North Atlantic Right Whale
(Eubalaena glacialis)

5-Year Review:
Summary and Evaluation

National Marine Fisheries Service
Greater Atlantic Regional Office
Gloucester, MA

November 2022

5-YEAR REVIEW

Species reviewed: North Atlantic right whale (*Eubalaena glacialis*)

Cover photo image collected under Marine Mammal Protection Act Research Permit #17355
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Image of North Atlantic right whale #2215 (AKA Aries)

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LIST OF ACRONYMS

ALWTRP	Atlantic Large Whale Take Reduction Plan
ALWTRT	Atlantic Large Whale Take Reduction Team
BOEM	Bureau of Ocean Energy Management
DFO	Fisheries and Oceans Canada
DMA	Dynamic Management Area
DST	Decision Support Tool
ESA	Endangered Species Act
FR	Federal Register
IHA	Incidental Harassment Authorization
MMPA	Marine Mammal Protection Act
MRA	Massachusetts Restricted Area
NARW	North Atlantic Right Whale
NEIT	Northeast Implementation Team
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
ONS	Ocean Noise Strategy
PAM	Passive Acoustic Modeling
PBR	Potential Biological Removal
PVA	Population Viability Analysis
SAR	Stock Assessment Report
SARA	Species at Risk Act
SEIT	Southeast Implementation Team
SMA	Seasonal Management Area
TC	Transport Canada
UME	Unusual Mortality Event
USACE	U.S. Army Corps of Engineer

5-YEAR REVIEW
North Atlantic right whale/*Eubalaena glacialis*

1.0 GENERAL INFORMATION

1.1 Reviewers

Lead Regional Office:
Greater Atlantic Regional Fisheries Office – Jennifer Anderson, Assistant Regional Administrator for Protected Resources, 978-281-9226

Cooperating Regional Office:
Southeast Regional Office – David Bernhart, Assistant Regional Administrator for Protected Resources, 727-824-5312

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Northeast Fisheries Science Center – Sean Hayes, Protected Species Branch Chief, 508-495-2347
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Headquarters Office:
Office of Protected Resources – Shannon Bettridge, Marine Mammal and Sea Turtle Conservation Division Chief, 301-427-8402

1.2 Methodology Used to Complete the Review

The Greater Atlantic Regional Fisheries Office led the 5-year review and requested review by the Northeast Fisheries Science Center, Office of Protected Resources, Southeast Regional Office, and Southeast Fisheries Science Center. The Recovery Plan for the North Atlantic Right Whale (*Eubalaena glacialis*), Marine Mammal Stock Assessment Reports, the North Atlantic Right Whale Scenario Planning Summary Report, and a review of the scientific literature by the NOAA Central library provided the information in this document. In addition, North Atlantic right whales are identified as one of NMFS' Species in the Spotlight, and the associated Priority Action Plan for 2021-2025 has informed this review. The literature review included publications related to the North Atlantic right whale made available through October 2022. We published a notification in the *Federal Register* on February 3, 2022 (87 FR 6146) initiating this review and requesting the submission of relevant scientific literature. We received 13 public comments during the 90 day comment period and have incorporated relevant literature provided through that process into this review. A draft of this 5-year review was shared with experts at the Northeast Fisheries Science Center, Southeast Regional Office, Southeast Fisheries Science Center, and Office of Protected Resources for review. The final 5-year review reflects the feedback we received from these offices.

1.3 Background

1.3.1 FR Notice Citation Announcing Initiation of this Review

87 FR 6146, February 2, 2022 – Endangered and Threatened Species; Initiation of a 5-Year Review for North Atlantic Right Whale

1.3.2 Listing History

Original Listing
FR notice: 35 FR 18319
Date listed: December 2, 1970
Entity listed: Northern right whale (*Eubalaena spp.*)
Classification: Endangered (Under the Endangered Species Conservation Act of 1969)

Revised Listing
FR notice: 73 FR 12024
Date listed: March 6, 2008
Entity listed: North Atlantic right whale (*Eubalaena glacialis*)
Classification: Endangered

1.3.3 Associated Rulemakings

Atlantic Large Whale Take Reduction Plan: 62 FR 39157, July 22, 1997; Taking of Marine Mammals Incidental to Commercial Fishing Operations; Atlantic Large Whale Take Reduction Plan Regulations and subsequent amendments. See 50 CFR 229.32.

Federal Regulations Governing the Approach to North Atlantic Right Whales: 69 FR 69536, November 30, 2004. See 50 CFR 222.32 and 217.12.

Speed Restrictions to Reduce the Threat of Ship Collisions with North Atlantic Right Whales: 73 FR 60173, October 10, 2008. Endangered Fish and Wildlife; Speed Restrictions to Reduce the Threat of Ship Collisions with North Atlantic Right Whales and subsequent amendments. See 50 CFR 224.105.

Revised Critical Habitat Designation: 81 FR 4838, January 27, 2016. Endangered and Threatened Species; Critical Habitat for Endangered North Atlantic Right Whale. See 50 CFR 226.203.

1.3.4 Review History

Review of the Status of the Right Whales in the North Atlantic and North Pacific Oceans. December 2006. Available at: https://www.fisheries.noaa.gov/resource/document/review-status-right-whales-north-atlantic-and-north-pacific-oceans Classification recommendation: Endangered

North Atlantic Right Whale (*Eubalaena glacialis*) 5-Year Review: Summary and Evaluation. August 2012. Available at: https://www.fisheries.noaa.gov/resource/document/north-atlantic-right-whale-eubalaena-glacialis-5-year-review-2012 Classification recommendation: Endangered

North Atlantic Right Whale (*Eubalaena glacialis*) 5-Year Review: Summary and Evaluation. October 2017. Available at: https://www.fisheries.noaa.gov/resource/document/5-year-review-north-atlantic-right-whale-eubalaena-glacialis Classification recommendation: Endangered

1.3.5 Species' Recovery Priority Number at Start of 5-Year Review

North Atlantic right whales have a species' recovery priority number of 1C based on the criteria in the updated Recovery Priority Guidelines and revisions (84 Fed. Reg. 18243, April 30, 2019) (NMFS 2022). These guidelines prioritize recovery implementation based on: a) demographic risk; b) recovery potential, which includes how well the threats are known, U.S. jurisdiction over management and protective actions, and certainty that the actions will be effective; and c) the potential for economic conflicts while implementing recovery actions. The Priority Number of 1C for North Atlantic right whales reflects a high demographic risk because of rapid population decline, habitat destruction, and continuing threats to recovery. This priority is given to species whose limiting factors and threats are well understood, and when the needed management actions are known (e.g., a recovery plan is in place) and have a high probability of success, but are also in conflict with economic activities.

North Atlantic right whale recovery requires a reduction in serious injuries and mortalities stemming from anthropogenic activities such as commercial fishing, vessel traffic, threats associated with emerging industries (e.g., wind energy, aquaculture), and impacts from climate change and increasing underwater noise. Recovery will also require increased collaboration with partners on various recovery techniques such as species monitoring efforts. In 2016, NMFS launched the Species in the Spotlight initiative to highlight conservation actions to aid in the recovery of priority species. North Atlantic right whales were included in the initiative in 2019 (NMFS 2019). The North Atlantic Right Whale Priority Action Plan for 2021-2025 can be found at https://www.fisheries.noaa.gov/resource/document/species-spotlight-priority-actions-2021-2025-north-atlantic-right-whale.

1.3.6 Recovery Plan

Name of plan or outline: Recovery Plan for the North Atlantic Right Whale (*Eubalaena glacialis*), Revision. Available at: https://www.fisheries.noaa.gov/resource/document/recovery-plan-north-atlantic-right-whale-eubalaena-glacialis
Date issued: May 2005
Dates of previous revisions, if applicable: December 1991

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) policy

2.1.1 Is the species under review a vertebrate?

__**X**_**Yes**, *go to section 2.1.2*
_____**No**, *go to section 2.2*

2.1.2 Is the species under review listed as a DPS?

_____**Yes**, *give date and go to section 2.1.3.1*
_**X**__**No**, *go to section 2.1.4*

2.1.3 Was the DPS listed prior to 1996?

_____**Yes**, *go to section 2.1.2*
_____**No**, *go to section 2.2*

2.1.3.1 Prior to this 5-year review, was the DPS classification reviewed to ensure it meets the 1996 policy standards?

_____**Yes**, *provide citation and go to section 2.1.4*
_____**No**, *go to section 2.1.3.2*

2.1.3.2 Does the DPS listing meet the discreteness and significance elements of the 1996 DPS policy?

_____**Yes**, *discuss how it meets the DPS policy, and go to section 2.1.4*
_____**No**, *discuss how it is not consistent with the DPS policy and consider the 5-year review completed. Go to section 2.4., Synthesis.*

2.1.4 Is there relevant new information for this species regarding the application of the DPS policy?

_____**Yes**, *provide citation(s) and a brief summary of the new information; explain how this new information affects our understanding of the species and/or the need to list as DPSs. This may be reflected in section 4.0, Recommendations for Future Actions. If the DPS listing remains valid, go to section 2.2, Recovery Criteria. If the new information indicates the DPS listing is no longer valid, consider the 5-year review completed, and go to section 2.4, Synthesis.*
__**X**__**No**, *go to section 2.2., Recovery Criteria*

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan containing objective, measurable criteria?

_X__ **Yes,** *continue to section 2.2.2.*
____ **No,** *consider recommending development of a recovery plan or recovery criteria in section IV, Recommendations for Future Actions, and go to section 3.4.1, Updated Information and Current Species Status.*

2.2.2 Adequacy of recovery criteria.

2.2.2.1 Do the recovery criteria reflect the best available and most up-to date information on the biology of the species and its habitat?

__X_Yes, *go to section 2.2.2.2*
_____No, *go to section 2.2.3, and note why these criteria do not reflect the best available information. Consider developing recommendations for revising recovery criteria in section 4.0.*

2.2.2.2 Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria (and is there no new information to consider regarding existing or new threats)?

__X_Yes, *go to section 2.2.3*
_____No, *go to section 2.2.3, and note which factors do not have corresponding criteria. Consider developing recommendations for revising recovery criteria in section 4.0.*

2.2.3 List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information.

North Atlantic right whales may be considered for reclassifying to threatened when all of the following have been met:

1) The population ecology (range, distribution, age structure, and gender ratios, etc.) and vital rates (age-specific survival, age-specific reproduction, and lifetime reproductive success) of right whales are indicative of an increasing population;

Although trends in population abundance are an important measure of a population's viability, a population can increase in abundance and still face very high risks of extinction because other aspects of its population ecology are unstable. To avoid reaching an erroneous conclusion based on changes in the population size of right whales, this criterion includes multiple measures that would indicate a right whale population that is growing and that the growth will probably be sustained.

This criterion has not been met. Please see sections 2.3.1.2, 2.3.1.3, 2.3.1.5, 2.3.1.6, and 2.3.1.7 of this document for further information.

2) The population has increased for a period of 35 years at an average rate of increase equal to or greater than 2% per year;

A 2% increase is generally accepted as the minimum detectable rate of growth of a long lived, slow-growing large mammal. Thirty-five years is the estimated amount of time it would take for the right whale population to double in size if the population grows at an average of 2 percent per year.

This criterion has not been met. Please see section 2.3.1.2 of this document for further information.

3) None of the known threats to North Atlantic right whales (summarized in the five listing factors) are known to limit the population's growth rate.

Listing/Recovery Factor A: *The Present or Threatened Destruction, Modification or Curtailment of a Species Habitat or Range*

In order to ensure the long-term recovery needs of the North Atlantic right whale and provide adequate assurance of population stability, threats to right whale habitat or range must be reduced or removed. Habitat degradation may occur from oil spills, noise pollution from shipping or oil and gas development, dredging, and contaminants.

- *Habitat degradation from oil spills, noise pollution, dredging and contaminants are not limiting the recovery of the species.*

This criterion has not been met. Please see section 2.3.2.1 of this document for further information. Emerging potential threats to right whale habitat include those associated with wind energy development, aquaculture development, and climate change.

Listing/Recovery Factor B: *Overutilization for Commercial, Recreational, Scientific, or Educational Purposes*

There are no data at this time to indicate that these issues are limiting the recovery of the North Atlantic right whale. However, prior to downlisting, the effects of commercial harvest, research activities, and recreational and educational activities such as whale-watching must be considered.

- *Recreational and educational activities are adequately regulated by the permitting process.*
- *No right whales are allowed to be harvested for commercial purposes.*

This criterion has been met. Please see section 2.3.2.2 of this document for further information.

Listing/Recovery Factor C: *Disease or Predation*

At this time, there are no data indicating that predation is limiting right whale recovery. However, results of body condition analysis and the occurrence of skin lesions on North Atlantic right whales may be indicative of health issues within the population.

> *• Disease is not appreciably affecting the recovery of the species and is not likely to do so in the foreseeable future.*

This criterion has not been met. Please see section 2.3.2.3 of this document for further information.

Listing/Recovery Factor D: *The Inadequacy of Existing Regulatory Mechanisms*

Regulations may be insufficient to adequately protect the population. In particular, it may be necessary to enhance existing regulations, or promulgate new regulations to reduce or eliminate the threat of ship strikes and fishing gear entanglement.

> *• Adequate regulations or other means to minimize ship strikes are in place and being implemented and the criterion set forth under Factor E is met.*
>
> *• Adequate regulations, gear, or other means to minimize entanglement in fishing gear exist and are being implemented and the criterion set forth under Factor E is met.*

This criterion has not been met. Please see section 2.3.2.4 of this document for further information.

Listing/Recovery Factor E: *Other Natural or Manmade Factors Affecting Its Continued Existence*

No natural factors are known to be limiting the recovery of North Atlantic right whales at this time. The most significant threat to North Atlantic right whale recovery remains human-related mortality, most notably, ship collisions and entanglement in fishing gear. Additionally, other factors may be identified as direct or indirect threats in the future, such as habitat degradation, coastal development, undersea noise, contaminant loads (covered under Factors A-D).

> *• Human-caused mortality and serious injury from ship strikes and fishery interactions result in a level of mortality considered to be biologically insignificant.*

This criterion has not been met. Please see section 2.3.2.5 of this document for further information.

To support and confirm a reclassification determination generated by the above criteria, the following criteria must also be met:

4) Given current and projected threats and environmental conditions, the right whale population has no more than a 1% chance of quasi-extinction in 100 years.

Criteria, i.e., population numbers, structure and trends, have not yet been developed; however, a top priority in the recovery action narrative of this plan is to conduct analyses to derive such criteria. These analyses should expressly indicate the assumptions, goals, uncertainties and approximations of the model used, and include sensitivity analyses of parameters and assumptions. In addition to being useful in examining the population viability analysis, sensitivity analyses can be useful in management of the species, and subsequent revisions or updates of this recovery plan. Finally, the analysis should be peer reviewed before being accepted as criteria.

This criterion has not been met. Please see section 2.3.2.1 of this document for further information.

If you answered yes to both 2.2.2.1. and 2.2.2.2., evaluating whether recovery and/or downlisting criteria have been met in section 2.2.3 may be sufficient to evaluate the species listing classification and no further analysis may be necessary; *go to section 2.4., Synthesis.*

If you answered no to either 2.2.2.1 or 2.2.2.2, *continue to section 2.3. , Updated Information and Current Species Status, and consider adding updating of recovery criteria in section 4.0, Recommendations for Future Actions.*

2.3 Updated Information and Current Species Status

Biology and life history information along with information included in the five factor analysis of this review was originally summarized in the Recovery Plan and updated in subsequent 5-year reviews in 2012 and 2017. Habitat needs were reviewed and described in the 2016 critical habitat designation and updated in the 2017 5-year status review. Sections 2.3.1 and 2.3.2 provide updates from new information that has become available since the 2017 5-year status review.

2.3.1 Biology and Habitat

2.3.1.1 New information on the species' biology and life history:

Life history studies continue to take place in areas where North Atlantic right whales have been found historically, such as Cape Cod Bay and the Bay of Fundy (Mayo et al. 2018; Root-Gutteridge et al. 2018; van der Hoop et al. 2019). However, studies also focus on behavior between mother-calf pairs on the calving grounds in waters off of coastal Georgia and Florida (Cusano et al. 2018; Dombroski et al. 2021; Parks et al. 2019a; Parks et al. 2019b). Studies have also been conducted in the Gulf of St. Lawrence and southern New England, which are areas more recently recognized as new habitat (Quintana-Rizzo et al. 2021; Simard et al. 2019).

The effects of energetic stress related to foraging, reproduction, and chronic entanglement in fishing gear have been examined through studies of glucocortisol, progesterone and testosterone levels in North Atlantic right whales (Ajo et al. 2018; Burgess et al. 2017; Burgess et al. 2018; Corkeron et al. 2017; Graham et al. 2021; Hunt et al. 2017a; Hunt et al. 2017b; Hunt et al. 2018;

Lanyon and Burgess 2019; Rolland et al. 2017). Across life stages, adult reproductive females have the highest levels of glucocortisol and progesterone which are elevated during pregnancy, while adult males and females record the highest levels of testosterone (Burgess et al. 2017, Burgess et al. 2018; Graham et al. 2021; Hunt et al. 2017a; Hunt et al. 2017b). Whales known to have suffered from chronic stressors (e.g., entanglement) have higher glucocortisol levels than those suffering from acute problems such as vessel strikes (Ajo et al. 2018). Over time, entanglement results in high drag, lower blubber stores, reduced reproductive success, and behavior changes (Lysiak et al. 2018; Reed et al. 2022; van der Hoop et al. 2016a; van der Hoop et al. 2016b). Wu et al. (2021) found that the drag coefficient for North Atlantic right whales at normal swimming speeds without entanglements was approximately twice that of other cetaceans. Van der Hoop et al. (2017) examined different entanglement cases with varying gear configurations and sizes to help understand the severity of each to provide a better understanding of when disentanglement was required to save a whale.

