A model of entanglement risk for lobster fishing off the coast of Maine

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Woods Hole Oceanographic Institution 1930
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New England Aquarium
MAINE Lobstermen's Association

Approach:

Estimate the expected number of whale/fishing gear encounters per year – this will depend on:

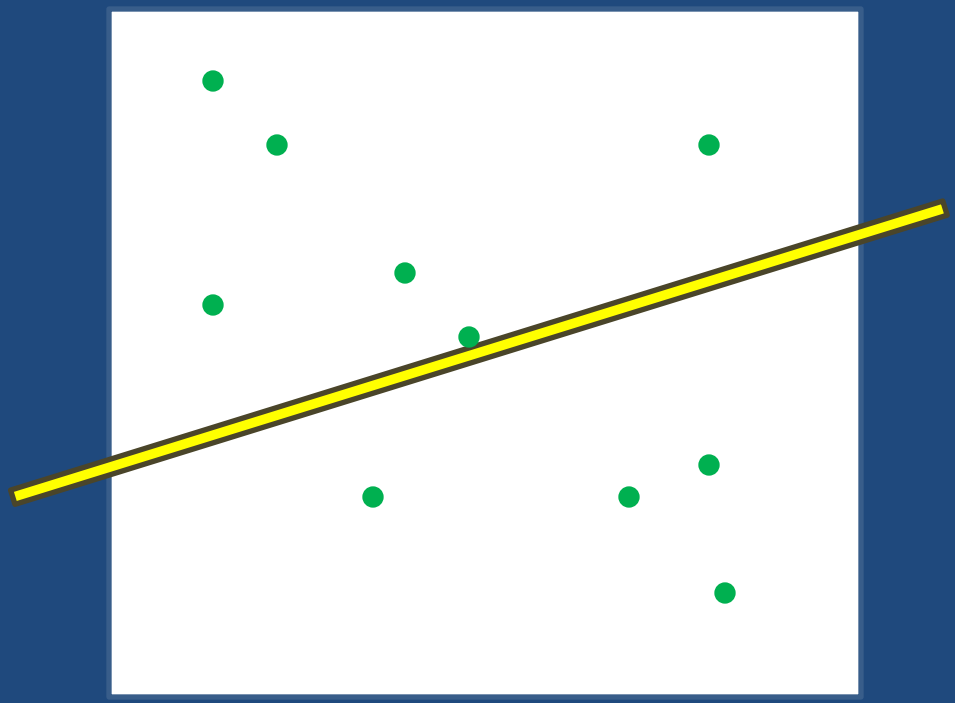
- fishing effort
  - vertical line density
  - trap string configuration
- whale activity
  - density
  - behavior (transiting, feeding, etc.)
- topography
  - water depth
  - bottom characteristics

Estimate reductions in risk (encounters/year) from adjustments to fishing effort (time, location, gear configuration).

Vertical Line Risk

Probability of whale-line encounter

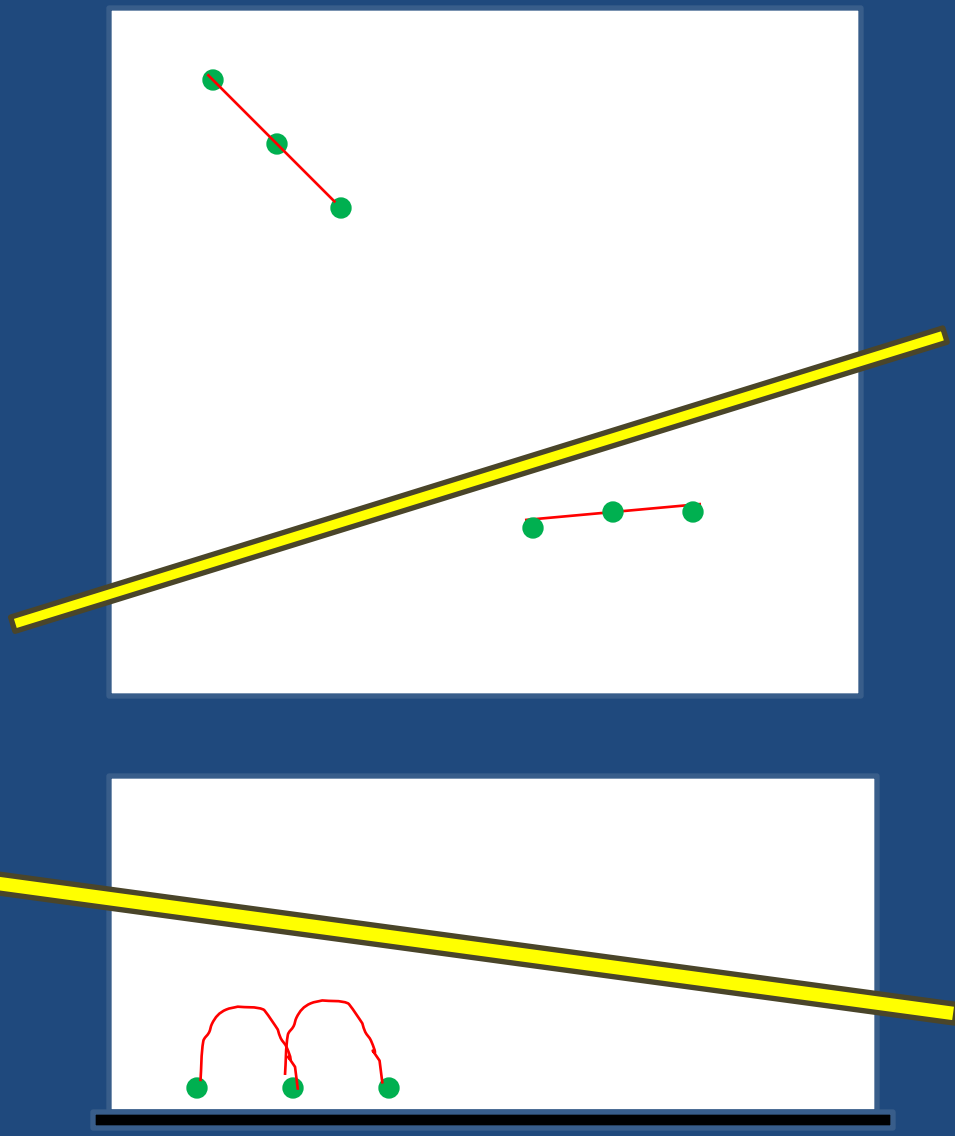
= f (lines/km^2
whale track/km^2
[whale size])



