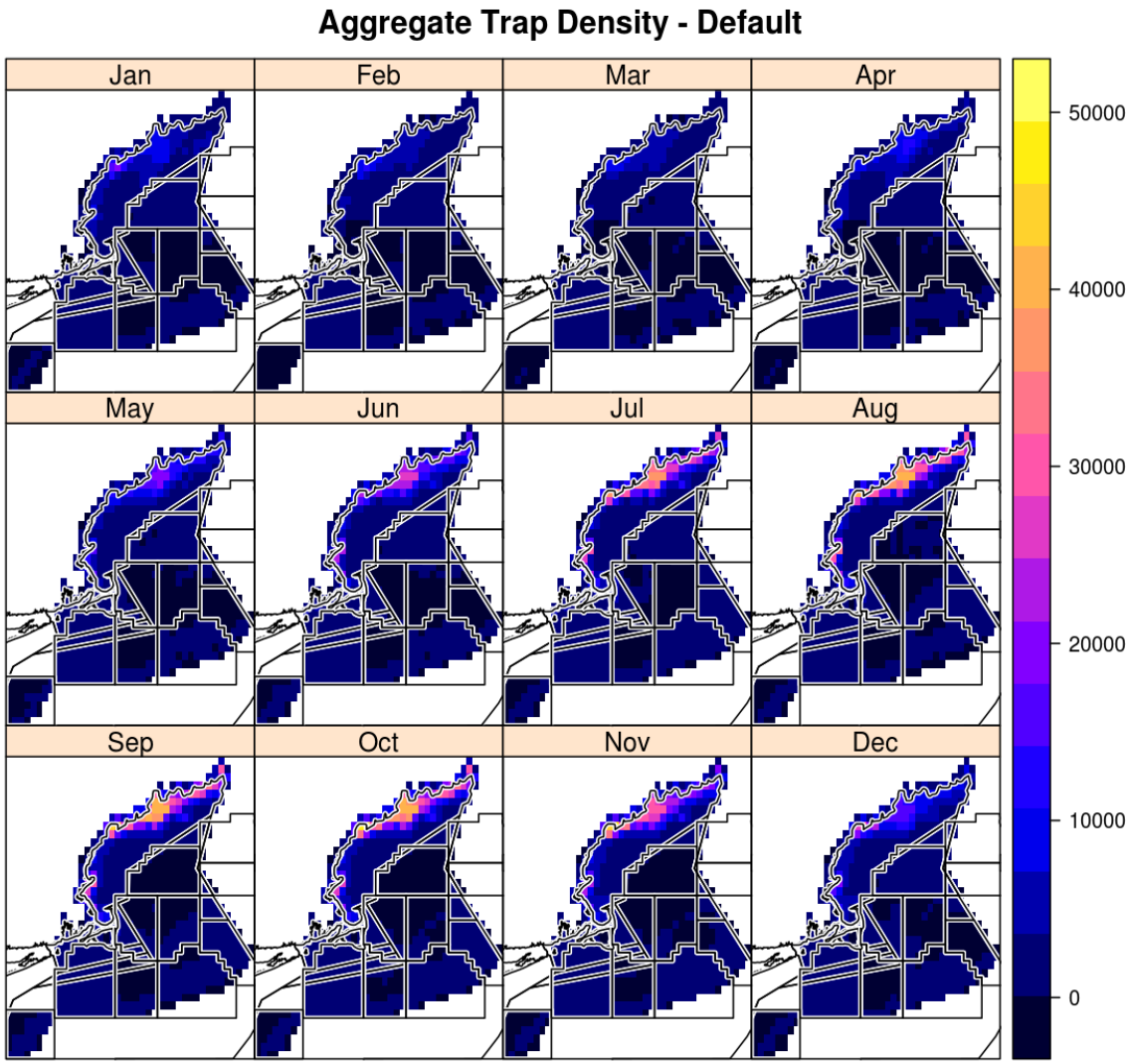




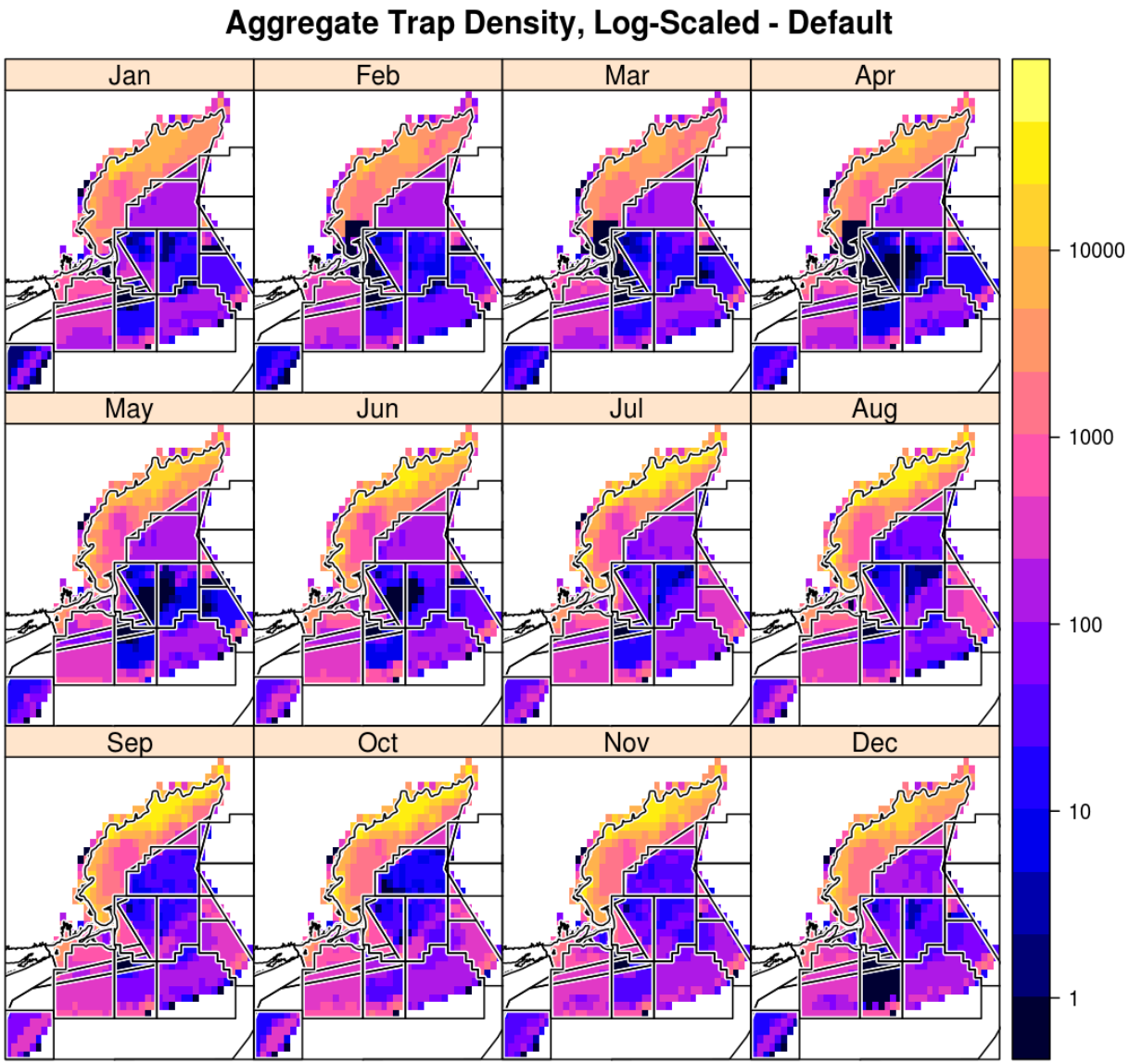
The Space Time continuum of whales and gear

