Density surface models for the North Atlantic right whale in U.S. waters

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Beginning in 2010, we initiated a multi-institution collaboration to build density surface models for U.S. waters of the western North Atlantic and Gulf of Mexico, for all extant cetacean species, from all available visual line transect surveys conducted with distance-sampling compatible protocols over the past two decades. This initial effort culminated in 2016 in the publication of models and associated absolute density maps (estimating individual animals per km²) for 26 species, including North Atlantic right whales, and 3 multi-species guilds (Roberts et al. 2016). The models were used first by the U.S. Navy, the primary funder of the effort, for the development of an Environmental Impact Statement that estimated marine mammal takes for Navy training and testing activities. Over the 2016-2018 period, we prepared several updates that expanded the number of collaborators and incorporated newly-available survey data and NOAA went on to use these results for various management activities, including the permitting of offshore energy development and geophysical surveying and the development of regulations for oil and gas leasing. Most recently, NOAA proposed to use the right whale model as a component in a Risk Reduction Decision Support Tool to be used to develop new regulations for U.S. trap and pot fisheries, with the intent of reducing risk that right whales become entangled in vertical fishing lines. NOAA presented initial results from this exercise at the April 2019 meeting of the Atlantic Large Whale Take Reduction Team. An important limitation of those results is that our right whale model available at that time, known as the v8 model, only incorporated data through mid-2016. Since then we have worked to prepare another update, the v9 model, which incorporates data through the end of 2018 and is intended for use in NOAA’s final analysis. This presentation will update the community on our progress.
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NARWC Annual Meeting
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Jason Roberts, Rob Schick, and Pat Halpin
Marine Geospatial Ecology Lab
Duke University

Photo: NOAA Fisheries/Leah Crowe (Permit #17355)
In collaboration with survey programs and scientists from:

Primary funding for modeling from: Additional funding from:
How this project got started

The U.S. Navy encounters marine mammals...
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
Navy Acoustic Effects Model (NAEMO)

Inputs
- Navy Activity Information
- Sound Propagation Modeling
- Population Density Maps

Exposure History of Each Simulated Individual Animal

Estimated Number of Exposures

Criteria Thresholds Applied

Results Database

Post Analysis Evaluation

Requested Takes

MMPA Request / ESA Consult

Density = individuals / km²
This is where we come in...
Density modeling

Survey effort and observations

Oceanographic maps

Statistical models

Density maps

Uncertainty maps
A critical problem:
The farther away they are, the lower the chance you’ll detect them.
Modeling detectability

- Cetacean sightings
- Vessel trackline
  - Cetacean sighted by observers
  - Cetacean missed by observers
- Histogram of observed distances
- Detection function

This technique is called “distance sampling”
Density surface modeling (DSM)
(Hedley and Buckland 2004; Thomas et al. 2010; Miller et al. 2013)

Stage 1
- Line transects
- Detectability
- Spatial model (GAM)
- Oceanographic data

Stage 2
- Model checking/criticism
- Predictions

Adapted from figure by David L. Miller
North Atlantic right whale
Tracklines and sightings: January

Abundance (CV):
- Block Island to Canada: 194 (0.140)
- Cape Cod Bay: 10 (0.350)
- Cape Fear to Block Island: 84 (0.240)
- Deeper than 1500m: 0
- Long Island Sound: 0
- South of Cape Fear: 56 (0.054)
- Total: 344 (0.100)
Project timeline and model versions

2015-2016

v5.6 1998-2014
- Roberts et al. 2016
- Used by Navy for AFTT Phase III EIS and Nov 2018 Letter of Authorization

2017

v7 1998-2016
- Added AMAPPS and SEUS NARW surveys
- Used by NMFS for Atlantic G&G IHA permitting

April 2019

v8 1998-2016
- Prepared for ALWTRT meeting
- Same surveys as v7
- Filled Cape Cod Bay with Ganley et al. (2019) results

Early 2020

v9 1998-2018
- Adds surveys from 2017-2018
- Will fit and compare models of recent period to older period, e.g. 1998-2010 vs 2010-2018
- Build a mother-calf model, if data permit

Maps you saw; what NMFS currently uses for the Risk Reduction Decision Support Tool

What NMFS currently uses for IHAs, etc.

In progress
So v9 is not done yet...

- What will it look like?
- We can’t know for sure, but let’s examine:
  1. The new data added
  2. 1998-2010 vs. 2010-2018
- Let’s start with surveys used in the v8 model (map on the left)
1998-2016

NOAA AMAPPS 2016

2017-2018

NOAA AMAPPS 2017

No right whales sighted
These programs all performed monthly surveys.
Jan 1998 - Mar 2010

Potential split for v9 models

Apr 2010 - Mar 2019

Clear decrease

Clear increase

?
Jan 1998-March 2010

April 2010-March 2019

Potential split for v9 models

Sparse effort in key areas makes modeling harder and uncertainty higher
Future plans and interests

- Incorporate autocorrelative term, to better capture persistent aggregations
- Incorporate *Calanus* zooplankton covariate (seeking collaborators)
- Collaborate with Canadians on joint U.S.-Canada models
- Incorporate passive acoustics and opportunistic data
- Develop near real time forecasts of right whale density for dynamic management problems
Thank you!

• Contact me: jason.roberts@duke.edu
• Main publication: Roberts et al. (2016) in Scientific Reports

• Attend NOAA’s Peer Review of the Right Whale Decision Support Tool
  • November 19-21 in Woods Hole, MA; open to the public; webinar available
  • Density model review is November 20 at 9:10-11:15 AM
  • https://www.fisheries.noaa.gov/event/peer-review-right-whale-decision-support-tool
Backup slides, if animation doesn’t work
North Atlantic right whale
Tracklines and sightings: Summer

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)
Caution advised
More data desired