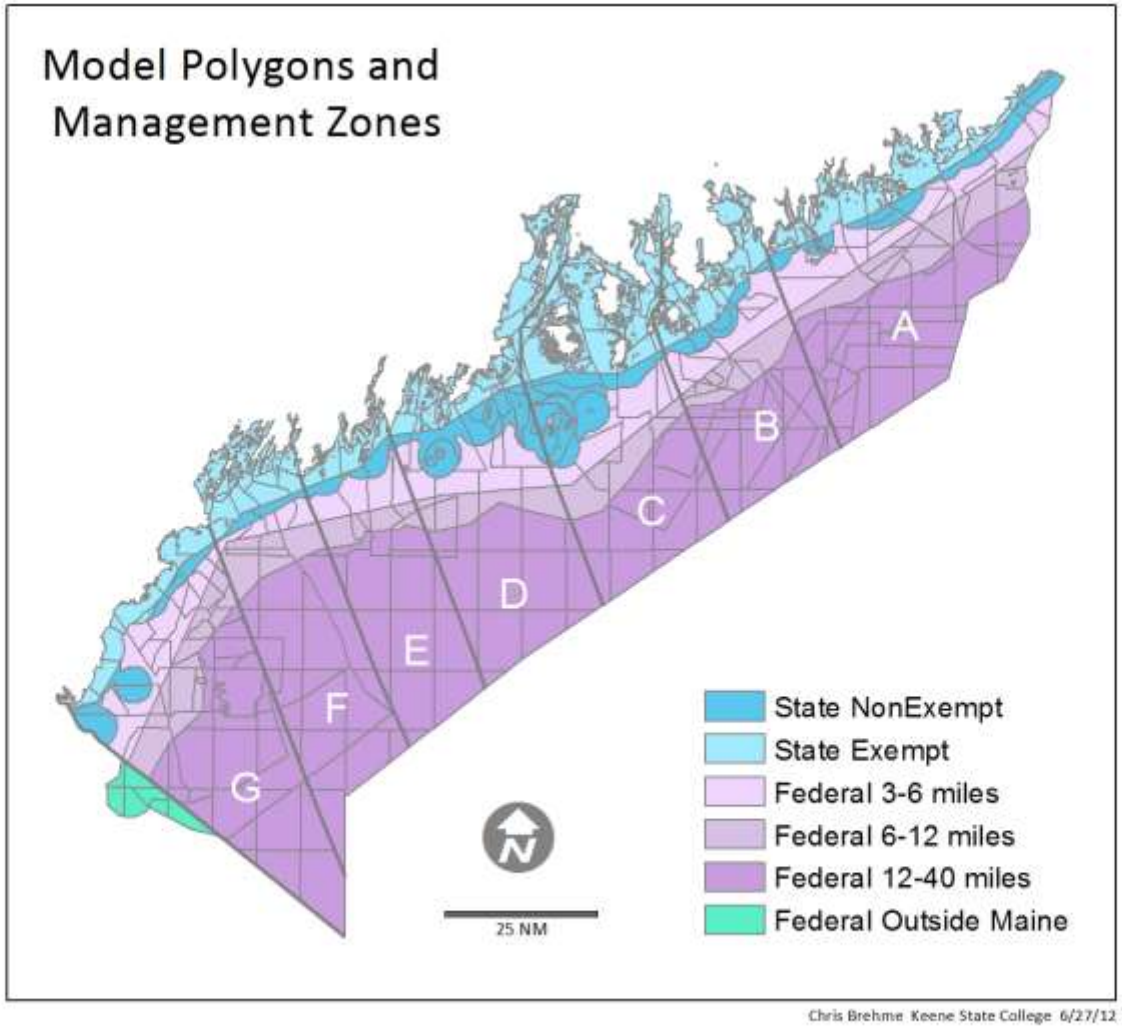
Ground Line Risk

Probability of whale-line encounter

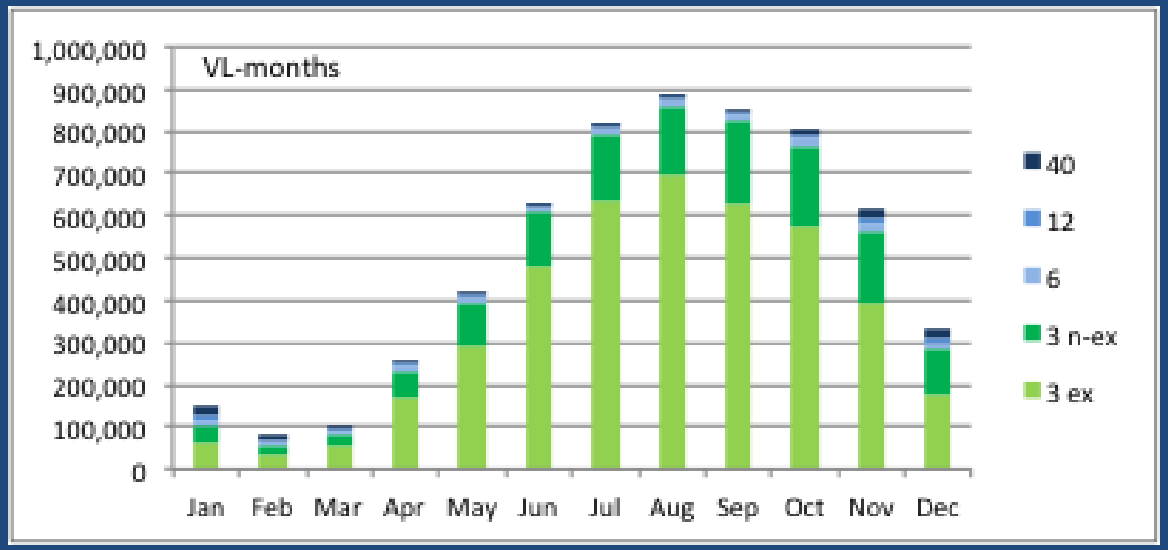
= f (h line length/km^2
whale track/km^2
[whale size]
water depth
whale diving)



