Entanglement Risk Modeling for North Atlantic Right Whale from the Lobster Fishery.

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- Maine Dept. Marine Resources
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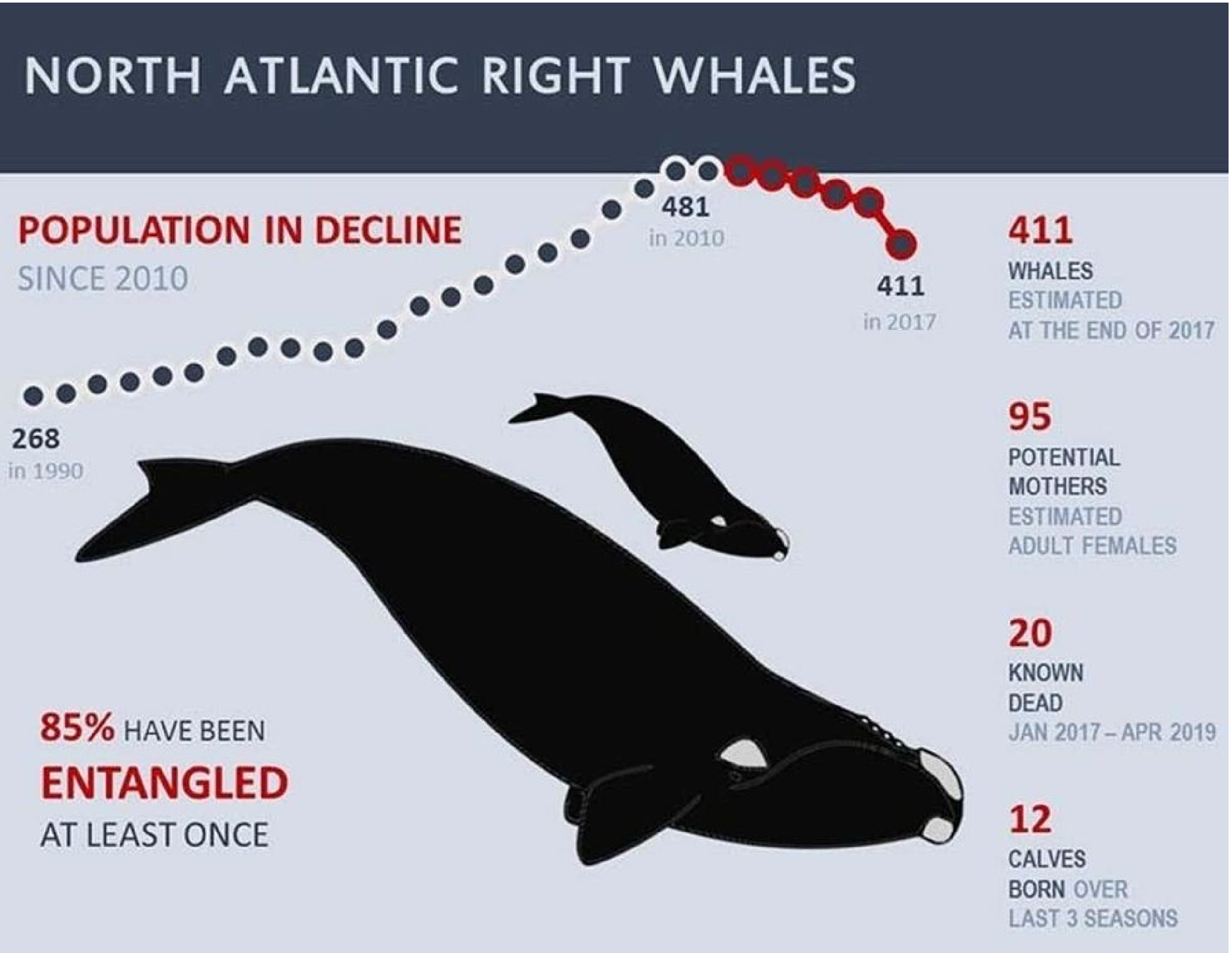
- North Atlantic Large Whale Take Reduction Team
  - Federal and State Managers
  - Industry Representatives
  - Conservation Organizations



- Prior to 2010, incidence of Serious Injury / Mortality were above PBR but the population was still recovering.
- 2010: Regime shift in the Gulf of Maine.
- Productivity of some typical seasonal feeding grounds declined.
- Whale distribution shifts to new feeding grounds, including Canada.
- Female calving rates decreased.
- Sudden need to further decrease entanglement mortalities attributed to the American lobster fishery.
- Parallel need for a tool to assess benefits from different proposed management options.

DST Introduction and Overview

The Right Whale Decision Support Tool (DST) was built to assist managers, decision makers, and stakeholders by

1. Visualizing and understanding spatiotemporal overlap between lobster fishing gear and North Atlantic Right Whale (NARW) distributions in the US, New England area.
2. Modeling how risk of entanglement to NARW may change as a result of changes to the spatial distribution and configuration of lobster gear.

DST Introduction and Overview

Within the model, risk posed to the NARW population is calculated spatially and temporally as the product of:

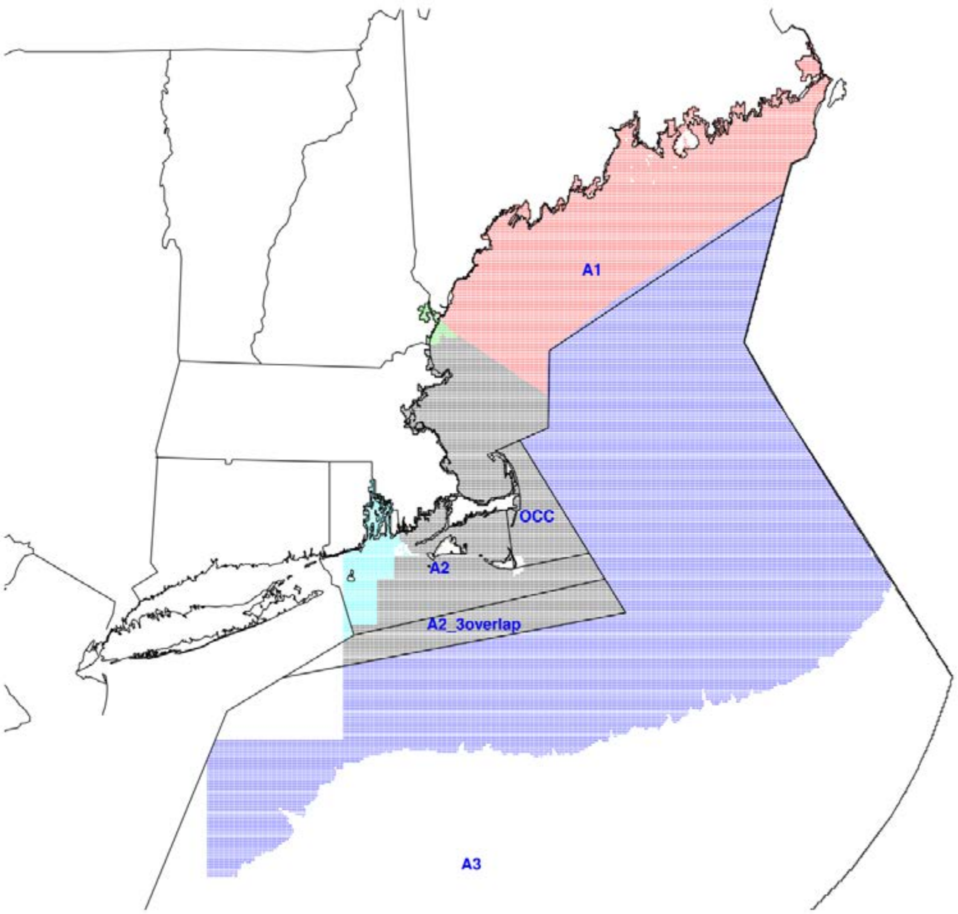
1. The density of vertical lines associated with lobster traps.
2. The threat vertical lines pose to NARW given the configuration of the lobster gear, relative to alternative gear configurations.
3. The expected densities of NARW in space and time.