Improved information

- Improved gear knowledge-
  - IEC model results and data sets
  - Observer data
  - VTR data
  - Data Contributions from ME
- Improved whale distribution
  - NARW density models- habitat affiliations- Roberts et al
  - Not in model- but available for key areas
    - Acoustic detections and recent Aerial survey observations



$$Risk = Whales * Gear\ density * severity$$



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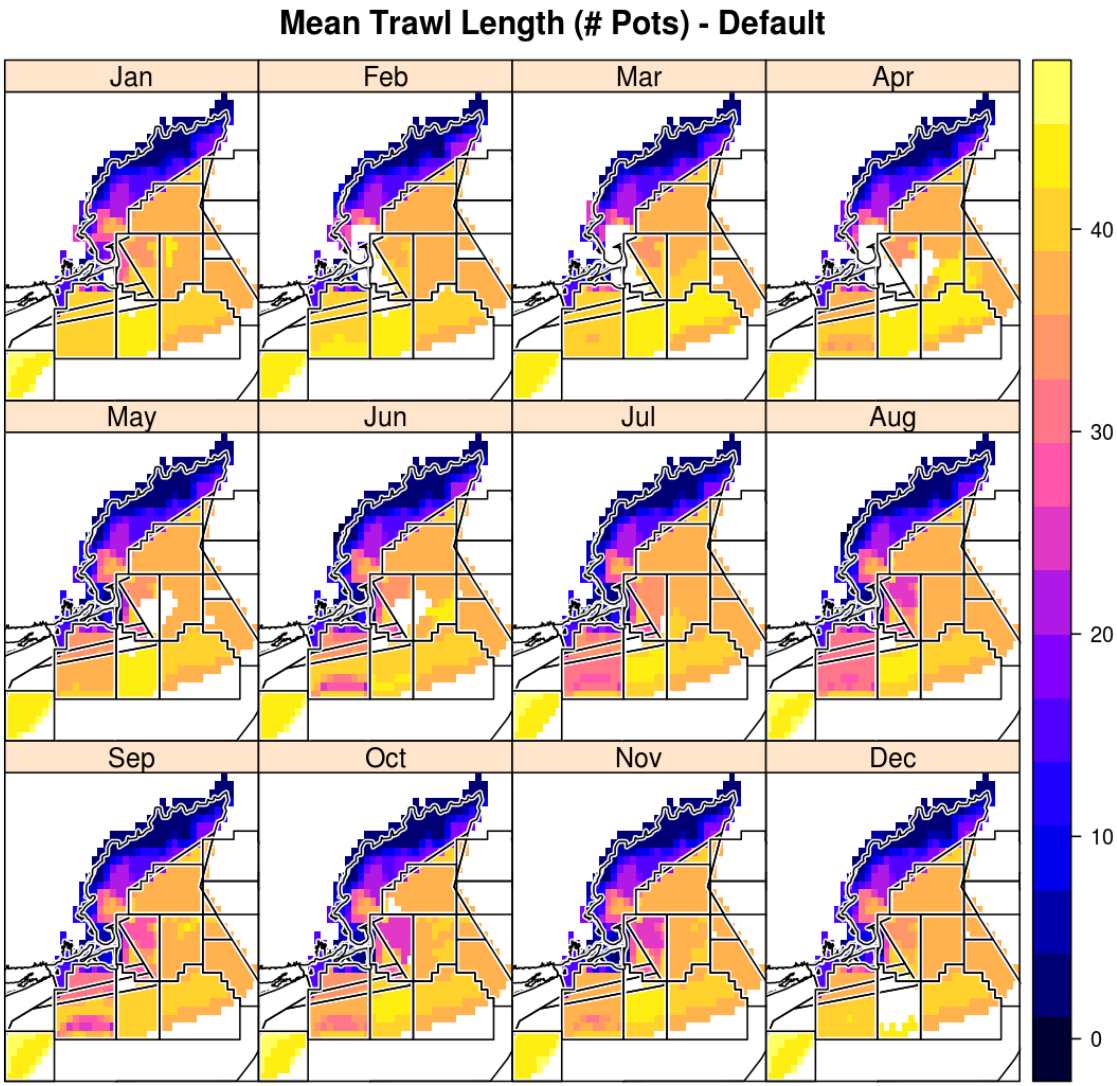

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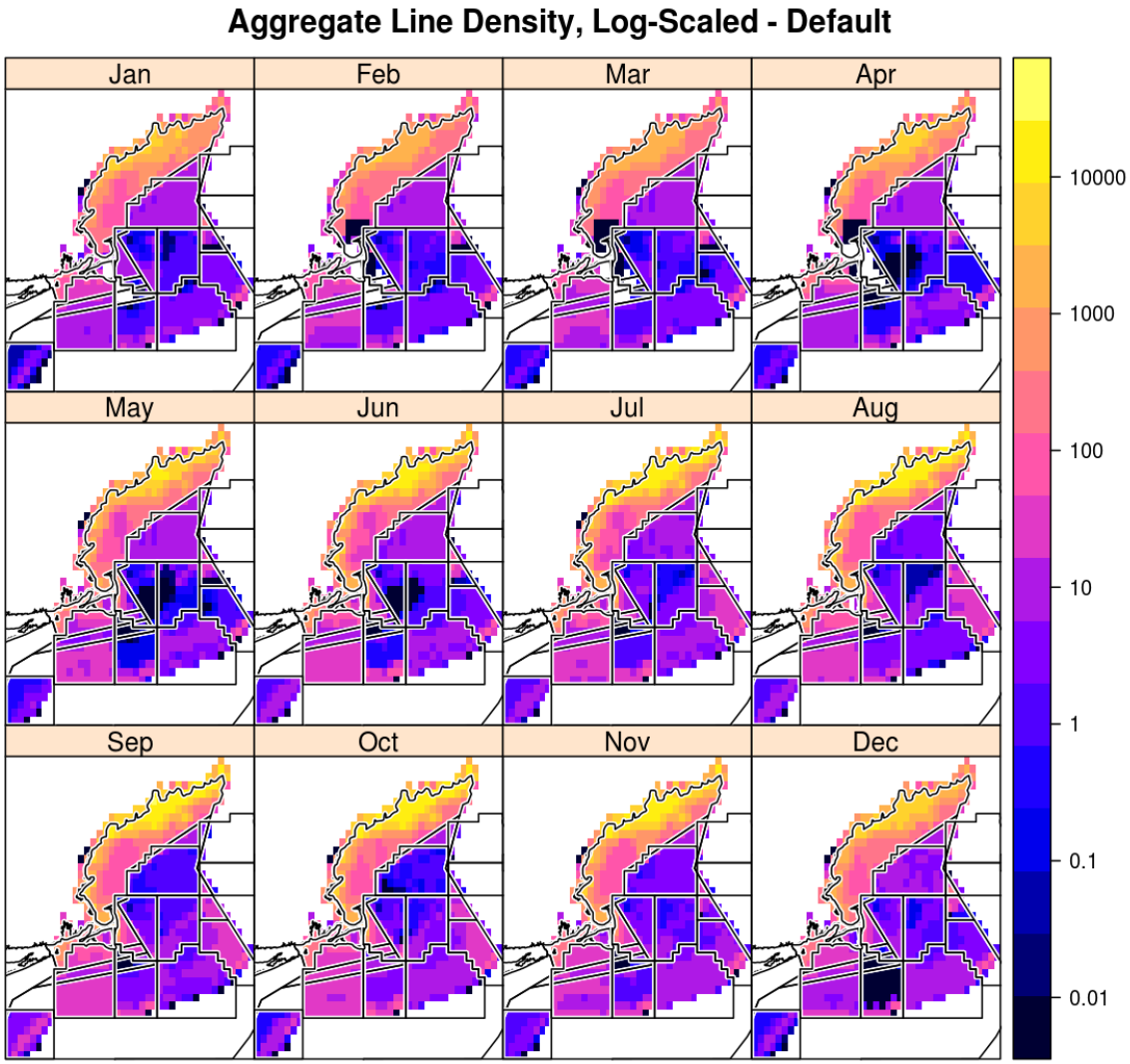