Model Polygons and Fishing Zones

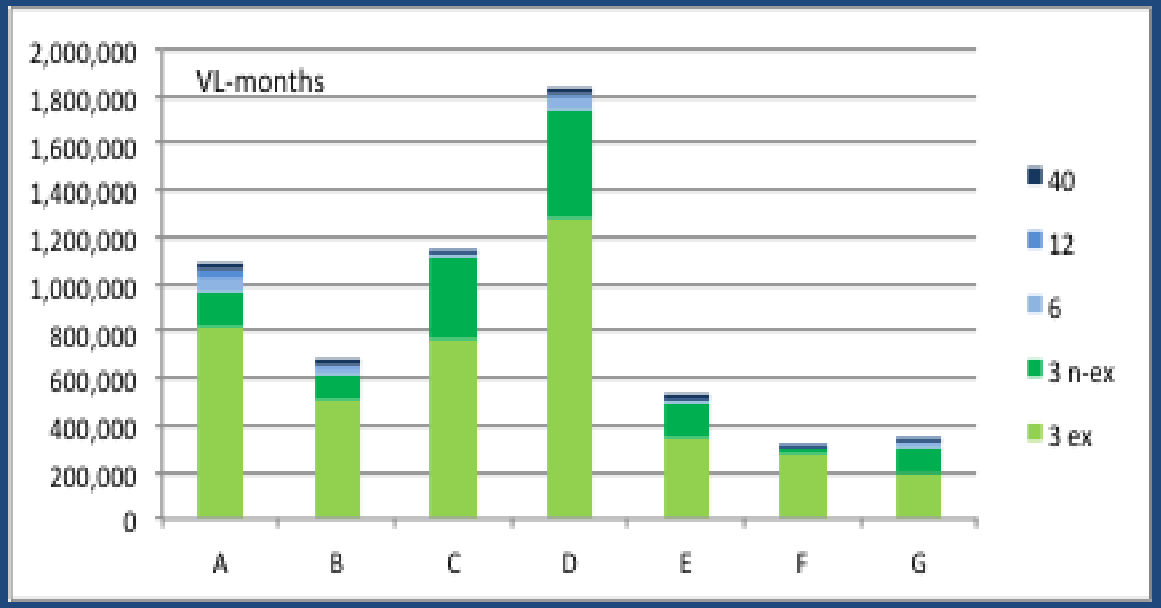


Fishing Activity Data

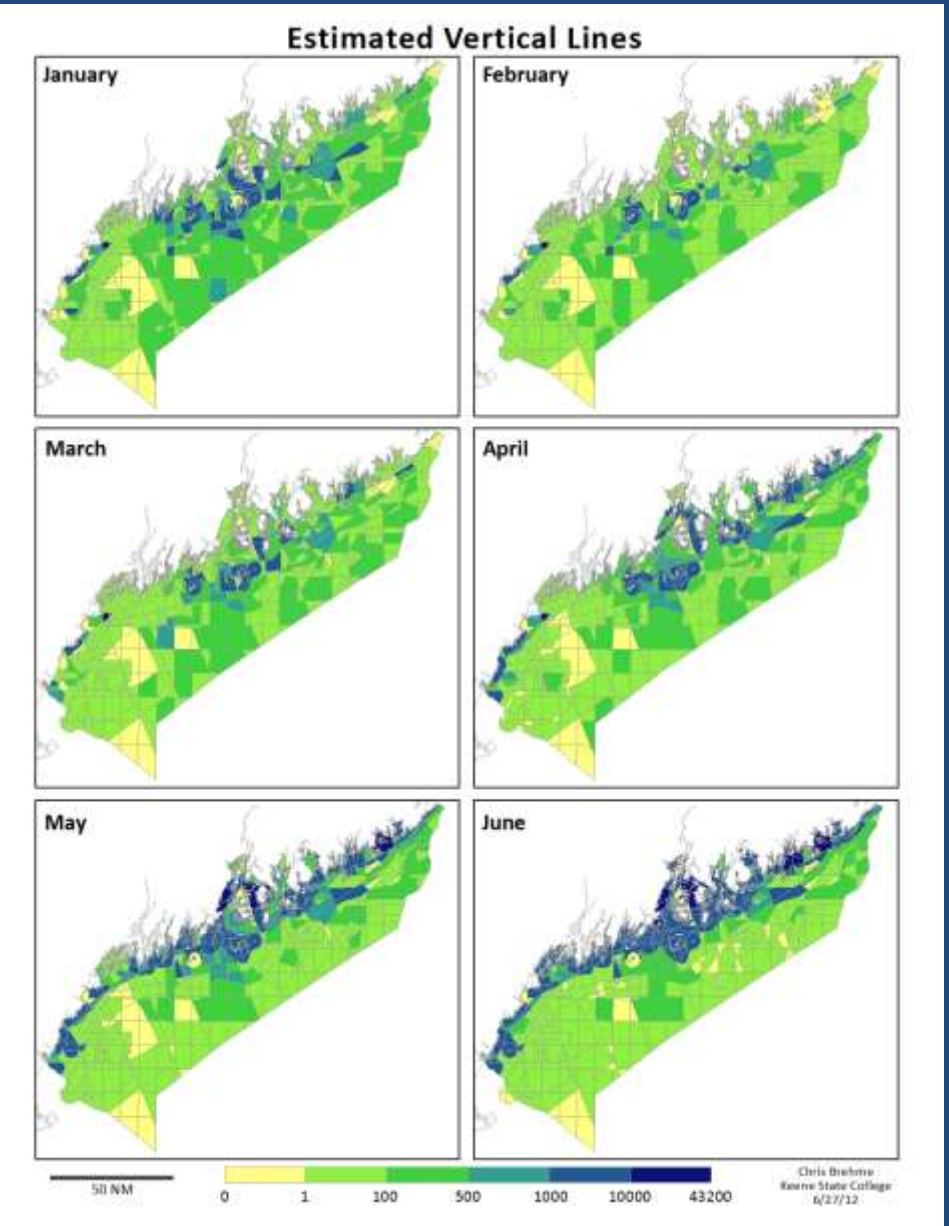


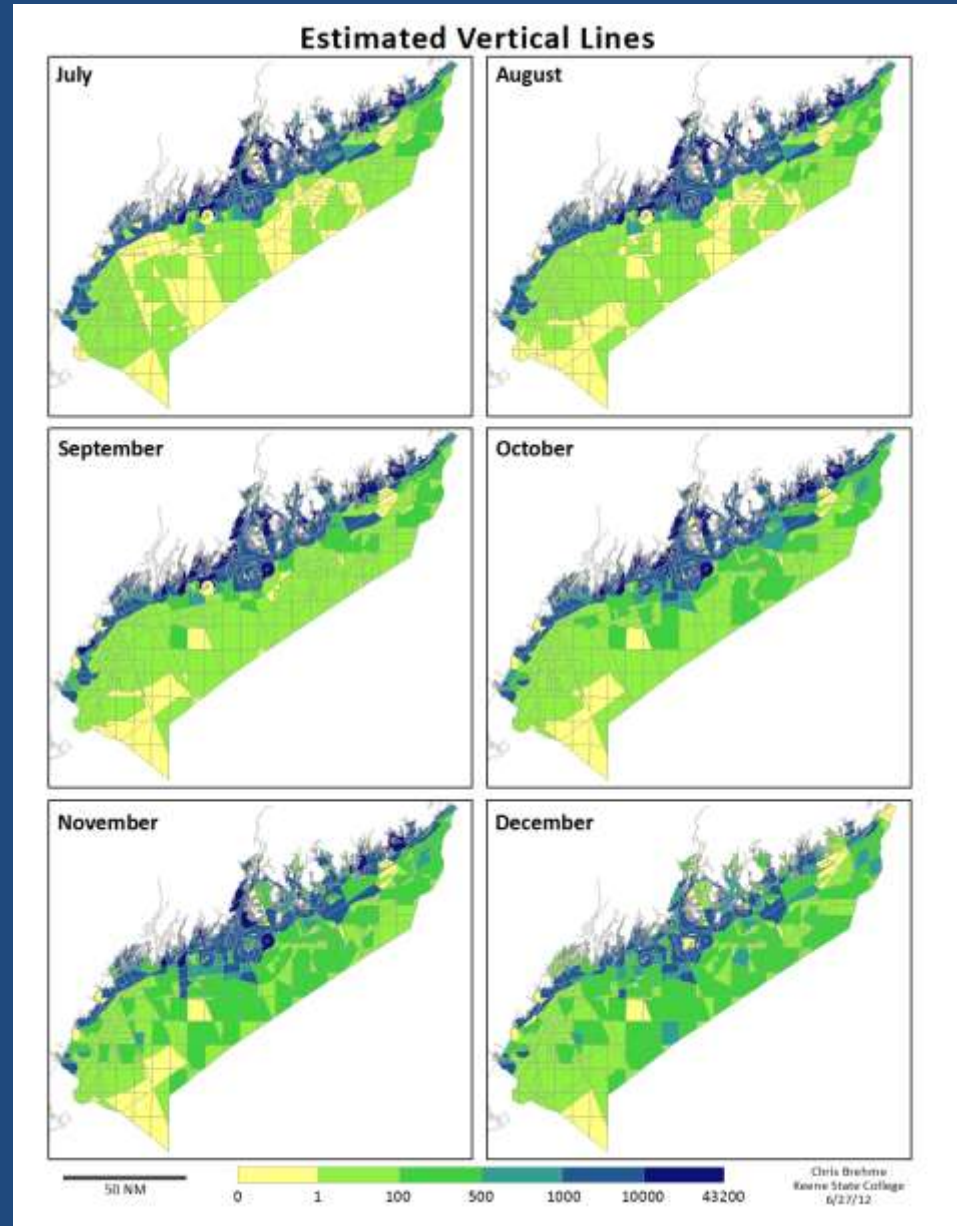
5.9 million VL-months

Exempt state:	70.6%
Non-ex. state:	22.7%
3-6 miles:	3.2%
6-12 miles:	1.4%
12-40 miles:	2.1%

