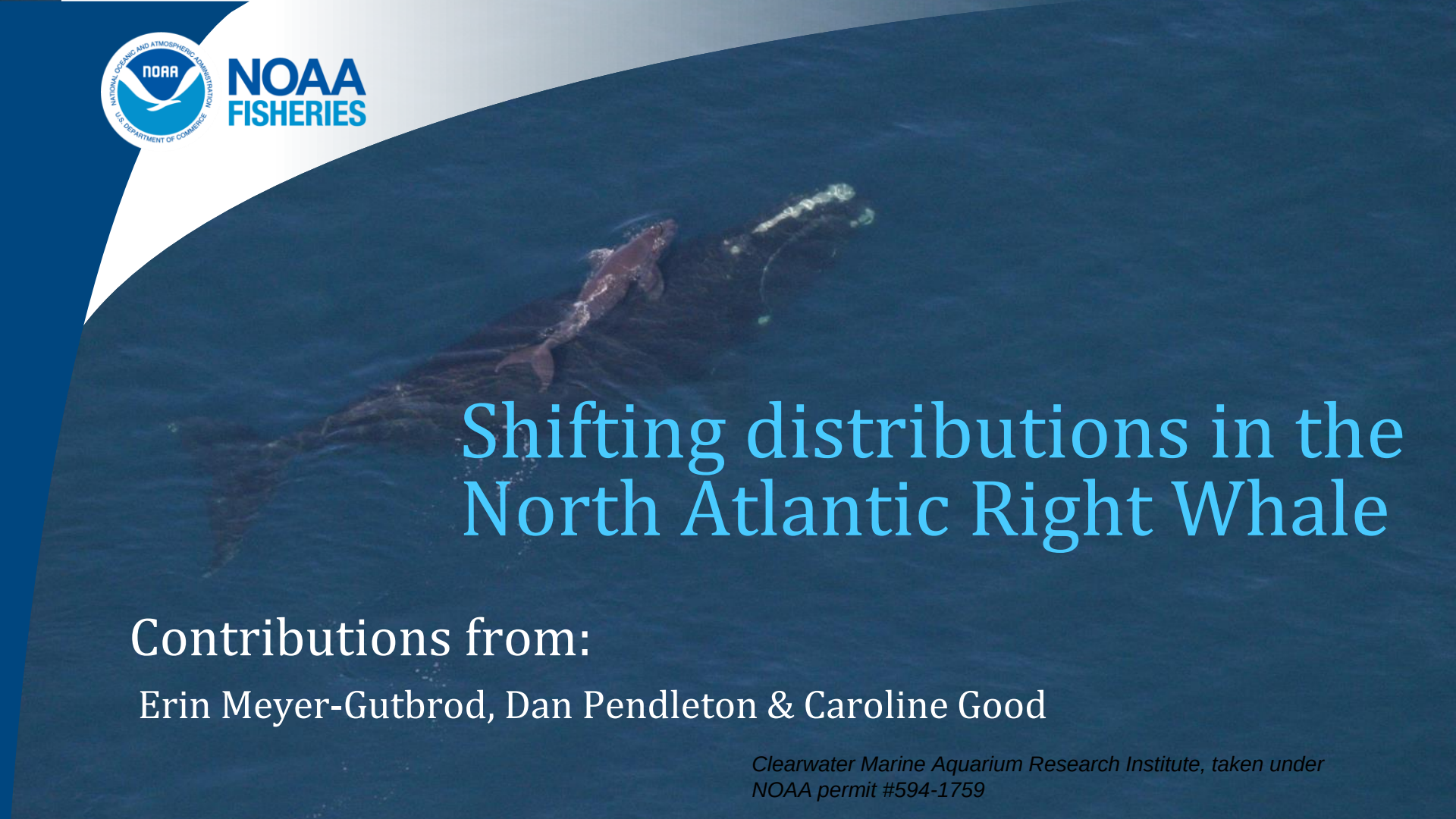


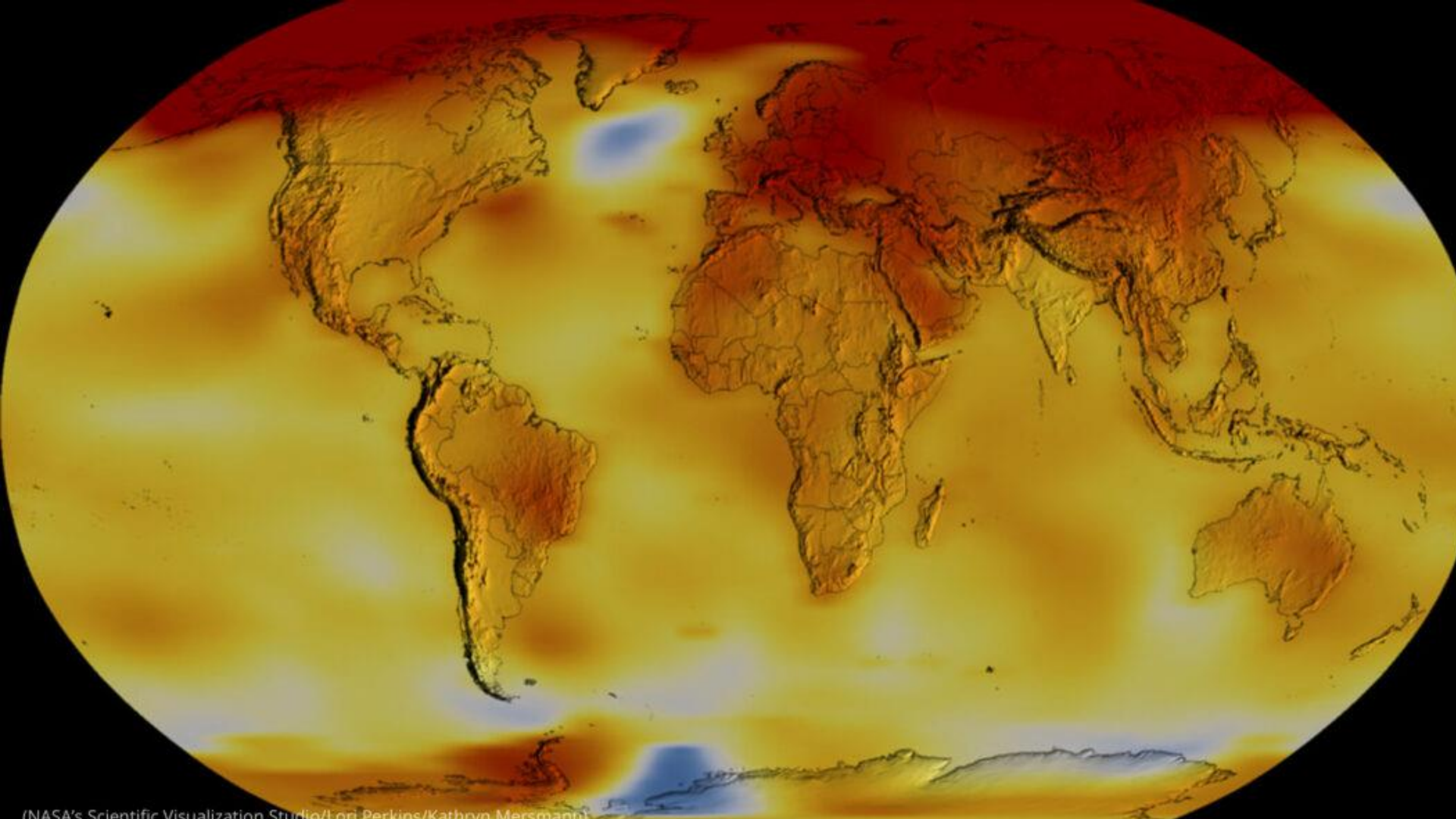
NOAA FISHERIES

Shifting distributions in the North Atlantic Right Whale

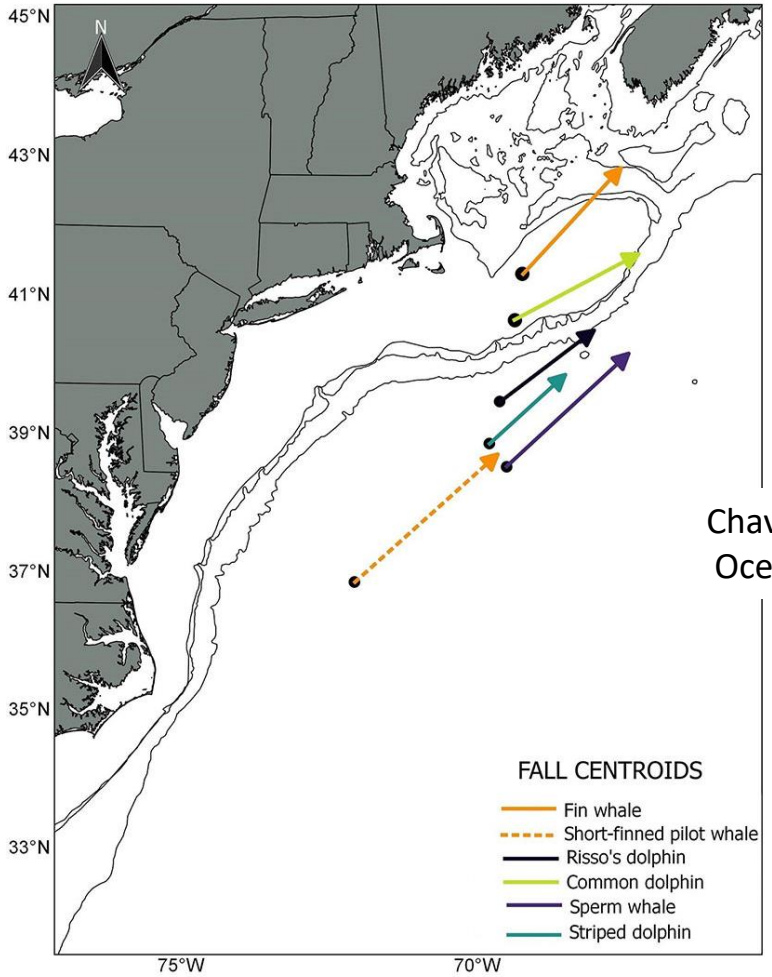
Contributions from:

Erin Meyer-Gutbrod, Dan Pendleton & Caroline Good

Clearwater Marine Aquarium Research Institute, taken under NOAA permit #594-1759


(NASA's Scientific Visualization Studio/Lori Perkins/Kathryn Mersmann)