The strengths and limitations of North Atlantic right whale sensory systems, along with the associated life history stage of the individual, influence behavior both on the foraging and calving grounds. North Atlantic right whales are visual foragers, sensing copepods, their primary prey, by seeking out dense patches of copepods rather than individuals using the contrast of the patch with background light at various depths (Cronin et al. 2017; Fasick et al. 2017). They lack cone photoreceptors and rely on rods with an absorbance maximum of 493 nanometers (Fasick et al. 2017). Their sense of hearing, vital for transmitting and receiving acoustic communication, helps North Atlantic right whales refine and perfect calls throughout their lifetime, with no fixation over any particular life stage after initially high increases in control of calls as calves (Root-Gutteridge et al. 2018). North Atlantic right whales produce the majority of their calls within the 50-600 Hz range, and they are short in duration; however, there is variation in their acoustic behavior between social contexts and among behaviors (Matthews and Parks 2021). Lactating females on the calving grounds spend up to 80 percent of their time within 3.5 meters of the surface, mostly at rest, whereas non-lactating females who continue to migrate to the calving ground spend more time at depth, continuing to forage (Cusano et al. 2018; Dombroski et al. 2021). North Atlantic right whales must target high density prey patches to justify the energy expenditure of foraging. Van der Hoop et al. (2019) examined the foraging rates of North Atlantic right whales during ram filtration and found that they filter large rates of water ($1.4m^2/s$, on average) at slow speed to reduce drag, resulting in the consumption of >60,000 copepods per minute based on previously determined density thresholds. Murphy et al. (2022) found that vibrissae, located on both the upper and lower jaws of North Atlantic right whales and previously thought to be vestigial, are scaled to the size of copepods and may help individuals localize prey while swimming through a patch.

2.3.1.2 Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends:

While historical pre-exploitation North Atlantic right whale abundance remains difficult to estimate, synthesis of genomic research, catch records, whaling effort, and availability of foraging habitat over time continues to point to a population size between 10,000 and 20,000 individuals (Laist 2017).

The methods described in Pace et al. (2017), which uses a state-space model of the sighting histories of individual whales identified using photo-identification techniques, continue to be considered the best available to generate estimates of North Atlantic right whale abundance (Hammond et al. 2021). The draft 2022 North Atlantic right whale Stock Assessment Report (SAR) reported 338 individuals as the best estimate of population size using the Pace model (Hayes et al. in prep). Examination of annual abundance estimates suggests that there was a 100 percent chance that abundance declined from 2011 to 2020 when the final estimate was 338 individuals. The overall abundance decline between 2011 and 2020 was 23.5 percent. North Atlantic right whale productivity over the past several decades has been highly variable. From 1990-2020, at least 481 calves were born into the population (Hayes et al. in prep). The number of calves born annually over that period ranged from 0 to 39 and averaged 15, but included many years with low birth rates; for example, during the winter of 2017-2018, no calves were born (Hayes et al. in prep). Based on the most recent population estimate, there are approximately 68 females known to have calved that are likely (>50 percent probability) still alive (Hayes et al. in prep).

Other methods are becoming increasingly available to supplement abundance information. Gowan et al. (2021) demonstrated how spatial capture-recapture modeling could be used in the southeast winter calving grounds to provide similar estimates of abundance to photo-ID and mark-recapture methods. Crum et al. (2021) compared spatial capture-recapture modeling to distance sampling using aerial survey data in the southeast, providing evidence that spatial capture-recapture may be the more robust method of the two because it better accounts for uncertainty due to patchy distribution of whales. Photo-ID analysis is also improving to support abundance modeling. In 2015, a data science challenge to automate identification of North Atlantic right whales using photos and artificial intelligence was hosted by NOAA on Kaggle, a web-based data science platform. The challenge led to several methods that applied deep learning models in the convolutional neural network family for automated identification, making identification a faster and more efficient process (Kabani and El-Sakka 2016; Khan et al. 2022; Bogucki et al. 2019). The winning algorithms were able to identify individuals with 87 percent accuracy, and have since been updated and expanded into a web-based platform that can be used by biologists with no machine learning expertise to identify North Atlantic and southern right whales and collaborate among conservation partners (Khan et al. 2022). A study that compared photo-ID based estimates and genetic pedigree based estimates found that there are likely only very few individuals who have not been photo-identified, and that photo-ID continues to be a highly accurate way to estimate abundance (Fitzgerald 2018).

Pace et al. (2021) found that observed carcasses detected via photo-ID only accounted for 36 percent of the total estimated mortalities between 1990 and 2017; unobserved carcasses are known as cryptic mortalities. While Pace et al. (2021) cautioned against using carcass counts for a single year to determine the total mortality rate for that year, they did indicate that increased surveillance and monitoring efforts do likely decrease the amount of mortalities that remain undetected and provide a more accurate mortality estimate. This study also suggested that mortalities from entanglement may be more likely to be cryptic (Pace et al. 2021), but further research on this matter is needed (Hayes et al. in prep). For calves and deceased whales, genetic identification is more effective than photo-ID because identifying features may not have stabilized for the former or may be decomposed for the latter (Hamilton et al. 2022). Additionally, while mother and calf pairs were previously thought to stay together through a calf's first year, Hamilton et al. (2022) found that some calves wean earlier and sightings of mothers alone on the feeding grounds may not be indicative of a deceased calf.

The steady population decline first highlighted in Pace et al. (2017) between 2010 and 2015 and exacerbated by a higher proportion of mortalities in 2017 led to the declaration of an Unusual Mortality Event (UME) under the Marine Mammal Protection Act (MMPA), extending across the species' range. Following the 17 mortalities included in the UME in 2017, three were documented in 2018, ten in 2019, three in 2020, and one in 2021. To date in 2022, no mortalities have been documented. Serious injury designations, which are assigned through a detailed assessment process to whales likely to die from their injuries (i.e., most often entanglements or vessel strikes), and morbidities, which are assigned through a similar process to North Atlantic right whales likely to have sublethal injuries or illness, are now also included in the UME, bringing the total number of North Atlantic right whales included to 91. Preliminary findings from necropsies support "human interactions" as the primary cause of death for the majority of UME mortality cases. There has been very little evidence of North Atlantic right whale mortality due to natural causes, aside from perinates and neonates (Moore et al. 2021; Sharp et al. 2019). The NMFS North Atlantic right whale UME core team has continued to investigate North Atlantic right whale mortalities and serious injuries and assess North Atlantic right whale health at the population and individual level. More information about efforts underway by the North Atlantic right whale UME core team can be found in Section 2.3.1.7. Due to the trans-boundary nature of mortalities during the UME, Canada has worked in collaboration with the United States on understanding and reducing mortalities and serious injuries from the initiation of the UME to the present (Bourque et al. 2020; Daoust et al. 2018; Fisheries and Oceans Canada 2021).

The North Atlantic right whale Implementation Team's Population Evaluation Tool Subgroup is developing a population viability analysis (PVA) to aid in planning and assessing recovery efforts. The PVA will forecast the future population trajectory under perceived current and future threats and can be used to examine effects of mitigation measures that might be used to recover North Atlantic right whales. The PVA will allow NMFS to examine how mortality and reproduction influence population recovery under multiple dimensions of uncertainty. This work expands projection efforts that supported the Conservation Framework and associated efforts (see Entanglement in Commercial Fishing Gear section below) by incorporating more nuanced demographic/population modeling (Linden 2021).

2.3.1.3 Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):

The complete mitochondrial genome of the North Atlantic right whale became publicly available in 2018 (Allwood et al. 2018). Despite low levels of genetic diversity in the population, measures of fitness and inbreeding using microsatellite loci found low variation in survival between years, some variation and lower levels of fitness in fecundity, and a low likelihood that inbreeding is affecting variation in survival and fecundity (Laist 2017; Radvan 2019). Low variation across individuals was also identified for genes that play a role in fertilization; however, evidence suggests that there may be some bias in mate choice for mates with similar genotypes within loci (Springate 2017). Wolf et al. (2022) found that North Atlantic right whales had a relatively high level of heterozygosity (0.14 percent) compared to other baleen whale species, and that, combined with increased inbreeding over time, could increase the risk of extinction disproportionally because the potential number of deleterious mutations could become fixed more rapidly.

Frasier et al. (2022) identified some differentiation of both nuclear DNA and mitochondrial DNA and many shared microsatellite alleles and mitochondrial DNA haplotypes between historical specimens of eastern North Atlantic right whales and the contemporary western population. Although this creates a challenge for determining whether the historical western North Atlantic and eastern North Atlantic populations were separate or one single population, they hypothesize that there were two unique breeding populations with some limited degree of gene flow (Frasier et al. 2022).

2.3.1.4 Taxonomic classification or changes in nomenclature:

There is no change in taxonomic classification nor are there changes in nomenclature. Northern right whales have been listed as endangered under the Endangered Species Act (ESA) since its passage in 1973. At the time of its listing, Northern right whales included right whales in both the North Pacific (*Eubalaena japonica*) and North Atlantic (*Eubalaena glacialis*). Genetic data provided support for distinguishing three right whale lineages as separate phylogenetic species (Rosenbaum et al. 2000), and three separate species of right whale are now recognized:

1. The North Atlantic right whale (*Eubalaena glacialis*), ranging in the North Atlantic Ocean
2. The North Pacific right whale (*Eubalaena japonica*), ranging in the North Pacific Ocean
3. The southern right whale (*Eubalaena australis*), ranging throughout the Southern Hemisphere

The North Atlantic right whale and the North Pacific right whale were listed as distinct species under the ESA in 2008 (73 FR12024, March 6, 2008).

In 2017, a neurocranium fossil previously attributed to a sister group of *Eubalaena* called *Balaena belgica* was re-examined and attributed to a new species called *Eubalaena ianitrix*, thought to be the direct ancestor of *Eubalaena glacialis* (Bisconti et al. 2017).

2.3.1.5 Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, etc.), or historic range (e.g. corrections to the historical range, change in distribution of the species' within its historic range, etc.):

Archeological studies have furthered understanding of the historic distribution and catch history of North Atlantic right whales using remnants of historic whaling. Bone samples from the Cantabrian Coast and Strait of Gibraltar regions were DNA sequenced in 2018, confirming North Atlantic right whales as the main target species for Basque whaling in Spain between the 13th and 18th centuries and potentially as a target species for a forgotten whaling industry in the Roman Empire (Rey-Iglesia et al. 2018; Rodrigues et al. 2018). These discoveries indicate that the historic range of North Atlantic right whales encompassed most of the Spanish coast, and likely included calving grounds in the Mediterranean Sea (Rey-Iglesia et al. 2018; Rodrigues et al. 2018). North Atlantic right whales were also hunted along the coast of Ireland between the 13th and 20th centuries, and sighted in Ireland as late as 1987 (O'Callaghan 2019). Bone fragments discovered in the Netherlands and Belgium were also attributed to North Atlantic right whales, and were most often found near sites of historic castles dating to the High Medieval Ages (1000-1250), providing evidence that whale meat was considered culturally elite during this period (van den Hurk et al. 2020). Today, North Atlantic right whales are found primarily in the western North Atlantic. However, periodic sightings of North Atlantic right whales in the eastern Atlantic do occur, most recently in July 2019 when a well known male North Atlantic right whale was sighted off the coast of Brittany and December 2020 when a calf was filmed swimming in waters off the coast of the Canary Islands in western Africa (Hayes et al. in prep, Pettis et al. 2021). The calf has not been spotted since (Pettis et al. 2021; https://www.fisheries.noaa.gov/national/endangered-species-conservation/north-atlantic-right-whale-calving-season-2021).

In the western North Atlantic, North Atlantic right whales range primarily along the North American coast from calving grounds in coastal waters of the southeastern U.S. to feeding grounds in New England waters and the Canadian Bay of Fundy, Scotian Shelf, and Gulf of St. Lawrence (Hayes et al. in prep). Prior to 2010, data revealed five major habitats or congregation areas for North Atlantic right whales in the western North Atlantic: the Georgia-North Florida coast; the Great South Channel and northern edge of Georges Bank; Massachusetts Bay and Eastern Cape Cod Bay; the Bay of Fundy; and the southeastern Scotian Shelf (Winn et al. 1986). The Georgia-Florida southeast region is used in winter as the only known calving area, and the other four areas were recognized as important feeding areas. In 2013, springtime aerial surveys of the Great South Channel failed to locate proportions of North Atlantic right whales similar to those found in the area in previous years (Khan et al. 2014). Around this time sightings also drastically decreased in the Bay of Fundy, Roseway Basin, and on the winter calving grounds, which previously saw individuals across life stages migrating to the area but more recently indicates a much higher proportion of reproductively active females over all other life stages (Davies et al. 2019; Davis et al. 2017; Gowan et al. 2019; Krzystan et al. 2018). Due to these decreases in sightings, NMFS diverted aerial survey efforts to other areas to attempt to discover other potential foraging habitats (Cole et al. 2020). During the spring of 2015, over 100 North Atlantic right whales were found in the offshore waters of the Gulf of St. Lawrence (Cole et al. 2020). The area was confirmed as a new summer/fall foraging habitat after surveys between 2016 and 2019 indicated similar findings (Cole et al. 2020; Crowe et al. 2021; Simard et al. 2019). In recent years, approximately 40 percent of the population has been observed using the Gulf of St. Lawrence as a summer foraging habitat, with over 100 individuals sighted each year in the region since 2016 (Crowe et al. 2021). Sightings also significantly increased in a new habitat south and southeast of Nantucket Island and in the known habitat of Cape Cod Bay, both during the expected late winter and early spring foraging period and during the 'off season' period of summer and fall (Charif et al. 2020; Ganley et al. 2019; Mayo et al. 2018; Moore et al. 2021; O'Brien et al. 2022; Quintana-Rizzo et al. 2021).

Beginning in 2016, efforts to aggregate all available and appropriate survey data resulted in monthly predictive habitat models along the U.S. east coast for North Atlantic right whales and several other cetacean species (Roberts et al. 2016). These habitat-informed density models are generated by the Duke University Marine Geospatial Ecology Laboratory and offer the most comprehensive evaluation of North Atlantic right whale density along the east coast over time, including separate models for the periods before and after the documented species distribution shift in 2010 and new updates to the models each year. It is worth noting that not all North Atlantic right whale surveys or datasets are appropriate for use in this type of quantitative model. This density modeling effort requires survey data collected using line-transect survey protocols. The Roberts et al. models are not able to incorporate opportunistic sightings, non-line transect survey data, or data from directed survey efforts (i.e., those directed at known aggregations of North Atlantic right whales).

Other methods of detection helped to document this distribution shift and the technology used in these methods has improved over time. Passive acoustic monitoring (PAM) suggested a shift to a year round consistent presence of North Atlantic right whales in the Mid-Atlantic post-2010, including year round detections in the New York Bight with the highest presence between late February and mid-May in the shelf zone and nearshore habitat (Davis et al. 2017; Estabrook et al. 2019; Muirhead et al. 2018; Zoidis et al. 2021). Long-term PAM indicates that the mean daily occurrence of North Atlantic right whales in the Gulf of St. Lawrence quadrupled after 2015 in comparison to 2011-2014 and that the mean percent presence of North Atlantic right whales in Cape Cod Bay was higher between 2010 and 2013 than between 2007 and 2010 for all months of the year (Charif et al. 2020; Simard et al. 2019). Slocum gliders equipped with digital acoustic monitoring instruments/low-frequency detection and classification systems were used to determine presence of North Atlantic right whales in near real-time (Baumgartner et al. 2020; Kowarski et al. 2020; Johnson et al. 2022). Deep learning using convolutional neural networks has improved the efficiency of analysis of acoustic detections of North Atlantic right whale upcalls (Esfahanian et al. 2017; Ibrahim et al. 2018a; Ibrahim et al. 2018b; Ibrahim et al. 2020; Ibrahim et al. 2021; Padovese et al. 2021; Shiu et al. 2020; Vickers et al. 2021). Other techniques to analyze acoustic data have also been explored in recent years, such as random forest classification and gradient boosting modeling, both of which can complement neural network modeling (Pegg et al. 2021; Salin and Ponomarenko 2021).

One issue for acoustic detections in the past has been localization uncertainty; however, Johnson et al. (2020) demonstrated that the uncertainty for acoustic detections becomes equivalent to visual sightings within 24-48 hours and that both methods are beneficial for understanding species distribution and dynamic management approaches. Johnson et al. (2022) compared North Atlantic right whale call detections using the same digital acoustic monitoring instrument/low-frequency detection and classification system on moored buoys and slocum gliders and determined detection ranges for both, reducing uncertainty and making both methods more reliable for dynamic management methods. Gervaise et al. (2021) determined the optimal placement of acoustic detection systems to best localize North Atlantic right whales in a noisy environment.

Work continues to be done to refine acoustic detection systems and the models used to generate accurate abundance and distribution estimates from these and other survey systems, and to evaluate the effectiveness of different types of systems (Baumgartner et al. 2019; Baumgartner et al. 2021; Palmer et al. 2022; Roberts and Halpin 2021). Despite these advancements in acoustic detection, calling rates between mother-calf pairs on the calving grounds stayed low over a several year period, indicating that visual survey methods may still be a better option to locate

North Atlantic right whales in that specific habitat (Cusano et al. 2018; Parks et al. 2019a). New visual survey techniques such as drone and satellite imagery are becoming more frequently used to document the presence of whales; Hodul et al. (2022) identified individual North Atlantic right whales using satellite imagery in Cape Cod Bay. In 2019, the NMFS North Atlantic right whale Steering Committee convened an expert Working Group to address two objectives related to monitoring North Atlantic right whales: (1) improve our understanding of population status by identifying and tracking essential population metrics, and (2) improve our understanding of distribution and habitat use (Oleson et al. 2020). The monitoring Working Group provided a set of recommendations in a NOAA technical report to improve NMFS' overall monitoring strategy for North Atlantic right whales, with recognition of the significant contribution to research and monitoring carried out by NMFS and partner institutions and agencies (Oleson et al. 2020). The report and its recommendations are informing the development of a NMFS North Atlantic Right Whale Monitoring Strategy, which will guide North Atlantic right whale monitoring efforts in the future.

2.3.1.6 Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem):

These are discussed in-depth in Section 2.3.2, below. On January 27, 2016 (81 FR 4837), we designated critical habitat for North Atlantic right whales under the ESA (Figure 1).