DST Introduction and Overview

The DST does not attempt to incorporate more complex location- or situation-specific variables that may lead to severe entanglements including:

- Whale behavior (transiting vs feeding)
- Adjacent gear density
- Spatial or temporal variations in environmental conditions that affect the characteristics of vertical lines in the water, including line tension and orientation.
- The DST does not currently quantify the length of groundline attributed to lobster traps and associated threat to whales.

DST Introduction and Overview



Spatial domain of the model.

- Underlying resolution of 1 nautical mile.
- Not all (actually most) data is not available at this resolution.

Model Inputs, User Inputs, SubModels

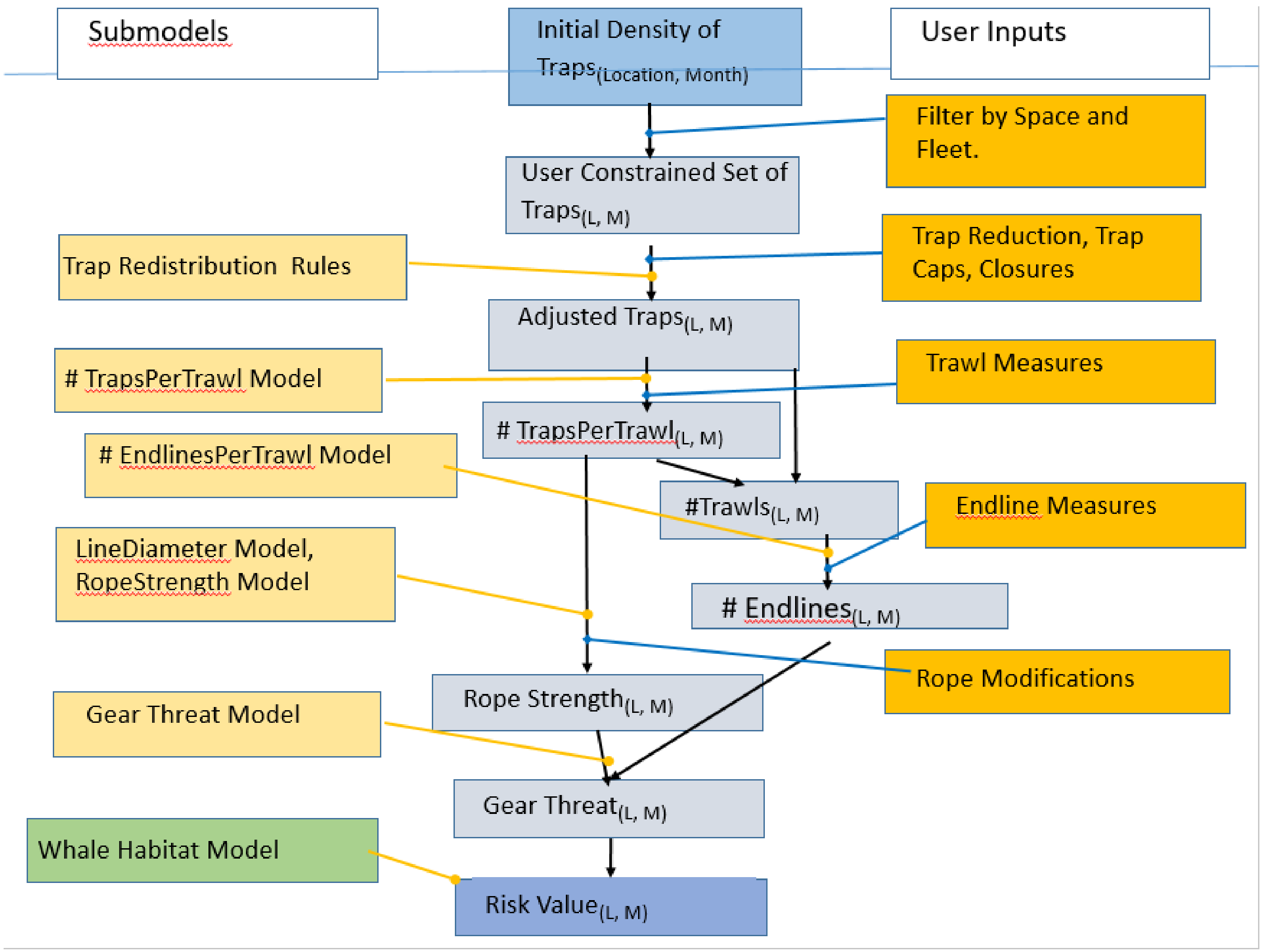
Model Options:

- Fishery Constraints
- Spatial Constraints
- Whale Distribution Model
- Gear Threat Model
- Rope Strength Model

Management Options implemented in space and time (months):

- Trap Reductions
- Trap Caps
- Closures
- Trawl Measures
- Endline Measures
- Rope Strength Measures