- 16 cetacean species
- 2010 to 2017
- ave shift N-178 km



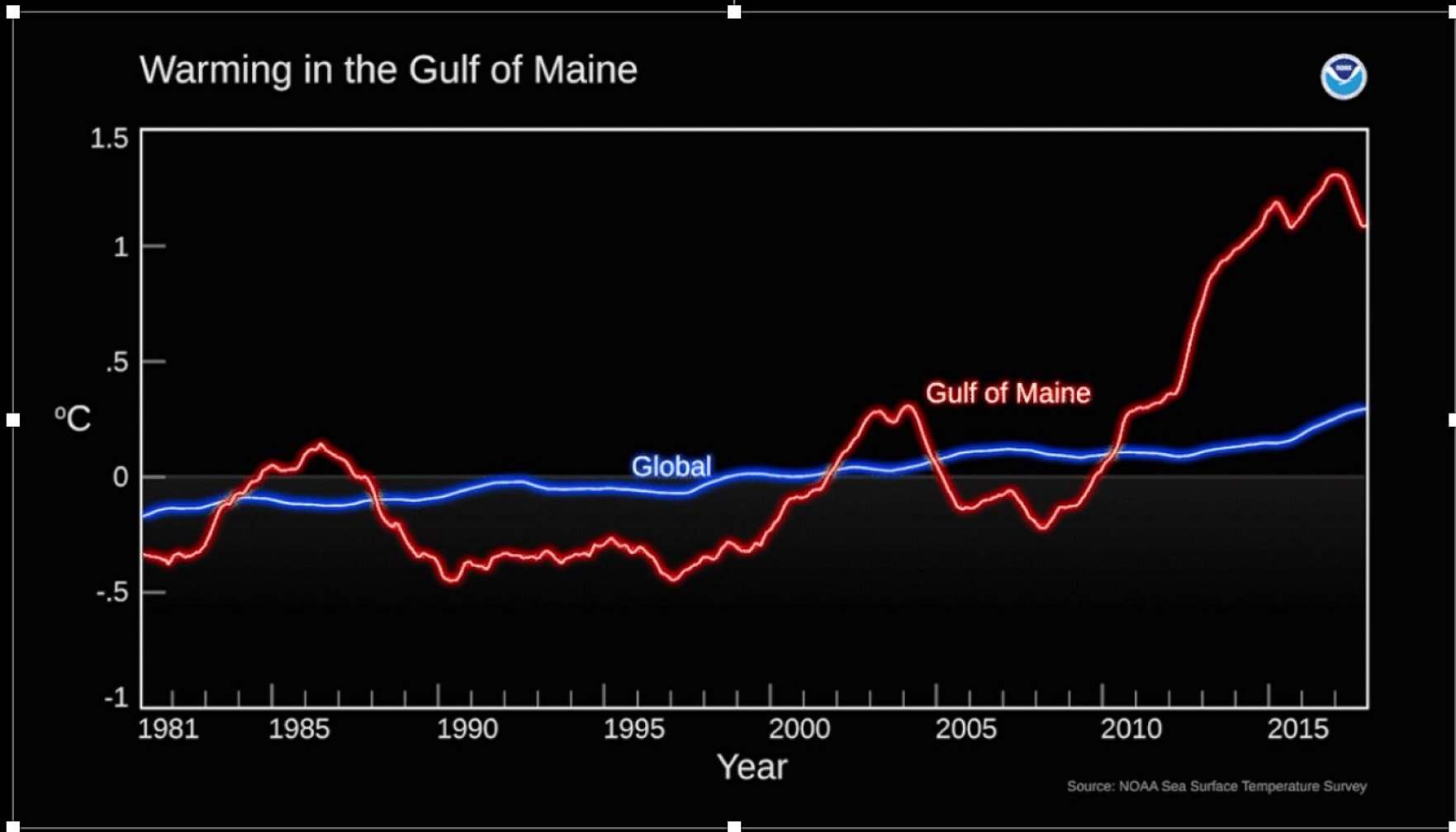
Chavez-Rosales, S., et al 2022.
Ocean Frontiers in Marine Science **9.**

NOAA FISHERIES

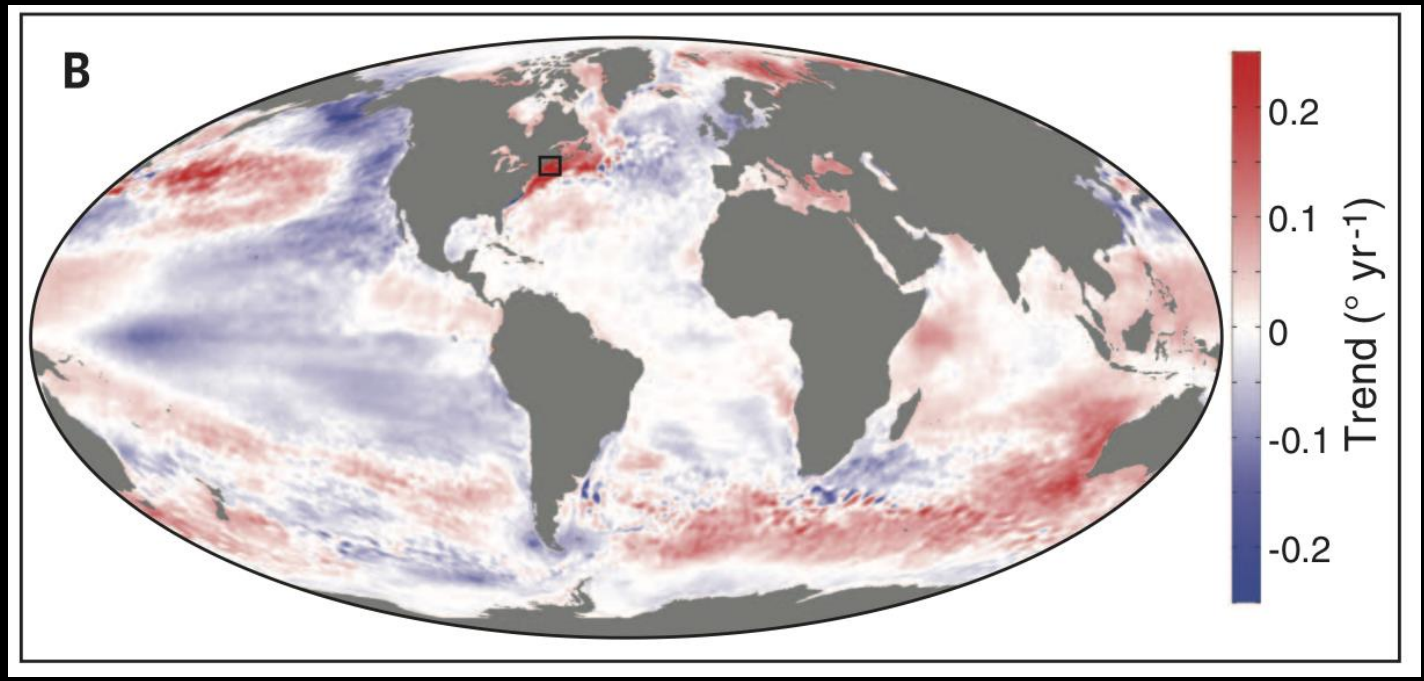
North Atlantic right whale

- Population collapse after centuries of whaling
- Despite 90 years of protection, recovery is slow
- Current population estimated at 356 whales
- Modern threats:
  - Collisions with ships
  - Entanglements in fishing gear
  - Prey limitation
  - Noise

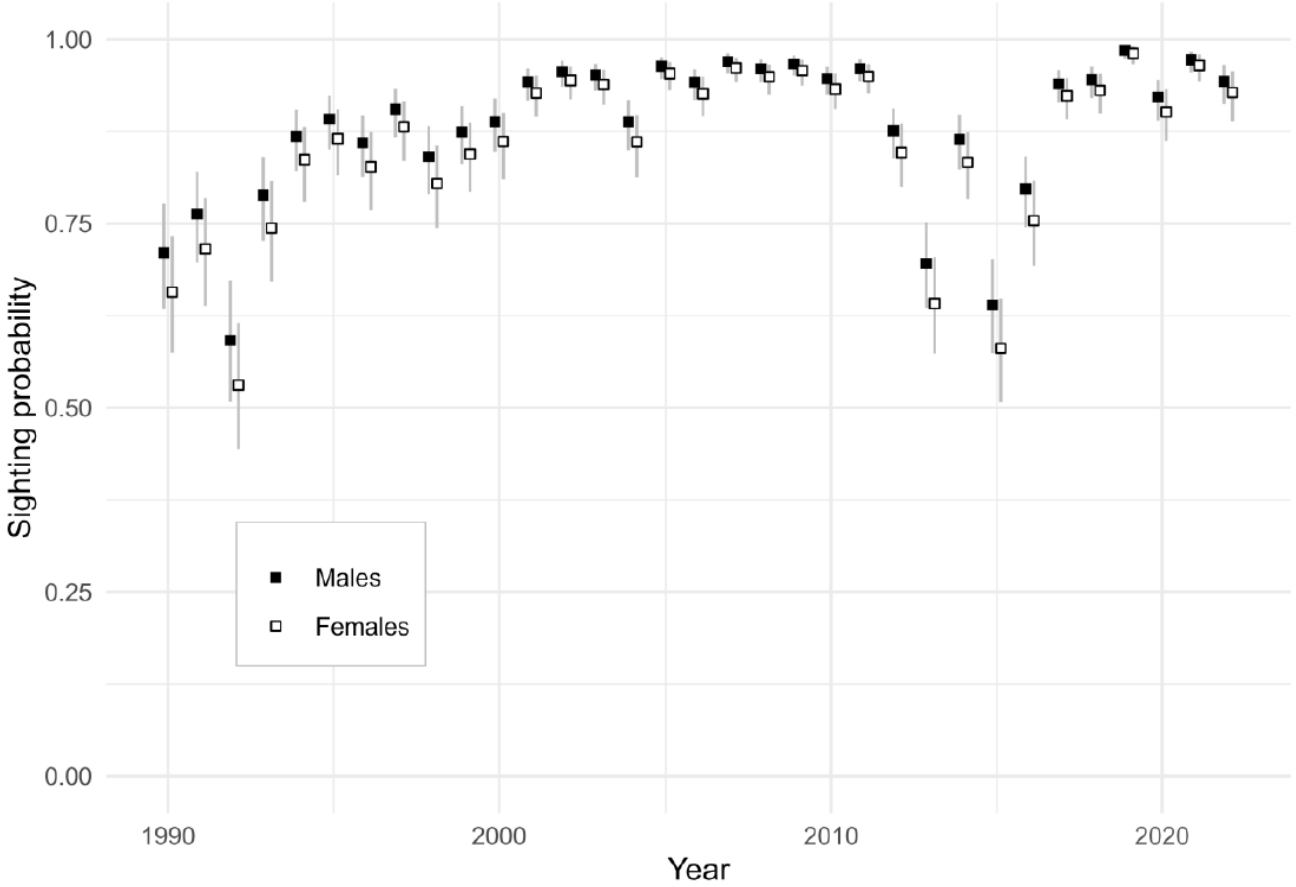
Adapted from E. Paul Oberlander, Woods Hole Oceanographic Institution Graphics


Warming in the Gulf of Maine
1.5
1
.5
0
-.5
-1
°C
Gulf of Maine
Global
1981
1985
1990
1995
2000
2005
2010
2015
Year
Source: NOAA Sea Surface Temperature Survey

Gulf of Maine SST is warming faster than 99% of the global ocean



Global SST Trends 2004-2013
Pershing et al. 2015



400 animals in
400,000km of ocean?

Figure 1. Sighting probabilities for North Atlantic right whales (*Eubalaena glacialis*) estimated from a Bayesian capture-recapture model of sightings data from 1990-2022.

Reasons to go elsewhere?