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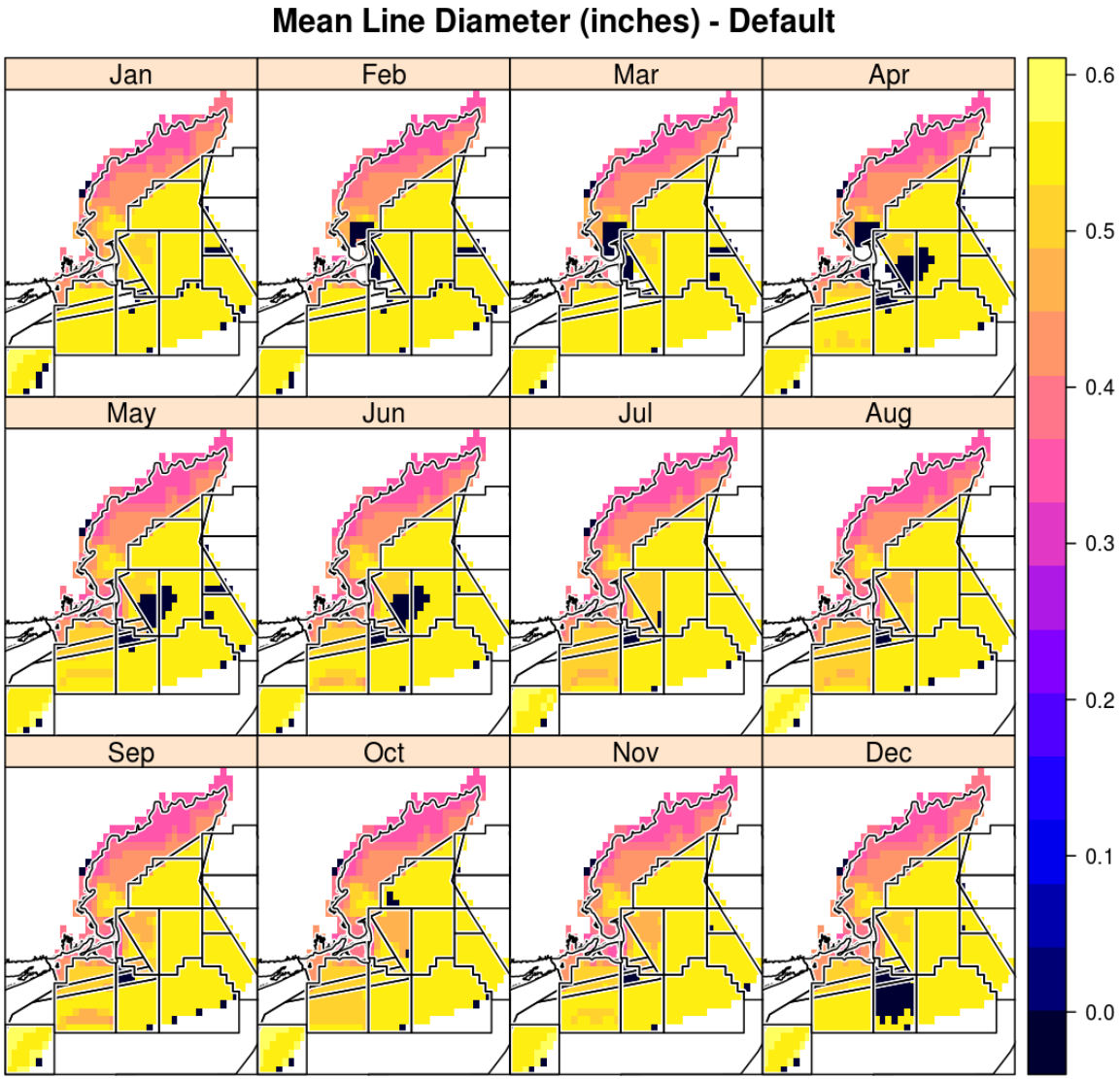