DST Information Flow

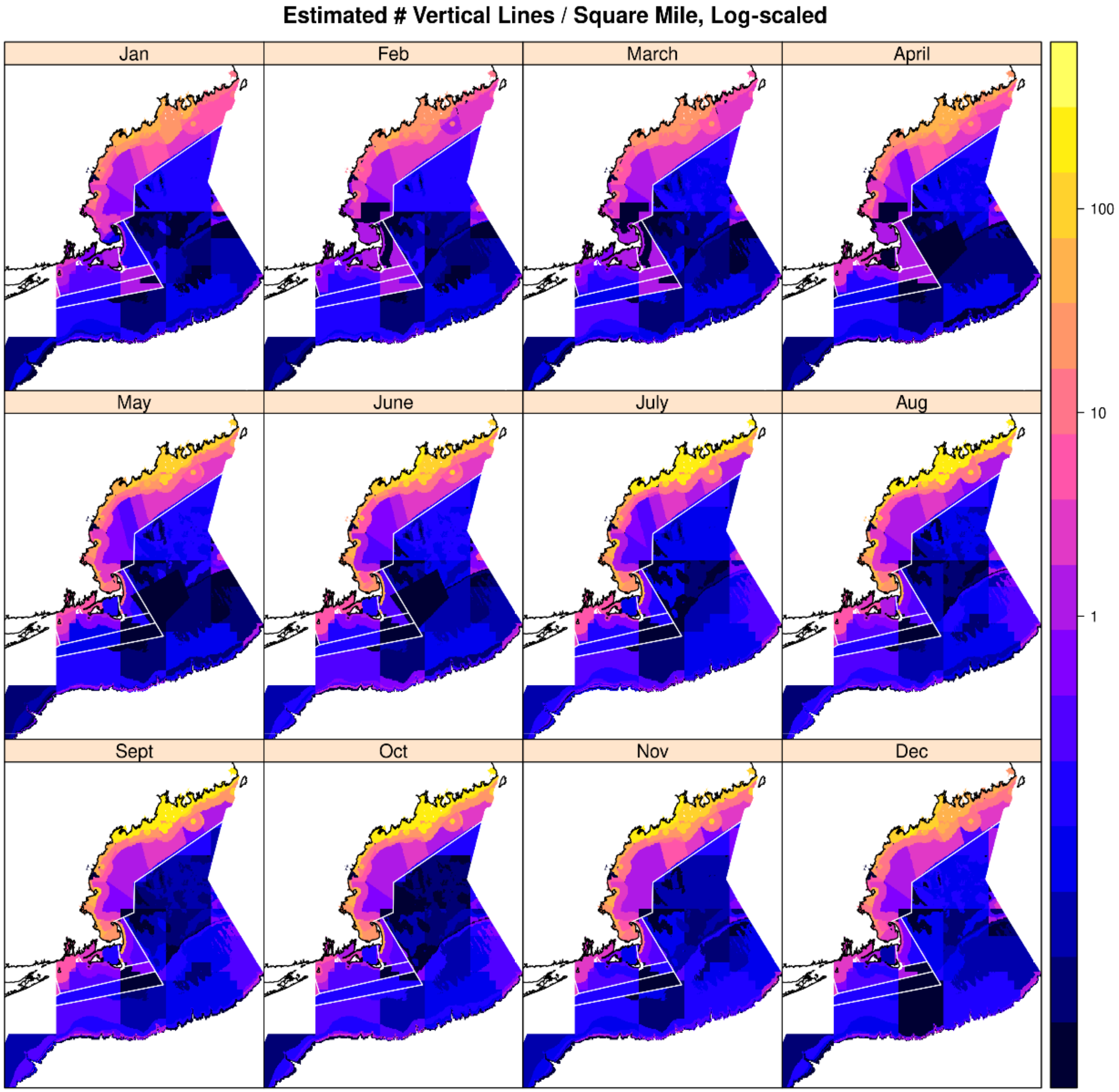


For most model runs, two sets of calculations are run in parallel.

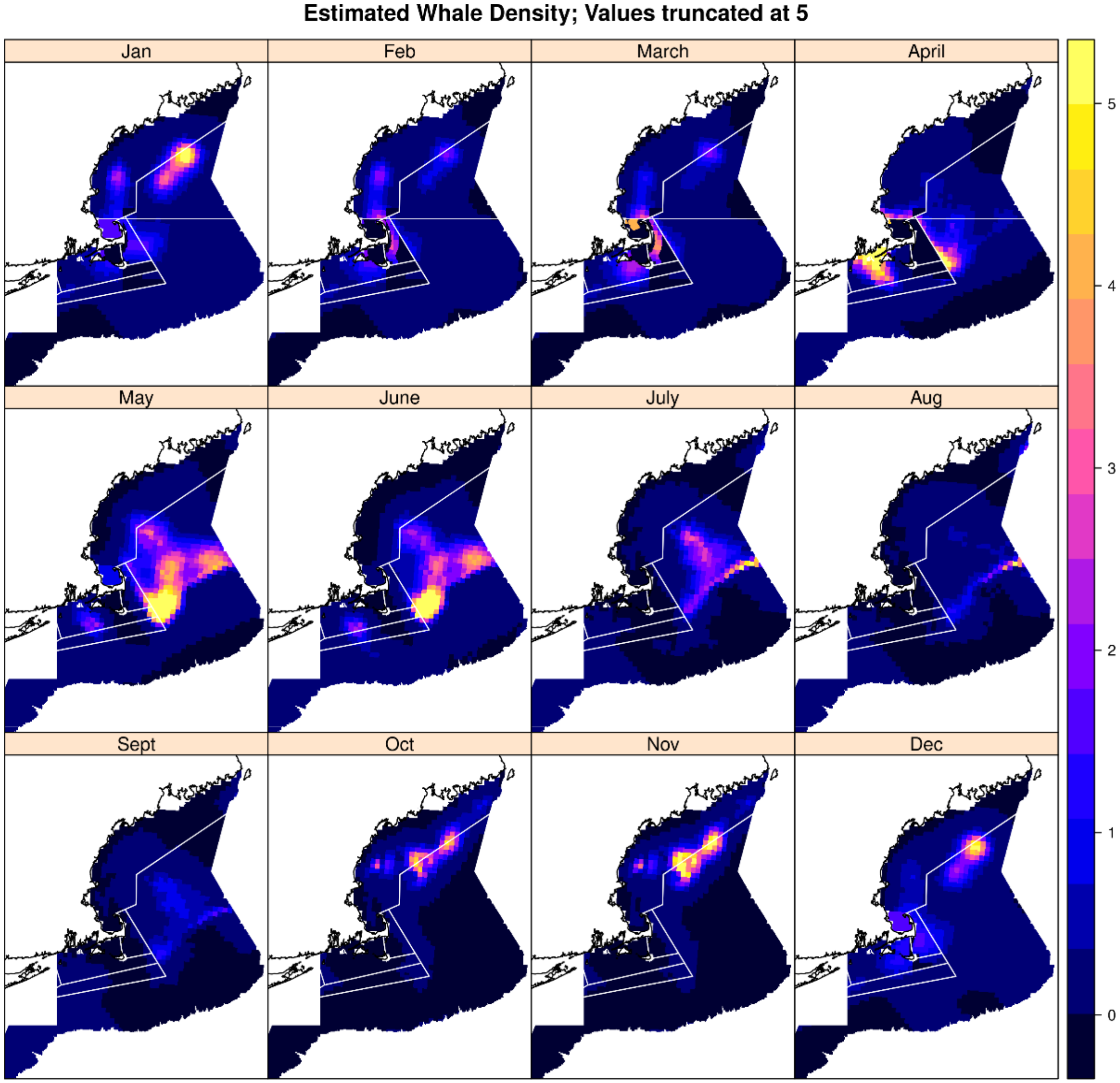
The "Default" model run excludes any user-specificed management actions.

The "Scenario" model run includes user-specified management actions.