1. Not cool anymore
2. Out of resources
3. Better resource elsewhere
4. New threat/danger

Right Whales are specialists
= less resilience to change

https://www.andersoncabotcenterforoceanlife.org/blog/a-zoomed-in-look-at-our-aerial-survey-photographs/

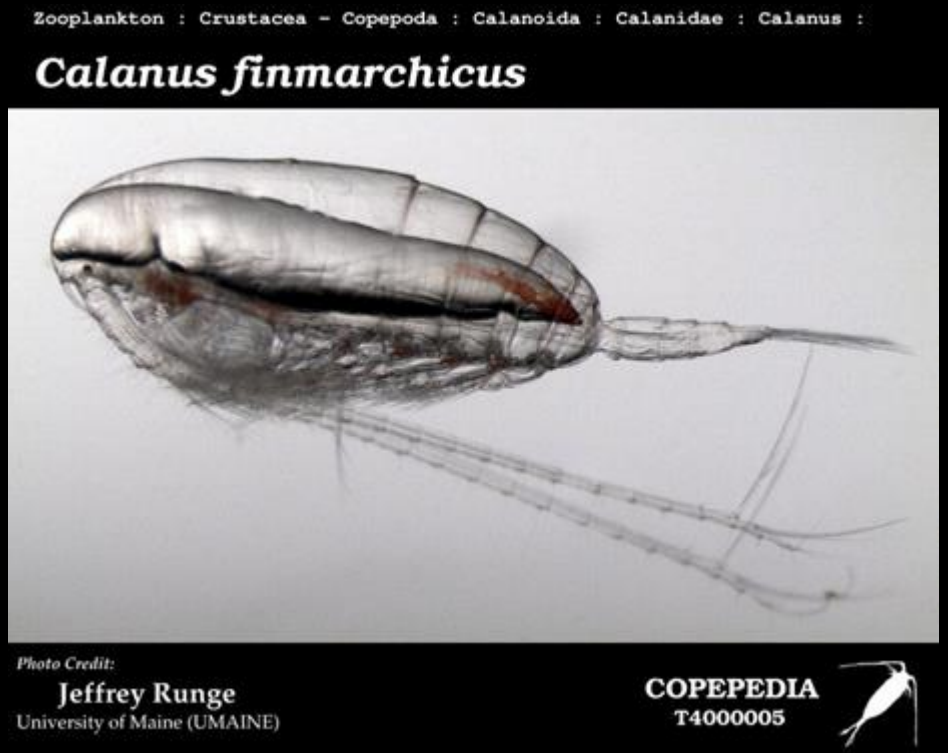
Foraging rates of ram-filtering North Atlantic right whales

	Bowhead Whale *Balaena mysticetus*	North Atlantic right whale *Eubalaena glacialis*	Whale shark *Rhincodon typus*	Basking shark *Cetorhinus maximus*
Gape Area	4.23 m^2	1–2 m^2	0.1 m^2	0.4 m^2
Body Length	12 m	10–14 m	6 m	4–6.5 m
Speed	0.7 m/s	1.2 m/s	0.3–1 m/s	0.85 m/s
Filtration Rate	3.0 m^3/s	1.4–2.4 m^3/s	0.01–0.1 m^3/s	0.3 m^3/s
Prey Concentration	1–10 g/m^3	>170 g/m^3 10^3–10^5 copepods/m^3	10^4 plankton/m^3	0.3–3 g/m^3
Pause Interval	150 s	50 s	120–180 s	30–60 s
References	Werth (2004) Simon et al. (2009) Laidre et al. (2007)	This study Murison & Gaskin (1989) Baumgartner & Mate (2003)	Nelson & Eckert (2007) Motta et al. (2010)	Hallacher (1977) Sims (2000)

Functional Ecology, Volume: 33, Issue: 7, Pages: 1290-1306, First published: 11 May 2019, DOI: (10.1111/1365-2435.13357)

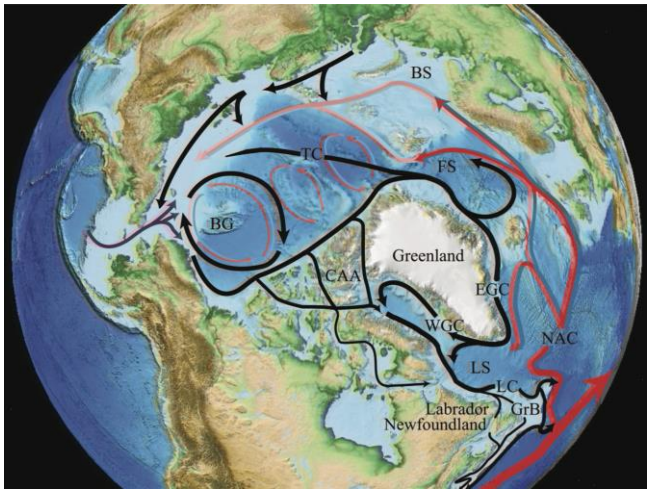
Plankton disruption concerns

- Abundance
- Distribution/Distance
- Density/Aggregation
- Energy content



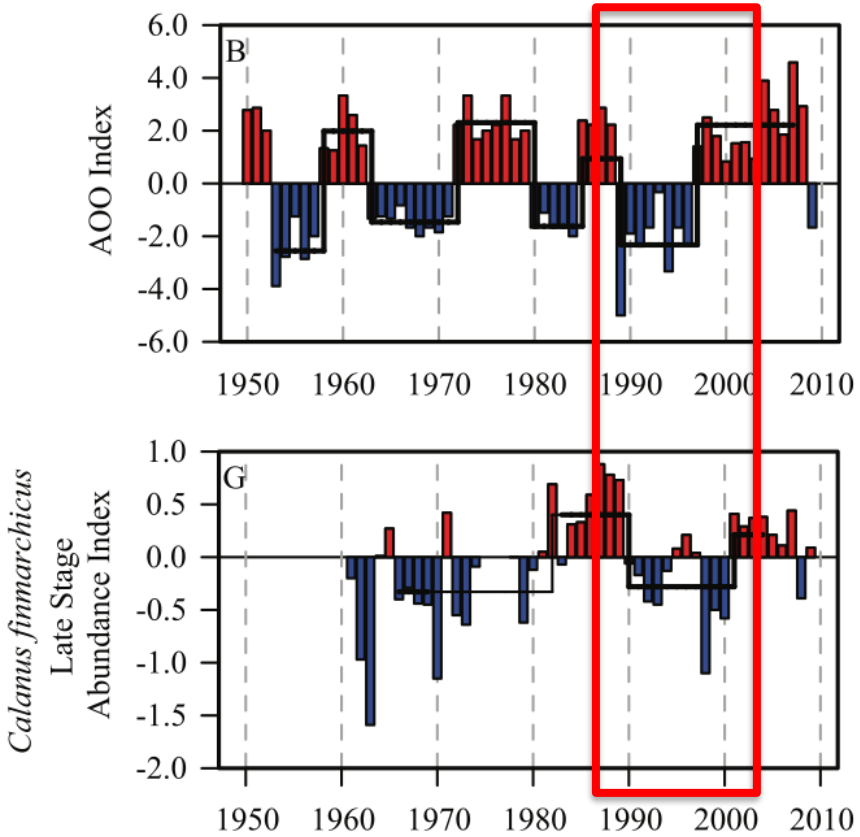
Remote climate forcing impacts Gulf of Maine on decadal

From the Arctic

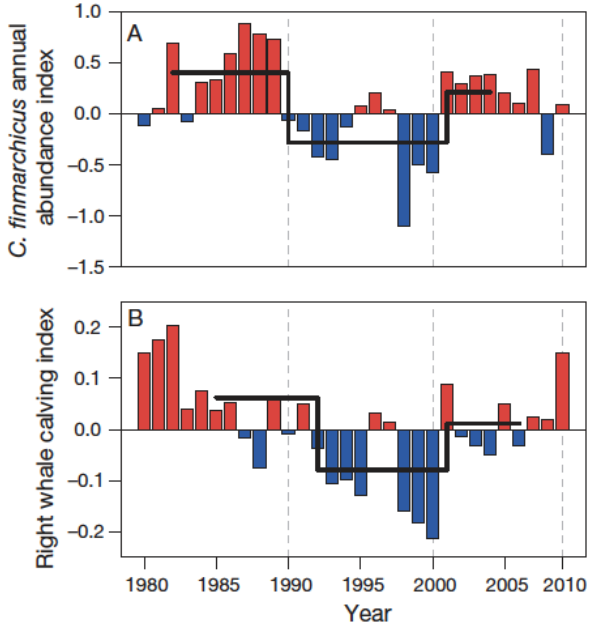


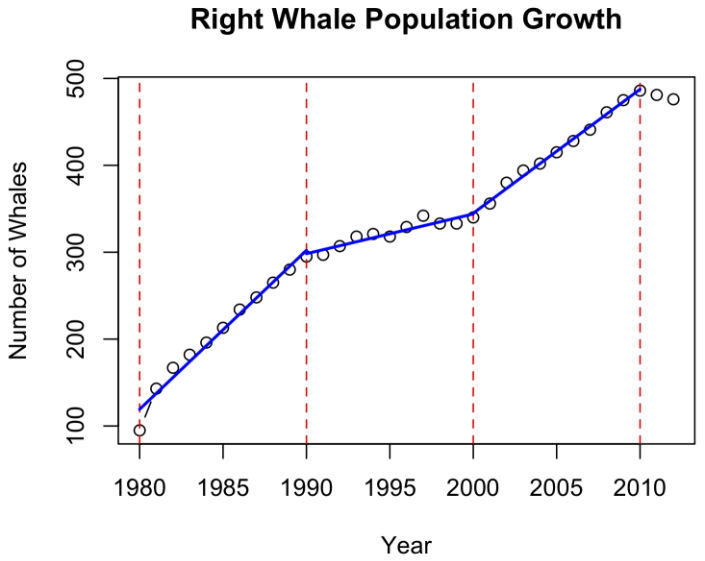
Freshwater pulses from Beaufort Gyre tracked through Arctic Oceanic Oscillation (AOO)

Greene et al. 2013



Changes in right whale population growth over 3 decades linked to regime shifts in prey abundance

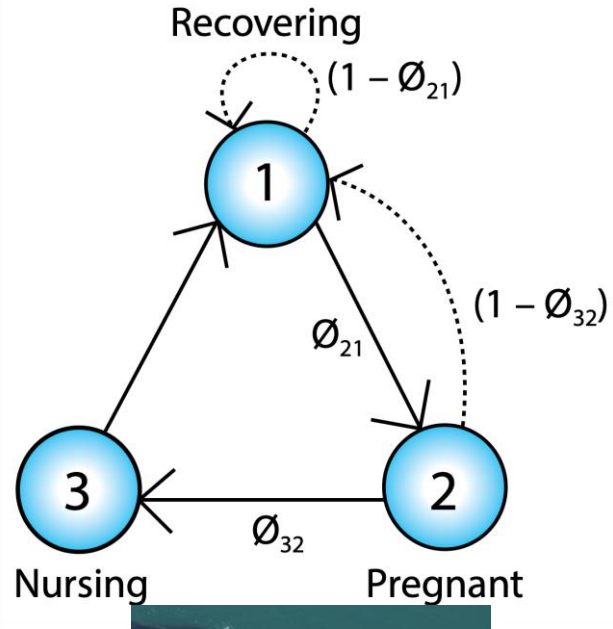


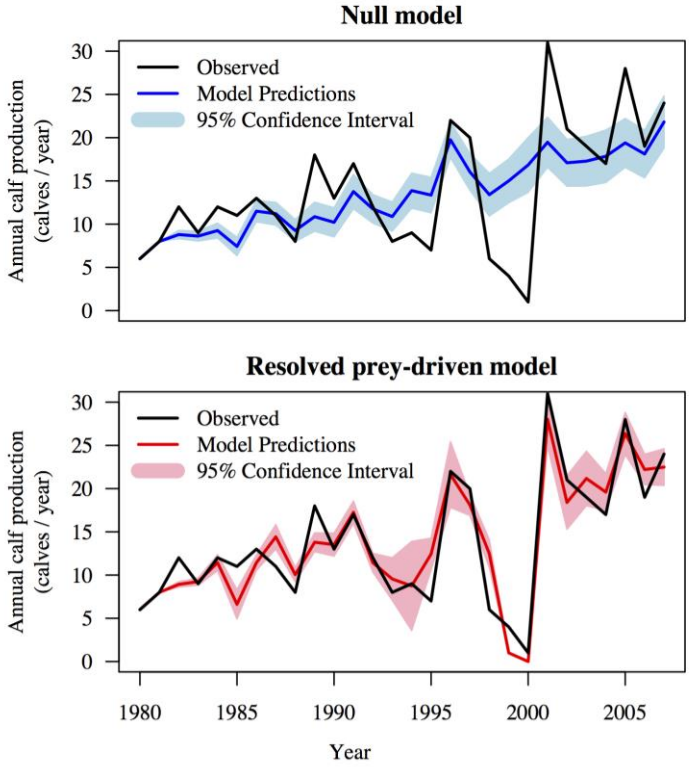


- Evidence of variable population growth between the three decades
- Low rates in 1990s driven by fewer copepods
- High calving rates in 1980s and 2000s driven by high copepod abundances