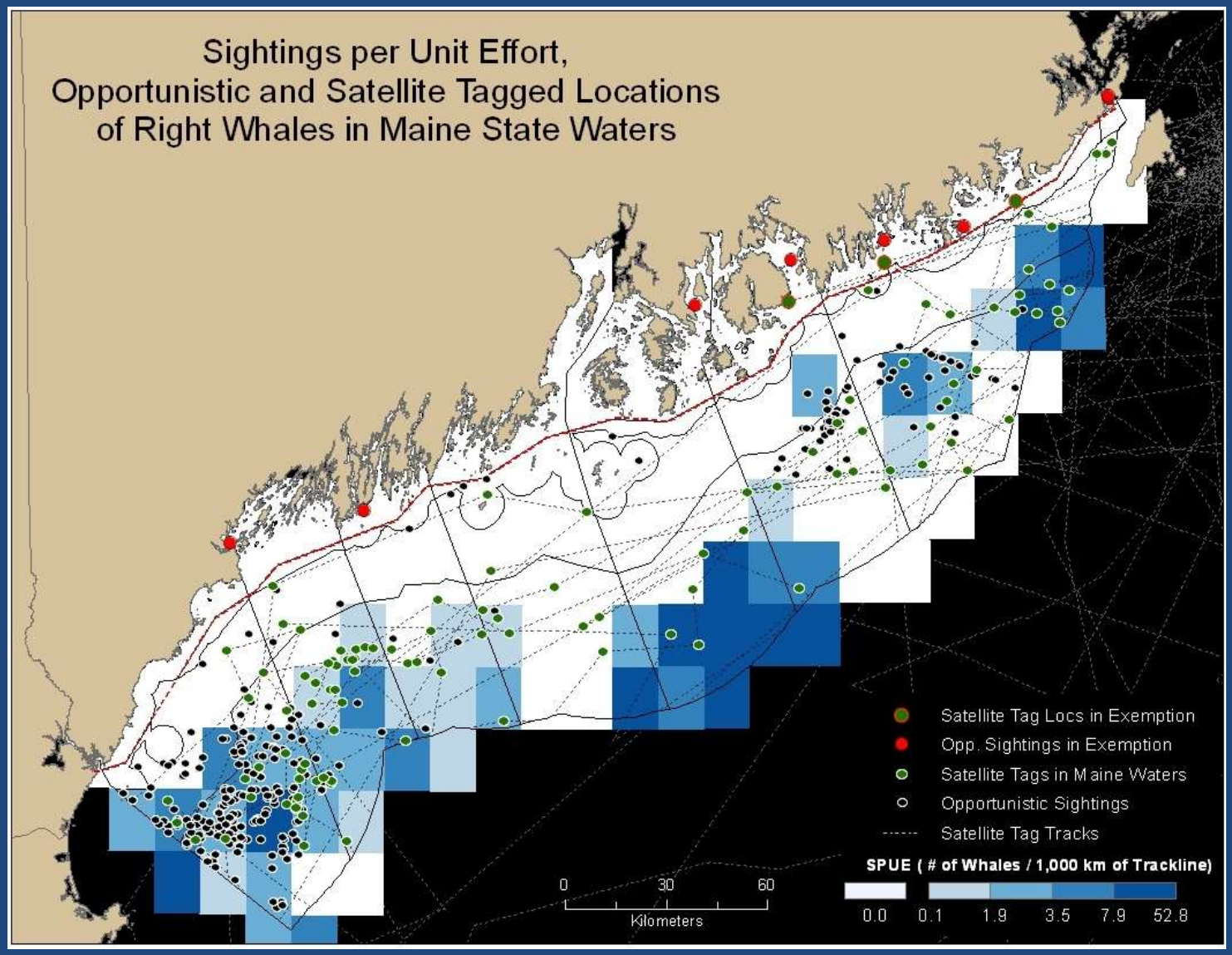


Fishing Gear in the Water

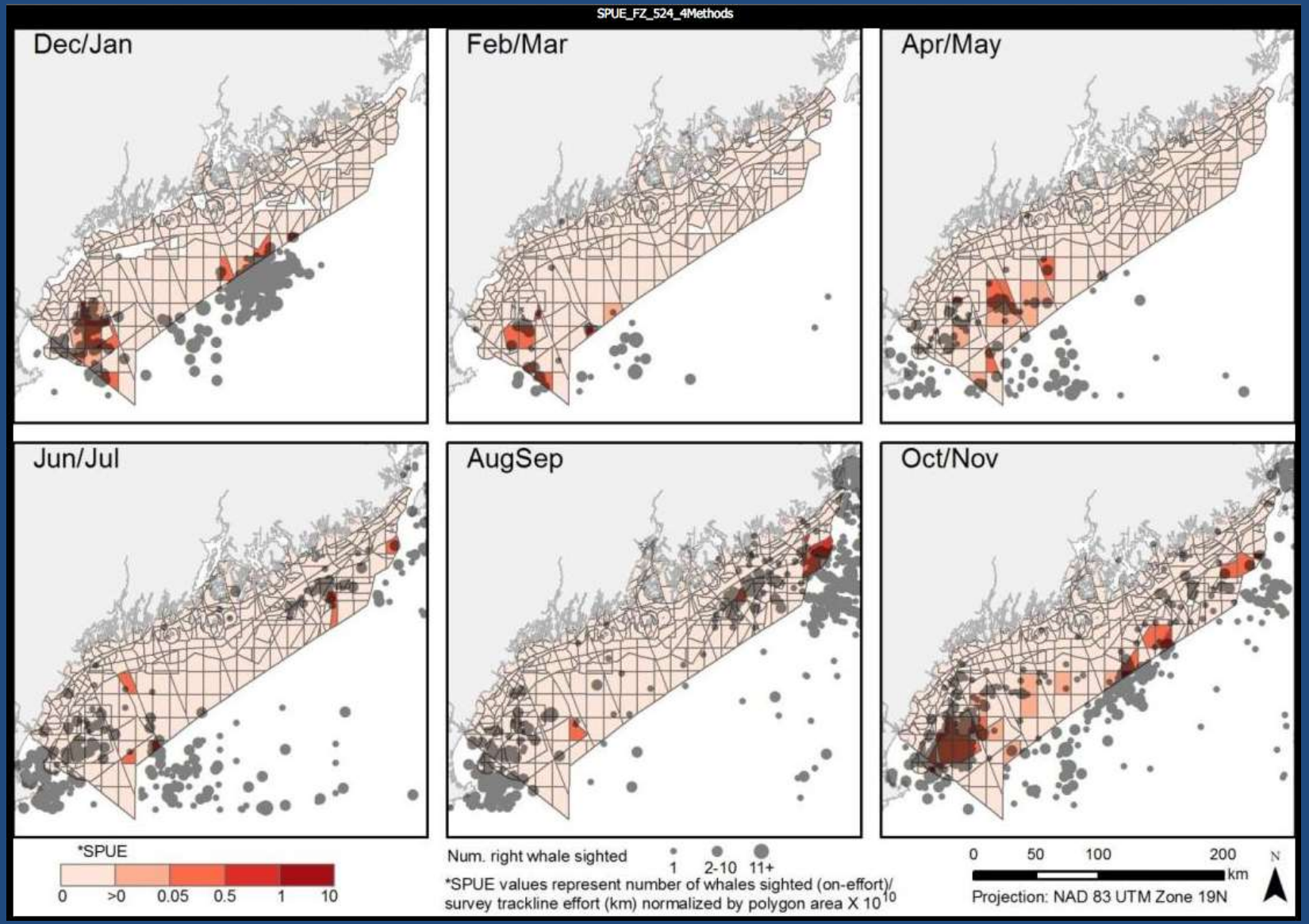




Whale Activity Data

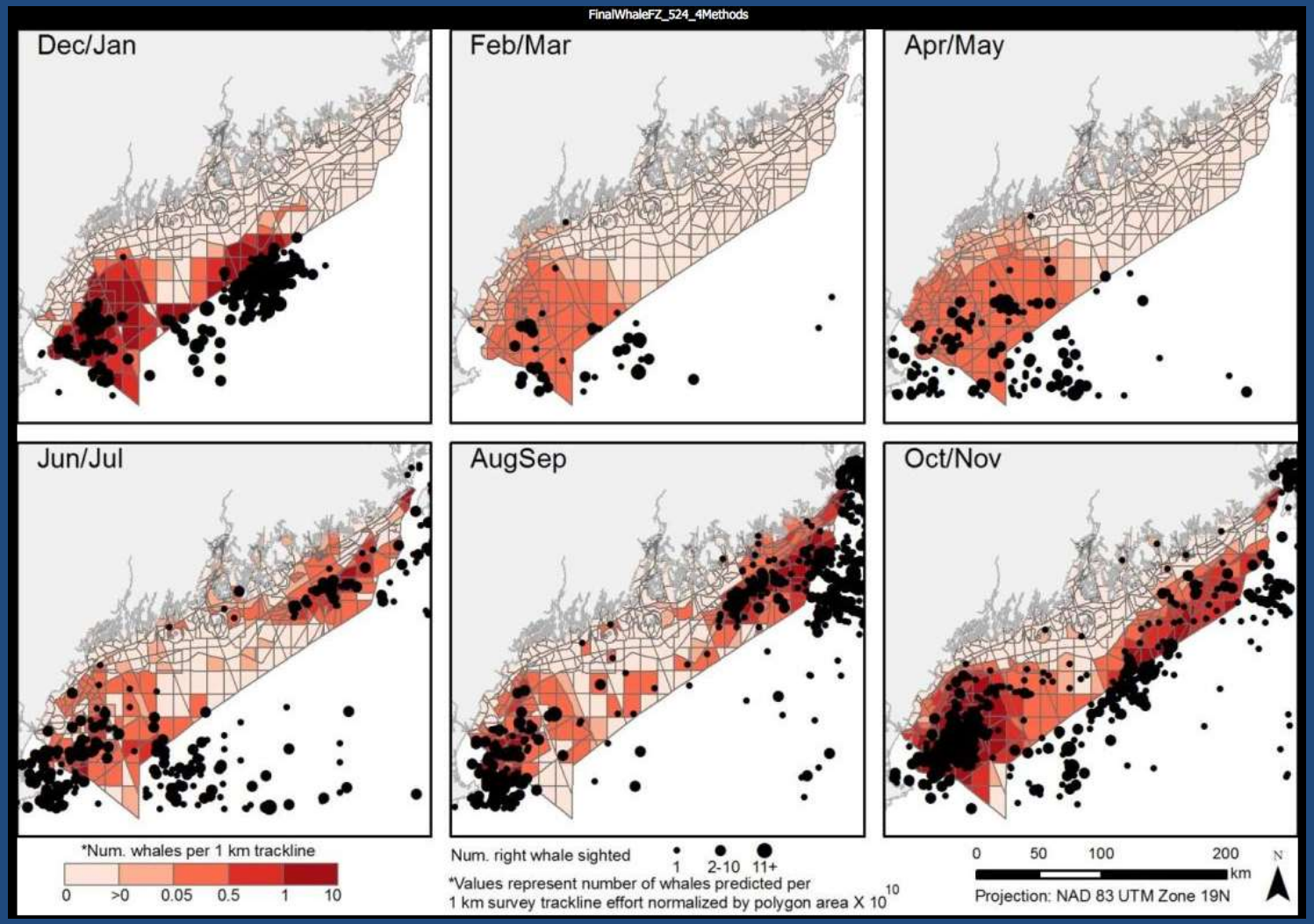


Survey effort is concentrated offshore



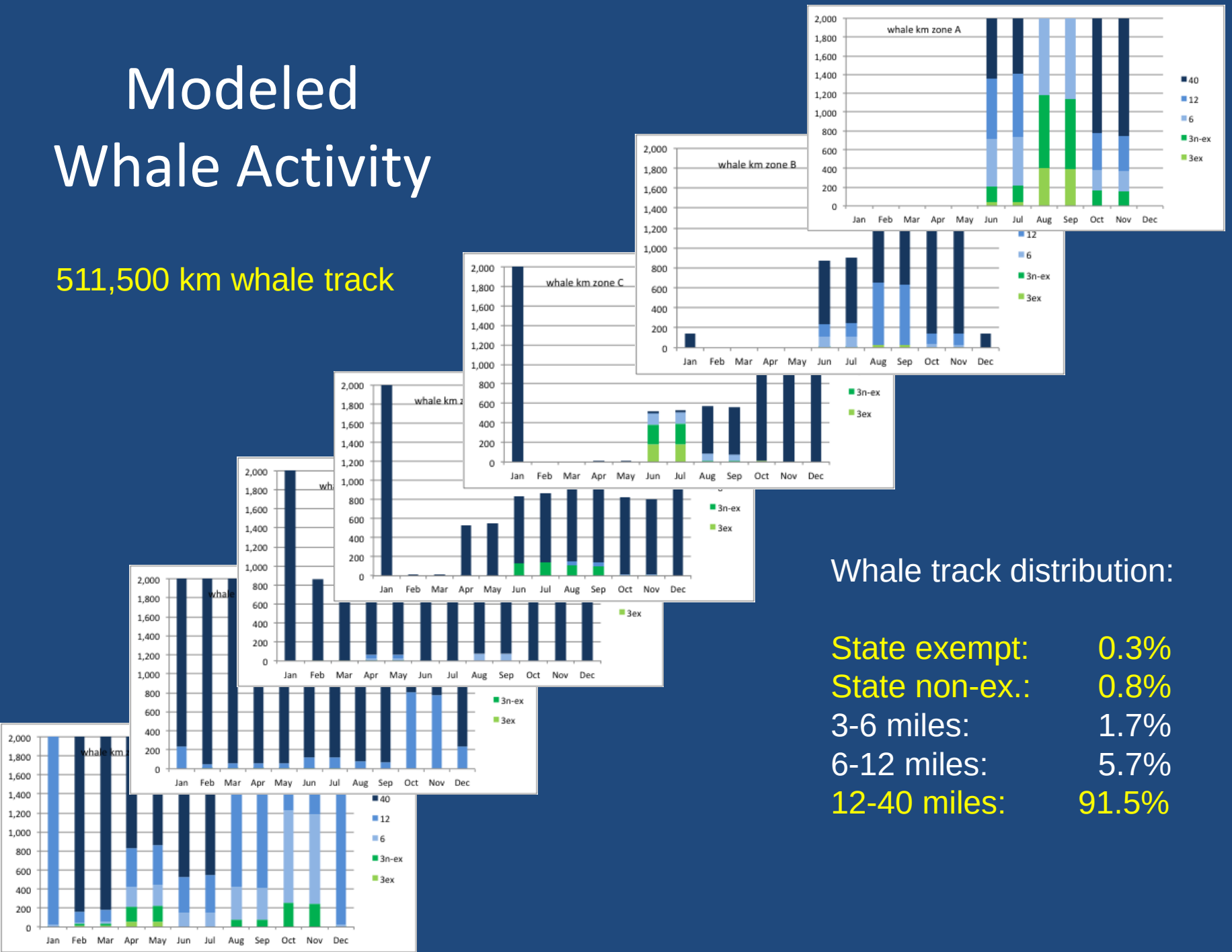
Modeled Whale Activity

Wikgren, B., H.L. Kite-Powell, and S. Kraus. 2014. Modeling the distribution of the North Atlantic right whale (*Eubalaena glacialis*) off coastal Maine by areal co-kriging. *Endangered Species Research* 24:21-31. doi: 10.3354/esr00579