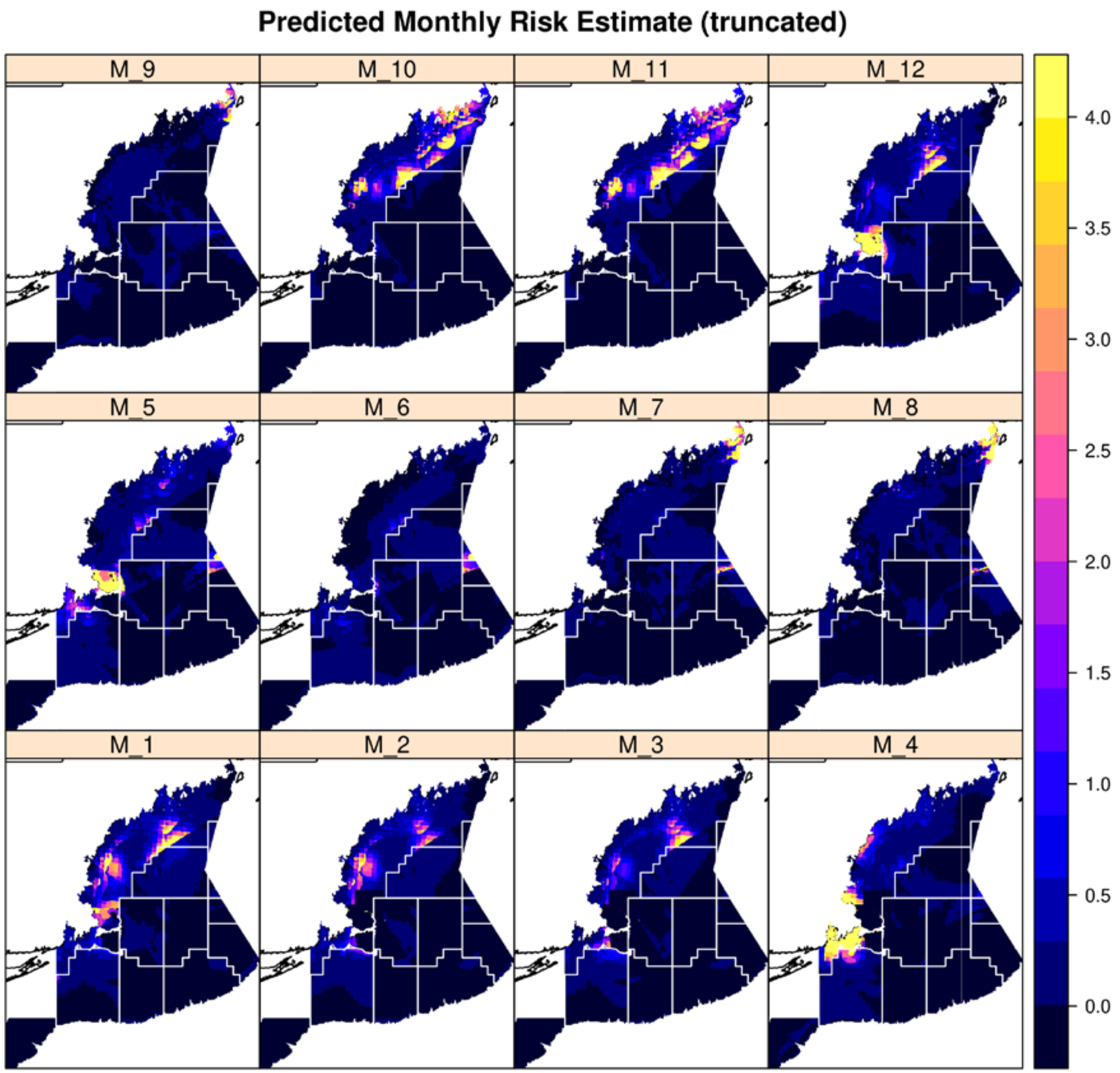
Two model runs compared upon completion to estimate outcome of management action.


Estimated # Vertical Lines / Square Mile, Log-scaled
Jan
Feb
March
April
May
June
July
Aug
Sept
Oct
Nov
Dec
100
10
1

Whale Habitat Models: Duke Spatial Ecology Lab.



Gear Threat and Whale Risk

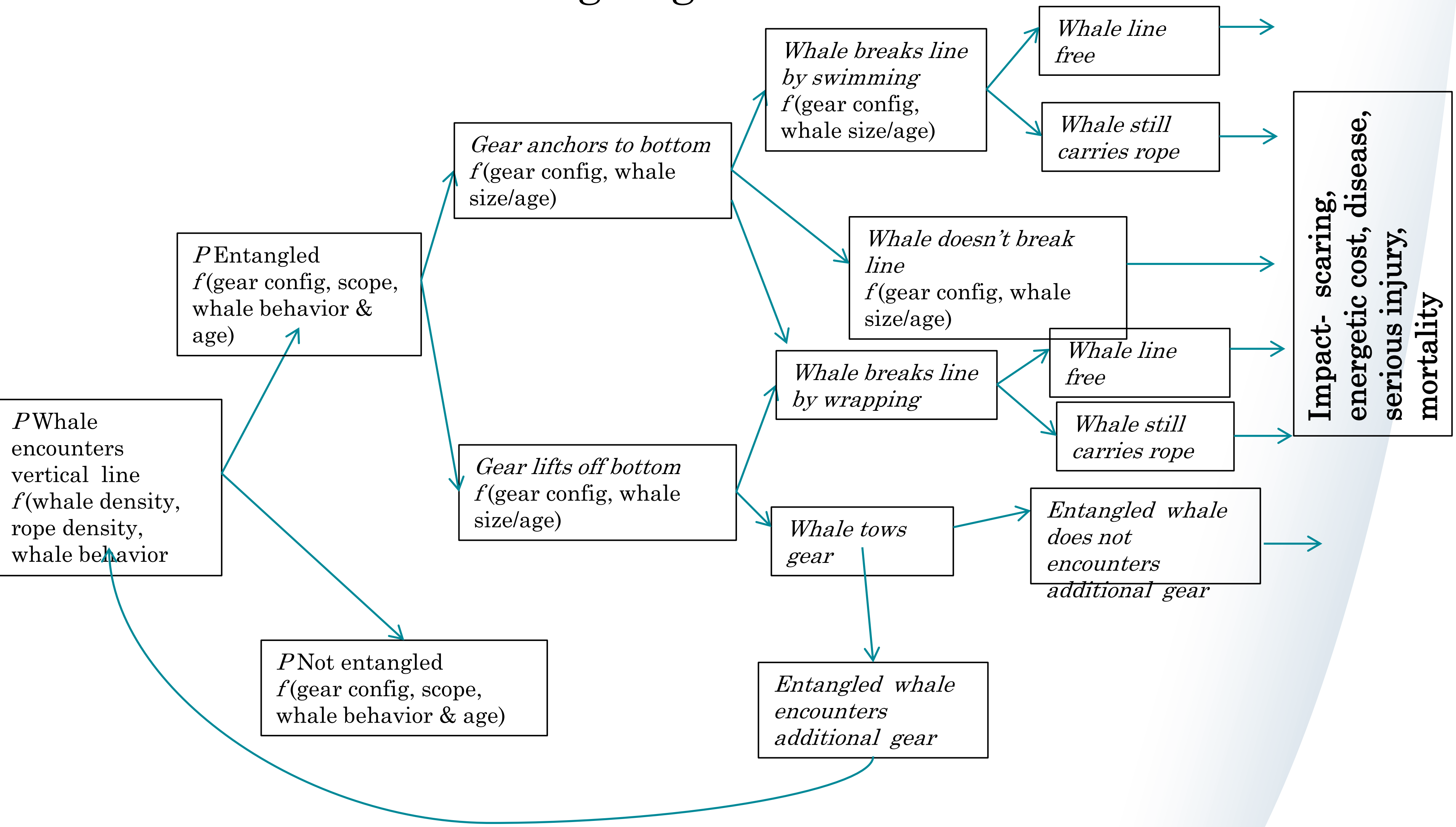


Total risk to whales is then just the product of whale density and total gear threat by location and month.