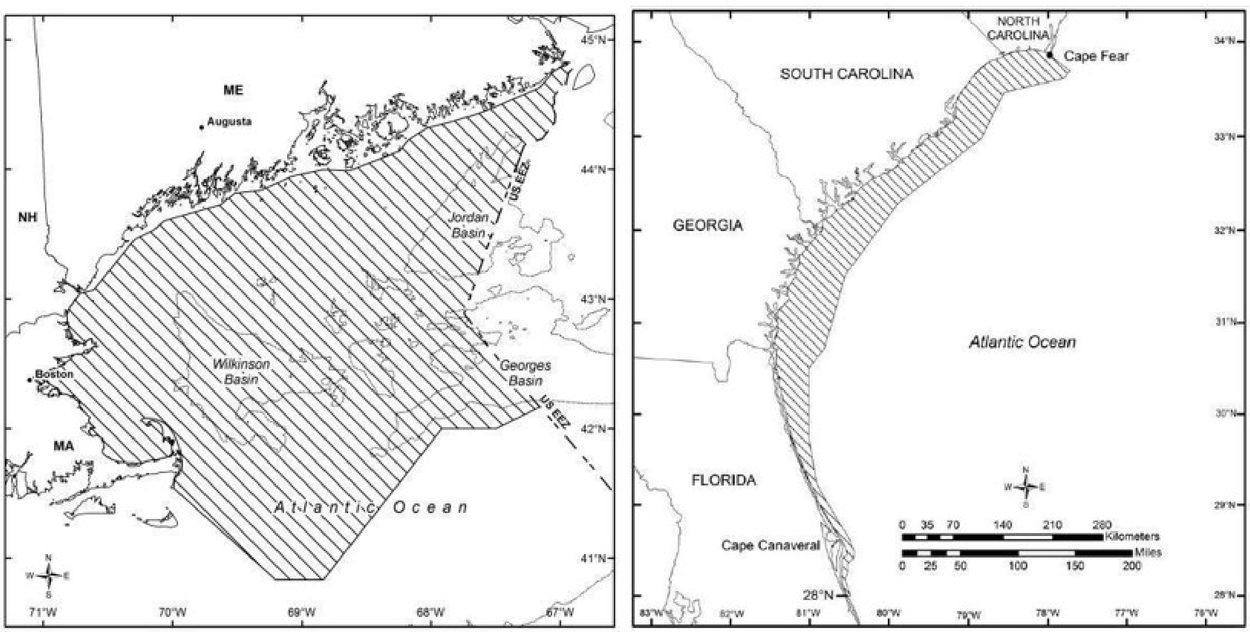

Figure 1: North Atlantic right whale critical habitat off the northeast U.S. (left) and southeast U.S. (right) coasts.

2.3.1.7 Health:

Body condition, an indicator of overall health for individuals within the population, is lower in adult, juvenile, and reproductive female North Atlantic right whales in comparison to several populations of Southern right whales (Christiansen et al. 2020). This is most likely due to a higher level of exposure to anthropogenic stressors in the northern hemisphere versus the southern, including increased fishing gear, anthropogenic noise, and climate effects influencing prey availability (Christiansen et al. 2020; Corkeron et al. 2018; Moore et al. 2021). North Atlantic right whale calves have good body condition in comparison to Southern right whale calves and lactating and entangled whales are most likely to exhibit declining condition, indicating that sub-lethal energetic stressors for North Atlantic right whales may suppress growth and survival over time (Christiansen et al. 2020; Pettis et al. 2017). Body size has also decreased over time, with individuals associated with entanglement in fishing gear being smaller than prior generations of North Atlantic right whales (Stewart et al. 2021). Entanglement has a negative effect on the health of both reproductive and non-reproductive North Atlantic right whales across severity levels, although reproductive females display worse health metrics at lower levels of severity than non-reproductive whales (Knowlton et al. 2022). Today, body growth models indicate that North Atlantic right whales attain mean lengths and weights of 4.3 meters and 1.0 metric tons at birth, and 13.1 meters and 31.7 metric tons when sexually mature (Fortune et al., 2021). Calf body length is correlated with maternal body condition, so reproductive females in poorer condition may reduce calf growth rates (Christiansen et al. 2020; Stewart et al. 2021). Poor body condition, arrested growth, and maternal body length have led to reduced reproductive success and are contributors to low birth rates for the population over the past decade (Christiansen et al. 2020; Reed et al. 2022; Stewart et al. 2021; Stewart et al. 2022). Length of the reproductively active female is related to inter-birth intervals and count of calves per potential reproductive year with longer whales having shorter intervals and more calves, but length appears to be unrelated to age at first reproduction (Stewart et al. 2022).

While photo-ID and photogrammetric assessments have long been a tool relied upon for estimating North Atlantic right whale body condition, size, age, sex, and the effects of anthropogenic stressors like vessel strikes and entanglement, other methodologies for non-invasive sampling to inform our understanding of other health metrics such as reproductive stage, disease, and levels of stress have become more common (Moore et al. 2021). Methods that have emerged include fecal and blow samples (Burgess et al. 2017; Burgess et al. 2018), however, biopsy sampling using blubber and baleen taken post-mortem during necropsy continue to be used as well (Graham et al. 2021; Hunt et al. 2017a; Hunt et al. 2017b; Hunt et al. 2018). Drone imagery is also in use to examine body condition, including past and current entanglement conditions, and may help to provide a better estimate of entanglement rates at a population level (Lonati et al. 2022; Ramp et al. 2021). King et al. (2021) developed a North Atlantic right whale welfare assessment tool for field biologists to assess welfare using scored categories (i.e., health, nutrition, and behavior) in real time, without waiting for biological tests. This can be combined with the objective data to provide a more complete indication of the welfare status of individuals and the population. To best understand and track the health of North Atlantic right whales at the individual and population levels over time, it will be vital to incorporate all of these data collection methods and use modeling tools such as the ongoing PVA to estimate the effects of compounding stressors (Fauquier et al. 2020; Moore et al. 2021). In 2019, a North Atlantic right whale Health Assessment Workshop was conducted under the auspice of the NMFS Working Group on Marine Mammal Unusual Mortality Events to assess current health information data, identify available and needed tools and techniques for collecting standardized health data that can be used to understand the health effects of environmental and human impacts (e.g., entanglement), and inform fecundity and survivorship models to ultimately guide population recovery (Fauquier et al. 2020, Moore et al. 2021)

2.3.1.8 Other science efforts:

To best address threats and recover North Atlantic right whales, NMFS coordinates and collaborates with several partners across management (see section 2.3.2.5) and science initiatives. We work with partners from Maine to Florida on science and research to monitor the North Atlantic right whale population. For example, the Maine Department of Marine Resources has implemented expanded PAM to gain better spatial and temporal resolution of North Atlantic right whale distribution along their coastline and is in the process of starting a wind energy research area in state waters to study the impacts of offshore wind farms on North Atlantic right whales, among other objectives. In the southeast, teams from the Georgia Department of Natural Resources and the Florida Fish and Wildlife Conservation Commission work in tandem with each other, NMFS, and other government agency partners to conduct high resolution aerial and boat based surveys for North Atlantic right whale population monitoring during the calving season. Duke University Marine Geospatial Ecology Laboratory habitat density modeling efforts are currently funded under a cooperative agreement with NMFS to continue to update the models using new survey data as it is collected.

We also collaborate with partners on ropeless, or on-demand, fishing gear development. Each year, the North Atlantic Right Whale Consortium hosts a Ropeless Consortium, where stakeholders from industry, government, non-profit organizations, academia, and members of the public come together to provide updates on new technologies and gear configurations for ropeless fishing. Technology has been developed by scientists at Woods Hole Oceanographic Institution that allows the gear to self-localize and broadcast its location to nearby vessels, removing potential problems associated with ropeless gear such as gear conflict with other vessels or losing gear (Baumgartner and Partan 2021). The Northeast Fisheries Science Center works closely with commercial fishermen to assess and trial geolocation methods for monitoring and retrieving gear. Entanglement simulators have been developed with partners to better understand the nature of various entanglement configurations and the effects of potential solutions in the absence of widespread ropeless fishing implementation (Howle et al. 2019). These collaborations in research and technology are needed before broad use of ropeless technologies under commercial fishing conditions can be implemented in lieu of seasonal closures to fishing or other risk reduction measures.

Representatives from these organizations, as well as numerous other partner organizations including partners in management efforts also play various roles in our implementation teams, UME core team, and take reduction team. We also highlight partnerships in the Species in the Spotlight initiative (e.g., Action Plan).

2.3.2 Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms)

2.3.2.1 Present or threatened destruction, modification or curtailment of its habitat or range:

<u>Climate Change</u>

Climate change continues to pose a significant threat to the recovery of North Atlantic right whales. While other threats are well defined, the effects of climate change in North Atlantic right whale habitat are still emerging and differ across the range. The documented shift in North Atlantic right whale summer habitat from the Gulf of Maine to waters further north in the Gulf of St. Lawrence in the early 2010s instigated several investigations to understand drivers of the shift. An oceanographic regime shift in Gulf of Maine waters linked to a northward shift of the Gulf Stream caused the availability of the primary North Atlantic right whale prey, the copepod *Calanus finmarchicus*, to decline locally, forcing North Atlantic right whales to forage in areas further north (Meyer-Gutbrod et al. 2021; Record et al. 2019; Sorochan et al. 2019). Fluctuating ocean circulation features within the Gulf of St. Lawrence also dictate where North Atlantic right whales forage on a finer scale; warming water influences the directionality of the Gaspé Current, pushing it eastward along the Laurentian Channel rather than west into the southern Gulf of St. Lawrence and leading North Atlantic right whales to forage closer to shipping lanes (Brennan et al. 2021). The Gulf of St. Lawrence also has a large population of another copepod species, *Calanus hyperboreus,* that is less common in Gulf of Maine waters but makes up a significant portion of North Atlantic right whale diet further north (Brennan et al. 2021; Lehoux et al. 2020; Sorochan et al. 2021a).

The decline of *C. finmarchicus* in the historical Gulf of Maine habitat and resulting shift of North Atlantic right whales to forage in the Gulf of St. Lawrence has created several new problems for the population. When prey availability is low, North Atlantic right whale calving rates decline, a well-documented phenomenon through periods of low prey availability in the 1990s and the 2010s; without increased prey availability in the future, low population growth is predicted (Meyer-Gutbrod and Greene 2018). Prey densities in the Gulf of St. Lawrence have fluctuated irregularly in the past decade, limiting suitable foraging habitat for North Atlantic right whales in some years and further limiting reproductive rates (Bishop et al. 2022; Gavrilchuck et al. 2020; Gavrilchuck et al. 2021; Lehoux et al. 2020). One study found that reproductively active females that returned to the Gulf of St. Lawrence from 2015 on were more likely to calf than females that did not use that area to forage during the same period (Bishop et al. 2022). The shift of North Atlantic right whale distribution into waters further north also created policy challenges for the Canadian government, which had to implement new regulations in areas that were not protected because they were not documented as habitat in the past (Davies and Brillant 2019; Meyer-Gutbrod et al. 2018; Record et al. 2019).

Other recent studies have investigated the spatial and temporal role of oceanography on copepod availability and distribution and resulting effects on foraging North Atlantic right whales. Changes in seasonal current patterns have an effect on the density of *Calanus* species in the Gulf of St. Lawrence, which may lead to further temporal variations over time (Sorochan et al. 2021a). Brennan et al. (2019) developed a model to estimate seasonal fluctuations in *C. finmarchicus* availability in the Gulf of St. Lawrence, which is highest in summer and fall, aligning with North Atlantic right whale distribution during those seasons. Pendleton et al. (2022) found that the date of maximum occupancy of North Atlantic right whales in Cape Cod Bay shifted 18.1 days later between 1998 and 2018 and was inversely related to the spring thermal transition date, when the regional ocean temperature surpasses the mean annual temperature for that location, which has trended towards moving earlier each year as an effect of climate change. This inverse relationship may be due to a 'waiting room' effect, where North

Atlantic right whales wait and forage on adequate prey in the waters of Cape Cod Bay while richer prey develops in the Gulf of St. Lawrence, and then migrate directly there rather than following migratory pathways used previously (Pendleton et al. 2022; Ganley et al. 2022). Although the date of maximum occupancy in Cape Cod Bay has shifted to later in the spring, initial sightings of individual North Atlantic right whales have started earlier, indicating that they may be using regional water temperature as a cue for migratory movements between habitats (Ganley et al. 2022).

North Atlantic right whales rely on late stage or diapause copepods, which are more energy-rich, for prey; diving behavior is highly reliant on where in the vertical strata *C. finmarchicus* is distributed (Baumgartner et al. 2017). There is evidence that *C. finmarchicus* are reaching the diapause phase at deeper depths to account for warming water on the Newfoundland Slope and Scotian Shelf, forcing North Atlantic right whales to forage deeper and further from shore (Krumhansl et al. 2018; Sorochan et al. 2021a). This may have management implications as North Atlantic right whales forage closer to the seafloor and the risk of becoming entangled in ground line increases (Baumgartner et al. 2017; Dombroski et al. 2021; Hamilton and Kraus 2019). In the spring, *C. finmarchicus* has not yet entered the diapause phase and spends more time at the surface, increasing the risk of vessel strikes for North Atlantic right whales (Baumgartner et al. 2017).

Several studies have already used this link between *Calanus* distribution and North Atlantic right whale distribution to determine suitable habitat, both currently and in the future, which will help to direct short and long term management approaches (Gavrilchuk et al. 2020; Pershing et al. 2021; Silber et al. 2017; Sorochan et al. 2021b). Plourde et al. (2019) used suitable habitat modeling using *Calanus* density to confirm new North Atlantic right whale hot spots for summer feeding in Roseway Basin and Grand Manan and also identified other potential aggregation areas further out on the Scotian Shelf. Gavrilchuk et al. (2021) determined suitable habitat for reproductive females in the Gulf of St. Lawrence, finding declines in foraging habitat over a 12-year period and indicating that the prey biomass in the area may become insufficient to sustain successful reproduction over time. Ross et al. (2021) used suitable habitat modeling to predict that the Gulf of Maine habitat would continue to decline in suitability until 2050 under a range of climate change scenarios. Similarly, models of future copepod density in the Gulf of Maine have predicted declines of up to 50 percent under high greenhouse gas emission scenarios by 2080-2100 (Grieve et al. 2017). It is clear that climate change does and will continue to have an impact on the availability, supply, aggregation, and distribution of *C. finmarchicus*, and North Atlantic right whale abundance and distribution will continue to vary based on those impacts; however, more research must be done to better understand these factors and associated impacts (Sorochan et al. 2021b).

Climate change will likely have other secondary effects on North Atlantic right whales, such as an increase in harmful algal blooms of the toxic dinoflagellate *Alexandrium catenella* due to warming waters, increasing the risk of North Atlantic right whale exposure to neurotoxins (Boivin-Rioux et al. 2021; Pershing et al. 2021). A recent NMFS scenario planning exercise explored plausible future conditions for North Atlantic right whales, which included consideration of harmful algal blooms and other drivers, to develop possible options to address these conditions to improve recovery (Borggaard et al. 2020). The phenological impacts associated with climate change may also lead to ecological mismatches with species at other trophic levels in the ecosystem (Pershing et al. 2021).

Wind Energy Development

Wind energy has emerged as a burgeoning industry over the last five years. The impacts of construction, operation and maintenance, and decommissioning associated with wind energy on North Atlantic right whales include several threats that are already well known. Construction noise and vessel traffic from development of offshore wind along the east coast of the United States could result in communication masking, behavioral disruption of foraging and socializing (potentially leading to increased energetic expenditure), increased risk of vessel strike, or avoidance of wind energy areas (Quintana-Rizzo et al. 2021). Floating wind turbines may introduce additional hazards for whales, including entanglement in turbine mooring lines or fishing gear or other marine debris caught on turbine mooring lines (Maxwell et al. 2022). Offshore wind turbines could also influence the hydrodynamics of seasonal stratification and ocean mixing, which, in turn, could influence shelf-wide primary production and copepod distribution, increasing North Atlantic right whale energetic stress and reducing reproduction rates (Dorrell et al. 2022; Quintana-Rizzo et al. 2021). Furthermore, the availability of essential calving habitat features may be limited by large arrays or fields of permanent structures that may act as barriers and prevent or limit the ability of right whale mothers and calves to move about and find (“select”) the optimal combinations of calving habitat essential features.

The Bureau of Ocean Energy Management (BOEM) is the lead federal agency for offshore wind projects, charged with scoping potential lease areas, issuing leases, and approving or disapproving developing the Construction and Operations Plan for each lease. BOEM currently has 17 active leases and offered several more potential lease sites in North Atlantic right whale range in 2021. The first utility scale offshore wind project in the United States was leased in Massachusetts waters 15 miles south of Martha’s Vineyard, and is titled the Vineyard Wind I project. Studies conducted between 2011 and 2015 for baseline projections of North Atlantic right whale abundance and distribution within the lease area found that no North Atlantic right whales were sighted within the area between May and November; however, North Atlantic right whales were detected in waters surrounding the lease area throughout the summer (Leiter 2017; Stone et al. 2017). Comparisons of the baseline 2011-2015 surveys to surveys conducted throughout the lease area between 2017 and 2019 indicated that North Atlantic right whales have established a year-round presence in those waters, with sightings every month of the year and an overall increase in the number of unique individuals identified in the area (O’Brien et al. 2022; Quintana-Rizzo et al. 2021). Monitoring measures (such as those reported in the studies mentioned above) are necessary to establish baselines of data and information on behavior and distribution within wind energy areas prior to widespread wind farm development (Macrander et al. 2021). This will help reduce the effects of implementation by providing an understanding of changes due to construction and operation that we can use to implement protections for living resources and concurrently provide increased certainty that development can proceed efficiently (Macrander et al. 2021).

NMFS works closely with BOEM to develop measures to protect North Atlantic right whales and promote their recovery in and around offshore wind energy lease sites during construction, operation, and decommissioning. In 2020, NMFS released the Biological Opinion for the development of the Vineyard Wind I project, which was superseded by a new Opinion (dated October 18, 2021; corrected November 1, 2021) following reinitiation of consultation. NMFS also issued the Biological Opinion for the South Fork Offshore Energy project on September 30, 2021 (NMFS 2021a; NMFS 2021b). Both incorporated measures aimed to reduce impacts for North Atlantic right whales and other baleen whales. Some examples include visual and acoustic monitoring during high impact activities like pile driving, conducting high impact activities during months when North Atlantic right whales are less likely to be in the area, and seasonal speed restrictions for most vessels transiting to, from, and within wind farm boundaries to reduce the risk of vessel strikes. In 2021, NOAA and BOEM also collaborated to create a set of minimum procedures, system requirements, and other important components for inclusion in PAM use for offshore wind energy development monitoring and mitigation programs to provide a guide for stakeholders to meet the rapid development of offshore wind in the United States (Van Parijs et al. 2021).