Meyer-Gutbrod *et al.* 2015

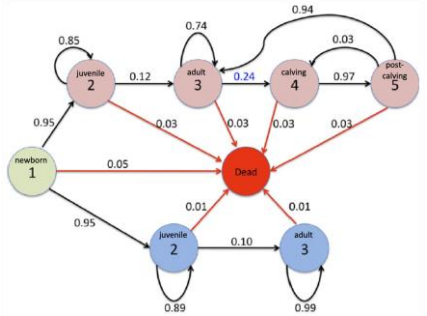
Prey abundance explains right whale birth rates





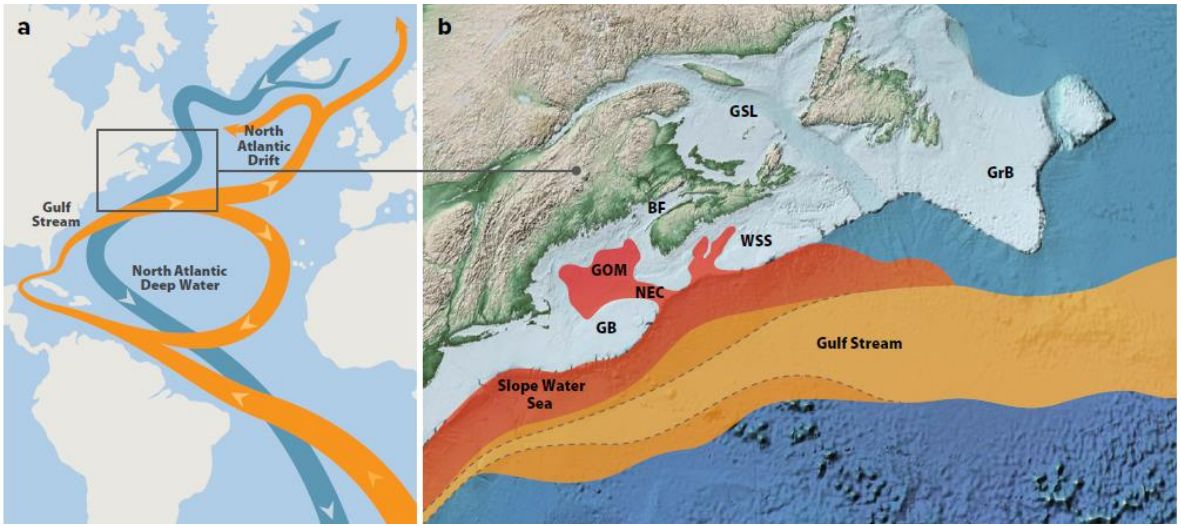
Meyer-Gutbrod et al. 2014, 2015

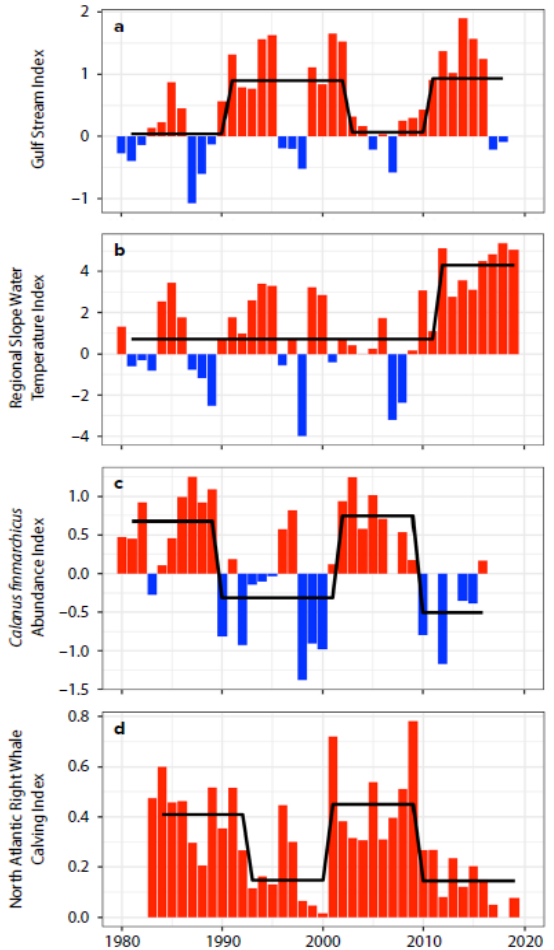
… but not death rates



Meyer-Gutbrod et al. 2018

Costs of Ecosystem Change

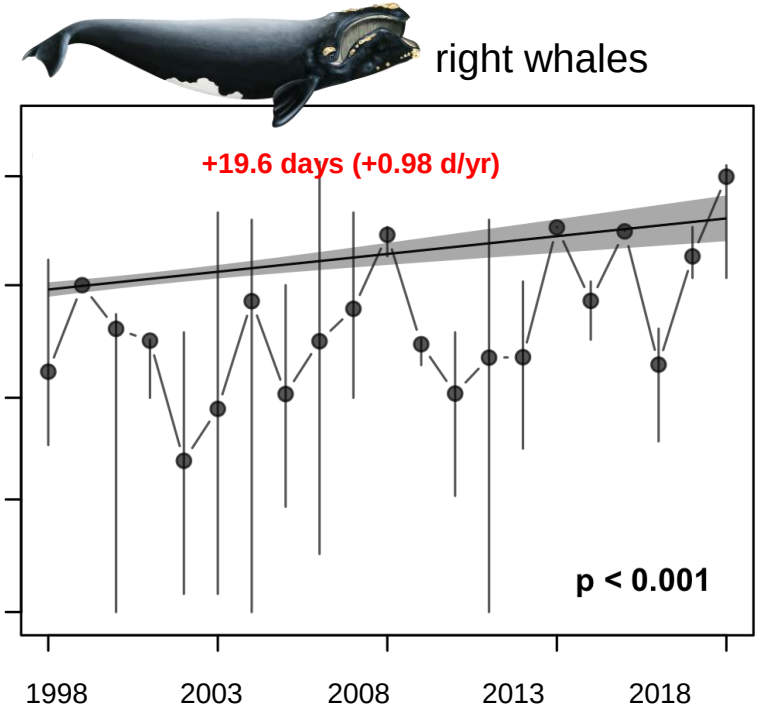


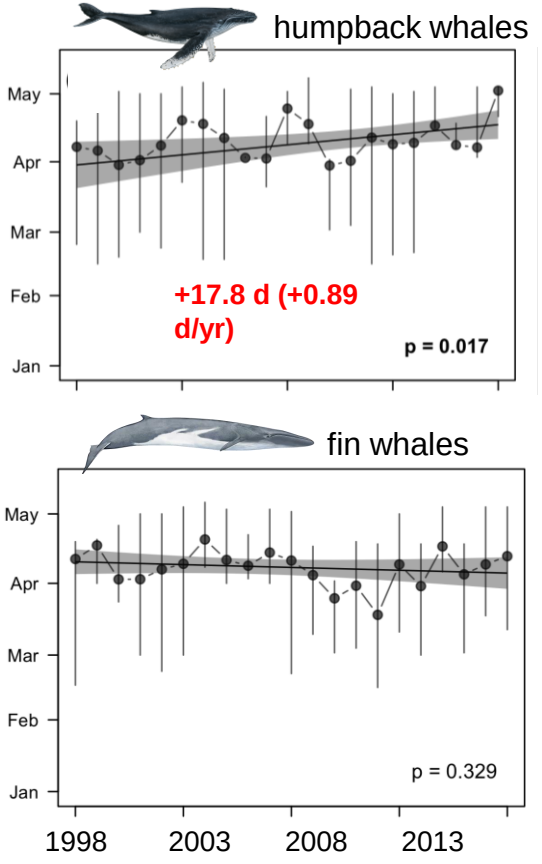


- 2010- NW Atlantic regime shift in gulf stream- warm water arrived
- Calanus abundance declines
- Calving rate declines
- Most successful moms find food in Gulf of St Lawrence
- Vessel strike and entanglement increase

Bishop, A.L. et al. 2022. Maternal lineage and habitat use patterns explain variation in the fecundity of a critically endangered baleen whale. **Front Ecol Environ** 9: 880910.
Meyer-Gutbrod, E.L., et al. 2021. Ocean Regime Shift is Driving Collapse of the North Atlantic Right Whale Population. Oceanography 34(3): 22-31.