Gear Threat Modeling

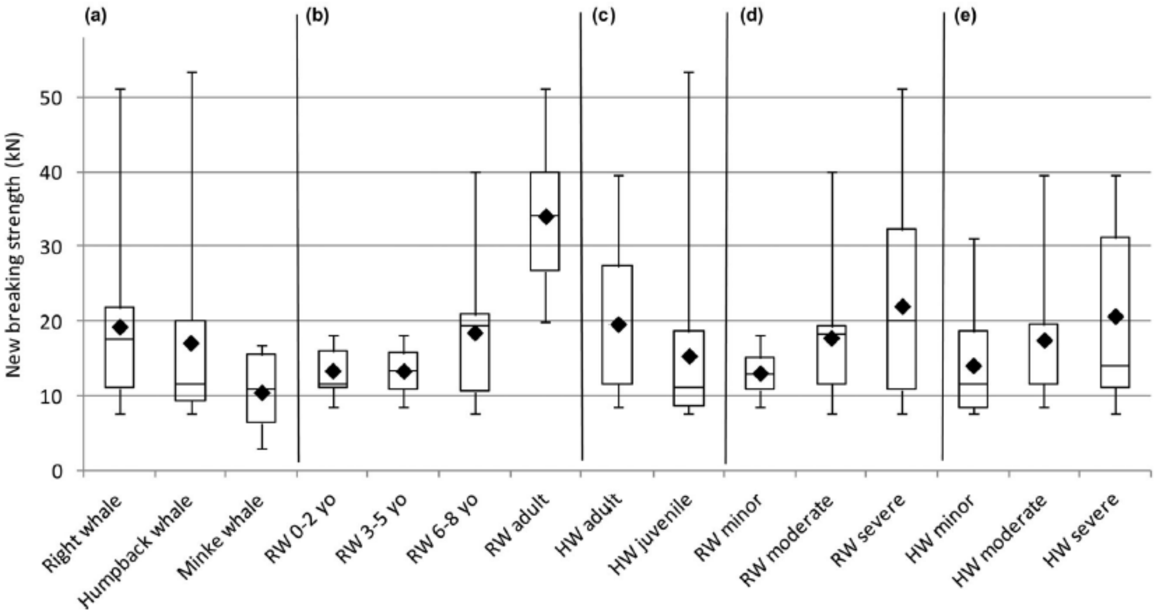
- Building an empirical model of gear threat for the DST has proved to be very challenging as it is necessarily attempting to distill the factors that contribute to complex outcomes for events that are generally rare and not directly observed.
- Most data on whale entanglements come from mortality or disentanglement events, both of which occur a considerable amount of time after the entanglement event took place.
- In both cases, the whales are generally not carrying the complete set of gear that they were entangled in.
- Because disentanglement is not attempted for minor cases, there is also necessarily a small amount of data on gear that does not result in serious injuries or mortality for comparison.

Process-based modeling of gear threat.



- Naïve attempt at process-based model.

4.7 Gear Threat Modeling



Observed trends from Knowlton et al 2016; Larger, stronger whales tend to be found entangled in heavier rope.

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Gear Threat Modeling

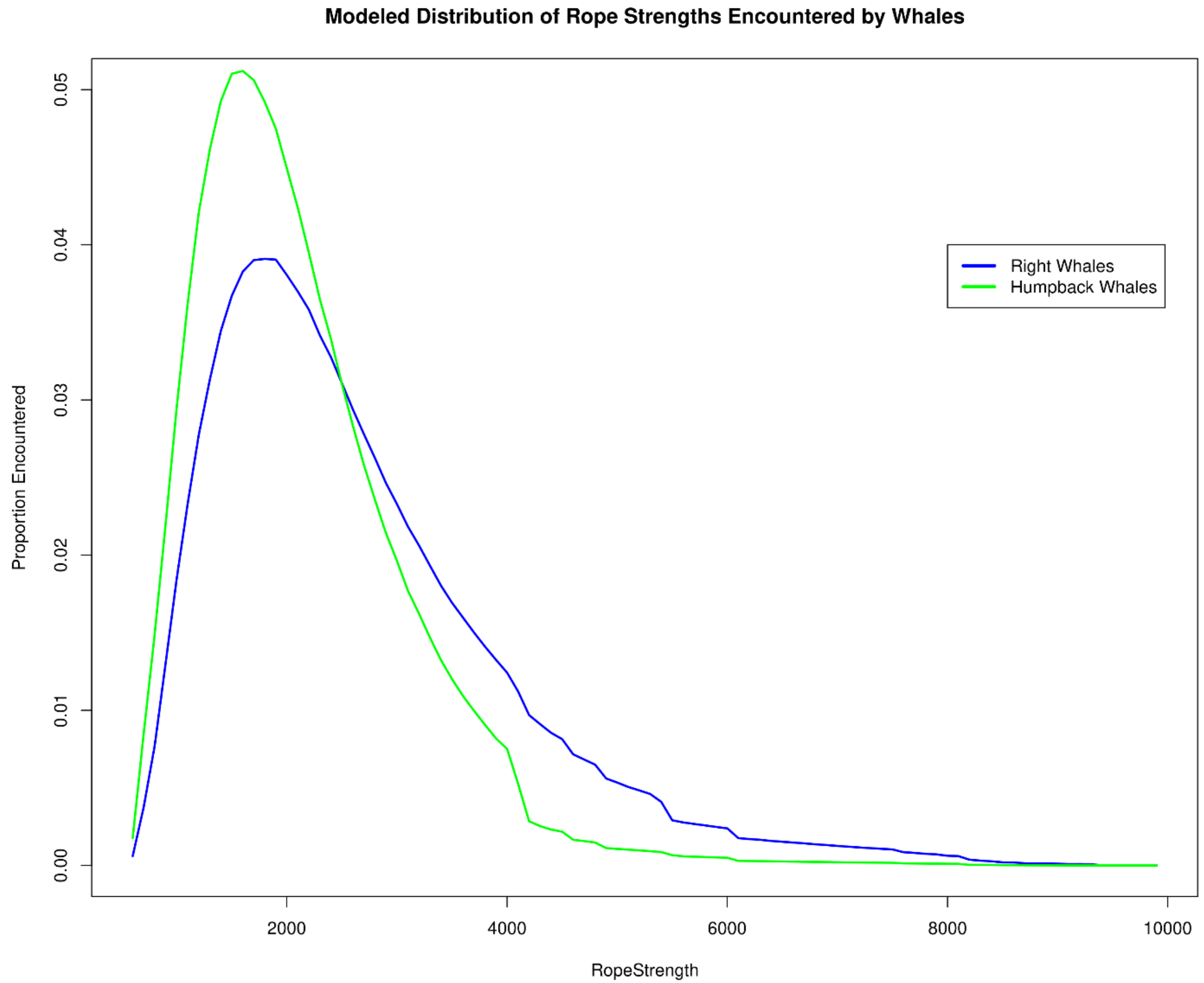
Threat Model from Apparent Rope Selectivity

Quantify threat of different rope strengths based on ropes of different strengths being under / over represented in entangled whales?