Noise Pollution

North Atlantic right whales continue to experience communication masking due to noise pollution from ambient and anthropogenic sound sources (Affatati et al. 2022; Cholewiak et al. 2018; Southall et al. 2018; Breeze et al. 2021). While North Atlantic right whale upcalls are highly masked due to noise pollution in the communication space, evidence shows that North Atlantic right whale gunshots, which may be indicative of male display behavior, are masked less than upcalls and calls from other large whale species (Hatch et al. 2012; Cholewiak et al. 2018). Matthews and Parks (2021) indicated that North Atlantic right whales do perceive various sound types (e.g., vessel noise) and display differential behavioral responses, which may be generating population level impacts from noise. More research is needed to understand the baseline in a communication space due to the complexities of modeling multiple sound sources in space and the lack of data on auditory sensitivity for any of the baleen whales (Affatati et al. 2022; Matthews and Parks 2021; Southall et al. 2019; Terhune and Killorn 2021). However, Terhune and Killorn (2021) created a simplified low-cost model that was able to show daily patterns of increased masking during the day and evening in the Bay of Fundy, when ferries and other vessels were most active, which may be applicable for use in future studies to help direct management. The COVID-19 pandemic offered a unique opportunity to study the changes in ocean noise due to decreased economic activity worldwide; however, in Nova Scotia, Breeze et al. (2021) demonstrated that although there were decreases in use for some vessel types, others continued to transit at pre-pandemic levels and some industry vessels that would normally dock at port stayed at-sea and elevated ambient noise levels for extended periods of time, potentially creating implications for North Atlantic right whales and other large whale species.

While vessel noise is often noted as one of the most persistent noise producing activities, other sound sources that are cause for concern include seismic surveys and military active SONAR (Marotte et al. 2022). In both the United States and Canada, seismic surveys do currently take place in North Atlantic right whale habitat (Marotte et al. 2022; Weatherwax 2021).

NOAA's Ocean Noise Strategy (ONS) Roadmap, which established goals to reduce noise impacts on NOAA trust resources, was completed in 2016 (Gedamke et al. 2016). The roadmap provides research goals to inform management on how best to reduce noise in North Atlantic right whale habitat, such as continuing and expanding long-term monitoring programs and developing models to understand the long term population level impacts of noise (Gedamke et al. 2016). The effectiveness of the ONS Roadmap will be evaluated in 2026. Additionally, 'quiet ship' certifications have been introduced by several ship classification societies as a way to incentivize the shipping industry to encourage reductions in noise volume (Southall et al. 2018).

Aquaculture Development

Expansions to the aquaculture industry, both inshore and offshore, may also affect North Atlantic right whales. Lines in the water for various types of aquaculture increase the potential for entanglement, both directly through whale interactions with aquaculture gear or secondarily through the entanglement of trailing gear from a whale in fixed aquaculture gear (Price et al. 2017). Increased vessel traffic in and around aquaculture farms will increase ambient noise levels and the risk of vessel strikes (Price et al. 2017). There may also be oceanographic changes to areas used for aquaculture that could affect the physical environment or create changes to prey availability, which may increase energetic stress and reduce reproduction rates. However, since large scale aquaculture in North Atlantic right whale habitat is still in early stages of planning, there is an opportunity to ensure that aquaculture development does not impact North Atlantic right whales. Several actions are underway within NMFS and with its partners to understand how aquaculture may affect North Atlantic right whales. For example, in 2021, NMFS published a framework for Section 7 evaluation of aquaculture projects in the Greater Atlantic Region, which includes information on how simulator models of North Atlantic right whales swimming through various gear configurations can be used to guide aquaculture gear configuration development to reduce the risk of entanglement (Howle et al. 2019; Mori and Riley 2021).

Dredging

North Atlantic right whales frequent coastal waters where dredging and its associated disposal operations occur on a regular basis. Collisions between vessels associated with dredging operations and North Atlantic right whales may occur as vessels transit or dredge through North Atlantic right whale habitat; these interactions have the potential to cause serious injuries (Kelley et al. 2021). The U.S. Army Corps of Engineers (USACE) has responsibility and oversight for many of these dredging and disposal operations and consults with NMFS under Section 7 of the ESA on these activities to account for all types of USACE vessels, which travel at a variety of speeds (i.e., from slow moving dredger vessels to survey vessels, which are capable of traveling at speeds in excess of 30 knots). NMFS has worked closely with USACE to develop measures to protect North Atlantic right whales and promote their recovery in and around dredging operation areas. Several Biological Opinions have been issued for dredging operations. For example, the South Atlantic Regional Biological Opinion for Dredging and Material Placement Activities in the Southeast United States, which was released in 2020, includes a Conservation Plan for North Atlantic right whale recovery under Section 7(a)(1) to reduce the risk of vessel strikes from dredging operations. The Conservation Plan lays out a robust survey plan for USACE to undertake that informs the Right Whale Early Warning System and expands data collection in the southeast. It also details avoidance measures for dredging projects and provides funding to the land-based volunteer sighting network. NMFS will continue to work with USACE to ensure a robust and comprehensive analysis of the effects of dredging on North Atlantic right whales and to develop effective measures to avoid and minimize effects of dredging operations.

Oil and Gas Development and Transportation

Oil and gas development and transportation along the Atlantic coast has long been identified as a threat to North Atlantic right whales. In 2018, five Incidental Harassment Authorizations (IHA) were issued for seismic exploration for oil and gas development (83 FR 63268, December 7, 2018). However, no work was ever conducted due to ongoing litigation throughout the duration of the authorizations. In October 2020, the oil and gas industry indicated that they would not currently pursue seismic exploration for offshore oil in the U.S. Atlantic, possibly for several years. All IHAs for oil and gas seismic exploration expired in November 2020. Future oil and gas exploration and development activities will be subject to consultations under Section 7 of the ESA[1] and permitting requirements of the MMPA.

New research has been done to examine the potential impact of an offshore oil spill due to development, transportation, and/or offloading of oil on North Atlantic right whales. Werth et al. (2019) tested the effects of oil on North Atlantic right whale baleen and found that water filtering through the hydrophilic and oleophobic baleen rinses oil off, reducing the opportunity for baleen to foul and be rendered ineffective at filtering prey. By examining drone imagery of the respiration cycle, Martins et al. (2020) determined that North Atlantic right whales had seawater present on the blowhole in 20 percent of all breaths, suggesting that oil could be inhaled through the blowhole if a whale surfaced in an oil slick. Martins et al. (2020) suggests that oil dispersants may help to reduce the risk of inhalation. In addition to the risks associated with oil spills, vessels associated with oil transportation may transit through North Atlantic right whale habitat, increasing the potential for vessel strikes.

Contaminants

Browning et al. (2017) examined the effect of hexavalent chromium, a carcinogenic heavy metal produced through industrial processes, on North Atlantic right whale lung cells, and determined that neither acute nor prolonged exposure had a significant effect on genetic pathways that repair and protect the genome from chemical induced carcinogenesis. Another study looked at the effect of cadmium, known to cause severe kidney damage in marine mammals and found in high concentrations in *Calanus finmarchicus* in the Bay of Fundy, on North Atlantic right whale kidney cells, and found that exposure to the contaminant down regulated several genes related to normal cell function and upregulated genes that protect the cell from metal toxicity and oxidative stress (Ierardi et al. 2021). More research on the effects of exposure to various contaminants on North Atlantic right whales at the cellular level are needed to provide a more comprehensive assessment of North Atlantic right whale health.

2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes:

[1] Under ESA section 7(a)(2), Federal agencies must consult with NOAA Fisheries when any project or action they take may affect an ESA-listed marine species or its designated critical habitat.

There are no data at this time to indicate that these issues are limiting the recovery of the North Atlantic right whale. Currently, there is no commercial harvest of North Atlantic right whales and research activities are not considered to be affecting North Atlantic right whale recovery in the North Atlantic. Whale-watching directed at North Atlantic right whales has been mitigated as the result of the prohibition on approaching or remaining within 500 yards of North Atlantic right whales (see 50 CFR 224.103(c)).

2.3.2.3 Disease or predation:

Disease

There is no new knowledge of North Atlantic right whale disease since the previous review in 2017; Sharp et al. (2019) reports no data on disease as far back as 2003, the earliest year of the data reviewed. Collecting information to assess health, including disease, is important at both the individual and population level (Moore et al. 2021).

Predation

On the calving grounds, mother-calf pairs demonstrate reduced acoustic communication possibly to avoid detection by predators such as sharks and orcas, both of which have been documented predating on North Atlantic right whale calves in the past (Parks et al. 2019b). This behavior is reduced when calves are around five months old and the pair leaves the calving ground (Cusano et al. 2018; Parks et al. 2019b). There are no data indicating that predation is limiting North Atlantic right whale recovery.

2.3.2.4 Inadequacy of existing regulatory mechanisms:

We have administered various conservation regulations to reduce anthropogenic impacts to the North Atlantic right whale. In 1997, we implemented the Atlantic Large Whale Take Reduction Plan (ALWTRP) to reduce entanglement in fishing gear, and continue to amend the plan with the assistance of the Atlantic Large Whale Take Reduction Team (ALWTRT) (Borggaard et al. 2017). In 2008, we issued regulations seeking to reduce lethal vessel strikes (73 FR 60173, October 10, 2008). Regulations attempting to curtail entanglement have been updated in recent years in both the United States and Canada based on the continued decline of North Atlantic right whales over the past decade and the declaration of the trans-boundary North Atlantic right whale UME in 2017 (Davies and Brillant 2019; Koubrak et al. 2021; Sisson and Long 2018). However, despite recent action, the North Atlantic right whale population has continued to decline due to anthropogenic impacts such as vessel strikes and entanglement from fishing gear; their tendency to spend large portions of time in waters near the surface and make deep dives while feeding make them particularly vulnerable to these two threats (Baumgartner et al. 2017; Corkeron et al. 2018; Dombrowski et al. 2021; Hamilton and Kraus 2019; Pace et al. 2021). For the most recent 5-year period of 2016-2020 reported in the North Atlantic right whale stock assessment report (Hayes et al. in prep), the annual average rate of observed human-caused North Atlantic right whale mortality is 8.1 whales per year. This includes commercial fisheries mortality of 5.7 whales per year and vessel strike mortalities of 2.4 whales per year; however, these numbers do not take into account undetected (or cryptic) mortalities as 2020 estimated mortality is not yet available (Hayes et al. in prep). Estimated total mortalities for the previous 5-

year period of 2015-2019 including undetected cryptic mortalities was 156, or 31.2 whales per year. This annual average was 4.4 times higher than the observed total of 7.7 mortalities and serious injuries per year (Hayes et al. in prep; Pace et al. 2021). North Atlantic right whale potential biological removal (PBR) over this period was <1 (0.7) whale per year (Hayes et al. in prep).

<u>Vessel Strikes</u>

In 2008, the North Atlantic right whale vessel speed rule (hereafter "speed rule") was put into effect to protect North Atlantic right whales from vessel strikes (73 FR 60173). The speed rule requires most vessels 65 feet in length or greater to reduce speed to 10 knots or less inside ten defined mandatory seasonal management areas (SMA). It also requests that such vessels voluntarily reduce speed to 10 knots or less within dynamic management areas (DMA) that are established via visual confirmation of three or more North Atlantic right whales sighted within a circle with a radius of at least 3 nautical miles. In 2020, NMFS released an assessment of the speed rule, evaluating its effectiveness (NMFS 2020). While the rule did decrease the number of known vessel strikes to eight in the first decade, down from 12 in the previous decade, mortalities and serious injuries continued, requiring further action from NMFS (Corkeron et al. 2018; NMFS 2020). One study of the effectiveness of the rule on reducing risk concluded that mortality rates decreased by 22 percent on average after the rule was implemented, but that effectiveness varied in space and time within the range (Crum et al. 2019). Another study examined recreational vessel strikes in the southeast, finding higher risk of vessel strikes near navigable inlets (Montes et al. 2020). Additionally, the NMFS report found that while the SMA program had high mariner compliance (85 percent), cooperation with DMAs was low. Evidence of both blunt and sharp trauma, as well as lethal vessel strikes by vessels <65 ft, was also indicative that more action was warranted to increase protections (Hayes et al. 2021; Kelley et al. 2021; NMFS, 2020; Sharp et al. 2019). On July 29, 2022, NMFS announced a proposed rule to amend the North Atlantic right whale vessel speed regulations and requested public comments (87 FR 46921, August 1, 2022). The proposed rule would: 1) modify the spatial and temporal boundaries of current speed restriction areas referred to as Seasonal Management Areas (SMAs), 2) include most vessels greater than or equal to 35 ft (10.7 m) and less than 65 ft (19.8 m) in length in the size class subject to speed restriction, 3) create a Dynamic Speed Zone framework to implement mandatory speed restrictions when whales are known to be present outside active SMAs, and 4) update the speed rule's safety deviation provision. NMFS evaluated the risk of North Atlantic right whales being struck and killed by vessels in U.S. waters along the east coast using an encounter risk model, and found that this potential expansion of vessel speed restrictions would result in an average reduction in vessel strike mortality of 27.5 percent (Garrison et al. 2022).

In July 2020, the NMFS Greater Atlantic Regional Office introduced the Right Whale Slow Zone program. The program expanded dynamic vessel speed restrictions for North Atlantic right whales to include real-time acoustic triggers from PAM buoys and acoustic gliders from Maine to Virginia. By utilizing acoustic detections, this program works in conjunction with the DMA program to provide more habitat coverage for North Atlantic right whales and works similarly, triggering notification of North Atlantic right whale presence and a 15 day voluntary speed reduction zone around the area where the whales were heard. The Slow Zone program was initiated based on a recommendation from the Northeast Implementation Team to enhance vessel strike reduction efforts using acoustic information. Between January 2017 and August 2022 we have administered 128 DMAs and 36 Slow Zones in the Greater Atlantic region and 4 DMAs in the Southeast region, although voluntary cooperation in Slow Zones is similarly low as with DMAs. The amendments presented in the 2022 proposed rule address this issue by making dynamic management measures mandatory.

Outreach and education to recreational and commercial mariners is important to reduce the threat of vessel collisions. One survey of the southeast found that only 65 percent of mariner respondents knew about the 500 yard approach rule for North Atlantic right whales (Montes et al. 2018). Additionally, mariners on vessels of all sizes are unlikely to spot North Atlantic right whales because of their low profile in the water. Compliance with the speed rule exceeds 80 percent overall within SMAs, but there are some areas where compliance remains low and mariner cooperation within DMAs remained well below levels reached in SMAs (NMFS 2020). Enhanced outreach will also be critical to successfully implement modifications to the speed rule (NMFS 2020).

Entanglement in Commercial Fishing Gear

Commercial fisheries regulations through the ALWTRP under the MMPA have been ongoing since 1996 (Borggaard et al. 2017; Laist 2017; 86 FR 51970). Bisack and Magnusson (2021) assessed the effectiveness of the Dynamic Area Management program implemented as part of the ALWTRP in 2002, finding that the program reduced total risk by 6.5 percent on average between 2002-2009, prior to implementation of broad-based gear modification requirements. Despite modifications to the ALWTRP to further reduce risk (notably the broad-based use of sinking groundlines effective in 2009 (72 FR 57104) and efforts to reduce the number of vertical buoy lines as well as an expansion of the Massachusetts Restricted Area (MRA) effective in 2015 (79 FR 36586, 79 FR 73848, and 80 FR 30367)), mortalities and serious injuries of North Atlantic right whales in U.S. gear and first seen in U.S. waters continue to be above PBR, requiring additional rulemaking (50 CFR Parts 229 and 697).The most recent amendment to the ALWTRP resulted in a Final Rule published in September 2021. This most recent rulemaking increases the minimum number of traps per trawl based on area fished and distance fished from shore in the Greater Atlantic Region; modifies existing restricted areas from seasonal fishing closures to seasonal closures to fishing with persistent buoy lines; expands the geographic extent of the MRA to include Massachusetts state waters north to the New Hampshire border; establishes two new restricted areas that are seasonally closed to lobster or Jonah crab trap/pot fishing with persistent buoy lines; requires modified buoy lines to incorporate rope or weak insertions engineered to break at no more than 1,700 pounds (771.1 kilograms); and requires additional marks on buoy lines to differentiate vertical buoy lines by principal port state, includes unique marks for Federal waters, and expands requirements into areas previously exempt from gear marking (50 CFR Parts 229 and 697, September 17, 2021). Willse et al. (2022) determined that gear hauled at depths closer to shore were safely fished with vertical lines within the recommended breaking strength specifications under the ALWTRP. Gear further offshore may require alternative measures to reduce entanglement risk. On March 2, 2022, NMFS released an emergency rule to prohibit trap/pot fishery buoy lines between Federal and State waters within the MRA during the month of April 2022 to close a critical gap in protection for that area (87 FR

11590, March 2, 2022). North Atlantic right whales were spotted within the area during aerial surveys in April of 2021 alongside the presence of aggregated fishing gear, and because updates to the plan did not go into effect until May 1, it was determined that the area presented an imminent entanglement threat.

The September 2021 ALWTRP amendments (i.e., Phase I) focus on the Northeast lobster and Jonah crab trap/pot fisheries and were intended to reduce risk by 60 percent in these fisheries. NMFS is currently working with the ALWTRT on additional rulemaking for coast wide U.S. fishery risk reduction for a cumulative risk reduction of 90 percent relative to 2017, identified as the risk reduction necessary to reduce serious injury and mortality to below the population's PBR Level. Scoping on the further modifications to the ALWTRP was held from August 10, 2021, through October 21, 2021, to gather input on reducing the risk for gillnet and other trap/pot fisheries not included in the modifications to the ALWTRP published on September 17, 2021 (86 FR 51970). Additional scoping in September/October 2022 will gather input on further changes that would include the Northeast lobster and Jonah crab fisheries.