Phenological shifts in CCB

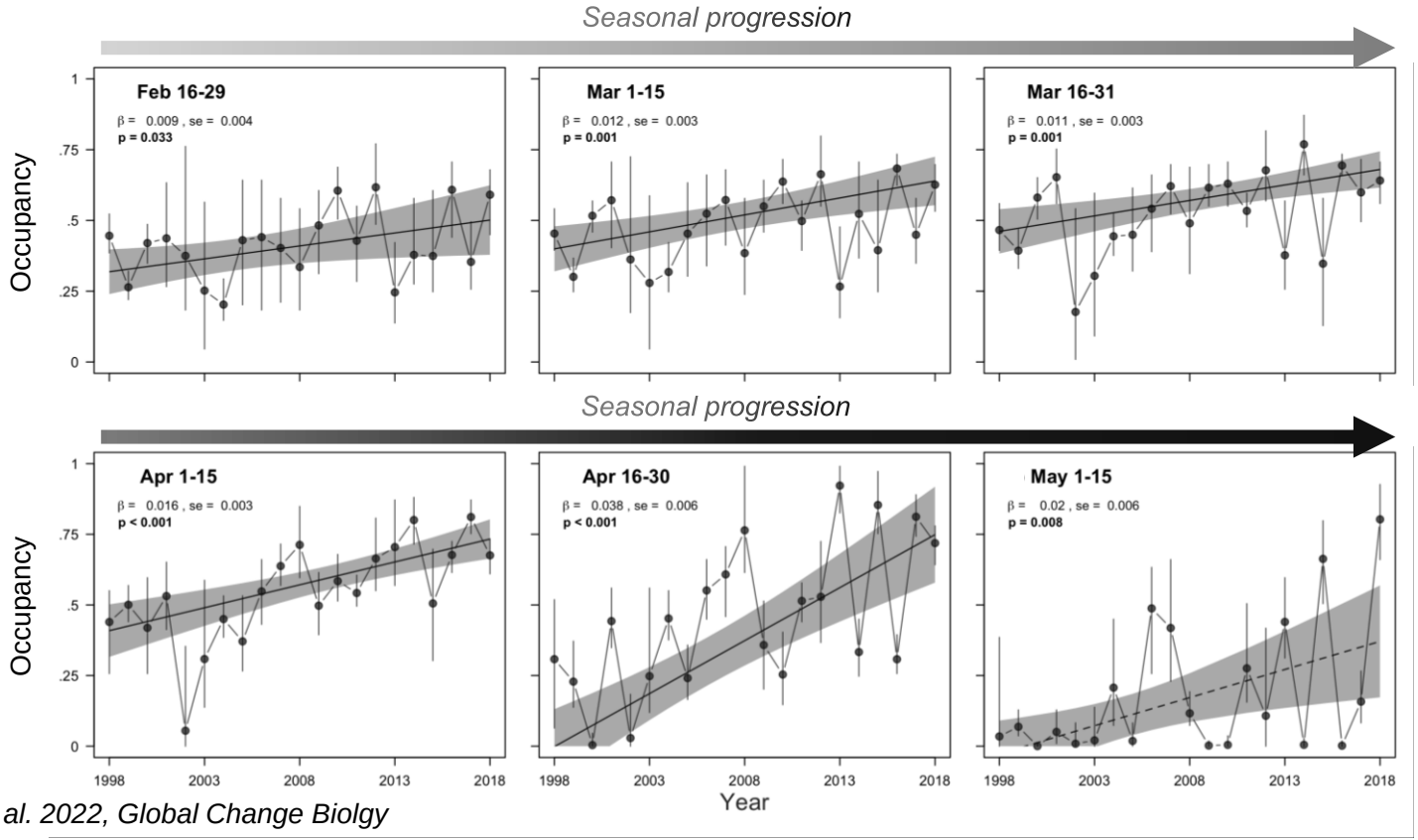




Pendleton et al. 2022, Global Change Biology

Illustrations: NOAA Fisheri

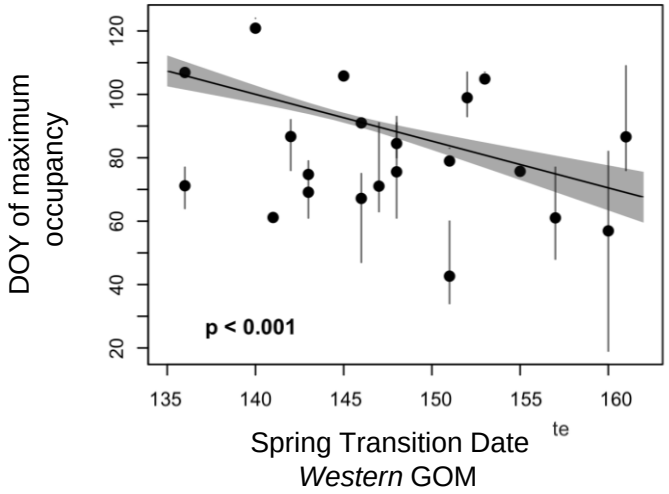
Right whale habitat use increased in CCB



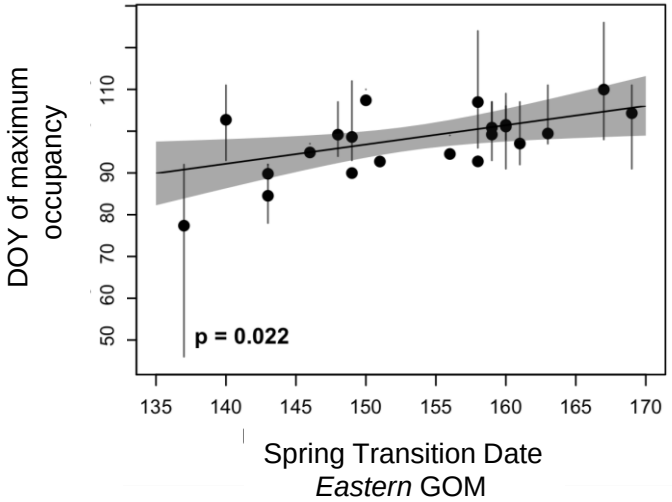
Pendleton et al. 2022, Global Change Biolgy

Differential effect of spring's advance in CCB

right whale *(Eubalaena glacialis)*



fin whale (*Balaenoptera physalus)*



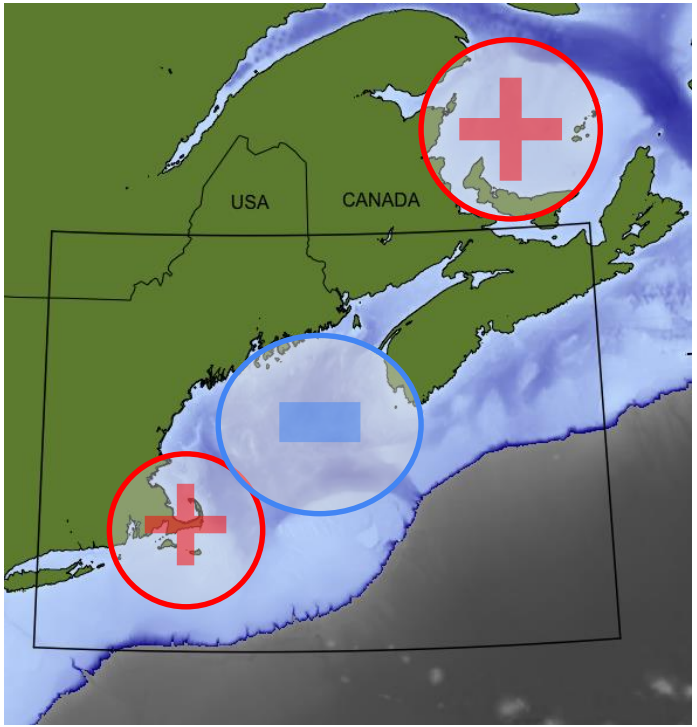
Pendleton et al. 2022, Global Change Biolgy

Illustrations: NOAA Fisheries

The waiting room hypothesis

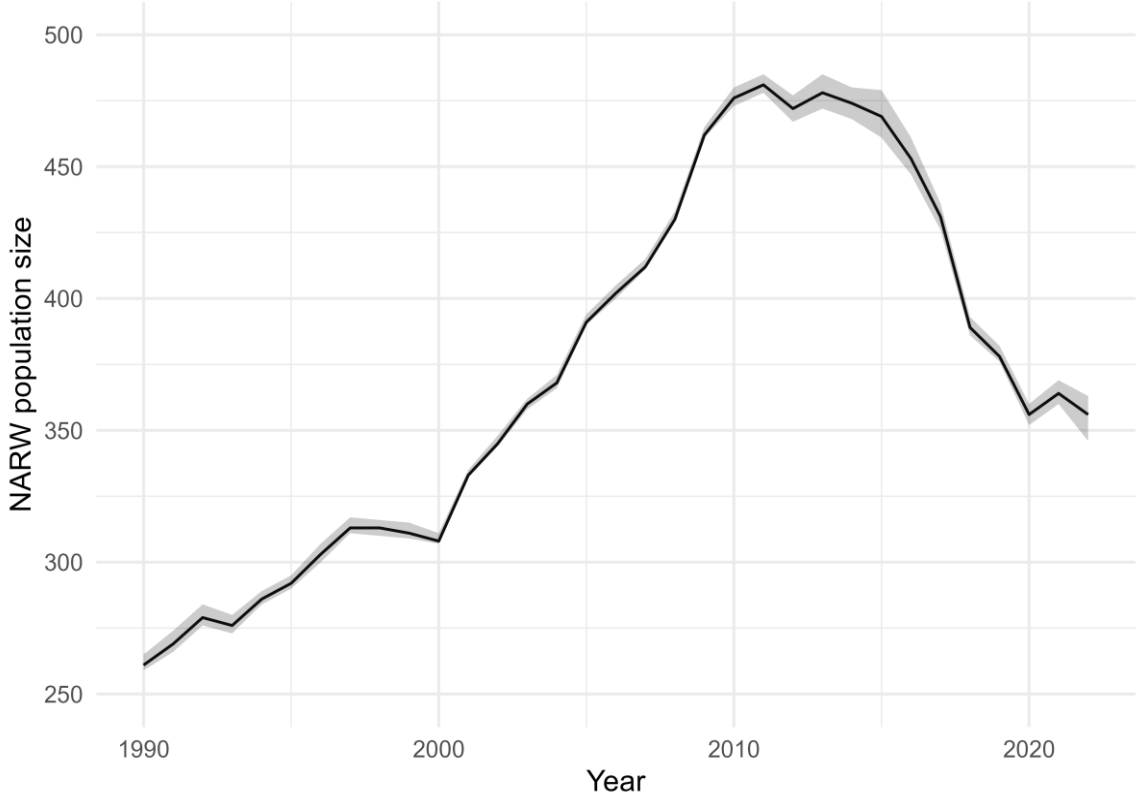
- Right whales wait in areas with sub-optimal prey as better prey develops elsewhere.
- CCB & SNE have seen increased abundance and use
  - Pendleton et al. (2022)
  - ***O'Brien et al. (2022)***
  - Ganley et al. (2019, 2022)
  - Mayo et al. (2018)
  - Record et al. (2019)
- Oceanographic processes support this
  - Record et al. (2019)
  - Meyer-Gutbrod et al. (2021)

Highly generalized areas of increased and decreased right whale habitat use



Right whale population estimate update

As of the beginning of 2022



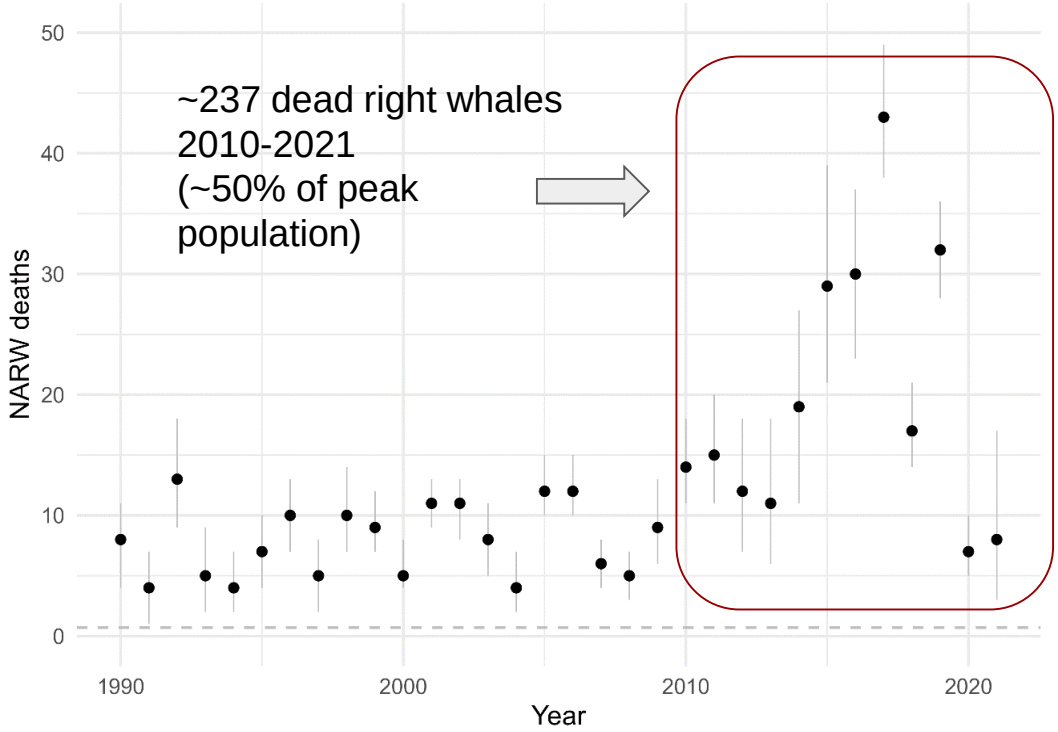
Population: 356

(credible interval 346-363)

Known reproductive female: <70 with >50% probability of being alive

Estimated Annual Mortality

(d[t] = N[t] + b[t] - N[t+1])