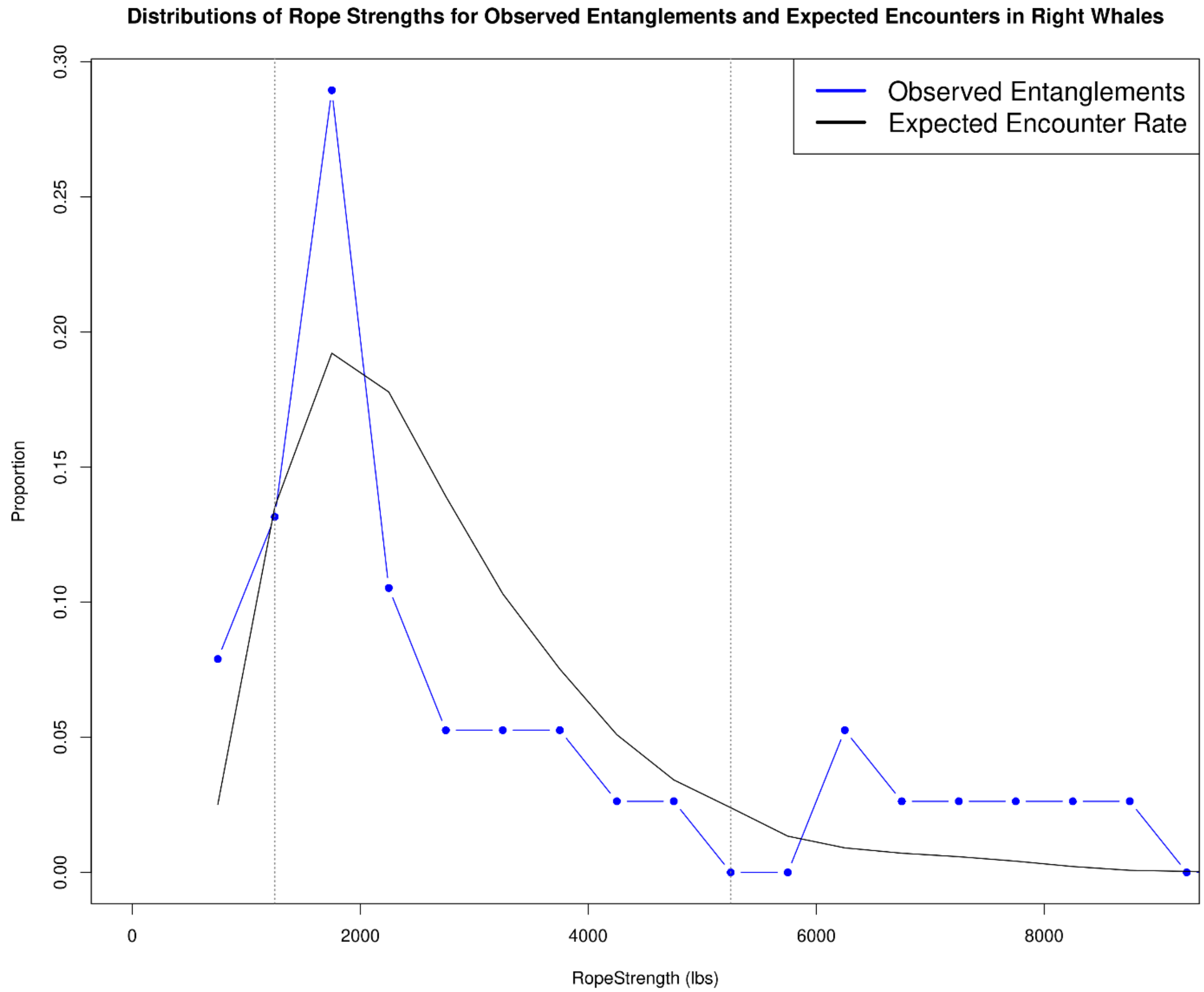
Data on the distribution of rope strength observed in entanglements from Knowlton et al. 2016, subset to entanglements judged to represent serious injury cases. (Thanks NEAQ!)

To get the distribution of rope strengths encountered, we used model runs of the DST, including right whales and humpbacks and extracted the densities and strength of endlines with co-located densities of whales.

Gear Threat Modeling



Gear Threat Modeling



If stronger ropes have higher threat, stronger ropes will be over-represented in severe entanglements, weaker ropes will be under-represented.

Use the ratio of observed : expected for any rope strength as the "selectivity" of the rope.