NMFS developed a Decision Support Tool (DST) to help the ALWTRT understand how different rulemaking measures could reduce risk for North Atlantic right whale entanglement. The DST was independently peer reviewed through the Center for Independent Experts Program in 2019 and a further review of an expanded DST that includes all U.S. commercial fisheries is anticipated in the fall of 2022.

These modifications to the ALWTRP are consistent with commitments made in a May 2021 Conservation Framework for Federal Fisheries in the Greater Atlantic Region, which describes a phased implementation plan for rulemaking that extends until 2030. The September 2021 rulemaking is consistent with Phase 1 of the Framework, and ongoing ALWTRT efforts toward recommendations to reduce coastwide risk reduction relative to 2017 by 90 percent cumulatively align with Phases 2 and 3 of the Framework. The Conservation Framework is adaptive and will consider risk reductions due to Canadian and United States measures as well as other new information as it becomes available. Reductions implemented in the final phase will be dynamic to reflect any new information and analyses. Several recent studies have examined the effect of potential updates to Canadian regulations for the snow crab industry, and it is likely that their regulations will continue to be updated under the Canadian Species at Risk Act (SARA) (Brillant et al. 2017; Cole et al. 2021; Cole and Brillant 2021). Shifts in the species range have created new challenges for areas that were not previously regulated and have required both governments to consider new options (Meyer-Gutbrod et al. 2018).

Fishing without buoy lines using remote retrieval technology or grappling is considered by many to be the next frontier for managing North Atlantic right whale entanglements (Moore 2019). Implementation of ropeless gear will require buy-in from more of the fishery; as it stands, various regional groups have widely differing levels of interest in implementing ropeless fishing (Besky 2021; Oppenheim 2022). To reach a common understanding among stakeholders, issues of utility, technology, legal and regulatory issues, and socioeconomics must be advanced with equal priority (Oppenheim 2022). On July 29, 2022, NMFS released a draft Ropeless Roadmap that lays out a four step approach to developing technology, resolving gear conflicts, expanding experimental fishing, and ultimately changing fishery management plan regulations. The draft is currently available for public comment and will be used as a guide for increasing adoption of on-demand fishing technology in commercial fisheries in the Northwest Atlantic Ocean.

2.3.2.5 Other management efforts:

To best address threats and recover North Atlantic right whales, NMFS coordinates and collaborates with several partners across management and science (see section 2.3.1.8) initiatives. Partners who are also implementing management measures include the Canadian government agencies Fisheries and Oceans Canada (DFO) and Transport Canada (TC), as well as the state of Massachusetts and Maine. DFO and TC have implemented fishery and vessel mitigation measures to reduce impacts to North Atlantic right whales, respectively, such as seasonal fishing area closures and speed restrictions (DFO 2021; DFO 2022). Due to the transboundary nature of North Atlantic right whale recovery, NMFS works closely with DFO and TC to collaborate on transboundary research and management efforts through discussions from leadership to staff levels. In Massachusetts, the Division of Marine Fisheries has expanded protections from entanglement for North Atlantic right whales (e.g., enacting seasonal and dynamic fishing closures based on the presence of North Atlantic right whales, implementing and incentivizing gear marking and gear modification systems) and vessel strikes (e.g., 10-knot small vessel [less than 65' overall] speed limit in Cape Cod Bay) in state waters. In Maine, the Department of Marine Resources has implemented gear marking in Maine's ALWTRP exempt waters.

Representatives from these organizations, as well as numerous other partner organizations including partners in science efforts also play various roles in our implementation teams, UME core team, and take reduction team. We also highlight partnerships through the Species in the Spotlight initiative (e.g., Action Plan).

2.3.2.6 Other natural or manmade factors affecting its continued existence:

Other than anthropogenic threats and energetic stress affecting the health and overall recovery of North Atlantic right whales as described above, there are no other known natural or manmade factors affecting continued existence at this time.

2.4 Synthesis

2.4.1 Recovery Status

The status of North Atlantic right whale recovery has declined since the last 5-year review was completed in 2017. Therefore, the recommended classification for the North Atlantic right whale is to remain the same: Endangered.

In many ways, progress toward right whale recovery has continued to regress. The population has been declining since 2010 and has exhibited changes in habitat use (Pace et al. 2017). Despite increased monitoring, there is evidence of undetected mortalities and serious injuries within the population (Pace et al. 2021). During this 5-year period, right whale calving rates have remained below average (Hayes et al. in prep) and overall body condition of the population has worsened (Christiansen et al. 2020; Corkeron et al. 2018; Fortune et al. 2021; Moore et al. 2021; Stewart et al. 2021). Habitat important to North Atlantic right whales has changed in response to an oceanographic regime shift that has altered prey availability, which will likely continue to fluctuate as a result of climate change (Gavrilchuck et al. 2020; Gavrilchuck et al. 2021; Lehoux et al. 2020; Meyer-Gutbrod et al. 2021; Record et al. 2019; Sorochan et al. 2019; Sorochan et al. 2021a). While NMFS continues to regulate activities that are known to generate major threats to North Atlantic right whales (e.g., vessel strikes and entanglement), our understanding of the full range of effects to North Atlantic right whales from emerging industries, such as offshore wind and aquaculture, is still developing. In addition, the UME that was announced in the summer of 2017 is still ongoing.

2.4.2 Recovery Efforts in the Next Five Years

There are several emerging threats that may affect right whale recovery going forward, such as climate change, increasing ocean noise, and those associated with burgeoning industries like offshore wind and aquaculture development. These threats bring new challenges, but also increase risk from known threats like vessel strikes and entanglement (Pirotta et al. 2022). These threats require a better understanding of risk to North Atlantic right whales, and NMFS is committed to a high level of collaboration with other Federal agencies, academia, industry partners, partners in Canada and U.S. state agencies, and others to ensure that these risks are adequately addressed.

NMFS developed the first 5-year Priority Action Plan for the North Atlantic right whale, which was added to the initiative in 2019 (NMFS 2021c). The action plan outlines actions NMFS and our partners need to take in the near-term to address the most urgent threats to the species. The action plan was developed with input from an expanded coastwide U.S. Right Whale Recovery Plan Implementation Team (composed of two region-specific implementation teams). The action plan builds off the recovery plan for North Atlantic right whales and identifies the following priority cross-regional recovery actions we can take from 2021-2025 to halt the decline of this species:

- Protect North Atlantic Right Whales from Entanglement in Fishing Gear
- Protect North Atlantic Right Whales from Vessel Strikes
- Investigate North Atlantic Right Whale Population Abundance, Status, Distribution and Health
- Collaborate with Canada on North Atlantic Right Whale Recovery
- Improve our Knowledge of Additional Factors Limiting Right Whale Recovery

A major part of the Species in the Spotlight initiative is to focus recovery efforts on high-priority actions that we and our partners can take in the near term to get species such as North Atlantic right whales on the road to recovery. In 2022, NMFS announced the availability of the latest Recovering Threatened and Endangered Species Report to Congress (FY 2019-2020) which includes highlights of recovery progress for the Species in the Spotlight (NMFS 2022). For the North Atlantic right whale, the Report to Congress focused on progress towards reducing entanglement in fishing gear and reducing vessel strikes based on the timing of the report. Future Report to Congress reports will include progress made toward implementing all the high-priority recovery actions noted in the action plan. NMFS also developed the North Atlantic Right Whale Road to Recovery strategy in 2022, which describes NMFS' efforts to halt the current population decline and recover the species. The strategy complements the North Atlantic right whale 2021–2025 Priority Action Plan by identifying our goals and related objectives, and by tracking and communicating progress on major activities and associated milestones.

3.0 RESULTS

3.1 Recommended Classification

Given your responses to previous sections, particularly section 2.4. Synthesis, make a recommendation with regard to the listing classification of the species

_____**Downlist to Threatened**
_____**Uplist to Endangered**
_____**Delist** *(Indicate reason for delisting per 50 CFR 424.11):*
    _____*Extinction*
    _____*Recovery*
    _____*Original data for classification in error*
__**X**__**No change is needed**

3.2 New Recovery Priority Number

No Change

Brief Rationale:

The North Atlantic right whale faces continued threat of human-caused mortality due to lethal interactions with commercial fisheries and vessel traffic. There is also uncertainty regarding the effect of long-term sublethal entanglements, emerging environmental stressors including climate change, and the compounding effects of multiple continuous stressors that may be limiting North Atlantic right whale calving and recovery. In addition, the North Atlantic right whale population has been in a state of decline since 2010. Management measures in the United States have been in place for an extended period of time and continued modifications are underway/anticipated, and measures in Canada since 2017 also suggest continued progress toward implementing conservation regulations.

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

Given the current state of North Atlantic right whale recovery, with a low rate of reproduction, longer calving intervals, declining population abundance, continued human-caused mortality and injury, changes in prey availability, increased trans-boundary movement and risk, and uncertainty regarding the effectiveness of conservation regulations, this review concludes with a specific list of recommendations. These recommendations are intended to focus recovery efforts over the next five years on increasing the understanding of the threats facing North Atlantic right whales and gaining insight into the best approaches to mitigate them. These recommendations rely on expanding partnerships between NMFS and the scientific community, marine community (e.g., recreational and commercial fishing, shipping industry, boating associations, recreational boaters, aquaculture, wind energy), and Canadian stakeholders to conserve and recover this shared resource. While recovery of the North Atlantic right whale will need to be assessed in the coming decades, NMFS' progress toward fulfilling the following recommendations will be critical when conducting the next 5-Year Review in 2027:

2022-1. Develop and implement a long-term, range wide plan for monitoring the North Atlantic right whale population, including trends (i.e., abundance), status, distribution and habitat use, mortality, morbidity, and health.

2022-2. Continue to prioritize and fund a combination of monitoring survey methods (e.g., passive acoustic, aerial, drone, shipboard, satellite) for right whale surveillance.

2022-3. Prioritize research on understanding the effects of climate change on North Atlantic right whale foraging, migration, reproduction, habitat use, and distribution to support management.

2022-4. Develop and test telemetry/tag technology that is appropriate for North Atlantic right whales to supplement monitoring efforts and help locate whales and their habitat in a changing ocean environment.

2022-5. Develop and implement a health assessment science plan and an emergency response plan for North Atlantic right whales.

2022-6. Continue to fund the maintenance and updates of a photo-ID database for North Atlantic right whales.

2022-7. Monitor and address impacts associated with new and emerging marine activities (e.g., offshore wind energy development, aquaculture development, climate change, ocean noise) to North Atlantic right whales.

2022-8. Continue to work with federal action agencies to fully utilize Section 7 (e.g., Section 7(a)(1) and 7(a)(2)) of the ESA to help address impacts from anthropogenic activities to North Atlantic right whales.

2022-9. Continue partnerships with the government of Canada on the reduction of human interactions with North Atlantic right whales (e.g., including the implementation and assessment of vessel speed regulations and cooperation on fishing gear marking and measures to reduce entanglements), and on research coordination (e.g., aerial surveys, PAM, and habitat modeling).

2022-10. Develop and support effective community/public engagement activities to help recover North Atlantic right whales.

2022-11. Continue to evaluate and improve the effectiveness of and compliance with regulations that protect North Atlantic right whales.

2022-12. Conduct research and implement gear modifications that reduce impacts of fishing gear on North Atlantic right whales and inform management for the development of more finely scaled commercial fisheries regulations.

2022-13. Prioritize programs for the removal of derelict fishing gear across the U.S. range for North Atlantic right whales.

2022-14. Conduct and fund research to collect information on risk (e.g., behavioral research) to North Atlantic right whales from vessels to help inform vessel strike reduction measures.

2022-15. Prioritize and fund the continued development of a PVA and subsequent versions that will allow the agency to characterize the North Atlantic right whale extinction risk, taking into account current and future threats.

2022- 16. Continue to develop decision making tools such as the DST to help visualize risk and risk reduction of alternatives towards the creation of effective conservation measures.

5.0 REFERENCES

Affatati, A., Scaini, C., and Salon, S. 2022. Ocean Sound Propagation in a Changing Climate: Global Sound Speed Changes and Identification of Acoustic Hotspots. Earth's Future, 10(3): e2021EF002099. https://doi.org/10.1029/2021EF002099

Ajo, A. A. F., Hunt, K. E., Uhart, M., Rowntree, V., Sironi, M., Maron, C. F., Di Martino, M., and Buck, C. L. 2018. Lifetime glucocorticoid profiles in baleen of right whale calves: potential relationships to chronic stress of repeated wounding by Kelp Gulls. Conservation Physiology, 6(1), coy045, Article coy045. https://doi.org/10.1093/conphys/coy045

Allwood, J. S., Scheible, M. K., and Faith, S. A. 2018. Demonstration of a basic mitochondrial enrichment method to produce the complete mitochondrial genome sequence of the endangered North Atlantic right whale (*Eubalaena glacialis*). Conservation Genetics Resources, 10(3), 483-486. https://doi.org/10.1007/s12686-017-0854-6

Baumgartner, M. F., Ball, K., Partan, J., Pelletier, L.-P., Bonnell, J., Hotchkin, C., Corkeron, P. J., and Van Parijs, S. M. 2021. Near real-time detection of low-frequency baleen whale calls from an autonomous surface vehicle: Implementation, evaluation, and remaining challenges. The Journal of the Acoustical Society of America, 149(5), 2950-2962. https://doi.org/10.1121/10.0004817

Baumgartner, M. F., Bonnell, J., Corkeron, P. J., Van Parijs, S. M., Hotchkin, C., Hodges, B., Thornton, J. B., Mensi, B. L., and Bruner, S. M. 2020. Slocum Gliders Provide Accurate Near Real-Time Estimates of Baleen Whale Presence From Human-Reviewed Passive Acoustic Detection Information. Frontiers in Marine Science, 7, Article 100. https://doi.org/10.3389/fmars.2020.00100

Baumgartner, M. F., Bonnell, J., Van Parijs, S. M., Corkeron, P. J., Hotchkin, C., Ball, K., Pelletier, L. P., Partan, J., Peters, D., Kemp, J., Pietro, J., Newhall, K., Stokes, A., Cole, T. V. N., Quintana, E., and Kraus, S. D. 2019. Persistent near real-time passive acoustic monitoring for baleen whales from a moored buoy: System description and evaluation. Methods in Ecology and Evolution, 10(9), 1476-1489. https://doi.org/10.1111/2041-210x.13244

Baumgartner, M. F., and Partan, J. 2021. Self-localization of buoyless fishing gear and other objects on the sea floor. Journal of the Acoustical Society of America, 1(8), 086001. https://doi.org/10.1121/10.0005739

Besky, S. 2021. Lobsters, Whales, and Traps: The Politics of Endangerment in the Gulf of Maine. Environment and Planning E: Nature and Space, 251484862110568. https://doi.org/10.1177/25148486211056811

Bisack, K. D., and Magnusson, G. M. 2021. Spatial Management to Reduce Entanglement Risk to North Atlantic Right Whales in Fishing Gear: A Case Study of U.S. Northeast Lobster Fishery 2002–2009. Frontiers in Marine Science, 08, 540966. https://doi.org/10.3389/fmars.2021.540966

Bisconti, M., Lambert, O., and Bosselaers, M. 2017. Revision of "Balaena" belgica reveals a new right whale species, the possible ancestry of the northern right whale, *Eubalaena glacialis*, and the ages of divergence for the living right whale species. PeerJ, 5, e3464, Article e3464. https://doi.org/10.7717/peerj.3464

Bishop, A.L., Crowe, L.M., Hamilton, P.K., and Meyer-Gutbrod, E.L. 2022. Maternal lineage and habitat use patterns explain variation in the fecundity of a critically endangered baleen whale. Frontiers in Marine Science, 9, 880910. https://doi.org/10.3389/fmars.202

Bogucki, R., Cygan, M., Khan, C. B., Klimek, M., Milczek, J. K., and Mucha, M. 2019. Applying deep learning to right whale photo identification. Conservation Biology, 33(3), 676-684. https://doi.org/10.1111/cobi.13226

Boivin-Rioux, A., Starr, M., Chasse, J., Scarratt, M., Perrie, W., and Long, Z. X. 2021. Predicting the Effects of Climate Change on the Occurrence of the Toxic Dinoflagellate Alexandrium catenella Along Canada's East Coast. Frontiers in Marine Science, 7, Article 608021. https://doi.org/10.3389/fmars.2020.608021

Borggaard, D. L., D. M. Dick, J. Star, B. Zoodsma, M. A. Alexander, M. J. Asaro. L. Barre, S. Bettridge, P. Burns, J. Crocker, Q. Dortch, L. Garrison, F. Gulland, B. Haskell, S. Hayes, A. Henry, K. Hyde, H. Milliken, J. Quinlan, T. Rowles, V. Saba, M. Staudinger, and H. Walsh. 2020. North Atlantic Right Whale (*Eubalaena glacialis*) Scenario Planning Summary Report. NOAA Tech. Memo. NMFS-OPR-68, 88 p.

Borggaard, D. L., Gouveia, D. M., Colligan, M. A., Merrick, R., Swails, K. S., Asaro, M. J., Kenney, J., Salvador, G., and Higgins, J. 2017. Managing US Atlantic large whale entanglements: Four guiding principles. Marine Policy, 84, 202-212. https://doi.org/10.1016/j.marpol.2017.06.027

Bourque, L., T. Wimmer, S. Lair, M. Jones, and P-Y. Daoust. 2020. Incident Report: North Atlantic Right Whale mortality event in eastern Canada. 2019. Collaborative report produced by: Canadian Wildlife Health Cooperative and Marine Animal Response Society. 210 pp.