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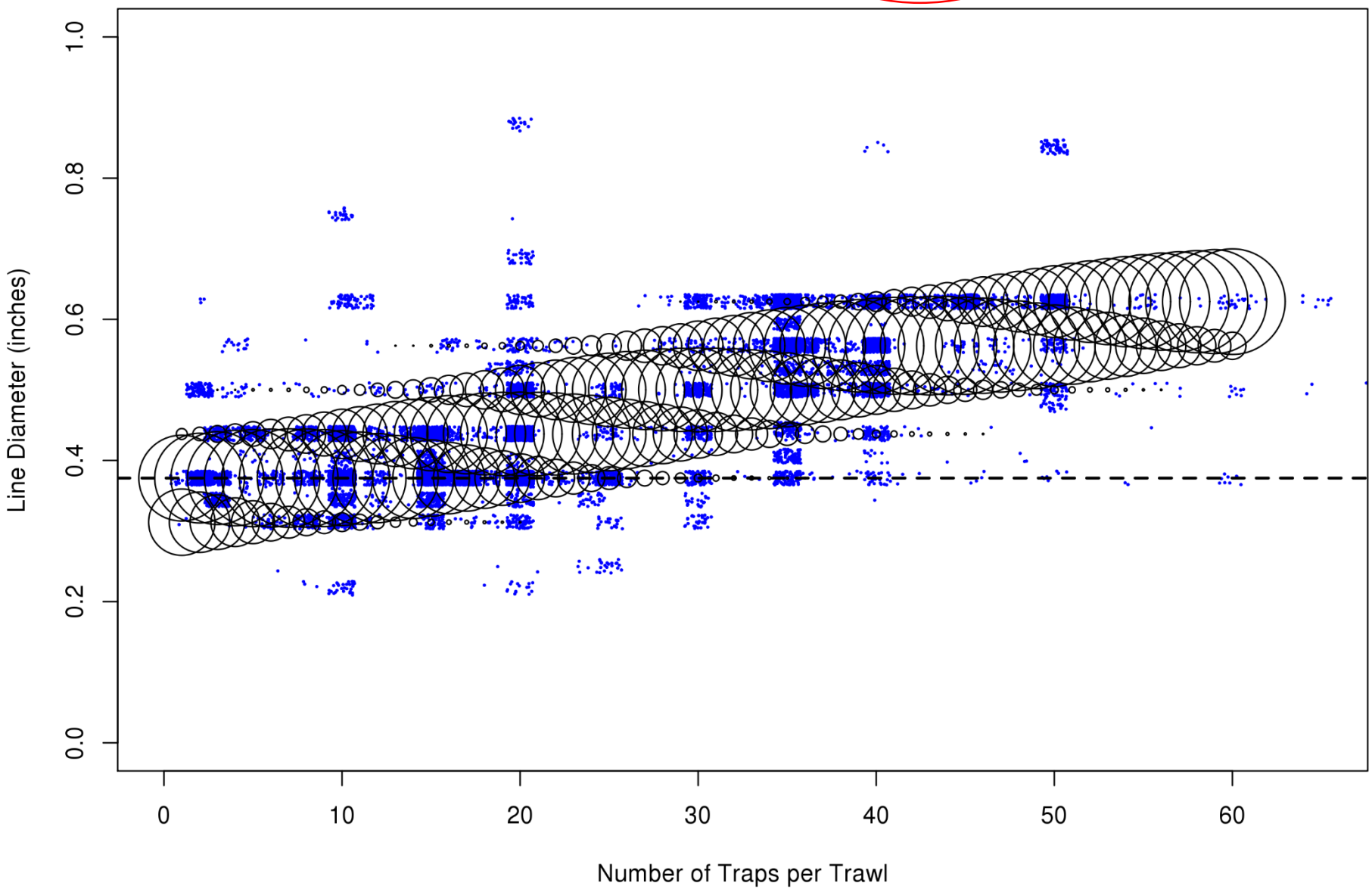
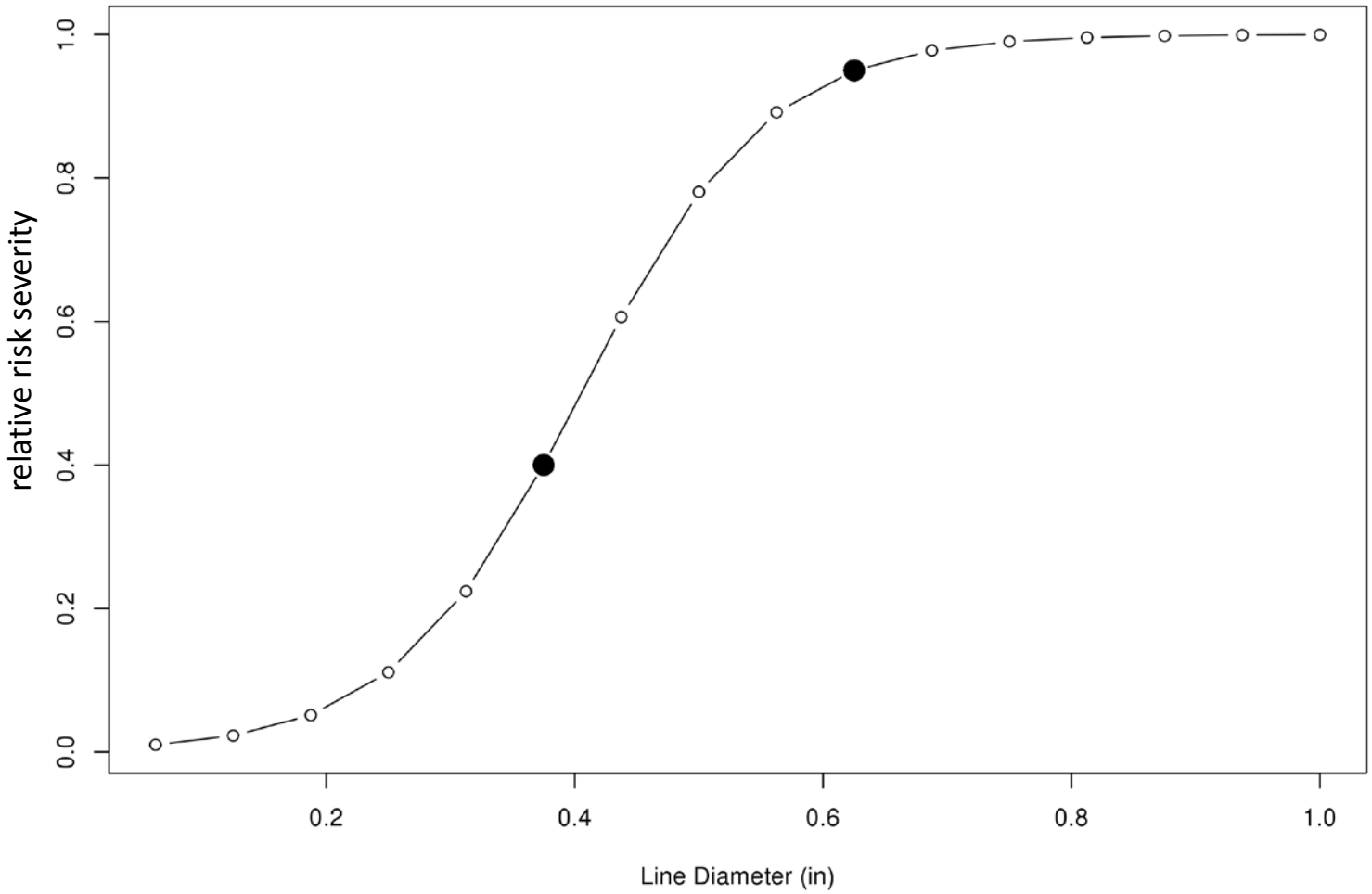
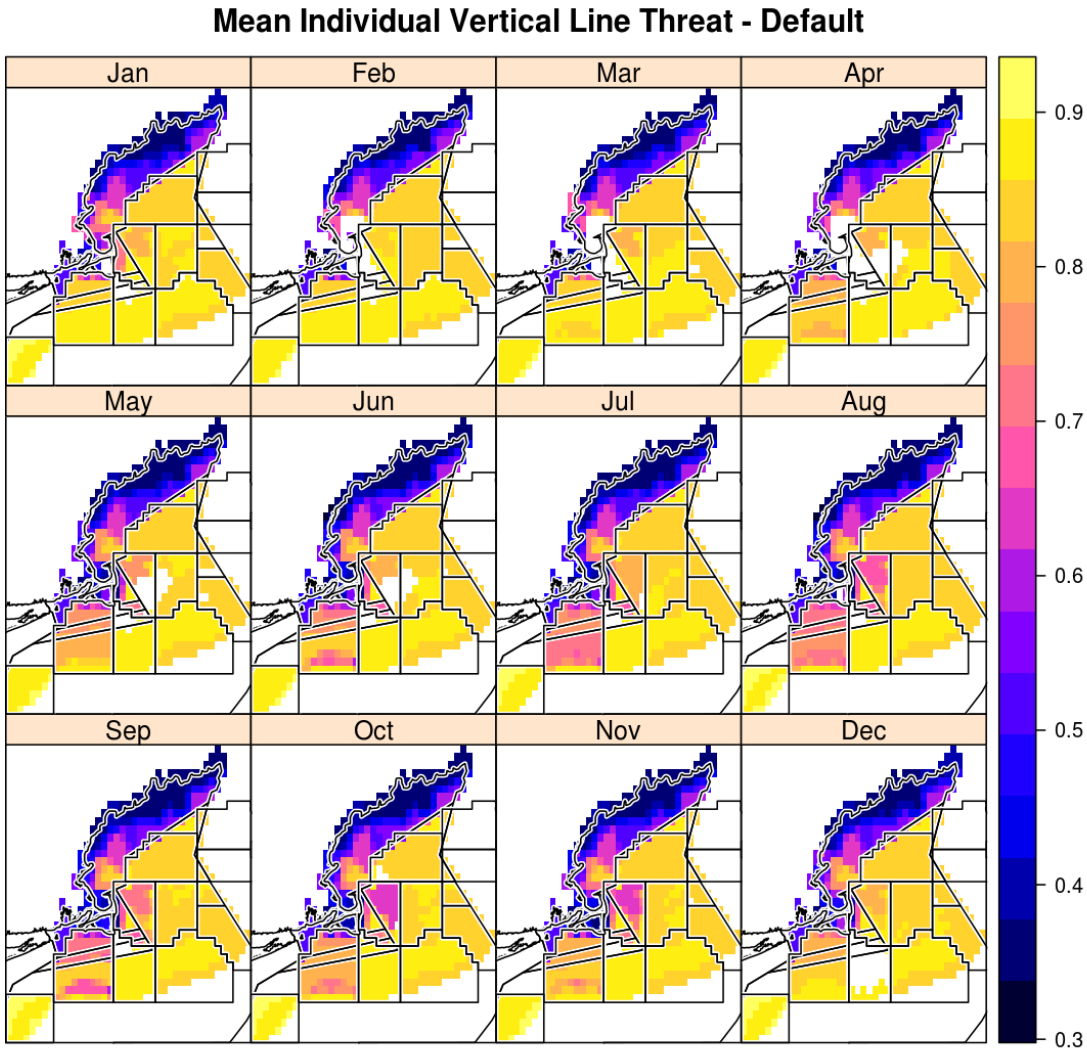