Higher selectivity ropes are more likely to be observed in lethal entanglements

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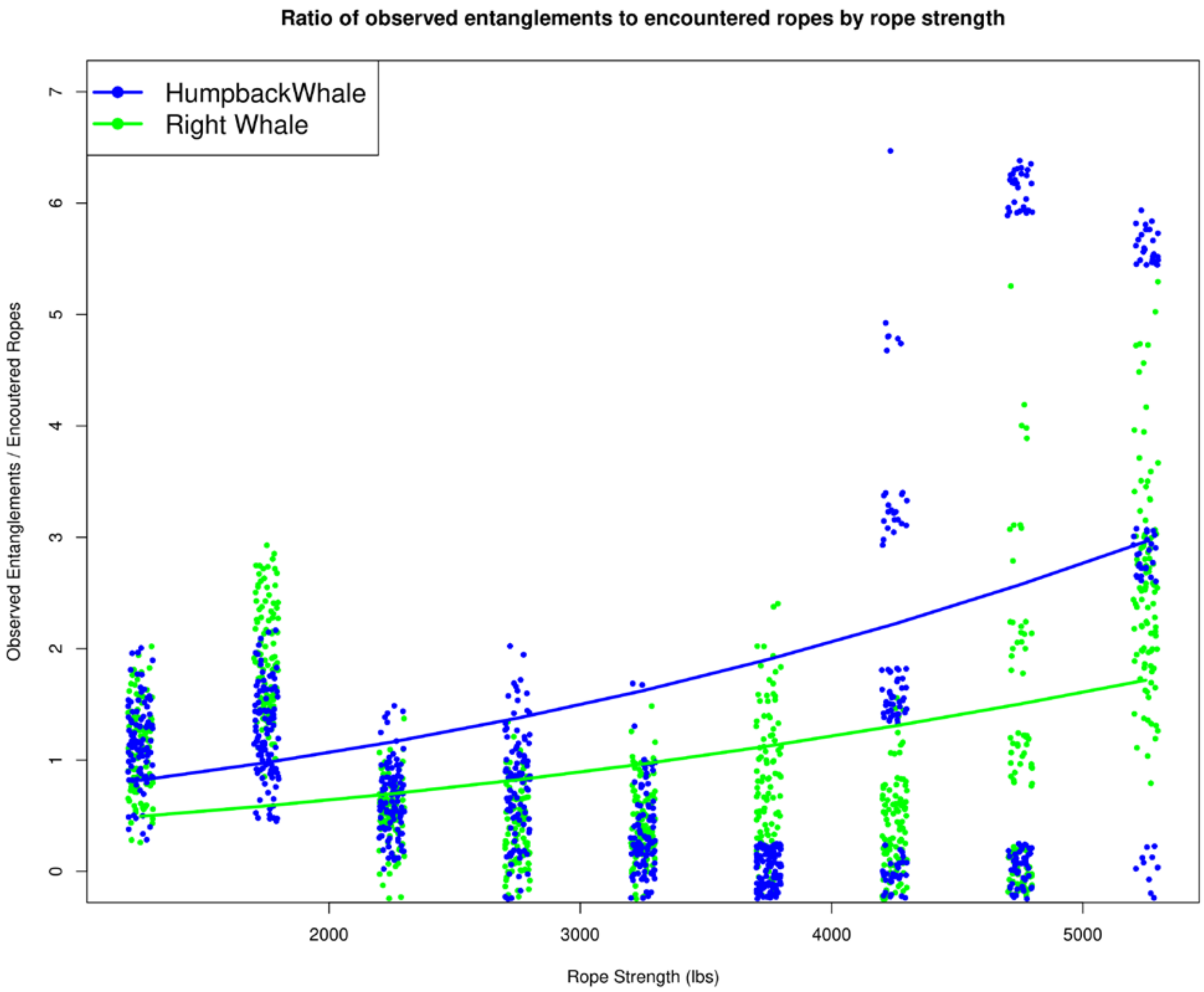
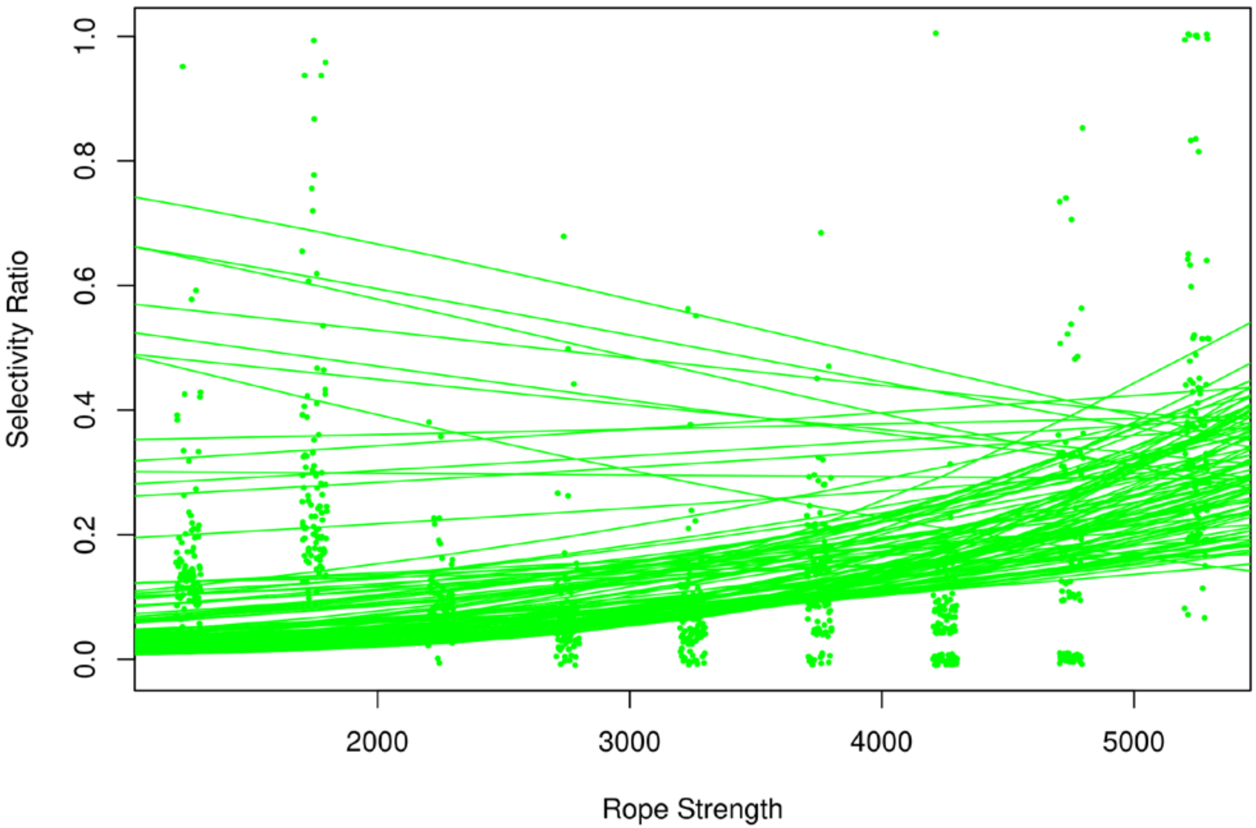
Gear Threat Modeling



Problems with lack of fit suggest model mis-specification.

Gear Threat Modeling



Selectivity Ratios from 100 Bootstraps for Right Whales.