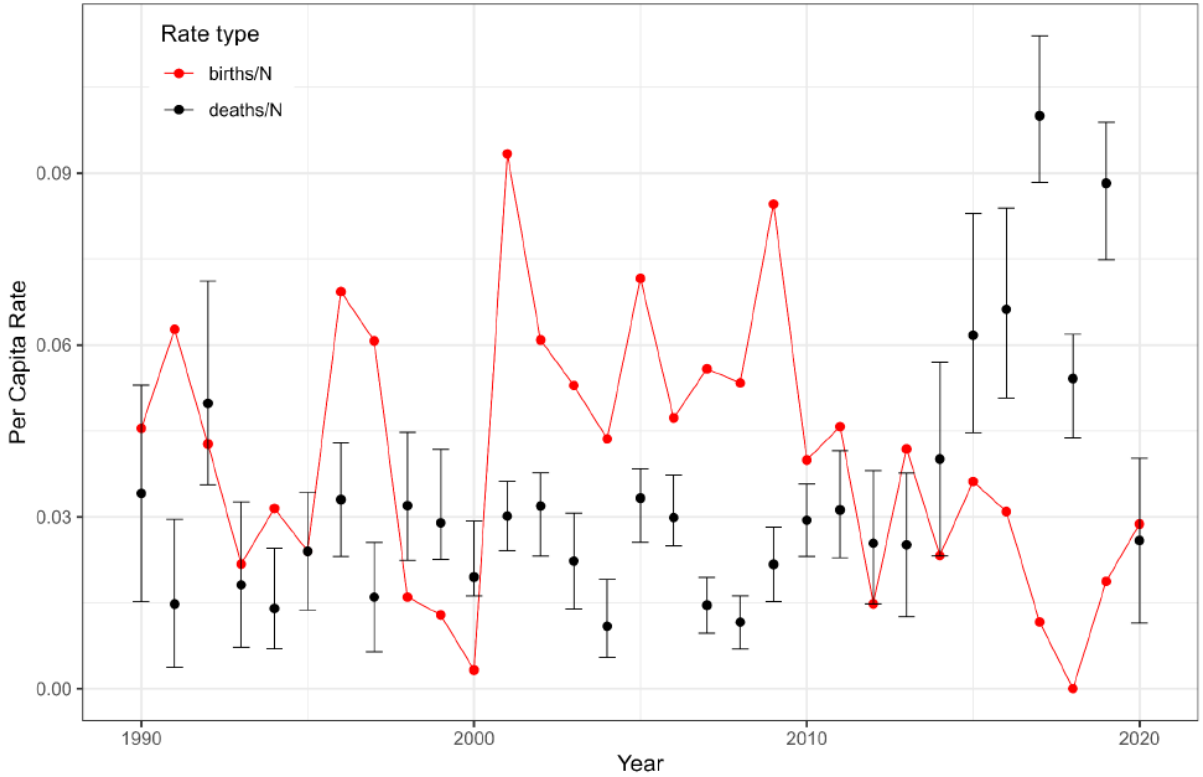


YEAR	EST Mort (median)	Obs Mort	Obs SI	Obs SI+M
2015	29	3	4	7
2016	30	4	9	13
2017	43	17	2	19
2018	17	3	6	9
2019	32	10	2	12
2020	7			
2021	8			

Linden et al 2023. NOAA Tech Memo.

Method in: **Pace III, R.M., et al.** 2021. Cryptic mortality of North Atlantic right whales. Conservation Science and Practice. 3(2): e346. doi:https://doi.org/10.1111/csp2.346.

Birth rates are down… (N[t+1] = N[t] + b[t] - d[t])



Hayes, S., et al. 2022. US Atlantic and Gulf of Mexico Marine Mammal Stock Assessments-2021 NOAA Tech Memo NMFS NE-288. 288: 479. Available from https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-stock-assessment-reports *2020 values in review for 2023 assessment. Figure from IWC report

Why?

- Ecosystem shifts
- Whale behavior/distribution change into ‘unmanaged’ areas
- More encounters between whales, fishing gear and vessels
- Skinny whales don’t have babies

NOAA proposes new vessel speed regulations to protect North Atlantic right whales

Agency also releases a “roadmap” for use of ropeless gear to boost endangered species recovery

Focus areas: Fisheries **Topics:** whales **Share:**

July 29, 2022

Snow Cone (#3560) entangled in fishing gear, sighted off the coast of Georgia with her second calf in December 2021. Her first known calf died from a vessel strike off the coast of New Jersey in June 2020. (Image credit: Georgia Department of Natural Resources taken under NOAA permit 20556)

NOAA FISHERIES

Current Vessel Speed Rule

Seasonal Management Areas (SMAs)

- Mandatory, 10-knot speed restrictions for most vessels ≥65 ft long in specified areas/times off the U.S. East Coast

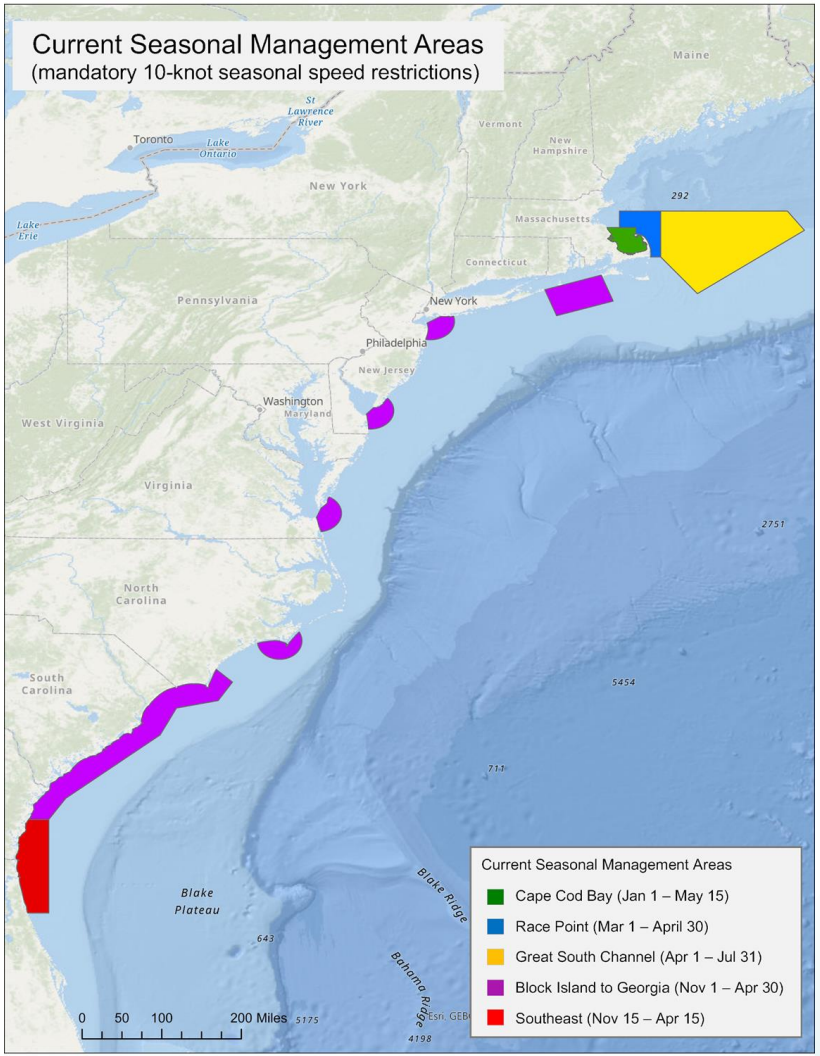
- Certain vessel categories are exempt, including:
  - Military
  - Federally owned or operated
  - Search and rescue (actively engaged)
  - Enforcement (actively engaged)

- Safety deviation provision - may exceed 10 knots if a vessel encounters conditions that severely impact maneuverability;

Dynamic Management Areas (DMAs) and Slow Zones

- NOAA Fisheries requests that all vessel transits at speeds 10 knots or less; DMAs/Slow Zones declared when right whales are detected visually or acoustically - outside active SMAs

- Vessel cooperation remains poor



Proposed Speed Rule Amendments: SSZs

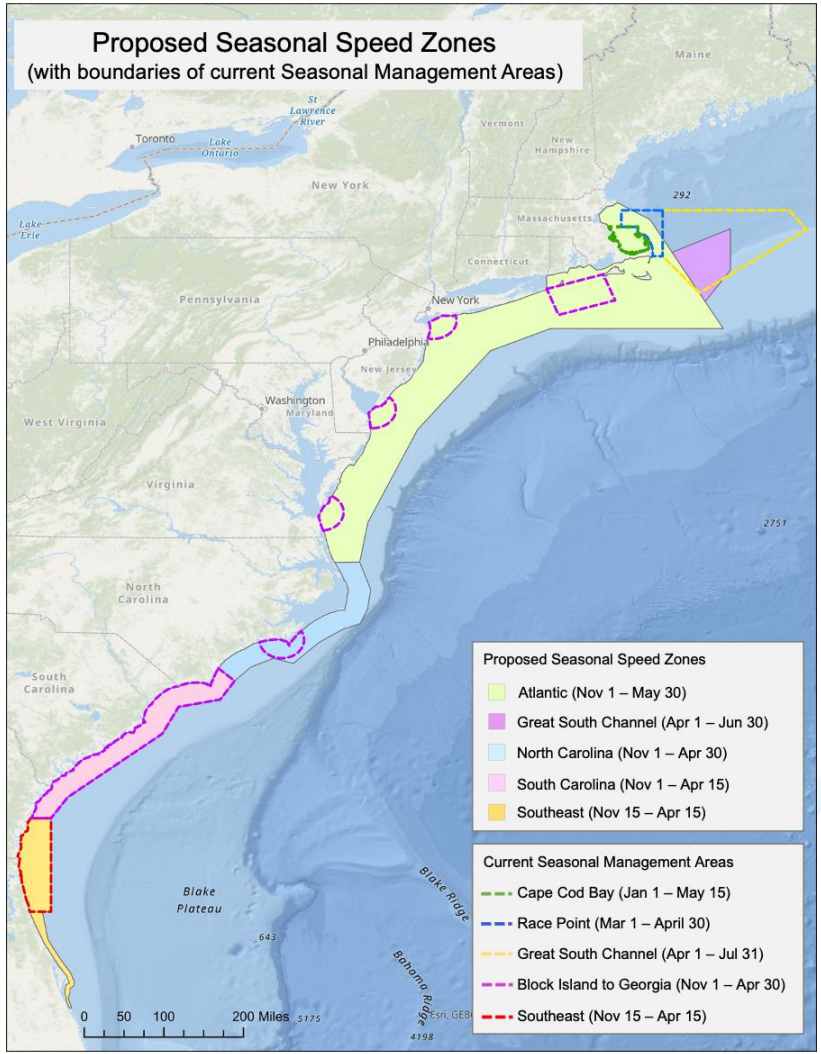
Seasonal Speed Zones (SSZs)