Example modeled relationship between vertical line diameter and relative risk severity

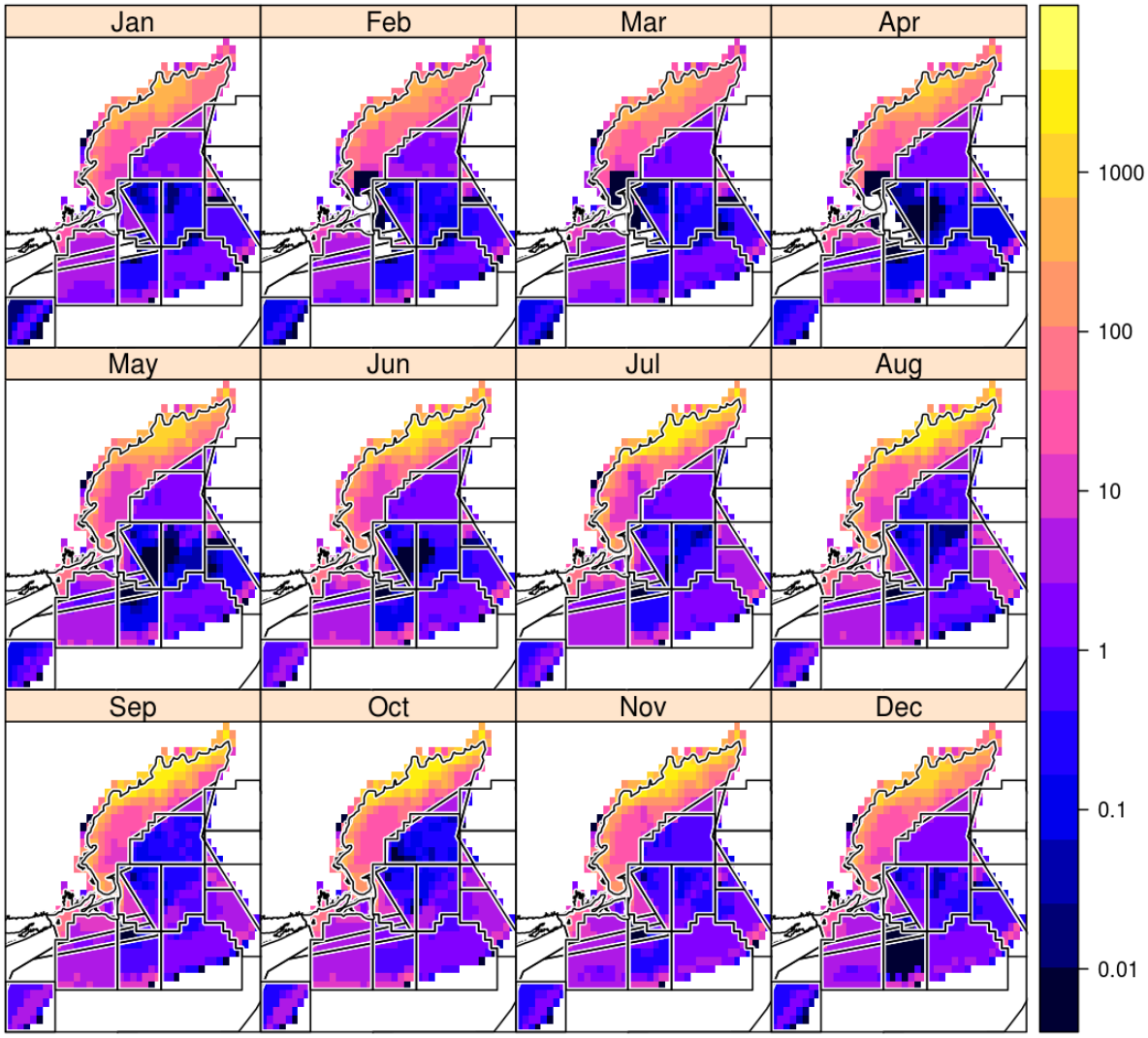


$$Risk = Whales \ * Gear\ density * severity$$

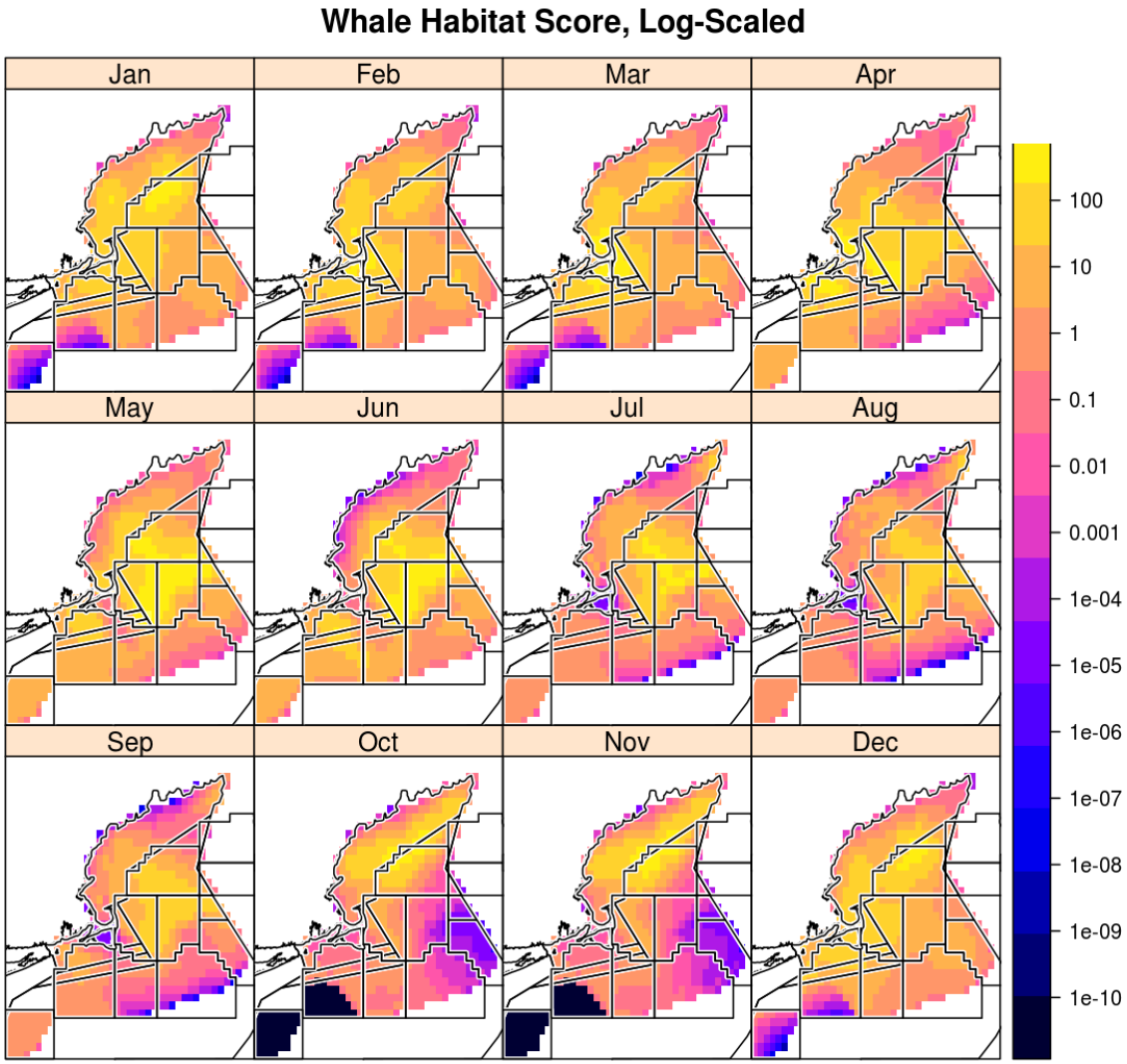


$$Risk = Whales * Gear\ density * severity$$

