Trends and Population Status NA Right Whales

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With thanks to Right Whale Consortium for data and inspiration
Objectives

- Review the principal metrics in the 2016 Stock Assessment Reports (SARs) for fin, humpback and right whales
- Review the Serious injury and Mortality report that will affect the upcoming SAR
- Remark on an upcoming changes in future SARs (humpback and right)
- Discuss current right whale assessments
First, I Digress

- Since I was very young, I have loved trees
As an old fart, I still love trees

I may have even started to resemble a tree – at least I am seeming pretty nutty to some
My Career as a Wildlife Scientist has focused on trying to understand Forests

Many will focus on examples and counter examples, but making sense out of the collective lives of ‘trees’ is how to assess a population (the forest)

RM Pace 2017
Example Statement

- Right whale **distribution** has shifted so you don’t know what is happening with the population.
- This confuses not informs.
  - It is not clear what you mean when you say this.
  - It connotes an *en mass* displacement of right whales to somewhere else.
- Information on the lives of RIWH comes nearly range wide.
- RIWH still spend enough time where we look so that if alive more likely than not to be seen.
“Distributional shift?”

Implies a ‘one-way’ trip...

Plenty of evidence against this
• Still more likely to “catch” a whale if alive than not
• Lots of acoustic detections
Most likely to have changed to

“Reduced residence times”

Whales move through same areas, but harder to ‘capture’
Assessments are Changing to match RIWH changing patterns

- We used to use simple accounting methods
- Recapture rates of known individuals were very high (near 90%)
- Just Count who is seen in a year plus those seen both before and after
- Only need to look a couple of years ahead because recapture rates were so high
- Reduced recapture rates are making Count-based $N_{\text{min}}$ less informative
- Need a statistical framework to account for whales not seen but likely still alive
- Must account for annually varying recapture rates
Enter MRR

• Acquaint you with MRR analysis
• Briefly mention my approach to estimating abundance RIWH data
• Demonstrate that this approach accounts for non-detection
Basic idea behind MRR

- Use statistical model to make inferences about whales that you DO NOT SEE based on patterns in what whales you did see
  - Estimate how many animals are alive but you don’t see
  - Add those to the ones you do see to get abundance
  - Estimate the fraction still alive at time $t+1$ given the number alive at time $t$
  - Add in the estimated number of new whales
Definitions

- **Capture Sequence** = a series of counts representing the number of times a whale resighted each year in the database
- **Capture History** = a capture sequence reduced to binary

- EGN2345 0 0 0 3 0 2 5 10 3 5 0 0 4 0 0 0
- EGN2345 0 0 0 1 0 1 1 1 1 1 0 0 1 0 0 0 Capture History

1990

2005
THE ELEPHANT IN THE ROOM

• But changed distributions change what you see!!!!
• Doesn’t matter (much)
• If you allow for changes in the pattern of what you do see, your inferences will be robust to changes
Clearly the number of alive individuals seen each year has changed dramatically!

Some Change due to changes in abundance

Some Change due to success “catching” whales
Distributions of recaptures

90-94

95-99

00-04

05-09

10-14

15-16
Whale Recapture Factoids and hypotheses

- Whale recapture takes time
- On a given survey day time is limited
- Whales recaptured per day is limited
- Whales have a culture (tendencies and memory)
- They visit places of familiarity and react to rewards (whale treats)
- Ecosystem indicators suggest some frequented spots have poor food
- Stay duration for a hungry whale correlated to food availability
- Biologists have a culture (tendencies and memory)
- They visit places of familiarity and react rewards (long term)
- Biologists are more hard headed and keep going back sans reward still limited in ability to catch short visit whales
- Whales are moving more, biologists are not
- Implies overall capture heterogeneity
Capture Heterogeneity

- Annual (overall)
  - Whales moving more
  - Variable effort (realized)
- Group
  - Sex (maybe haplotype and age)
- Individual
  - Many individuals seen nearly every year
  - Some seen infrequently (Icelandic mamma)
  - Some intermediate
Enter the Multi-state Hierarchical MRR Model

- Use capture histories of individual RIWHs
- Use known dead to help inform estimates of survival rates
- Use recapture rates and appearance of new whales to estimate additions to the population
- Allow group and individual variation in recapture rates
- Allow annual survival and capture rates to vary over time (in different ways)
Modeling Survival ($\Phi_{i,t}$)

- Model the logit ($\Phi_{i,t}$), i.e. $\log[\Phi/(1-\Phi)]$
  - Varies by Age (0-5)
  - Unknown ages lumped with 5s
  - Varies by Sex for animals 5+
  - Unknown sex estimated by model
  - Random fluctuations between years
Modeling Capture Rate ($p_{i,t}$)

- Model the logit($p_{i,t}$), i.e. $\log_n[p/(1-p)]$
  - Varies by Sex
  - Varies by Year (fixed)
  - Varies by individual – random component
    $\sim$normal$(0, \sigma)$

- Remembering that $E = F^b$
Bayesian Modeling Framework

Full model fitted via simulation
- describe distr'n parameters
  - assume flat (non-informative priors)
MCMC (Markov chain Monte Carlo)
Let the parameter estimates stabilize
Run many more iterations
JAGS 4.2.0

Relationships

ESTIMATES!
ABUNDANCE

99.88% Chance
$N_{2015} < N_{2011}$
More Bad News

Abundance is heavily skewed to males

Females appear to be the big losers during hard times
Enough about death and decline

- 2017 Calving and a new beginning
- 3 calves detected in Fl-Ga and 1 off Cape Cod
  - Total of 4
  - Second lowest recorded during 1980-2017
  - Despite the modest increase in abundance documented 1990-2010
- Recall 2016 was a mere 14 calves
Basic Population Ecology

\[ N_{t+1} = N_t + B_t - D_t \]

Or

\[ \text{Growth} = 1 + \frac{(B_t - D_t)}{N_{t+1}} \]
Back to the Forest: put on a population basis - PCP
Per Capita Production $< 4\%$ spells decline

2016 & 2017 PCP $< 4\%$ (based on $N_{2015}$)
Yah, but what about the Tree

- Icelandic mamma seen with a calf in CCB and not down south
- Maybe there’s a bunch more whales that we don’t know about!

- A single tree does not a forest make!
Are we missing calves?

- Unlikely more than a handful (of course one whale is more than a handful)
- Since 1990 → 429 calves detected
- 313 of those were catalogued as known-age animals (I’ll do the math ... that leaves 116)
- Since 1990, 98 individuals of unknown age have been added to the catalog
- 98/116 * 100% = 84% which is about what would be expected based on estimated survival of a mixture of 0-3 year olds
Parallel Work

- Recapture rates of seriously injured (NMFS term) whales and recovery rates of dead whales inform latent mortality due to entanglement.
- Bayesian State-space (HMM) model to estimate latent mortality.
- Approach suggests actual $\text{mort}_e$ is twice the observed number!
Estimated Entanglement SIM

- Median est. = $\frac{43.7}{5} = 8.7$/year
- About 30% chance
- $>10$/year
- Possibly biased low
- But more realistic
- Observed 4.2