Breeze, H., Li, S., Marotte, E. C., Theriault, J. A., Wingfield, J., and Xu, J. 2021. Changes in Underwater Noise and Vessel Traffic in the Approaches to Halifax Harbor, Nova Scotia, Canada. Frontiers in Marine Science, 8. https://doi.org/10.3389/fmars.2021.674788

Brennan, C. E., Maps, F., Gentleman, W. C., Lavoie, D., Chasse, J., Plourde, S., and Johnson, C. L. 2021. Ocean circulation changes drive shifts in Calanus abundance in North Atlantic right whale foraging habitat: A model comparison of cool and warm year scenarios. Progress in Oceanography, 197. https://doi.org/10.1016/j.pocean.2021.102629

Brennan, C. E., Maps, F., Gentleman, W. C., Lavoie, D., Chasse, J., Plourde, S., and Johnson, C. L. 2021. Ocean circulation changes drive shifts in Calanus abundance in North Atlantic right whale foraging habitat: A model comparison of cool and warm year scenarios. Progress in Oceanography, 197. https://doi.org/10.1016/j.pocean.2021.102629

Brillant, S. W., Wimmer, T., Rangeley, R. W., and Taggart, C. T. 2017. A timely opportunity to protect North Atlantic right whales in Canada. Marine Policy, 81, 160-166. https://doi.org/10.1016/j.marpol.2017.03.030

Browning, C. L., Wise, C. F., and Wise, J. P. 2017. Prolonged particulate chromate exposure does not inhibit homologous recombination repair in North Atlantic right whale (*Eubalaena glacialis*) lung cells. Toxicology and Applied Pharmacology, 331, 18-23. https://doi.org/10.1016/j.taap.2017.04.006

Burgess, E. A., Hunt, K. E., Kraus, S. D., and Rolland, R. M. 2017. Adrenal responses of large whales: Integrating fecal aldosterone as a complementary biomarker to glucocorticoids. General and Comparative Endocrinology, 252, 103-110. https://doi.org/10.1016/j.ygcen.2017.07.026

Burgess, E. A., Hunt, K. E., Kraus, S. D., and Rolland, R. M. 2018. Quantifying hormones in exhaled breath for physiological assessment of large whales at sea. Scientific Reports, 8(1), 10031, Article 10031. https://doi.org/10.1038/s41598-018-28200-8

Charif, R. A., Shiu, Y., Muirhead, C. A., Clark, C. W., Parks, S. E., and Rice, A. N. 2020. Phenological changes in North Atlantic right whale habitat use in Massachusetts Bay. Global Change Biology, 26(2), 734-745. https://doi.org/10.1111/gcb.14867

Christiansen, F., Dawson, S. M., Durban, J. W., Fearnbach, H., Miller, C. A., Bejder, L., Uhart, M., Sironi, M., Corkeron, P., Rayment, W., Leunissen, E., Haria, E., Ward, R., Warick, H. A., Kerr, I., Lynn, M. S., Pettis, H. M., and Moore, M. J. 2020. Population comparison of right whale body condition reveals poor state of the North Atlantic right whale. Marine Ecology Progress Series, 640, 1-16. https://doi.org/10.3354/meps13299

Cholewiak, D., Clark, C. W., Ponirakis, D., Frankel, A., Hatch, L. T., Risch, D., Stanistreet, J. E., Thompson, M., Vu, E., and Van Parijs, S. M. 2018. Communicating amidst the noise: modeling the aggregate influence of ambient and vessel noise on baleen whale communication space in a national marine sanctuary. Endangered Species Research, 36, 59-75. https://doi.org/10.3354/esr00875

Cole, A. K., Brillant, S. W., and Boudreau, S. A. 2021. Effects of time-area closures on the distribution of snow crab fishing effort with respect to entanglement threat to North Atlantic right whales. ICES Journal of Marine Science. https://doi.org/10.1093/icesjms/fsab103

Cole, T. V. N., Crowe, L. M., Corkeron, P. J., and Vanderlaan, A. S. M. 2020. North Atlantic right whale abundance, demography and residency in the southern Gulf of St. Lawrence derived from directed aerial surveys (14993848). (Canadian Science Advisory Secretariat Research Document.

Corkeron, P., Rolland, R. M., Hunt, K. E., and Kraus, S. D. 2017. A right whale pootree: classification trees of faecal hormones identify reproductive states in North Atlantic right whales (*Eubalaena glacialis*). Conservation Physiology, 5(1), cox006, Article cox006. https://doi.org/10.1093/conphys/cox006

Corkeron, P., Hamilton, P., Bannister, J., Best, P., Charlton, C., Groch, K. R., Findlay, K., Rowntree, V., Vermeulen, E., and Pace, R. M. 2018. The recovery of North Atlantic right whales, *Eubalaena glacialis*, has been constrained by human-caused mortality. Royal Society Open Science, 5(11), 180892, Article 180892. https://doi.org/10.1098/rsos.180892

Cronin, T. W., Fasick, J. I., Schweikert, L. E., Johnsen, S., Kezmoh, L. J., and Baumgartner, M. F. 2017. Coping with copepods: do right whales (*Eubalaena glacialis*) forage visually in dark waters? Philosophical Transactions of the Royal Society B-Biological Sciences, 372(1717), Article 20160067. https://doi.org/10.1098/rstb.2016.0067

Crowe, L. M., Brown, M. W., Corkeron, P. J., Hamilton, P. K., Ramp, C., Ratelle, S., Vanderlaan, A. S. M., and Cole, T. V. N. 2021. In plane sight: a mark-recapture analysis of North Atlantic right whales in the Gulf of St. Lawrence. Endangered Species Research, 46, 227-251. https://doi.org/10.3354/esr01156

Crum, N., Gowan, T., Krzystan, A., and Martin, J. 2019. Quantifying risk of whale-vessel collisions across space, time, and management policies. Ecosphere, 10(4), Article e02713. https://doi.org/10.1002/ecs2.2713

Crum, N. J., Neyman, L. C., and Gowan, T. A. 2021. Abundance estimation for line transect sampling: A comparison of distance sampling and spatial capture-recapture models. PLoS ONE, 16(5), 1-17. https://doi.org/10.1371/journal.pone.0252231

Cusano, D. A., Conger, L. A., Van Parijs, S. M., and Parks, S. E. 2018. Implementing conservation measures for the North Atlantic right whale: considering the behavioral ontogeny of mother-calf pairs. Animal Conservation, 22(3), 228-237. https://doi.org/10.1111/acv.12457

Daoust, P.-Y., Couture, E.L., Wimmer, T., and Bourque, L. 2018. Incident Report: North Atlantic Right Whale Mortality Event in the Gulf of St. Lawrence, 2017. Collaborative Report Produced by: Canadian Wildlife Health Cooperative, Marine Animal Response Society, and Fisheries and Oceans Canada. 256 pp.

Davies, K. T. A., and Brillant, S. W. 2019. Mass human-caused mortality spurs federal action to protect endangered North Atlantic right whales in Canada. Marine Policy, 104, 157-162. https://doi.org/10.1016/j.marpol.2019.02.019

Davies, K. T. A., Brown, M. W., Hamilton, P. K., Knowlton, A. R., Taggart, C. T., and Vanderlaan, A. S. M. 2019. Variation in North Atlantic right whale *Eubalaena glacialis* occurrence in the Bay of Fundy, Canada, over three decades. Endangered Species Research, 39, 159-171. https://doi.org/10.3354/esr00951

Davis, G. E., Baumgartner, M. F., Bonnell, J. M., Bell, J., Berchok, C., Thornton, J. B., Brault, S., Buchanan, G., Charif, R. A., Cholewiak, D., Clark, C. W., Corkeron, P., Delarue, J., Dudzinski, K., Hatch, L., Hildebrand, J., Hodge, L., Klinck, H., Kraus, S.,...Van Parijs, S. M. 2017. Long-term passive acoustic recordings track the changing distribution of North Atlantic right whales (*Eubalaena glacialis*) from 2004 to 2014. Scientific Reports, 7(1), 13460, Article 13460. https://doi.org/10.1038/s41598-017-13359-3

Dombroski, J. R. G., Parks, S. E., and Nowacek, D. P. 2021. Dive behavior of North Atlantic right whales on the calving ground in the Southeast USA: implications for conservation. Endangered Species Research. https://doi.org/10.3354/esr01141

Dorrell, R.M., Lloyd, C.J., Lincoln, B.J., Rippeth, T.P., Taylor, J.R., Colm-cille, P.C., Sharples, J., Polton, J.A., Scannell, B.D., Greaves, D.M., Hall, R.A., and Simpson, J.H. 2022. Anthropogenic mixing in seasonally stratified shelf seas by offshore wind farm infrastructure. Frontiers in Marine Science, 9:830927. doi: 10.3389/fmars.2022.830927

Esfahanian, M., Erdol, N., Gerstein, E., and Zhuang, H. Q. 2017. Two-stage detection of north Atlantic right whale upcalls using local binary patterns and machine learning algorithms. Applied Acoustics, 120, 158-166. https://doi.org/10.1016/j.apacoust.2017.01.025

Estabrook, B. J., Hodge, K. B., Salisbury, D. P., Ponirakis, D., Harris, D. V., Zeh, J. M., Parks, S. E., and Rice, A. N. 2019. Year-1 Annual Survey Report for New York Bight Whale Monitoring Passive Acoustic Surveys: October 2017 – October 2018 (Passive Acoustic Survey. https://www.dec.ny.gov/lands/113828.html

Fasick, J. I., Baumgartner, M. F., Cronin, T. W., Nickle, B., and Kezmoh, L. J. 2017. Visual predation during springtime foraging of the North Atlantic right whale (*Eubalaena glacialis*). Marine Mammal Science, 33(4), 991-1013. https://doi.org/10.1111/mms.12417

Fauquier, D., Long, K., Biedron, I., Wilkin, S., Rowles, T., Patterson, E., Henry, A., Garron, M., Fougeres, E., Farmer, N. A., Baker, J., and Ziccardi, M. 2020. Report of the Health Assessment Workshop for North Atlantic Right Whales (*Eubalaena glacialis*), June 24-26, 2019. https://repository.library.noaa.gov/view/noaa/27432/noaa_27432_DS1.pdf

Fisheries and Oceans Canada. 2021. Action Plan for the North Atlantic Right Whale (*Eubalaena glacialis*) in Canada. Species at Risk Act Action Plan Series. Fisheries and Oceans Canada, Ottawa. v + 46 pp.

Fisheries and Oceans Canada. 2022. Protecting the North Atlantic Right Whale: Speed Restriction Measures in the Gulf of St. Lawrence (401/22). Notices to Mariners - Special Edition 02/22. https://tc.canada.ca/en/ministerial-orders-interim-orders-directives-directions-response-letters/interim-order-protection-north-atlantic-right-whales-eubalaena-glacialis-gulf-st-lawrence-2022

Fitzgerald, K. 2018. Combing genetic and photo-identification data to improve abundance estimates for the North Atlantic right whale LENS. Halifax Nova Scotia. http://library2.smu.ca/handle/01/27525

Fortune, S. M. E., Moore, M. J., Perryman, W. L., and Trites, A. W. 2021. Body growth of North Atlantic right whales (*Eubalaena glacialis*) revisited. Marine Mammal Science, 37(2), 433-447. https://doi.org/10.1111/mms.12753

Frasier, B. A., Springate, L., and Frasier, T. R. 2022. Genetic examination of historical North Atlantic right whale (*Eubalaena glacialis*) bone specimens from the eastern North Atlantic: Insights into species history, transoceanic population structure, and genetic diversity. Marine Mammal Science. https://doi.org/10.1111/mms.12916

Ganley, L. C., Brault, S., and Mayo, C. A. 2019. What we see is not what there is: estimating North Atlantic right whale *Eubalaena glacialis* local abundance. Endangered Species Research, 38, 101-113. https://doi.org/10.3354/esr00938

Ganley, L.C., Byrnes, J., Pendleton, D.E., Mayo, C.A., Friedland, K.D., Redfern, J.V., Turner, J.T., and Brault, S. 2022. Effects of changing temperature phenology on the abundance of a critically endangered baleen whale. Global Ecology and Conservation, 38, e02193. https://doi.org/10.1016/j.gecco.2022.e02193

Garrison, L.P., Adams, J., Patterson. E.M., and Good, C.P. 2022. Assessing the risk of vessel strike mortality in North Atlantic right whales along the U.S East Coast. NOAA Technical Memorandum NOAA NMFS-SEFSC-757: 42 p.

Gavrilchuk, K., Lesage, V., Fortune, S., Trites, A. W., and Plourde, S. 2020. A mechanistic approach to predicting suitable foraging habitat for reproductively mature North Atlantic right whales in the Gulf of St. Lawrence. Canada Science Advisory Report.

Gavrilchuk, K., Lesage, V., Fortune, S. M. E., Trites, A. W., and Plourde, S. 2021. Foraging habitat of North Atlantic right whales has declined in the Gulf of St. Lawrence, Canada, and may be insufficient for successful reproduction. Endangered Species Research, 44, 113-136. https://doi.org/10.3354/esr01097

Gedamke, J., Harrison, J., Hatch, L., Angliss, R., Barlow, J., Berchok, C., Caldow, C., Castellote, M., Cholewiak, D., DeAngelis, M.L., Dziak, R., Garland, E., Guan, S., Hastings, S., Holt, M., Laws, B., Mellinger, D., Moore, S., Moore, T.J., Oleson, E., Pearson-Meyer, J., Piniak, W., Redfern, J., Rowles, T., Scholik-Schlomer, A., Smith, A., Soldevilla, M., Stadler, J., Van Parijs, S., and Wahle, C. 2016. NOAA Ocean Noise Strategy Roadmap. https://oceannoise.noaa.gov/sites/default/files/2021-02/ONS_Roadmap_Final_Complete.pdf

Gervaise, C., Simard, Y., Aulanier, F., and Roy, N. 2021. Optimizing passive acoustic systems for marine mammal detection and localization: Application to real-time monitoring north Atlantic right whales in Gulf of St. Lawrence. Applied Acoustics, 178, Article 107949. https://doi.org/10.1016/j.apacoust.2021.107949

Gowan, T. A., Crum, N. J., and Roberts, J. J. 2021. An open spatial capture–recapture model for estimating density, movement, and population dynamics from line-transect surveys. Ecology and Evolution. https://doi.org/10.1002/ece3.7566

Gowan, T. A., Ortega-Ortiz, J. G., Hostetler, J. A., Hamilton, P. K., Knowlton, A. R., Jackson, K. A., George, R. C., Taylor, C. R., and Naessig, P. J. 2019. Temporal and demographic variation in partial migration of the North Atlantic right whale. Scientific Reports, 9(1), 353, Article 353. https://doi.org/10.1038/s41598-018-36723-3

Graham, K. M., Burgess, E. A., and Rolland, R. M. 2021. Stress and reproductive events detected in North Atlantic right whale blubber using a simplified hormone extraction protocol. Conservation Physiology, 9(1), coaa133, Article coaa133. https://doi.org/10.1093/conphys/coaa133

Grieve, B. D., Hare, J. A., and Saba, V. S. 2017. Projecting the effects of climate change on Calanus finmarchicus distribution within the US Northeast Continental Shelf. Scientific Reports, 7(1), 6264, Article 6264. https://doi.org/10.1038/s41598-017-06524-1

Hamilton, P. K., Frasier, B. A., Conger, L. A., George, R. C., Jackson, K. A., and Frasier, T. R. 2022. Genetic identifications challenge our assumptions of physical development and mother-calf associations and separation times: a case study of the North Atlantic right whale (*Eubalaena glacialis*). Mammalian Biology. https://doi.org/10.1007/s42991-021-00177-4

Hamilton, P. K., and Kraus, S. D. 2019. Frequent encounters with the seafloor increase right whales' risk of entanglement in fishing groundlines. Endangered Species Research, 39, 235-246. https://doi.org/10.3354/esr00963

Hammond, P. S., Francis, T. B., Heinemann, D., Long, K. J., Moore, J. E., Punt, A. E., Reeves, R. R., Sepúlveda, M., Sigurðsson, G. M., Siple, M. C., Víkingsson, G., Wade, P. R., Williams, R., and Zerbini, A. N. 2021. Estimating the Abundance of Marine Mammal Populations. Frontiers in Marine Science, 8. https://www.frontiersin.org/article/10.3389/fmars.2021.735770

Hatch, L.T., Clark, C.W., Van Parijs, S.M., Frankel, A.S., and Ponirakis, D.W. 2012. Quantifying loss of acoustic communication space for right whales in and around a US National Marine Sanctuary. Conservation Biology, 26: 983−994

Hayes, S.A., Josephson, E., Maze-Foley, K., Rosel, P.E., and Turek, J. 2021. US Atlantic and Gulf of Mexico Marine Mammal Stock Assessments 2020. NOAA Technical Memorandum NMFS-NE-271.

Hayes, S.A., Josephson, E., Maze-Foley, K., Rosel, P.E., and Turek, J. Draft US Atlantic and Gulf of Mexico Marine Mammal Stock Assessments 2021. In prep.