Aggregate Line Threat Score (Line Threat X Line Density), Log-Scaled - Default



$$Risk = Whales * Gear\ density * severity$$



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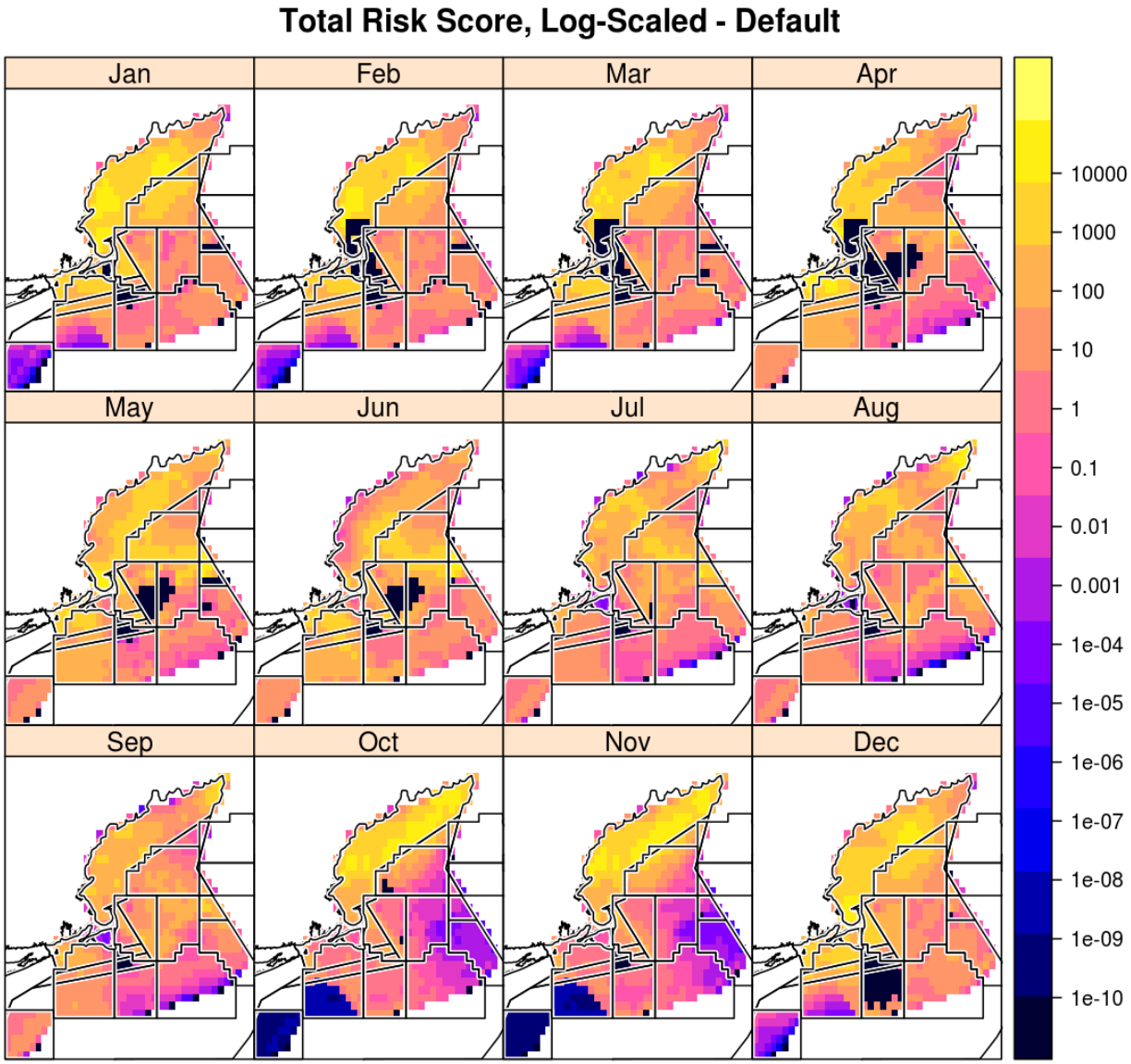