Modeled Whale Activity

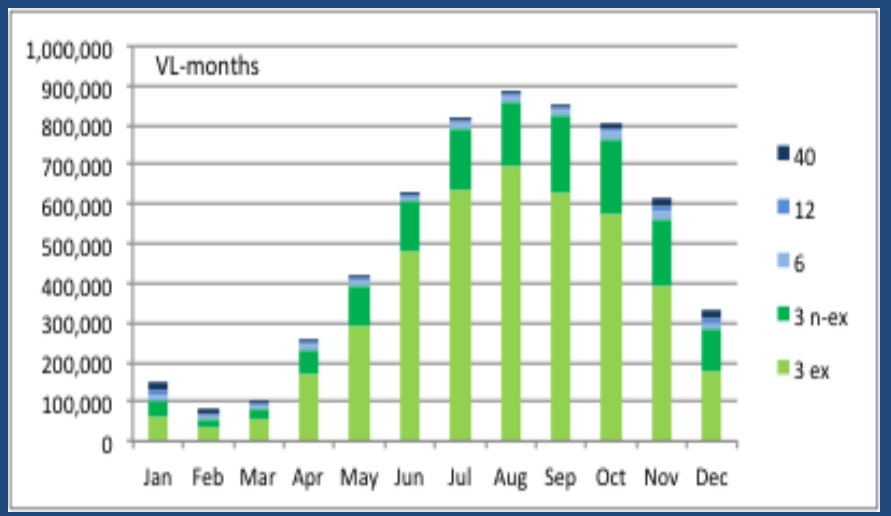
511,500 km whale track

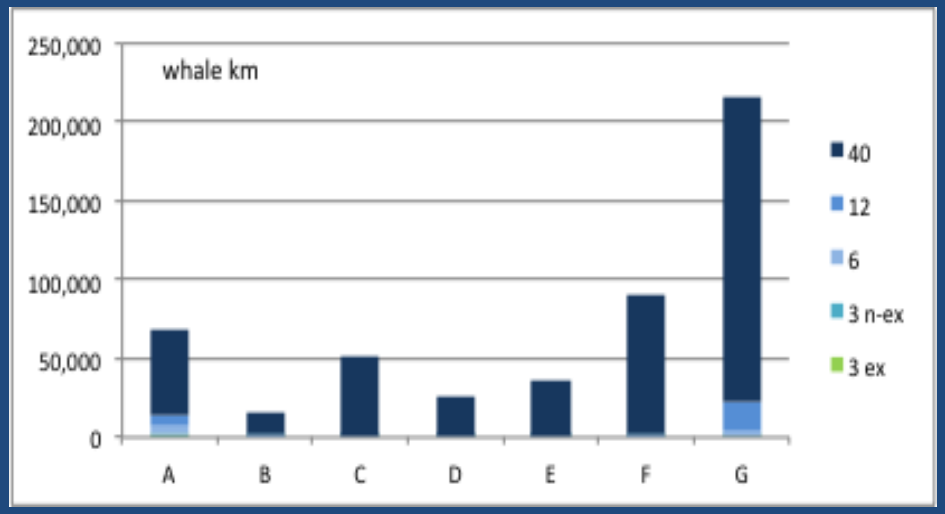


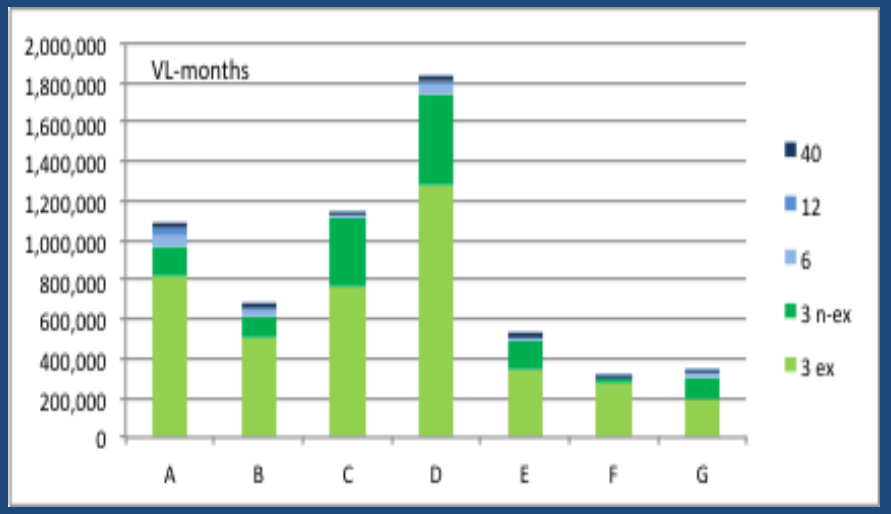
Whale track distribution:

State exempt:	0.3%
State non-ex.:	0.8%
3-6 miles:	1.7%
6-12 miles:	5.7%
12-40 miles:	91.5%

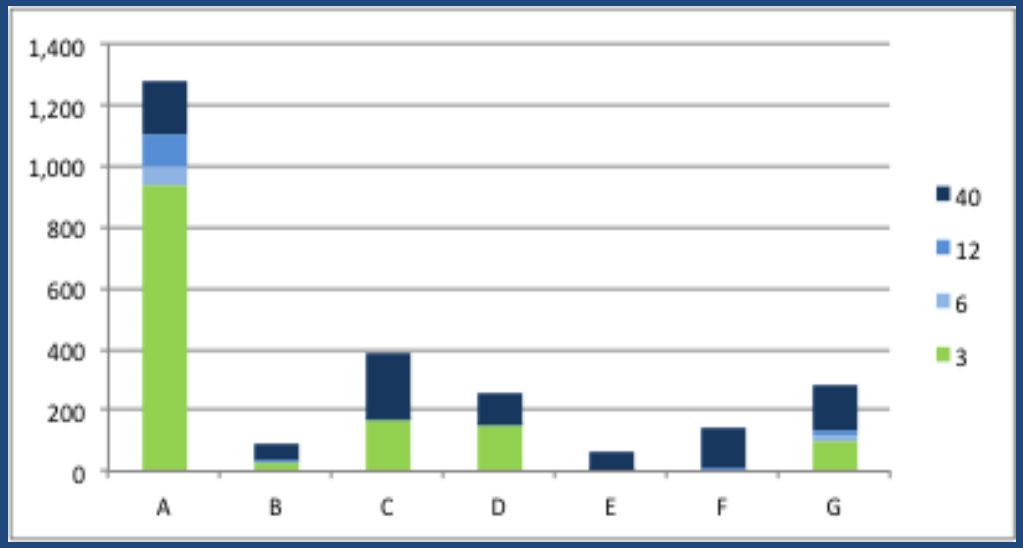
Model Input Summary





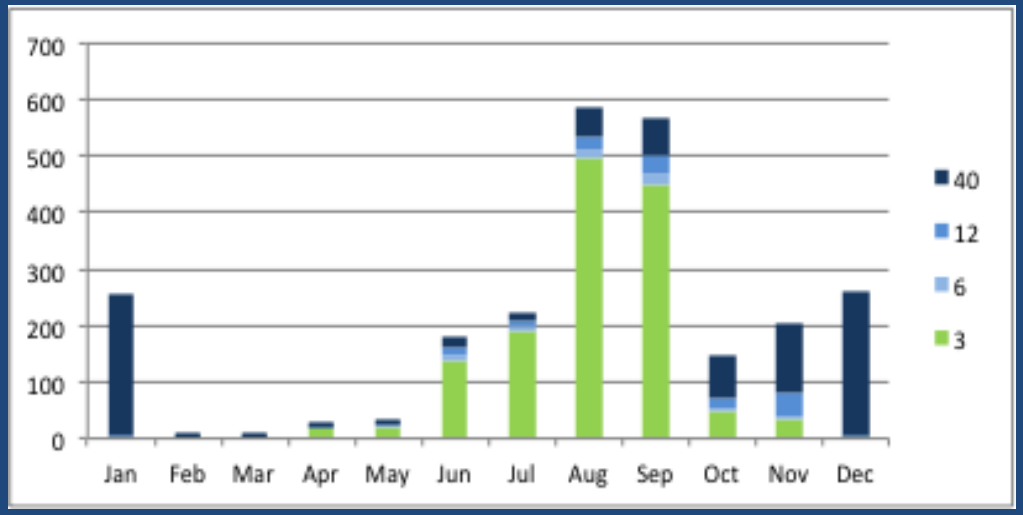


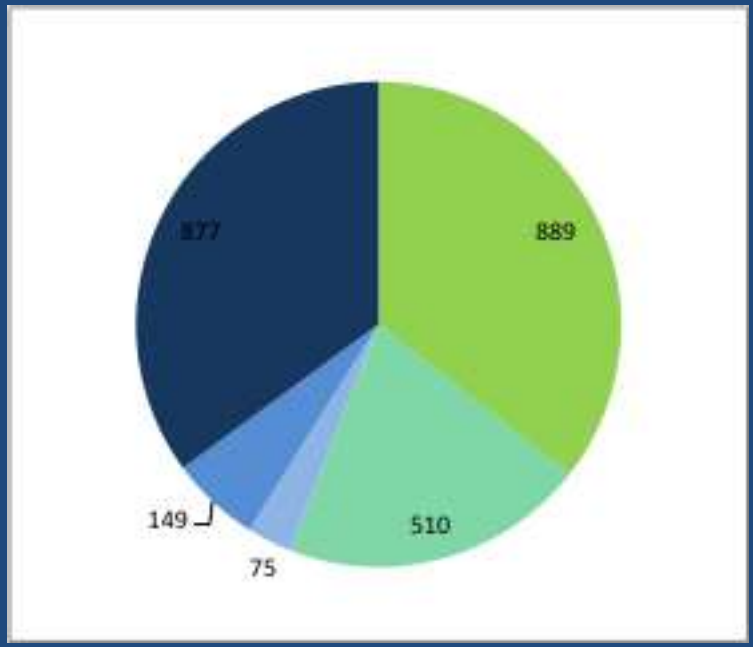
Baseline: Expected Encounters 2011



expected encounters/year:

VL	2,163
GL	342
total	**2,505**

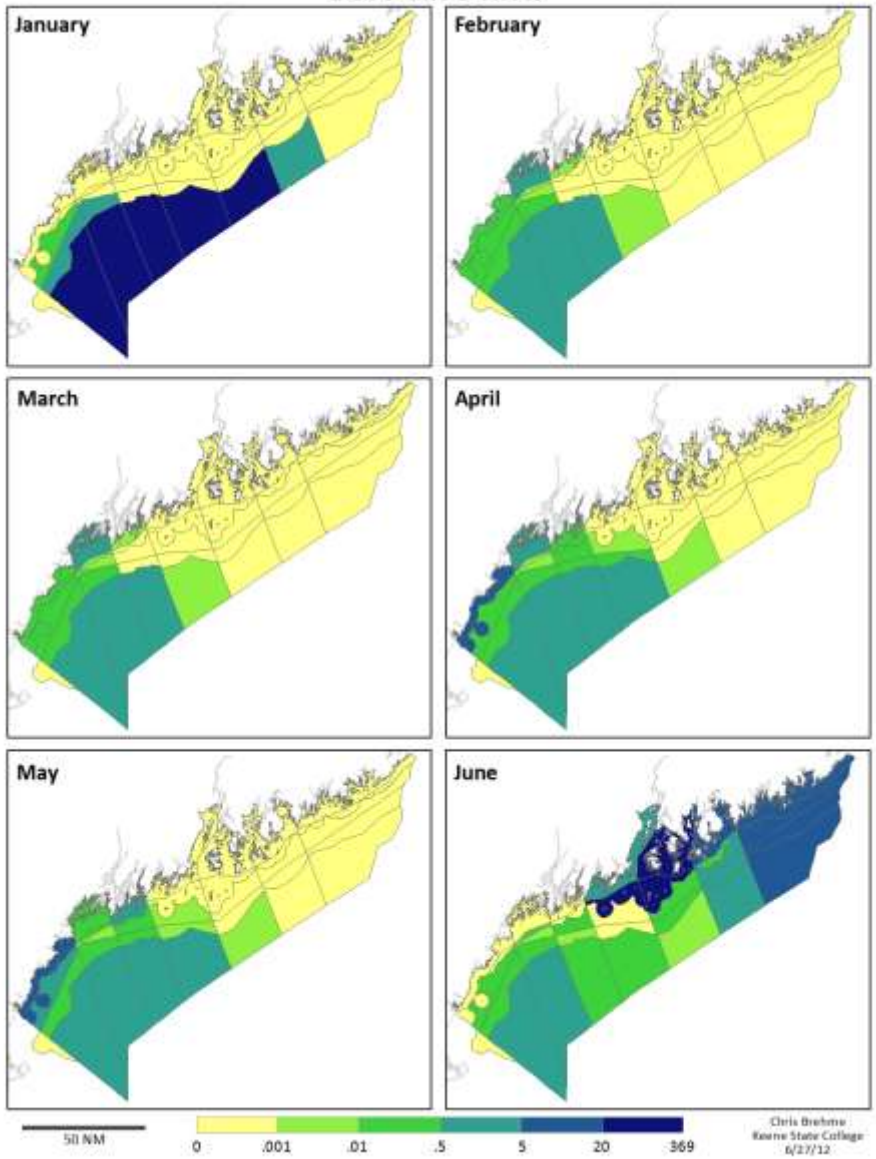


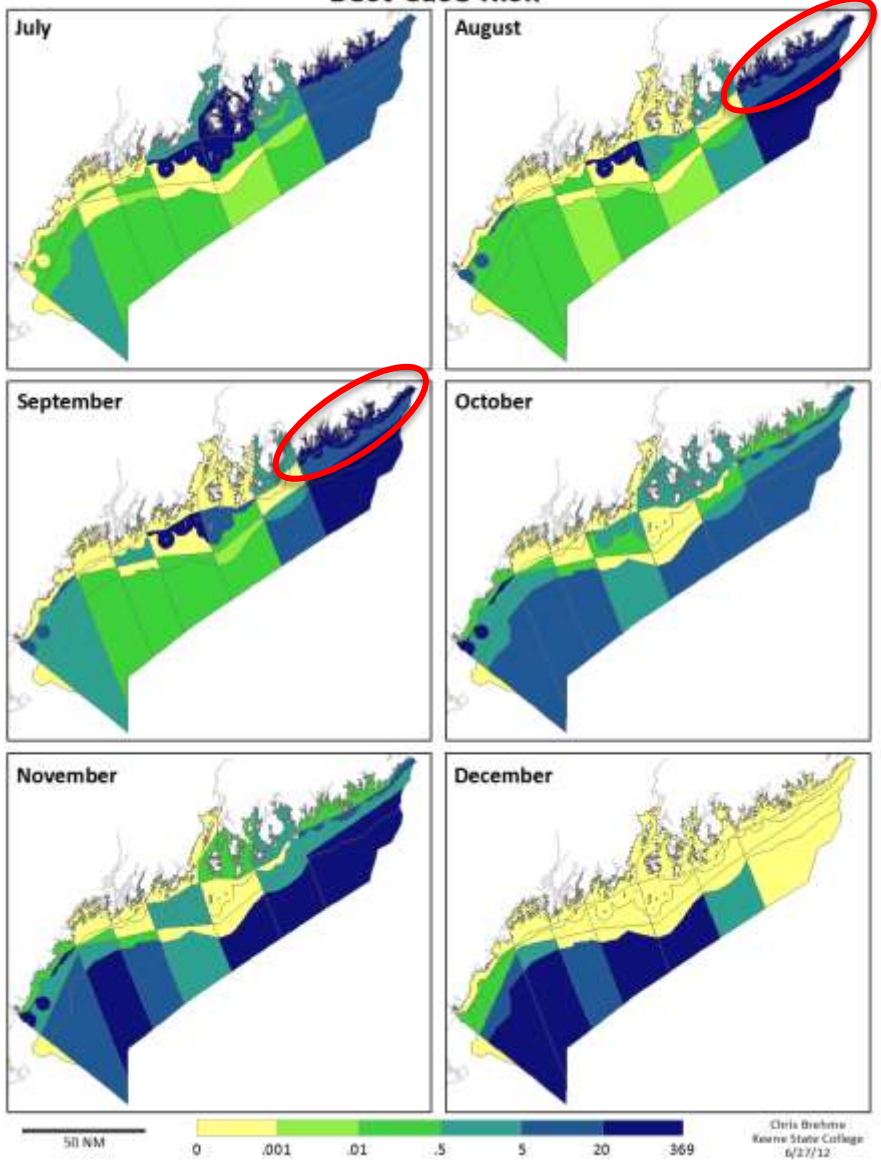


Baseline: Expected Encounters

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
A-3 ex	-	-	-	-	-	16	32	369	334	0	0	-	30%
A-3 n-ex	-	-	-	-	-	11	14	76	66	13	10	-	8%
A-6	-	-	-	-	-	7	7	17	19	3	3	-	2%
A-12	-	-	-	-	-	15	9	21	26	13	26	-	4%
A-40	-	-	-	-	-	14	10	47	60	18	25	-	7%
A outside	-	-	-	-	-	-	-	-	-	-	-	-	0%
B-3 ex	-	-	-	-	-	11	5	4	4	1	1	-	1%
B-3 n-ex	-	-	-	-	-	0	0	-	-	-	-	-	0%
B-6	-	-	-	-	-	1	2	-	-	0	1	-	0%
B-12	-	-	-	-	-	1	0	0	3	2	2	-	0%
B-40	1	-	-	-	-	1	0	3	5	18	26	1	2%
B outside	-	-	-	-	-	-	-	-	-	-	-	-	0%
C-3 ex	-	-	-	-	-	32	52	-	-	2	0	-	3%
C-3 n-ex	-	-	-	-	-	33	42	2	7	-	-	-	3%
C-6	-	-	-	-	-	0	0	0	0	-	-	-	0%
C-12	-	-	-	-	-	0	-	-	0	-	-	-	0%
C-40	84	-	-	0	0	0	0	0	0	17	21	89	8%
C outside	-	-	-	-	-	-	-	-	-	-	-	-	0%
D-3 ex	-	-	-	-	-	1	1	-	-	-	-	-	0%
D-3 n-ex	-	-	-	-	-	33	46	37	32	1	1	-	6%
D-6	-	-	-	0	0	-	-	-	-	0	1	-	0%
D-12	-	-	-	0	0	-	-	0	0	-	-	-	0%
D-40	48	0	0	1	1	0	0	0	0	1	2	46	4%
D outside	-	-	-	-	-	-	-	-	-	-	-	-	0%
E-3 ex	-	0	0	0	1	-	-	-	-	-	-	-	0%
E-3 n-ex	-	-	-	0	1	-	-	-	-	-	-	-	0%
E-6	-	-	-	0	0	0	0	0	1	-	-	-	0%
E-12	-	-	-	0	0	0	0	-	-	0	0	-	0%
E-40	22	1	2	5	1	0	0	0	0	5	11	17	3%
E outside	-	-	-	-	-	-	-	-	-	-	-	-	0%
F-3 ex	-	2	2	2	0	-	-	-	-	-	-	-	0%
F-3 n-ex	-	0	0	0	0	0	0	-	-	-	-	-	0%
F-6	-	0	0	0	0	0	-	-	-	0	0	-	0%
F-12	2	0	0	0	0	0	-	0	0	1	3	1	0%
F-40	37	3	4	4	2	1	0	0	0	8	27	40	5%
F outside	-	-	-	-	-	-	-	-	-	-	-	-	0%
G-3 ex	-	0	0	8	7	-	-	-	-	0	0	-	1%
G-3 n-ex	-	0	0	6	12	-	-	8	7	30	21	0	3%
G-6	0	0	0	0	5	0	0	0	1	4	3	0	1%