Hodul, M., Knudby, A., McKenna, B., James, A., Mayo, C., Brown, M., Durette-Morin, D., and Bird, S. 2022. Individual North Atlantic right whales identified from space. Marine Mammal Science, 1-12. https://doi.org/10.1111/mms.12971

Howle, L. E., Kraus, S. D., Werner, T. B., and Nowacek, D. P. 2019. Simulation of the entanglement of a North Atlantic right whale (*Eubalaena glacialis*) with fixed fishing gear. Marine Mammal Science, 35(3), 760-778. https://doi.org/10.1111/mms.12562

Hunt, K. E., Lysiak, N. S., Moore, M., and Rolland, R. M. 2017a. Multi-year longitudinal profiles of cortisol and corticosterone recovered from baleen of North Atlantic right whales (*Eubalaena glacialis*). General and Comparative Endocrinology, 254, 50-59. https://doi.org/10.1016/j.ygcen.2017.09.009

Hunt, K. E., Lysiak, N. S., Robbins, J., Moore, M. J., Seton, R. E., Torres, L., and Buck, C. L. 2017b. Multiple steroid and thyroid hormones detected in baleen from eight whale species. Conservation Physiology, 5(1), cox061, Article cox061. https://doi.org/10.1093/conphys/cox061

Hunt, K. E., Lysiak, N. S., Matthews, C. J. D., Lowe, C., Ajo, A. F., Dillon, D., Willing, C., Heide-Jorgensen, M. P., Ferguson, S. H., Moore, M. J., and Buck, C. L. 2018. Multi-year patterns in testosterone, cortisol and corticosterone in baleen from adult males of three whale species. Conservation Physiology, 6(1), coy049, Article coy049. https://doi.org/10.1093/conphys/coy049

Ibrahim, A. K., Zhuang, H., Erdol, N., and Ali, A. M. 2018a. Detection of North Atlantic Right Whales with a Hybrid System of CNN and Dictionary Learning. 2018 International Conference on Computational Science and Computational Intelligence (CSCI), DOI 10.1109/CSCI46756.2018.00232

Ibrahim, A. K., Zhuang, H., Erdol, N., and Ali, A. M. 2018b. Feature Extraction Methods for the Detection of North Atlantic Right Whale Up-calls. 2018 International Conference on Computational Science and Computational Intelligence (CSCI), DOI 10.1109/CSCI46756.2018.00042

Ibrahim, A. K., Zhuang, H., Cherubin, L. M., Erdol, N., Corry-Crowe, G. O., and Ali, A. M. 2020. North Atlantic Right Whales Up-call Detection Using Multimodel Deep Learning. arXiv. https://arxiv.org/abs/2005.08356

Ibrahim, A. K., Zhuang, H., Cherubin, L. M., Erdol, N., O'Corry-Crowe, G., and Ali, A. M. 2021. A multimodel deep learning algorithm to detect North Atlantic right whale up-calls. Journal of the Acoustical Society of America, 150(2), 1264-1272. https://doi.org/10.1121/10.0005898

Ierardi, J. L., Veloso, A., and Mancia, A. 2021. Transcriptome analysis of cadmium exposure in kidney fibroblast cells of the North Atlantic Right Whale (*Eubalaena glacialis*). Comparative Biochemistry and Physiology C-Toxicology and Pharmacology, 242, 108946, Article 108946. https://doi.org/10.1016/j.cbpc.2020.108946

Johnson, H. D., Baumgartner, M. F., and Taggart, C. T. 2020. Estimating North Atlantic right whale (*Eubalaena glacialis*) location uncertainty following visual or acoustic detection to inform dynamic management. Conservation Science and Practice, 2(10), Article e267. https://doi.org/10.1111/csp2.267

Johnson, H. D., Taggart, C. T., Newhall, A. E., Lin, Y.-T., and Baumgartner, M. F. 2022. Acoustic detection range of right whale upcalls identified in near-real time from a moored buoy and a Slocum glider. Journal of the Acoustical Society of America, 151(4), 2558-2575. https://doi.org/10.1121/10.0010124

Kabani, A., and El-Sakka, M. R. 2016. North Atlantic right whale localization and recognition using very deep and leaky Neural Network. Mathematics for Applications, 5(2), 155-170. https://doi.org/10.13164/ma.2016.11

Kelley, D. E., Vlasic, J. P., and Brillant, S. W. 2021. Assessing the lethality of ship strikes on whales using simple biophysical models. Marine Mammal Science, 37(1), 251-267. https://doi.org/10.1111/mms.12745

Khan, C., Blount, D., Parham, J., Holmburg, J., Hamilton, P., Charlton, C., Christiansen, F., Johnston, D., Rayment, W., Dawson, S., Vermeulen, E., Rowentree, V., Groch, K., Levenson, J.J., and Bogucki, R. 2022. Artificial intelligence for right whale photo identification: from data science competition to worldwide collaboration. Mammalian Biology. https://doi.org/10.1007/s42991-022-00253-3

Khan, C., Duley, P., Henry, A., Gatzke, J., and Cole, T.V.N. 2014. North Atlantic Right Whale Sighting Survey (NARWSS) and Right Whale Sighting Advisory System (RWSAS) 2013 Results Summary. US Department of Commerce, Northeast Fisheries Science Center Reference Document. 14-11; 10 p. doi: 10.7289/V5PN93MK.

King, K., Joblon, M., McNally, K., Clayton, L., Pettis, H., Corkeron, P., and Nutter, F. 2021. Assessing North Atlantic Right Whale (*Eubalaena glacialis*) Welfare. Journal of Zoological and Botanical Gardens, 2(4), 728-739. https://doi.org/10.3390/jzbg2040052

Knowlton, A.R., Clark, J. S., Hamilton, P.K., Kraus, S.D., Pettis, H.M., Rolland, R.M., and Schick, R.S. 2022. Fishing gear entanglement threatens recovery of critically endangered North Atlantic right whales. Conservation Science and Practice, 4(8): e12736. https://doi.org/10.1111/csp2.12736

Koubrak, O., VanderZwaag, D. L., and Worm, B. 2021. Saving the North Atlantic right whale in a changing ocean: Gauging scientific and law and policy responses. Ocean & Coastal Management, 200, Article 105109. https://doi.org/10.1016/j.ocecoaman.2020.105109

Kowarski, K. A., Gaudet, B. J., Cole, A. J., Maxner, E. E., Turner, S. P., Martin, S. B., Johnson, H. D., and Moloney, J. E. 2020. Near real-time marine mammal monitoring from gliders: Practical challenges, system development, and management implications. Journal of the Acoustical Society of America, 148(3), 1215-1230. https://doi.org/10.1121/10.0001811

Krumhansl, K. A., Head, E. J. H., Pepin, P., Plourde, S., Record, N. R., Runge, J. A., and Johnson, C. L. 2018. Environmental drivers of vertical distribution in diapausing Calanus copepods in the Northwest Atlantic. Progress in Oceanography, 162, 202-222. https://doi.org/10.1016/j.pocean.2018.02.018

Krzystan, A. M., Gowan, T. A., Kendall, W. L., Martin, J., Ortega-Ortiz, J. G., Jackson, K., Knowlton, A. R., Naessig, P., Zani, M., Schulte, D. W., and Taylor, C. R. 2018. Characterizing residence patterns of North Atlantic right whales in the southeastern USA with a multistate open robust design model. Endangered Species Research, 36, 279-295. https://doi.org/10.3354/esr00902

Laist, D. W. 2017. Estimating Pre-exploitation Population Size. In North Atlantic Right Whales: From Hunted Leviathan to Conservation Icon (pp. 251-265). Johns Hopkins University Press.

Lanyon, J. M., and Burgess, E. A. 2019. Reproductive Science Methods for Wild, Fully-Marine Mammals: Current Approaches and Future Applications. In P. Comizzoli, J. L. Brown, & W. V. Holt (Eds.), Reproductive Sciences in Animal Conservation, 2nd Edition (Vol. 1200, pp. 363-411). https://doi.org/10.1007/978-3-030-23633-5_13

Lehoux, C., Plourde, S., and Lesage, V. 2020. Significance of dominant zooplankton species to the North Atlantic Right Whale potential foraging habitats in the Gulf of St. Lawrence : a bio-energetic approach. DFO Canadian Science Advisory Secretariat. Research Document 2020/033. iv + 44 p.

Leiter, S. M., Stone, K. M., Thompson, J. L., Accardo, C. M., Wikgren, B. C., Zani, M. A., Cole, T. V. N., Kenney, R. D., Mayo, C. A., and Kraus, S. D. 2017. North Atlantic right whale *Eubalaena glacialis* occurrence in offshore wind energy areas near Massachusetts and Rhode Island, USA. Endangered Species Research, 34, 45-59. https://doi.org/10.3354/esr00827

Linden, D. 2021. Population projections of North Atlantic right whales under varying human-caused mortality risk and future uncertainty. National Marine Fisheries Service, Greater Atlantic Region, Gloucester, MA.

Lonati, G.L., Zitterbart, D.P., Miller, C.A., Corkeron, P., Murphy, C.T., and Moore, M.J. 2022. Investigating the thermal physiology of critically endangered North Atlantic right whales Eubalaena glacialis via aerial infrared thermography. Endangered Species Research, 48, 139-154. https://doi.org/10.3354/esr01193

Lysiak, N. S. J., Trumble, S. J., Knowlton, A. R., and Moore, M. J. 2018. Characterizing the Duration and Severity of Fishing Gear Entanglement on a North Atlantic Right Whale (*Eubalaena glacialis*) Using Stable Isotopes, Steroid and Thyroid Hormones in Baleen. Frontiers in Marine Science, 5, Article 168. https://doi.org/10.3389/fmars.2018.00168

Macrander, A. M., Brzuzy, L., Raghukumar, K., Preziosi, D., and Jones, C. 2021. Convergence of emerging technologies: Development of a risk-based paradigm for marine mammal monitoring for offshore wind energy operations. Integrated Environmental Assessment and Management. https://doi.org/10.1002/ieam.4532

Martins, M. C. I., Miller, C., Hamilton, P., Robbins, J., Zitterbart, D. P., and Moore, M. 2020. Respiration cycle duration and seawater flux through open blowholes of humpback (Megaptera novaeangliae) and North Atlantic right (*Eubalaena glacialis*) whales. Marine Mammal Science, 36(4), 1160-1179. https://doi.org/10.1111/mms.12703

Marotte, E., Wright, A. J., Breeze, H., Wingfield, J., Matthews, L. P., Risch, D., Merchant, N. D., Barclay, D., Evers, C., Lawson, J., Lesage, V., Moors-Murphy, H., Nolet, V., and Theriault, J. A. 2022. Recommended metrics for quantifying underwater noise impacts on North Atlantic right whales. Marine Pollution Bulletin, 175. https://doi.org/10.1016/j.marpolbul.2022.113361

Matthews, L. P., and Parks, S. E. 2021. An overview of North Atlantic right whale acoustic behavior, hearing capabilities, and responses to sound. Marine Pollution Bulletin, 173. https://doi.org/10.1016/j.marpolbul.2021.113043

Maxwell, S.M., Kershaw, F., Locke, C.C., Conners, M.G., Dawson, C., Aylesworth, S., Loomis, R., and Johnson, A.F. 2022. Potential impacts of floating wind turbine technology for marine species and habitats. Journal of Environmental Management, 307: 114577. https://doi.org/10.1016/j.jenvman.2022.114577

Mayo, C. A., Ganley, L., Hudak, C. A., Brault, S., Marx, M. K., Burke, E., and Brown, M. W. 2018. Distribution, demography, and behavior of North Atlantic right whales (*Eubalaena glacialis*) in Cape Cod Bay, Massachusetts, 1998-2013. Marine Mammal Science, 34(4), 979-996. https://doi.org/10.1111/mms.12511

Meyer-Gutbrod, E. L., and Greene, C. H. 2018. Uncertain recovery of the North Atlantic right whale in a changing ocean. Global Change Biology, 24(1), 455-464. https://doi.org/10.1111/gcb.13929

Meyer-Gutbrod, E. L., Greene, C. H., and Davies, K. T. A. 2018. Marine Species Range Shifts Necessitate Advanced Policy Planning The case of the North Atlantic right whale. Oceanography, 31(2), 19-23. https://doi.org/10.5670/oceanog.2018.209

Meyer-Gutbrod, E.L., C.H. Greene, K.T.A. Davies, and D.G. Johns. 2021. Ocean regime shift is driving collapse of the North Atlantic right whale population. Oceanography, 34(3):22–31. https://doi.org/10.5670/oceanog.2021.308

Montes, N. L., Swett, R., and Gowan, T. A. 2020. Risk of encounters between North Atlantic right whales and recreational vessel traffic in the southeastern United States. Ecology and Society, 25(4), Article 12. https://doi.org/10.5751/es-11923-250412

Montes, N., Swett, R., Jacobson, S. K., and Sidman, C. 2018. Factors Influencing Recreational Boaters' Intentions to Comply with Right Whale Regulations in the Southeastern United States. Society & Natural Resources, 31(4), 1-16. https://doi.org/10.1080/08941920.2017.1377795

Moore, M. J. 2019. How we can all stop killing whales: a proposal to avoid whale entanglement in fishing gear. ICES Journal of Marine Science, 76(4), 781-786. https://doi.org/10.1093/icesjms/fsy194

Moore, M. J., Rowles, T. K., Fauquier, D. A., Baker, J. D., Biedron, I., Durban, J. W., Hamilton, P. K., Henry, A. G., Knowlton, A. R., McLellan, W. A., Miller, C. A., Pace, R. M., Pettis, H. M., Raverty, S., Rolland, R. M., Schick, R. S., Sharp, S. M., Smith, C. R., Thomas, L., . . . Ziccardi, M. H. 2021. Assessing North Atlantic right whale health: threats, and development of tools critical for conservation of the species. Diseases of Aquatic Organisms, 143, 205-226. https://doi.org/10.3354/dao03578

Mori, C, and Riley, M. 2021. Framework for ESA Section 7 Evaluation of Aquaculture Projects in the Greater Atlantic Region. Greater Atlantic Region Policy Series [21-02]. NOAA Fisheries Greater Atlantic Regional Fisheries Office - www.greateratlantic.fisheries.noaa.gov/policyseries/. 183pp

Muirhead, C. A., Warde, A. M., Biedron, I. S., Mihnovets, A. N., Clark, C. W., and Rice, A. N. 2018. Seasonal acoustic occurrence of blue, fin, and North Atlantic right whales in the New York Bight. Aquatic Conservation-Marine and Freshwater Ecosystems, 28(3), 744-753. https://doi.org/10.1002/aqc.2874

Murphy, C. T., Marx, M., Martin, W. N., Jiang, H., Lapseritis, J. M., French, A. N., Simmons, N. B., and Moore, M. J. 2022. Feeling for food: Can rostro-mental hair arrays sense hydrodynamic cues for foraging North Atlantic right whales? The Anatomical Record, 305(3), 577-591. https://doi.org/10.1002/ar.24858

National Marine Fisheries Service. 2019. Recovering Threatened and Endangered Species, FY 2017 - 2018 Report to Congress. National Marine Fisheries Service. Silver Spring, MD.

National Marine Fisheries Service. 2020. North Atlantic Right Whale (*Eubalaena glacialis*) Vessel Speed Rule Assessment. National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD. https://media.fisheries.noaa.gov/2021-01/FINAL_NARW_Vessel_Speed_Rule_Report_Jun_2020.pdf?null

National Marine Fisheries Service. 2021a. National Marine Fisheries Service Endangered Species Act Section 7 Biological Opinion Construction, Operation, Maintenance, and Decommissioning of the South Fork Offshore Energy Project (Lease OCS-A 0517) – Corrected. https://media.fisheries.noaa.gov/2021-12/SFW_BiOp_OPR1.pdf

National Marine Fisheries Service. 2021b. National Marine Fisheries Service Endangered Species Act Section 7 Biological Opinion Construction, Operation, Maintenance, and Decommissioning of the Vineyard Wind 1 Offshore Wind Energy Project (Lease OCS-A 0501) - Reinitiation. https://repository.library.noaa.gov/view/noaa/37556

National Marine Fisheries Service. 2021c. North Atlantic Right Whale Species in the Spotlight Priority Actions 2021-2025. https://media.fisheries.noaa.gov/2021-04/SIS%20Action%20Plan%202021_NARightWhale-FINAL%20508.pdf

National Marine Fisheries Service. 2022. Recovering Threatened and Endangered Species, FY 2019–2020 Report to Congress. National Marine Fisheries Service. Silver Spring, MD.

O'Brien, O., Pendleton, D.E., Ganley, L.C., McKenna, K.R., Kenney, R.D., Quintana-Rizzo, E., Mayo, C.A., Kraus, S.D., and Redfern, J.V. 2022. Repatriation of a historical North Atlantic right whale habitat during an era of rapid climate change. Scientific Reports, 12, 12407. https://doi.org/10.1038/s41598-022-16200-8

O'Callaghan. 2019. North Atlantic right whales (*Eubalaena glacialis*) in Irish Waters: 1300-1987. Biology & Environment Proceedings of the Royal Irish Academy, 119B(2-3), 111. https://doi.org/10.3318/bioe.2019.10

Oleson, E.M., Baker, J., Barlow, J., Moore, J.E., and Wade, P. 2020. North Atlantic Right Whale Monitoring and Surveillance: Report and Recommendations of the National Marine Fisheries Service's Expert Working Group. NOAA Tech. Memo. NMFS-F/OPR-64, 47 p.

Oppenheim, N.G. 2022. Assessing the Feasibility of On-demand Gear in New England Lobster Fisheries. Homarus Strategies LLC, Brunswick, Maine, USA.

Pace, R. M., Corkeron, P. J., and Kraus, S. D. 2017. State–space mark–recapture estimates reveal a recent decline in abundance of North Atlantic right whales. Ecology and Evolution, 7(21), 8730-8741. https://doi.org/10.1002/ece3.3406

Pace, R. M., Williams, R., Kraus, S. D., Knowlton, A. R., and Pettis, H. M. 2021. Cryptic mortality of North Atlantic right whales. Conservation Science and Practice, 3(2), Article e346. https://doi.org/10.1111/csp2.346

Padovese, B., Frazao, F., Kirsebom, O. S., and Matwin, S. 2021. Data augmentation for the classification of North Atlantic right whales upcalls. Journal of the Acoustical Society of America, 149(4), 2520. https://doi.org/10.1121/10.0004258

Palmer, K. J., Wu, G.-M., Clark, C., and Klinck, H. 2022. Accounting for the Lombard effect in estimating the probability of detection in passive acoustic surveys: Applications for single sensor mitigation and monitoring. Journal of the Acoustical Society of America, 151(1), 67-79. https://doi.org/10.1121/10.0009168

Parks, S. E., Cusano, D. A., Van Parijs, S. M., and Nowacek, D. P. 2019a. North Atlantic right whale (*Eubalaena glacialis*) acoustic behavior on the calving grounds. Journal of the Acoustical Society of America, 146(1), EL15-EL21. https://doi.org/10.1121/1.5115332

Parks, S. E., Cusano, D. A., Van Parijs, S. M., and Nowacek, D. P. 2019b. Acoustic crypsis in communication by North Atlantic right whale mother–calf pairs on the calving grounds. Biology Letters, 15(10), 20190485. https://doi.org/10.1098/rsbl.2019.0485

Pegg, N., Roca, I. T., Cholewiak, D., Davis, G. E., and Van Parijs, S. M. 2021. Evaluating the Efficacy of Acoustic Metrics for Understanding Baleen Whale Presence in the Western North Atlantic Ocean. Frontiers in Marine Science, 8. https://doi.org/10.3389/fmars.2021.749802

Pendleton, D.E., Tingley, M.W., Ganley, L.C., Friedland, K.D., Mayo, C., Brown, M.W., McKenna, B.E., Jordaan, A., and Staudinger, M.D. 2022. Decadal-scale phenology and seasonal climate drivers of migratory baleen whales in a rapidly warming marine ecosystem. Global Change Biology, 28(16): 4989-5005. https://doi.org/10.1111/gcb.16225

Pershing, A. J., Alexander, M. A., Brady, D. C., Brickman, D., Curchitser, E. N., Diamond, A. W., McClenachan, L., Mills, K. E., Nichols, O. C., Pendleton, D. E., Record, N. R., Scott, J. D., Staudinger, M. D., and Wang, Y. 2021. Climate impacts on the Gulf of Maine ecosystem: A review of observed and expected changes in 2050 from rising temperatures. Elemental-Science of the Anthropocene, 9(1). https://doi.org/10.1525/elementa.2020.00076

Pettis, H., Pace, R., and Hamilton, P. 2021. North Atlantic Right Whale Consortium 2020 Annual Report Card. Report to the North Atlantic Right Whale Consortium.