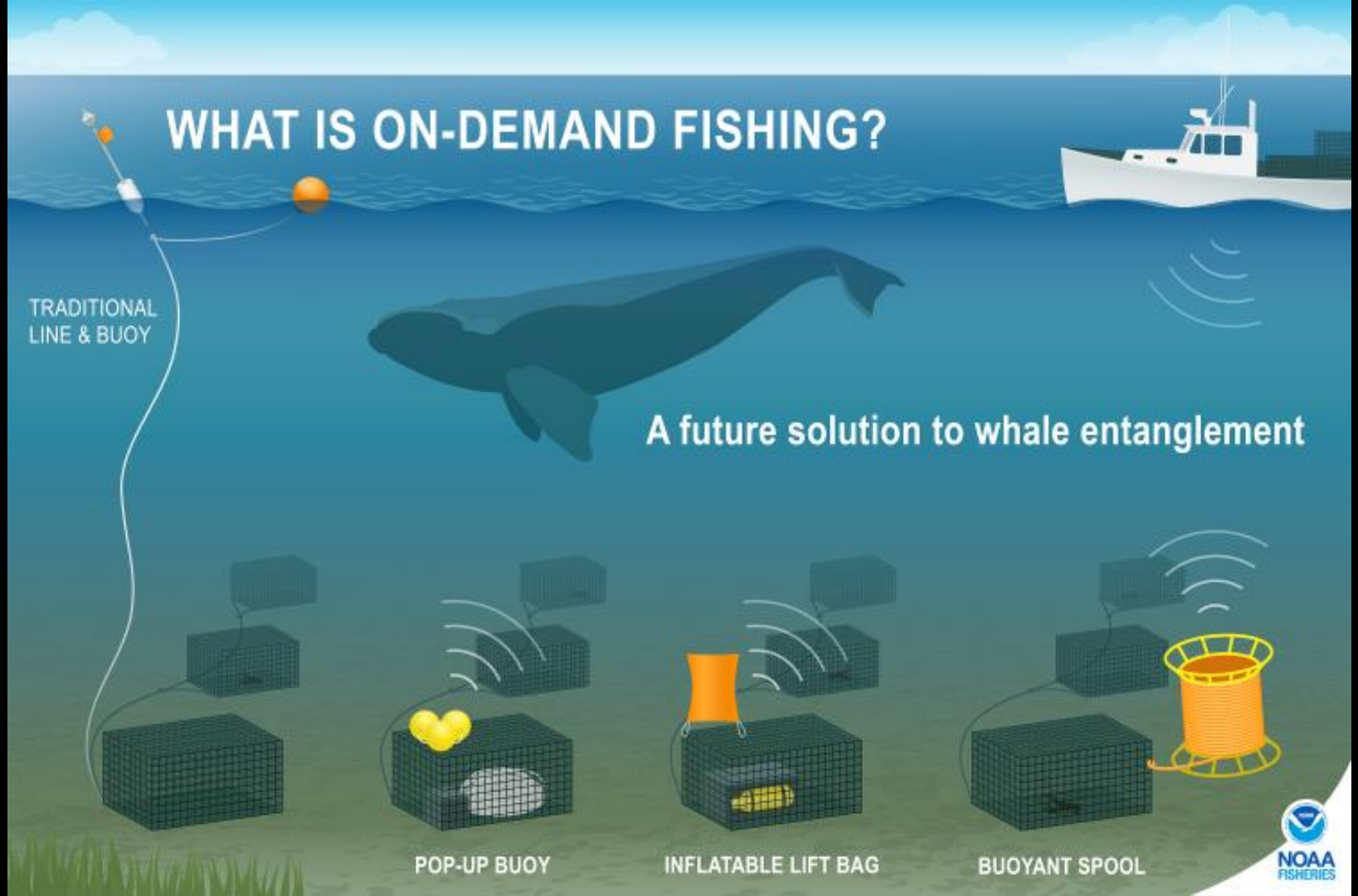
- Modified whale distribution and habitat use has resulted in a misalignment between current protections and areas/times with elevated lethal strike risk

- Developed updated SSZ boundaries and timing:
  - Coastwide vessel strike risk model using the latest data on right whale distribution and vessel traffic characteristics
  - NARW sightings and acoustic data
  - Limited data on vessel traffic 35-65 ft in length

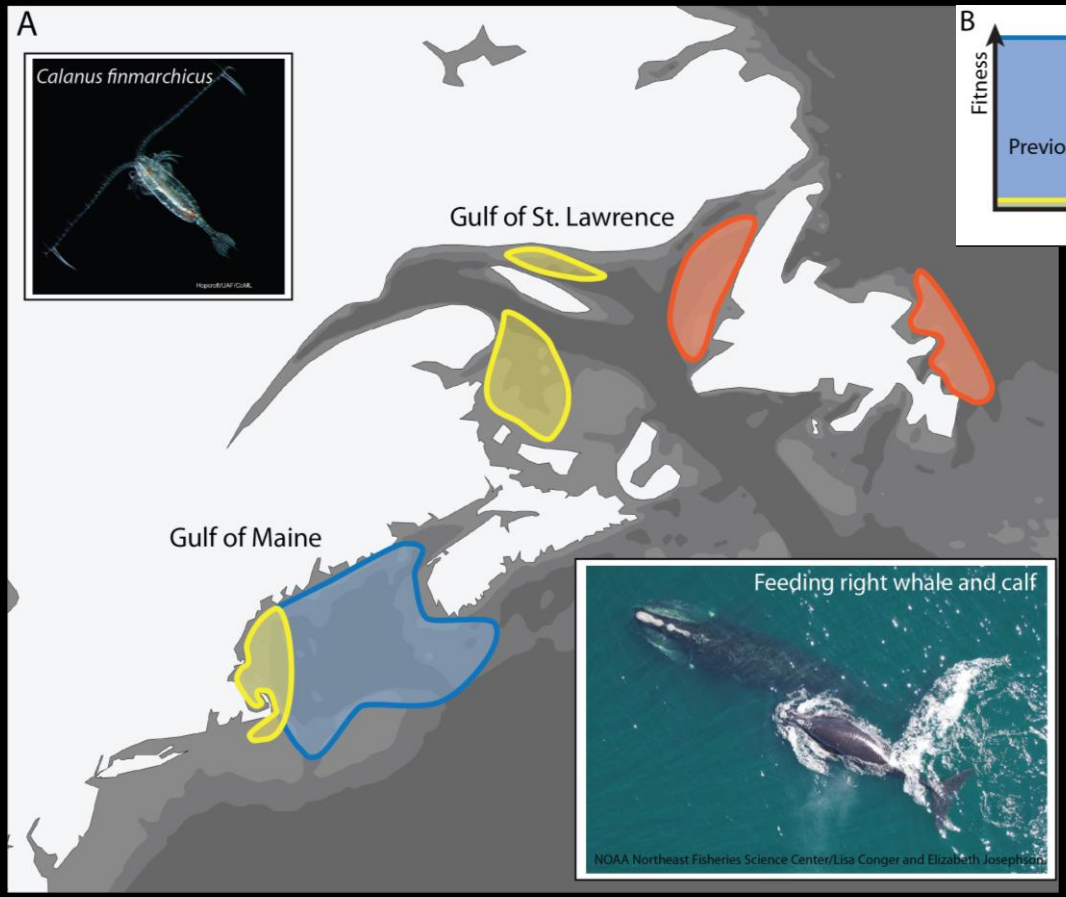
- Considered future wind energy development and possible US Coast Guard shipping safety fairways

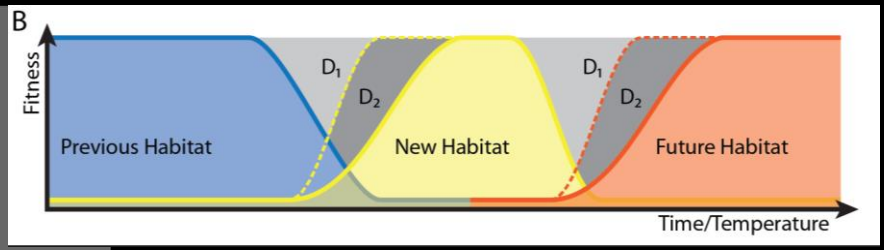
- Proposed changes would approximately double the area under speed restriction - however, there are few or no seasonal speed restrictions in summer and early fall



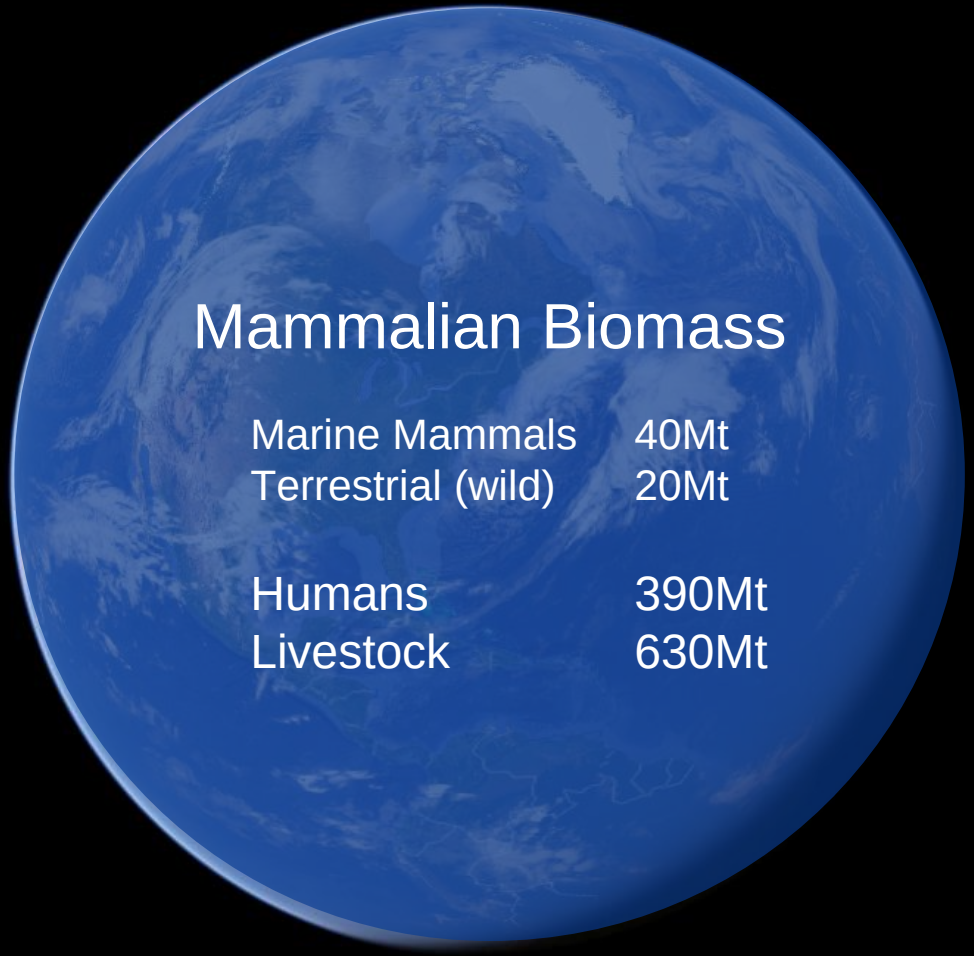

WHAT IS ON-DEMAND FISHING?
TRADITIONAL
LINE & BUOY
A future solution to whale entanglement
POP-UP BUOY
INFLATABLE LIFT BAG
BUOYANT SPOOL
NOAA
FISHERIES

Stationarity is dead. They will move again.