G-12	5	0	0	0	0	0	0	0	1	4	8	6	1%
G-40	57	2	2	2	1	1	1	0	1	7	13	60	6%
G outside	2	0	0	0	0	0	0	-	0	0	1	2	0%
	10%	0%	0%	1%	1%	7%	9%	23%	23%	6%	8%	10%	
													2,505

Baseline Risk by Zone





Sensitivity Analysis

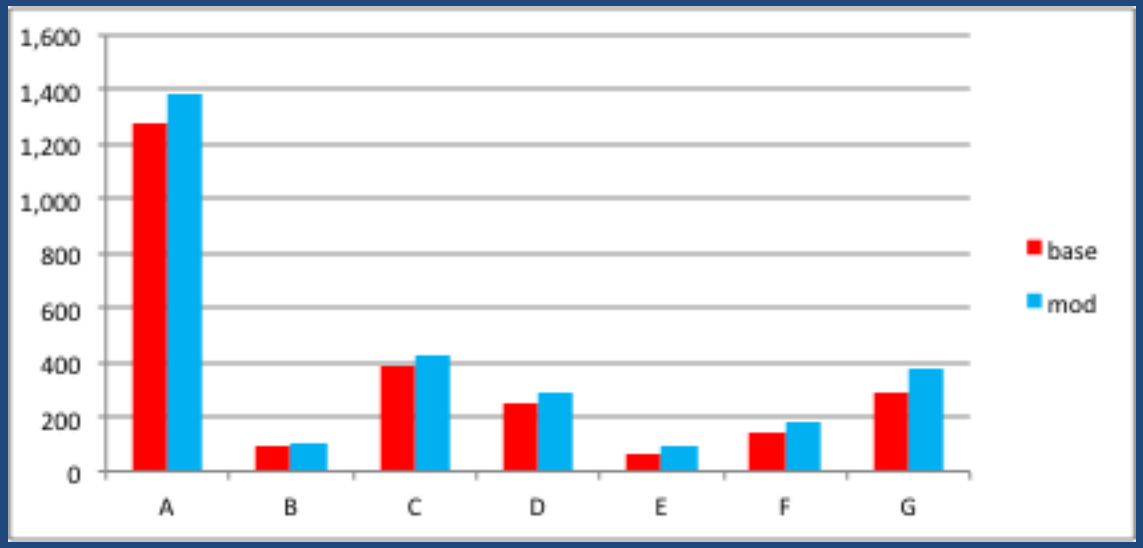
- Both fishing effort and whale activity data sets incorporate assumptions
  - allocation of active traps to areas
  - whale activity level in nearshore waters

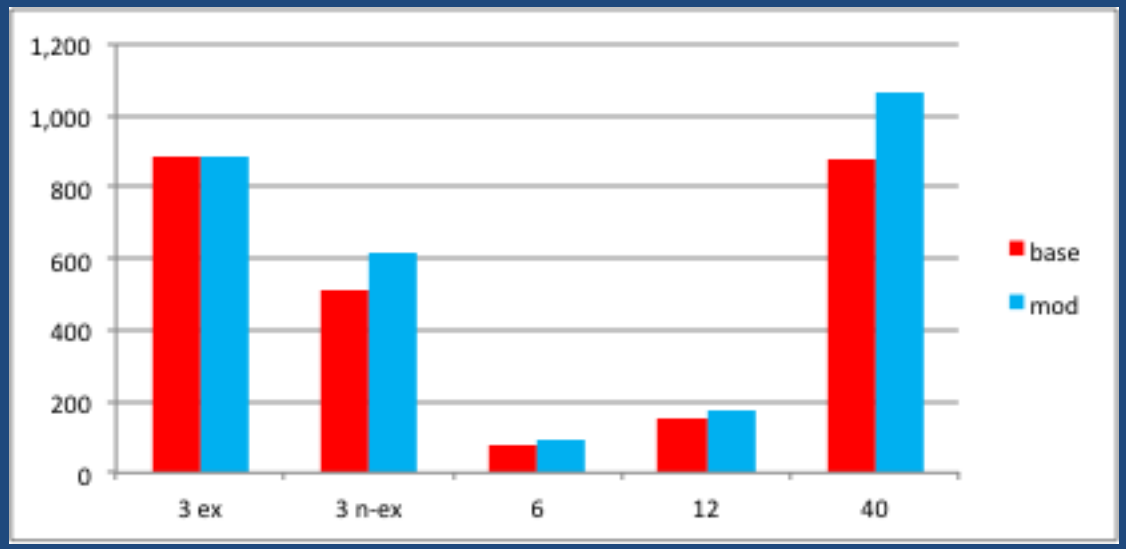
- Results: risk hot spots predicted by the model are robust over wide range of input assumptions

Example: Sinking Ground Line Rule

12% reduction in total pre-rule encounter risk

(347 avoided encounters/year)





Main Points

- Spatial distribution of risk is sensitive to assumptions about inshore whale activity
  - Assuming inshore activity = 0 is a sure way to NOT address significant percentage of total risk

- Risk is concentrated in temporal/spatial hot spots
  - Danger: blanket measures that miss hot spots are unlikely to reduce risk significantly (though they may reduce VLs)
  - Opportunity: targeted management measures can reduce risk with minimal disruption of fishing (but may be harder to enforce)

Acknowledgements

Collaborators:

Chris Brehme, Keene State College
Tara Hetz, WHOI Summer Student Fellow
Scott Kraus, New England Aquarium
Kerry Lagueux, New England Aquarium
Cris Lutazzi, WHOI Summer Student Fellow
Patrice McCarron, Maine Lobstermen's Association
Heather Tetreault, Maine Lobstermen's Association
Sophia Weinman, WHOI Guest Student
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