Relative Risk

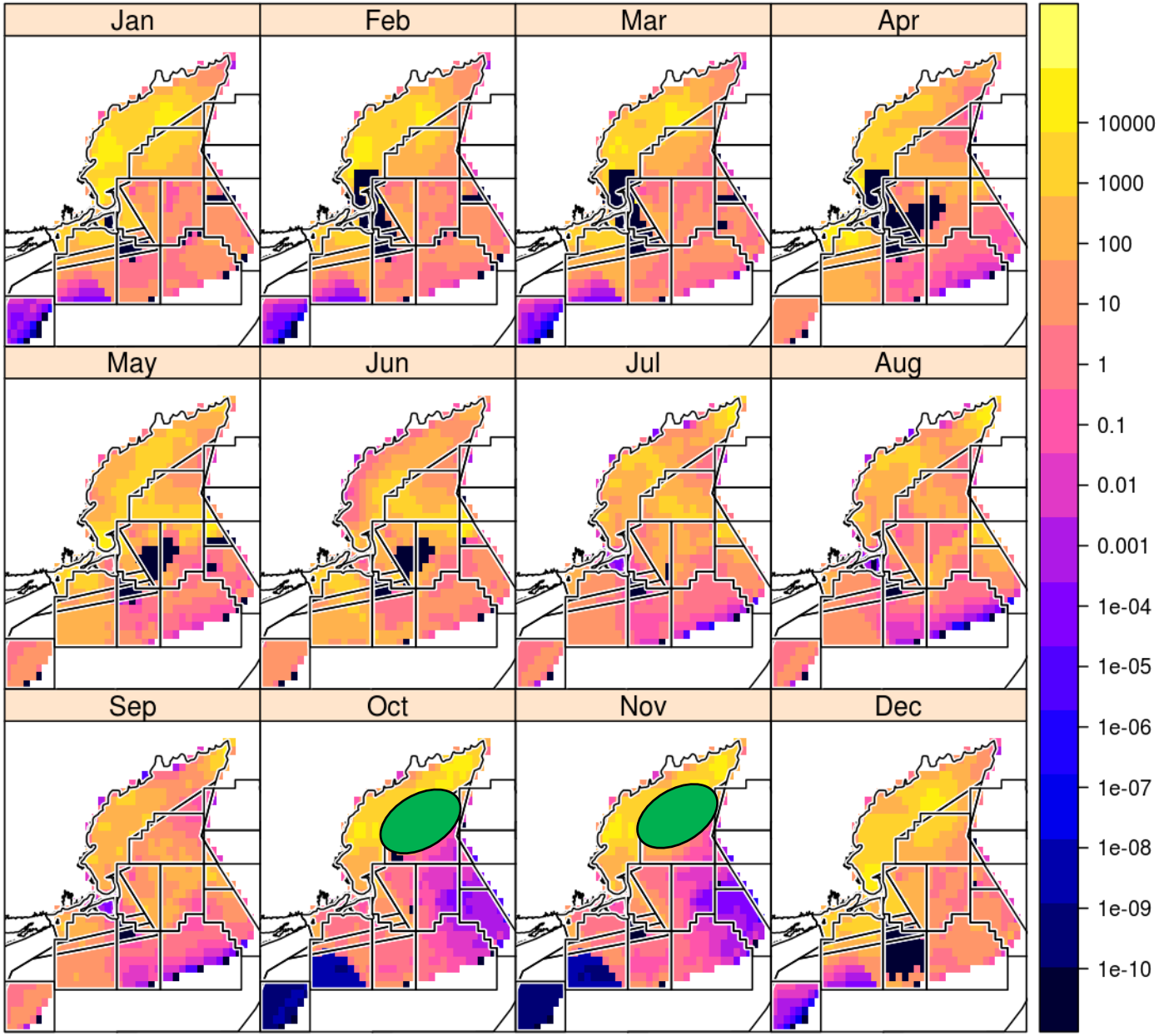
	Variable	Month	Default
40	RelativeRisk	1	850757.2
41	RelativeRisk	2	480243.2
42	RelativeRisk	3	408800.9
43	RelativeRisk	4	727481.4
44	RelativeRisk	5	661472.5
45	RelativeRisk	6	246594.6
46	RelativeRisk	7	238812.2
47	RelativeRisk	8	300872.2
48	RelativeRisk	9	104023.2
49	RelativeRisk	10	960176.7
50	RelativeRisk	11	1172830.2
51	RelativeRisk	12	827609.5
52	RelativeRisk	Total	6979673.9

Current Risk		6,979,674
Goal	60%	2,791,870
	80%	1,395,935

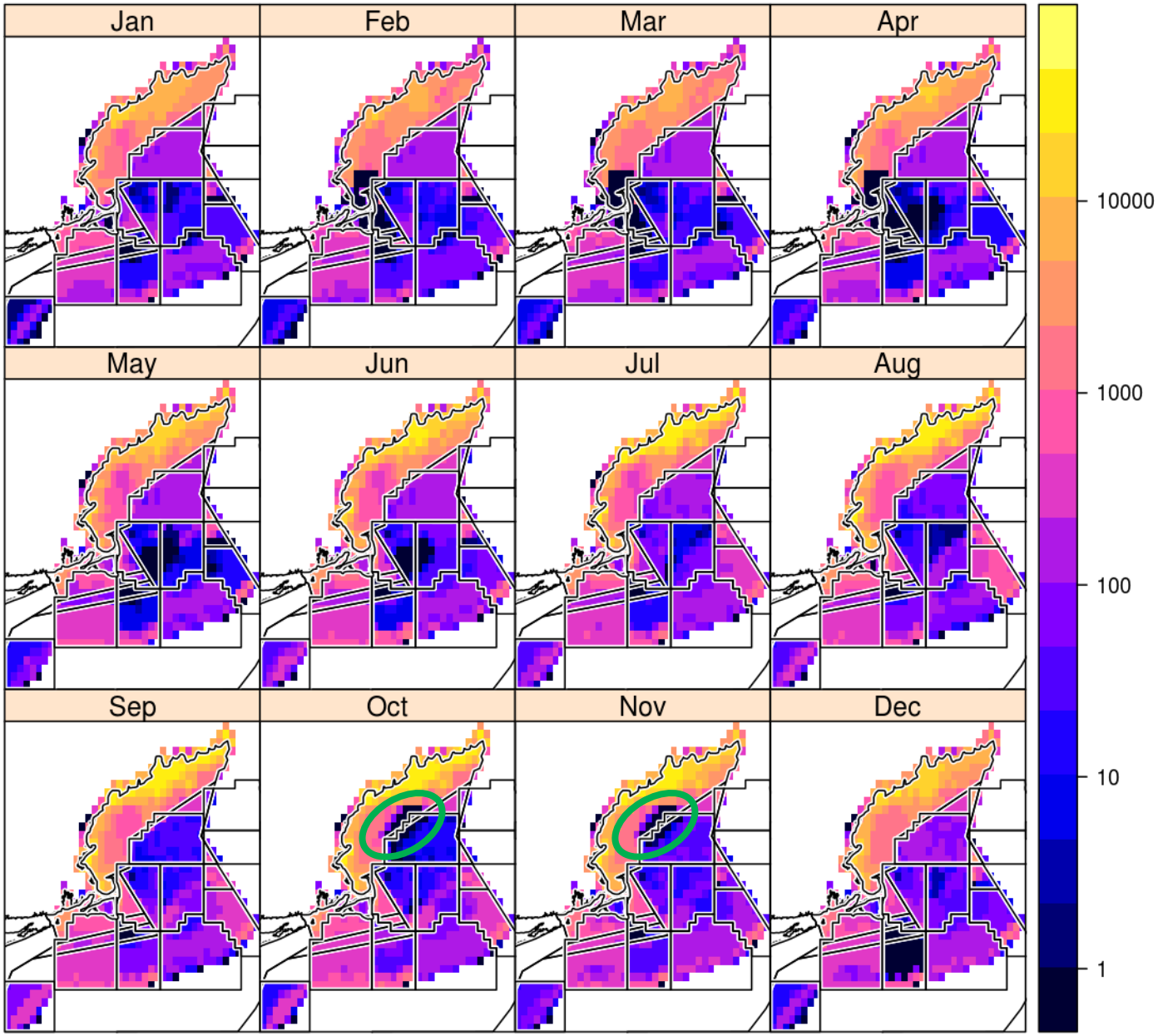
$$Risk = Whales * Gear\ density * severity$$