Pettis, H. M., Rolland, R. M., Hamilton, P. K., Knowlton, A. R., Burgess, E. A., and Kraus, S. D. 2017. Body condition changes arising from natural factors and fishing gear entanglements in North Atlantic right whales *Eubalaena glacialis*. Endangered Species Research, 32, 237-249. https://doi.org/10.3354/esr00800

Pirotta, E., Thomas, L., Costa, D. P., Hall, A. J., Harris, C. M., Harwood, J., Kraus, S. D., Miller, P. J. O., Moore, M. J., Photopoulou, T., Rolland, R. M., Schwacke, L., Simmons, S. E., Southall, B. L., and Tyack, P. L. 2022. Understanding the combined effects of multiple stressors: A new perspective on a longstanding challenge. Science of the Total Environment, 821, 153322. https://doi.org/10.1016/j.scitotenv.2022.153322

Plourde, S., Lehoux, C., Johnson, C. L., Perrin, G., and Lesage, V. 2019. North Atlantic right whale (*Eubalaena glacialis*) and its food: (I) a spatial climatology of Calanus biomass and potential foraging habitats in Canadian waters. Journal of Plankton Research, 41(5), 667-685. https://doi.org/10.1093/plankt/fbz024

Price, C.S., Keane, E., Morin, D., Vaccaro, C., Bean, D., and Morris Jr., J.A. 2017. Protected Species & Marine Aquaculture Interactions. NOAA Technical Memorandum NOS NCCOS 211. 85 pp

Quintana-Rizzo, E., Leiter, S., Cole, T. V. N., Hagbloom, M. N., Knowlton, A. R., Nagelkirk, P., O'Brien, O., Khan, C. B., Henry, A. G., Duley, P. A., Crowe, L. M., Mayo, C. A., and Kraus, S. D. 2021. Residency, demographics, and movement patterns of North Atlantic right whales *Eubalaena glacialis* in an offshore wind energy development area in southern New England, USA. Endangered Species Research, 45, 251-268. https://doi.org/10.3354/esr01137

Radvan, S. N. 2019. Effects of inbreeding on fitness in the North Atlantic right whale (*Eubalaena glacialis*) LENS. Halifax, Nova Scotia. https://library2.smu.ca/handle/01/28821

Ramp, C., Gaspard, D., Gavrilchuk, K., Unger, M., Schleimer, A., Delarue, J., Landry, S., and Sears, R. 2021. Up in the air: drone images reveal underestimation of entanglement rates in large rorqual whales. Endangered Species Research, 44, 33-44. https://doi.org/10.3354/esr01084

Record, N. R., Runge, J. A., Pendleton, D. E., Balch, W. M., Davies, K. T. A., Pershing, A. J., Johnson, C. L., Stamieszkin, K., Ji, R. B., Feng, Z. X., Kraus, S. D., Kenney, R. D., Hudak, C. A., Mayo, C. A., Chen, C., Salisbury, J. E., and Thompson, C. R. S. 2019. Rapid Climate-Driven Circulation Changes Threaten Conservation of Endangered North Atlantic Right Whales. Oceanography, 32(2), 162-169. https://doi.org/10.5670/oceanog.2019.201

Reed, J., New, L., Corkeron, P., and Harcourt, R. 2022. Multi-event modeling of true reproductive states of individual female right whales provides new insights into their decline. Frontiers in Marine Science, 994481. https://doi.org/10.3389/fmars.2022.994481

Rey-Iglesia, A., Martínez-Cedeira, J., López, A., Fernández, R., and Campos, P. F. 2018. The genetic history of whaling in the Cantabrian Sea during the 13th–18th centuries: Were North Atlantic right whales *(Eubalaena glacialis*) the main target species? Journal of Archaeological Science: Reports, 18, 393-398. https://doi.org/10.1016/j.jasrep.2018.01.034

Roberts, J.J., Best, B.D., Mannocci, L., Fujioka, E., Halpin, P.N., Palka, D.L., Garrison, L.P., Mullin, K.D., Cole, T.V.N., Khan, C.B., McLellan, W.A., Pabst, D.A., and Lockhart, G.G. 2016. Habitat-based cetacean density models for the U.S. Atlantic and Gulf of Mexico. Scientific Reports 6: 22615. doi: 10.1038/srep22615

Roberts, J.J. and Halpin, P.N. 2021. North Atlantic right whale v12 model overview. Duke University Marine Geospatial Ecology Lab, Durham, NC

Rodrigues, A. S. L., Charpentier, A., Bernal-Casasola, D., Gardeisen, A., Nores, C., Millan, J. A. P., McGrath, K., and Speller, C. F. 2018. Forgotten Mediterranean calving grounds of grey and North Atlantic right whales: evidence from Roman archaeological records. Proceedings of the Royal Society B-Biological Sciences, 285(1882), Article 20180961. https://doi.org/10.1098/rspb.2018.0961

Rolland, R. M., McLellan, W. A., Moore, M. J., Harms, C. A., Burgess, E. A., and Hunt, K. E. 2017. Fecal glucocorticoids and anthropogenic injury and mortality in North Atlantic right whales *Eubalaena glacialis*. Endangered Species Research, 34, 417-429. https://doi.org/10.3354/esr00866

Root-Gutteridge, H., Cusano, D. A., Shiu, Y., Nowacek, D. P., Van Parijs, S. M., and Parks, S. E. 2018. A lifetime of changing calls: North Atlantic right whales, *Eubalaena glacialis*, refine call production as they age. Animal Behaviour, 137, 21-34. https://doi.org/10.1016/j.anbehav.2017.12.016

Rosenbaum, H.C., M.G. Egan, P.J. Clapham, R.L. Brownell, Jr., M.W. Brown, B.N. White, S. Malik, P.D. Walsh, and R. DeSalle. 2000. Utility of North Atlantic right whale museum specimens in assessing changes in genetic diversity. Conservation Biology, 14 (6): 1837-1842.

Ross, C. H., Pendleton, D. E., Tupper, B., Brickman, D., Zani, M. A., Mayo, C. A., and Record, N. R. 2021. Projecting regions of North Atlantic right whale, *Eubalaena glacialis*, habitat suitability in the Gulf of Maine for the year 2050. Elementa: Science of the Anthropocene, 9(1). https://doi.org/10.1525/elementa.2020.20.00058

Salin, M., and Ponomarenko, A. 2021. Marine mammal calls detection in acoustic signals via gradient boosting model. 6th Underwater Acoustics Conference and Exhibition,

Sharp, S. M., McLellan, W. A., Rotstein, D. S., Costidis, A. M., Barco, S. G., Durham, K., Pitchford, T. D., Jackson, K. A., Daoust, P. Y., Wimmer, T., Couture, E. L., Bourque, L., Frasier, T., Frasier, B., Fauquier, D., Rowles, T. K., Hamilton, P. K., Pettis, H., and Moore, M. J. 2019. Gross and histopathologic diagnoses from North Atlantic right whale *Eubalaena glacialis* mortalities between 2003 and 2018. Diseases of Aquatic Organisms, 135(1), 1-31. https://doi.org/10.3354/dao03376

Shiu, Y., Palmer, K. J., Roch, M. A., Fleishman, E., Liu, X. B., Nosal, E. M., Helble, T., Cholewiak, D., Gillespie, D., and Klinck, H. 2020. Deep neural networks for automated detection of marine mammal species. Scientific Reports, 10(1), 607, Article 607. https://doi.org/10.1038/s41598-020-57549-y

Silber, G. K., Lettrich, M. D., Thomas, P. C., Baker, J. D., Baumgartner, M. F., Becker, E. A., Boveng, P. L., Dick, D., Fiechter, J., Forcada, J., Forney, K. A., Griffis, R., Hare, J. A., Hobday, A. J., Howell, D., Laidre, K. L., Mantua, N. J., Quakenbush, L. T., Santora, J. A., . . . Waples, R. S. 2017. Projecting Marine Mammal Distribution in a Changing Climate. Frontiers in Marine Science, 4, 1-14. https://doi.org/10.3389/fmars.2017.00413

Simard, Y., Roy, N., Giard, S., and Aulanier, F. 2019. North Atlantic right whale shift to the Gulf of St. Lawrence in 2015, revealed by long-term passive acoustics. Endangered Species Research, 40, 271-284. https://doi.org/10.3354/esr01005

Sisson, N. B., and Long, K. J. 2018. Evaluating Effectiveness of U.S. Management Measures: Summary of the North Atlantic Right Whale Technical Expert Working Group on Evaluating Effectiveness of U.S. Management Measures, 21-23 May 2018, Woods Hole, Massachusetts (NOAA Technical Report, Issue. https://repository.library.noaa.gov/view/noaa/23429

Sorochan, K. A., Brennan, C. E., Plourde, S., and Johnson, C. L. 2021a. Spatial variation and transport of abundant copepod taxa in the southern Gulf of St. Lawrence in autumn. Journal of Plankton Research, 43(6), 908-926. https://doi.org/10.1093/plankt/fbab066

Sorochan, K. A., Plourde, S., Baumgartner, M. F., and Johnson, C. L. 2021b. Availability, supply, and aggregation of prey (Calanus spp.) in foraging areas of the North Atlantic right whale (*Eubalaena glacialis*). ICES Journal of Marine Science, 78(10), 3498-3520. https://doi.org/10.1093/icesjms/fsab200

Sorochan, K. A., Plourde, S., Morse, R., Pepin, P., Runge, J., Thompson, C., and Johnson, C. L. 2019. North Atlantic right whale (*Eubalaena glacialis*) and its food: (II) interannual variations in biomass of Calanus spp. on western North Atlantic shelves. Journal of Plankton Research, 41(5), 687-708. https://doi.org/10.1093/plankt/fbz044

Southall, B. L., Finneran, J. J., Reichmuth, C., Nachtigall, P. E., Ketten, D. R., Bowles, A. E., Ellison, W. T., Nowacek, D. P., and Tyack, P. L. 2019. Marine mammal noise exposure criteria: updated scientific recommendations for residual hearing effects. Aquatic Mammals, 45(2). https://doi.org/10.1578/AM.45.2.2019.125

Southall, B. L., Hatch, L., Scholik-Schlomer, A. R., Bergmann, T., Jasny, M., Metcalf, K., Weilgart, L., Wright, A. J., and Perera, M. E. 2018. Reducing Noise from Large Commercial Ships Progress and partnerships. Marine Safety and Security Council - Coast Guard Journal of Safety and Security at Sea.

Springate, L. D. 2017. Gamete compatibility and reproductive success in the North Atlantic right whale LENS. Halifax, Nova Scotia. http://library2.smu.ca/handle/01/27153

Stewart, J. D., Durban, J. W., Europe, H., Fearnbach, H., Hamilton, P. K., Knowlton, A. R., Lynn, M. S., Miller, C. A., Perryman, W. L., Tao, B. W. H., and Moore, M. J. 2022. Larger females have more calves: influence of maternal body length on fecundity in North Atlantic right whales. Marine Ecology Progress Series, 689, 179. https://doi.org/10.3354/meps14040

Stewart, J. D., Durban, J. W., Knowlton, A. R., Lynn, M. S., Fearnbach, H., Barbaro, J., Perryman, W. L., Miller, C. A., and Moore, M. J. 2021. Decreasing body lengths in North Atlantic right whales. Current Biology. https://doi.org/10.1016/j.cub.2021.04.067

Stone, K. M., Leiter, S. M., Kenney, R. D., Wikgren, B. C., Thompson, J. L., Taylor, J. K. D., and Kraus, S. D. 2017. Distribution and abundance of cetaceans in a wind energy development area offshore of Massachusetts and Rhode Island. Journal of Coastal Conservation, 21(4), 527-543. https://doi.org/10.1007/s11852-017-0526-4

Terhune, J., and Killorn, D. 2021. A Method for Preliminary Assessment of the Masking Potential of Anthropogenic Noise to Baleen Whale Calls. Aquatic Mammals, 47, 283-291. https://doi.org/10.1578/AM.47.3.2021.283

van den Hurk, Y., Spindler, L., McGrath, K., and Speller, C. 2020. Medieval Whalers in the Netherlands and Flanders: Zooarchaeological Analysis of Medieval Cetacean Remains. Environmental Archaeology, 1-15. https://doi.org/10.1080/14614103.2020.1829296

van der Hoop, J., Corkeron, P., and Moore, M. 2016a. Entanglement is a costly life-history stage in large whales. Ecology and Evolution, 7(1), 317-319. https://doi.org/10.1002/ece3.2615

van der Hoop, J. M., Corkeron, P., Henry, A. G., Knowlton, A. R., and Moore, M. J. 2016b. Predicting lethal entanglements as a consequence of drag from fishing gear. Marine Pollution Bulletin, 115(1-2), 91-104. https://doi.org/10.1016/j.marpolbul.2016.11.060

van der Hoop, J. M., Nowacek, D. P., Moore, M. J., and Triantafyllou, M. S. 2017. Swimming kinematics and efficiency of entangled North Atlantic right whales. Endangered Species Research, 32, 1-17. https://doi.org/10.3354/esr00781

van der Hoop, J. M., Nousek-McGregor, A. E., Nowacek, D. P., Parks, S. E., Tyack, P., and Madsen, P. T. 2019. Foraging rates of ram-filtering North Atlantic right whales. Functional Ecology, 33(7), 1290-1306. https://doi.org/10.1111/1365-2435.13357

Van Parijs, S. M., Baker, K., Carduner, J., Daly, J., Davis, G. E., Esch, C., Guan, S., Scholik-Schlomer, A., Sisson, N. B., and Staaterman, E. 2021. NOAA and BOEM Minimum Recommendations for Use of Passive Acoustic Listening Systems in Offshore Wind Energy Development Monitoring and Mitigation Programs. Frontiers in Marine Science, 8. https://doi.org/10.3389/fmars.2021.760840

Vickers, W., Milner, B., Risch, D., and Lee, R. 2021. Robust North Atlantic right whale detection using deep learning models for denoising. Journal of the Acoustical Society of America, 149(6), 3797-3812. https://doi.org/10.1121/10.0005128

Weatherwax, J. 2021. The Right to Live: How North Atlantic Right Whales Are Going Extinct Despite Environmental Protections. University of Miami Inter-American law review, 52(2), 237. https://repository.law.miami.edu/umialr/vol52/iss2/8/

Werth, A. J., Blakeney, S. M., and Cothren, A. I. 2019. Oil adsorption does not structurally or functionally alter whale baleen. Royal Society Open Science, 6(5), 182194, Article 182194. https://doi.org/10.1098/rsos.182194

Willse, N., Summers, E., and Chen, Y. 2022. Vertical Line Requirements and North Atlantic Right Whale Entanglement Risk Reduction for the Gulf of Maine American Lobster Fishery. Marine and Coastal Fisheries, 14(2). https://doi.org/10.1002/mcf2.10203

Winn, H.E., Price, C.A., and Sorensen, P.W. 1986. The distributional biology of the right whale (*Eubalaena glacialis*) in the western north Atlantic. Rep. Int. Whal. Comm. (Special issue) 10:129-138.

Wolf, M., de Jong, M., Daníel Halldórsson, S., Árnason, Ú., and Janke, A. 2022. Genomic impact of whaling in North Atlantic fin whales. Molecular biology and evolution. https://doi.org/10.1093/molbev/msac094

Wu, C. Y., Nowacek, D. P., Nousek-McGregor, A. E., McGregor, R., and Howle, L. E. 2021. Computational fluid dynamics of flow regime and hydrodynamic forces generated by a gliding North Atlantic right whale (*Eubalaena glacialis*). Marine Mammal Science. https://doi.org/10.1111/mms.12798

Zoidis, A. M., Lomac-MacNair, K. S., Ireland, D. S., Rickard, M. E., McKown, K. A., and Schlesinger, M. D. 2021. Distribution and density of six large whale species in the New York Bight from monthly aerial surveys 2017 to 2020. Continental Shelf Research, 230, 104572. https://doi.org/10.1016/j.csr.2021.104572

NATIONAL MARINE FISHERIES SERVICE
5-YEAR REVIEW
North Atlantic Right Whale (*Eubalaena glacialis*)

Current Classification: Endangered

Recommendation resulting from the 5-Year Review

- [ ] Downlist to Threatened
- [ ] Uplist to Endangered
- [ ] Delist
- [X] No change is needed

Review Conducted By (Name and Office):

Greater Atlantic Regional Fisheries Office
National Marine Fisheries Service

REGIONAL OFFICE APPROVAL:

Approve Michael Pentony Digitally signed by Michael Pentony Date: 2022.11.10 14:26:52 -05'00' Date: 11/10/22

Cooperating Regional Administrator, NOAA Fisheries

[X] Concur [ ] Do Not Concur [ ] N/A

Signature AMENDOLA.KIMBERLY.BARBARA.1365830769 Digitally signed by AMENDOLA.KIMBERLY.BARBARA.1365830769 Date: 2022.11.17 17:48:21 -05'00' Date: 11/17/22

HEADQUARTERS APPROVAL:

Assistant Administrator, NOAA Fisheries

[X] Concur [ ] Do Not Concur

Signature RAUCH.SAMUEL.D.III.1365850948 Digitally signed by RAUCH.SAMUEL.D.III.1365850948 Date: 2022.12.09 14:29:54 -05'00' Date: ________