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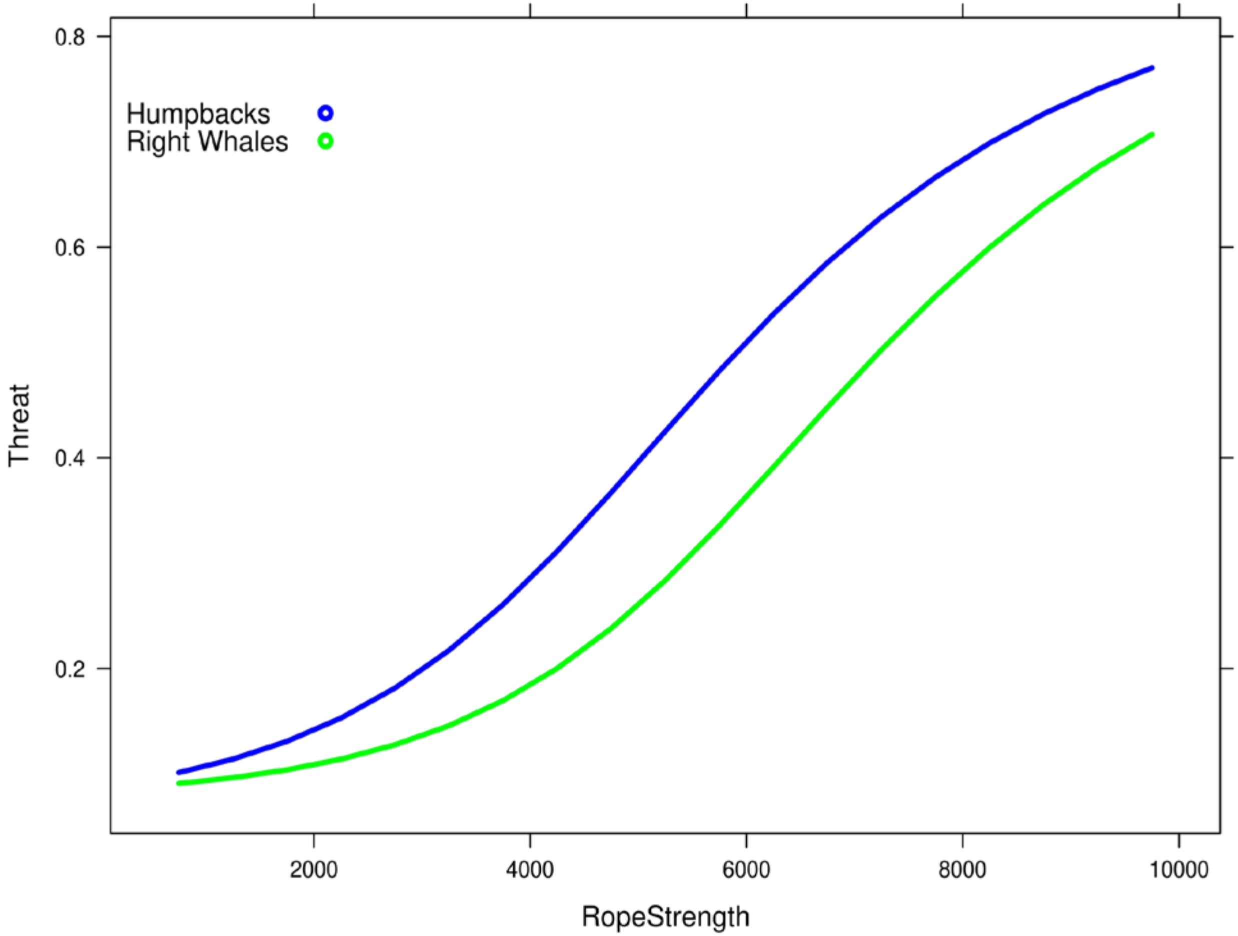
Gear Threat Modeling



Averaging across curves and rescaling gives a final threat curve for rope strength by species.

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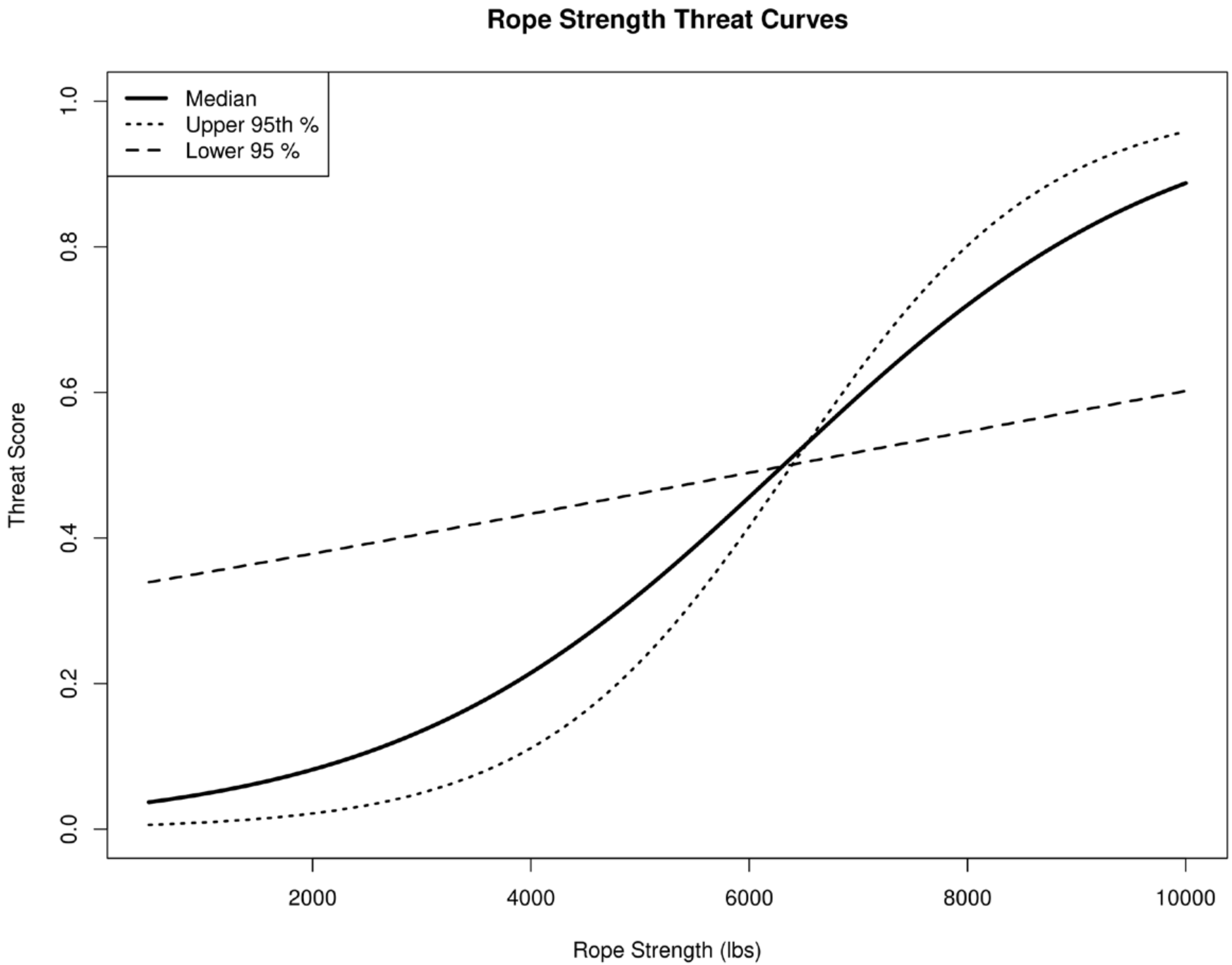
Rope Strength Threat Curves
Median
Upper 95th %
Lower 95 %
Threat Score
0.0
0.2
0.4
0.6
0.8
1.0
2000
4000
6000
8000
10000
Rope Strength (lbs)

Key Take-Home Messages:

- Don't wait for a crisis; build, test, and familiarize stakeholders with a management support model ahead of time. Start now.

- The process of building the model teaches you a lot about knowledge and data gaps. Leave time to learn and do further research.

- Set reasonable expectations. These are very complex processes that are prone to change and adaptation by fishers. These models may be informative but will not fully capture the complexity or dynamic nature of the problem.