Pershing & Pendleton, 2021
doi.org/10.5670/oceanog.2021.315

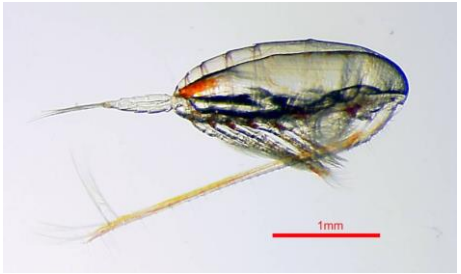


Greenspoon et al 2023 PNAS

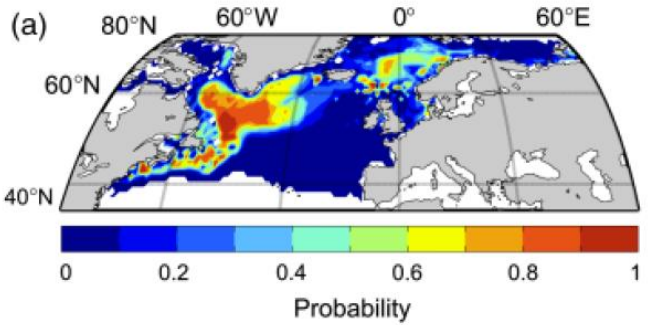
EXTRA SLIDES

Chief prey species: *Calanus finmarchicus*

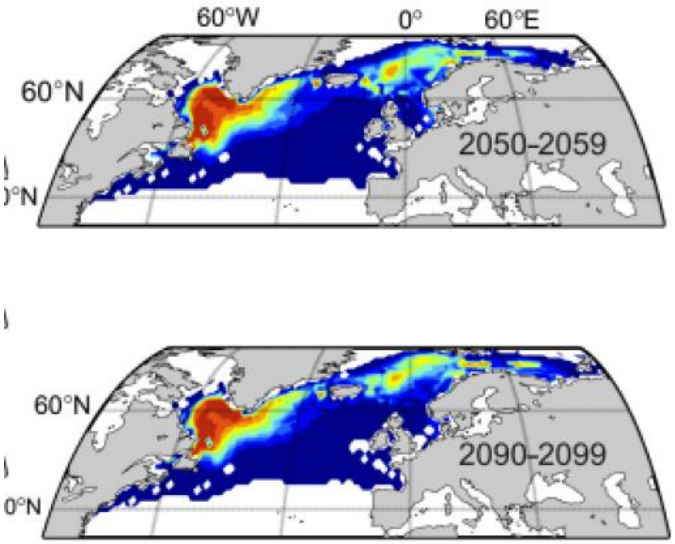
- Whales forage seasonally on high-density patches of copepods
- *C. finmarchicus* is lipid-rich (highly caloric)
- Reduced prey access can cause:
  - Declines in calving rates
  - Abrupt changes in whale distribution



Historical *Calanus* distribution

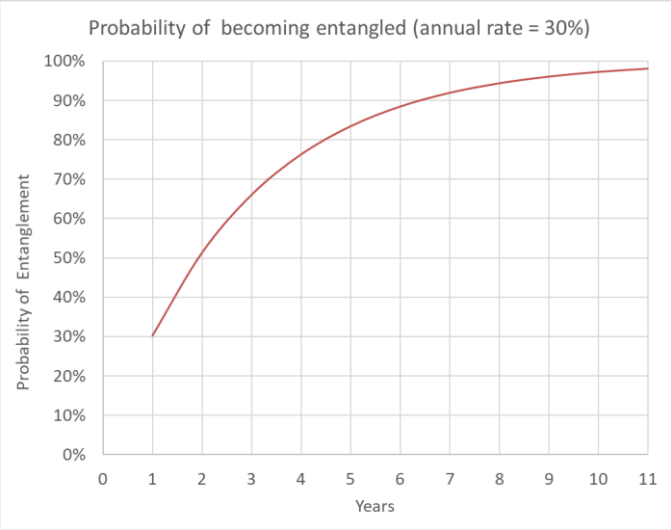


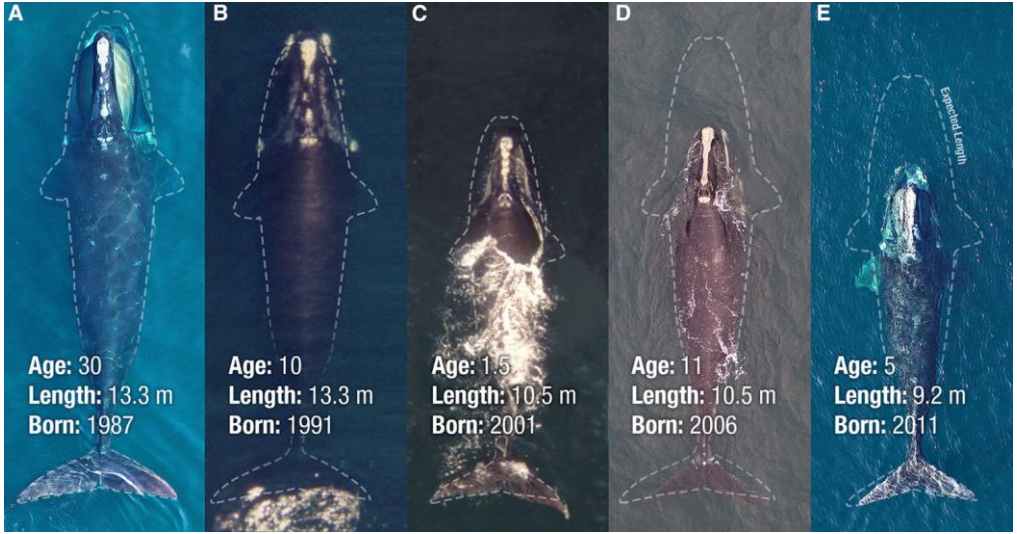
Future *Calanus* distribution



Reygondeau et al. 2010

NARW Stress and Energetic Costs of Entanglement





- Entanglement chronic- ~30% show fresh entanglement injury annually
- NARW increasingly stunted through entanglement stress -> less fecund
- Capital breeder- must acquire sufficient resources to produce calves
  - Breeding interval currently doubled from 4 to 8 years between calves, and most animal die before 40
  - Approx lifetime calving potential dropped from >15 to <4

Hamilton, P.K. et al 2022. Maintenance of the North Atlantic Right Whale Catalog . Anderson Cabot Center for Ocean Life, New England Aquarium. Submitted to NOAA/NMFS/NEFSC Contract No. 1305M2-18-P-NFFM-0108. https://www.narwc.org/narw-catalog-reports.html
Stewart, J.D., et al. 2021. Decreasing body lengths in North Atlantic right whales. 31(14): 3174-3179. e3173.
Stewart, J.D., et al. 2022. Larger females have more calves: influence of maternal body length on fecundity in North Atlantic right whales. MEPS 689: 179-189.
Pettis et al 2022NARW report card 2022 https://www.narwc.org/uploads/1/1/6/6/116623219/2022reportcardfinal.pdf

Potential conservation concerns with wind development

General threat categories

1. Vessel Strikes
2. Entanglement
    a. Fisheries Displacement
    b. Increased pot/trap fishing?
    c. Ghost gear on cables/pilings
    d. Floating wind structures?
3. Noise
4. Ecosystem change
    a. Predation
    b. Habitat alterations
    c. Oceanographic processes

- Evaluated at project level and above scaled up across many projects
- NMFS PET PVA considers 1-4 in general but specifics require more development

Offshore Wind Energy Development and North Atlantic Right Whale Foraging Ecology

1

Ocean Circulation

Wind energy development affects both horizontal and vertical ocean circulation in the area

2

Zooplankton

Ocean circulation impacts zooplankton abundance, density, energy content, and distribution in foraging habitat

3

Health

Changes in zooplankton communities affect body condition and health

4

Population

Changes in body condition affect female calving rates

NOAA FISHERIES

NOAA Fisheries Approach

Build Capacity

Best available science

- Acknowledge and plan for uncertainty
- Expert elicitation
- Short term- oceanographic modeling
- Long term- adapt surveys, evaluate impacts of OSW
- Build Decision Support Tools

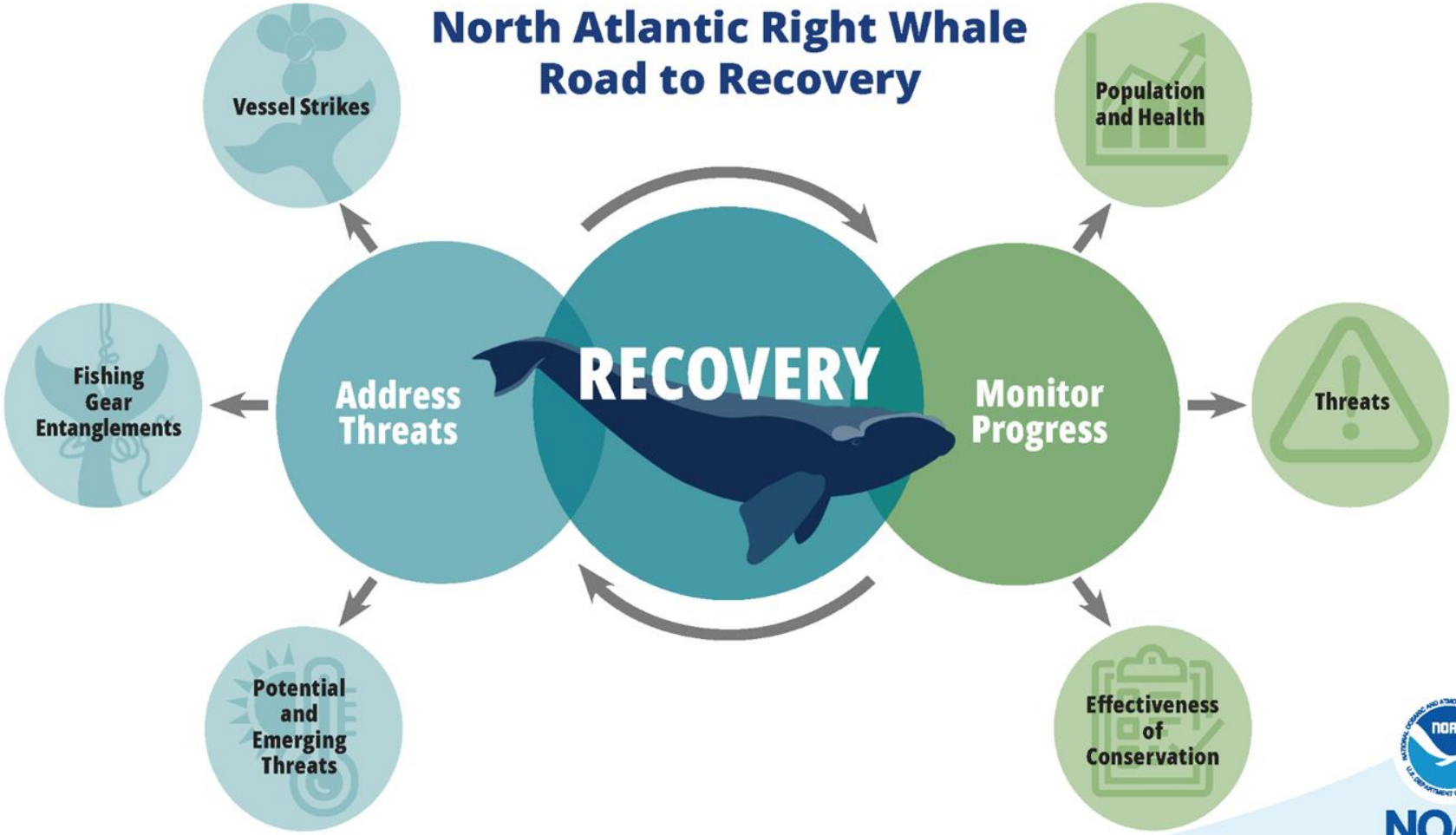
Management- MMPA and ESA (See 02.05.03 Nick Sisson)

- Develop biological opinions (ESA) and issue requested MMPA incidental take authorizations (MMPA; requires public comment)
- Evaluate potential impacts from incidental take
- Develop and require mitigation, monitoring, and reporting strategies to avoid and minimize potential impacts

Work with Partner Agencies- BOEM/DOI, DOE and others

- NMFS is cooperating agency on wind project EISs under NEPA

NOAA FISHERIES


North Atlantic Right Whale
Road to Recovery
Vessel Strikes
Population and Health
Fishing Gear Entanglements
Address Threats
RECOVERY
Monitor Progress
Threats
Potential and Emerging Threats
Effectiveness of Conservation
NOAA
FISHERIES