Example closure scenario

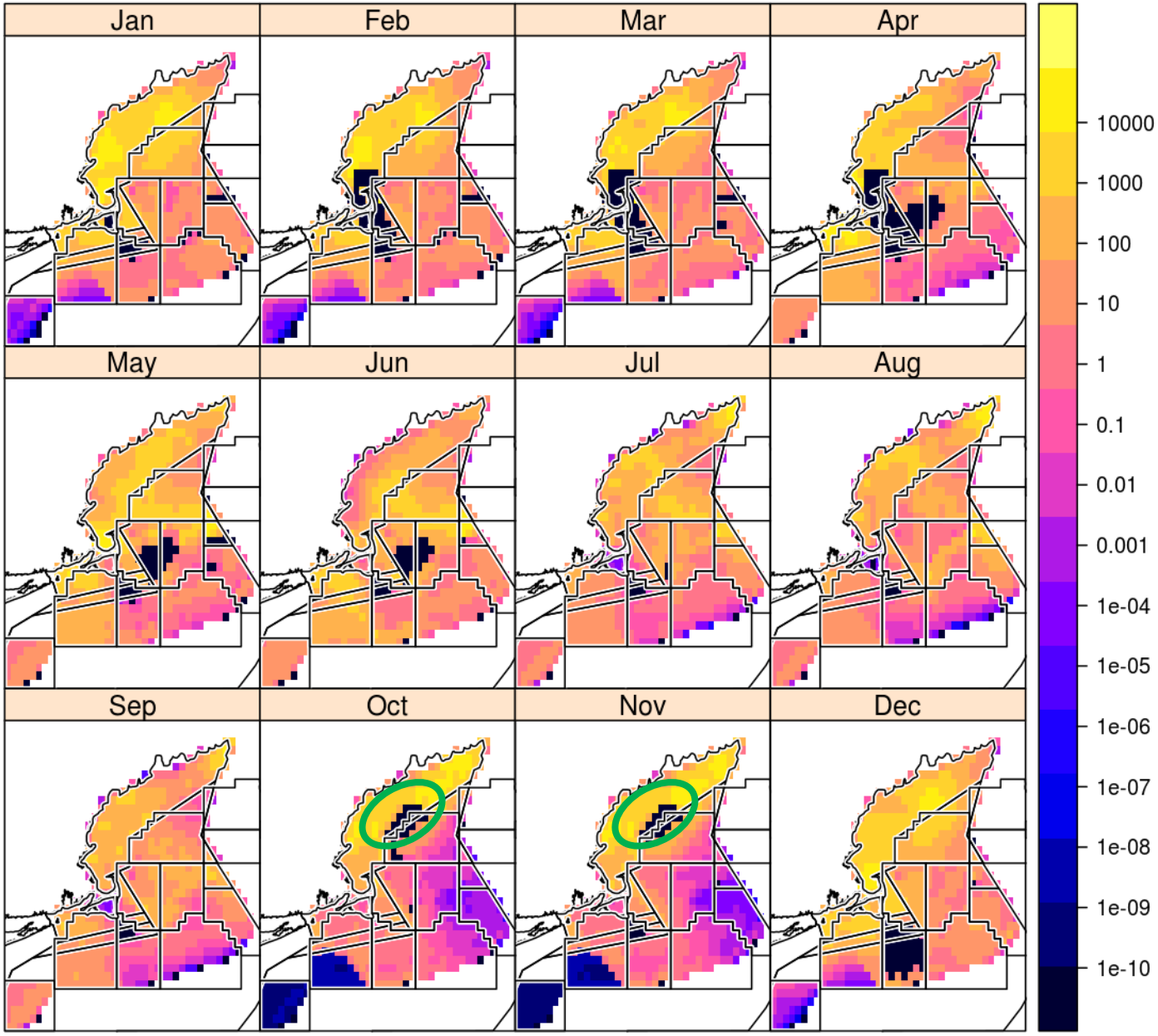
Total Risk Score, Log-Scaled - Default



Aggregate Trap Density, Log-Scaled - Scenario



Total Risk Score, Log-Scaled - Default



Trap Numbers

	Variable	Month	Default	Scenario	Change
1	TrapsFished	1	788532.0	788532.0	1.0000000
2	TrapsFished	2	536218.4	536218.4	1.0000000
3	TrapsFished	3	524014.1	524014.1	1.0000000
4	TrapsFished	4	739229.2	739229.2	1.0000000
5	TrapsFished	5	1090979.1	1090979.1	1.0000000
6	TrapsFished	6	1485203.4	1485203.4	1.0000000
7	TrapsFished	7	1921503.8	1921503.8	1.0000000
8	TrapsFished	8	2124201.3	2124201.3	1.0000000
9	TrapsFished	9	2152331.2	2152331.2	1.0000000
10	TrapsFished	10	2171781.2	2137022.5	0.9839953
11	TrapsFished	11	1810620.4	1773237.4	0.9793535
12	TrapsFished	12	1171224.0	1171224.0	1.0000000
13	TrapsFished	Total	16515837.9	16443696.2	0.9956320

<1% trap reduction

Total Trawls

	Variable	Month	Default	Scenario	Change
14	Trawls	1	152697.70	152697.70	1.0000000
15	Trawls	2	97742.35	97742.35	1.0000000
16	Trawls	3	96938.60	96938.60	1.0000000
17	Trawls	4	182147.06	182147.06	1.0000000
18	Trawls	5	338355.28	338355.28	1.0000000
19	Trawls	6	521224.71	521224.71	1.0000000
20	Trawls	7	764735.53	764735.53	1.0000000
21	Trawls	8	853819.40	853819.40	1.0000000
22	Trawls	9	830436.36	830436.36	1.0000000
23	Trawls	10	798160.28	796174.15	0.9975116
24	Trawls	11	585919.86	583726.55	0.9962566
25	Trawls	12	280951.24	280951.24	1.0000000
26	Trawls	Total	5503128.38	5498948.94	0.9992405

<0.1% trawl reduction

Total Vertical Line

	Variable	Month	Default	Scenario	Change
27	VerticalLines	1	187301.3	187301.3	1.0000000
28	VerticalLines	2	120795.8	120795.8	1.0000000
29	VerticalLines	3	119028.9	119028.9	1.0000000
30	VerticalLines	4	210195.9	210195.9	1.0000000
31	VerticalLines	5	373807.0	373807.0	1.0000000
32	VerticalLines	6	568879.1	568879.1	1.0000000
33	VerticalLines	7	821544.1	821544.1	1.0000000
34	VerticalLines	8	914007.2	914007.2	1.0000000
35	VerticalLines	9	893679.6	893679.6	1.0000000
36	VerticalLines	10	866479.4	862507.1	0.9954156
37	VerticalLines	11	650196.3	645809.7	0.9932534
38	VerticalLines	12	328702.0	328702.0	1.0000000
39	VerticalLines	Total	6054616.8	6046257.9	0.9986194

<0.2% line reduction

Relative Risk

	Variable	Month	Default	Scenario	Change
40	RelativeRisk	1	850757.2	850757.2	1.0000000
41	RelativeRisk	2	480243.2	480243.2	1.0000000
42	RelativeRisk	3	408800.9	408800.9	1.0000000
43	RelativeRisk	4	727481.4	727481.4	1.0000000
44	RelativeRisk	5	661472.5	661472.5	1.0000000
45	RelativeRisk	6	246594.6	246594.6	1.0000000
46	RelativeRisk	7	238812.2	238812.2	1.0000000
47	RelativeRisk	8	300872.2	300872.2	1.0000000
48	RelativeRisk	9	104023.2	104023.2	1.0000000
49	RelativeRisk	10	960176.7	697549.6	0.7264804
50	RelativeRisk	11	1172830.2	780127.6	0.6651667
51	RelativeRisk	12	827609.5	827609.5	1.0000000
52	RelativeRisk	Total	6979673.9	6324344.1	0.9061088

9.4% risk reduction

Note- not a closure example from TRT

- this example focuses on a strategic closure in a high risk area
- Assumes ‘high accuracy’ in model that is intentionally relative
- Assumes all gear pulled out of water
- not a preferred solution over time as fisheries and whales move.

More complex scenarios

- Remember this simple formula

$$Risk = Whales \ * Gear\ density \ * severity$$

- Closures where gear is displaced?
  - Risk in closed area goes to 0, apply formula to adjacent areas- if whale density is less, risk can still go down.
- 30% line reduction with fixed trawl length (fewer traps)-
  - gear density (and risk) reduced 30%
  - Line reduction with trawling up- can reduce risk- but must adjust for trawling up risk
- Apply some severity modifier- sleeves, time-tension cutter, 1700lb rope etc.

What is next?

- Apply new severity scores from poll to tool
- Score the TRT scenarios
- Provide trained model operators to TRT breakout groups
- TRT works to build strawman solution