North Atlantic Right Whale Consortium Annual Meeting

26-27 October 2021

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NARWC
THE NORTH ATLANTIC RIGHT WHALE CONSORTIUM

North Atlantic Right Whale Consortium

Annual Meeting
26-27 October 2021

The times list below indicate timing for the live Q&A sessions with those who have uploaded pre-recorded presentations to the meeting site. Meeting participants will receive a unique site login code and should view these presentations in advance of the meeting. Participants may submit questions/comments for presenters both in advance and during the meeting. The six-digit number preceding the presentation title corresponds to the video number on the meeting site.

Please Note: The materials contained (both static and live) within the meeting site are intended for registered participants only and may not be shared in any capacity. All meeting participants have agreed to the meeting Code of Conduct. There is no recording (including but not limited to video, audio, screenshots, or photography) or sharing (including social media) of any material (including but not limited to presentations, presentation content, discussions, breakout sessions) without explicit consent of the presenter, speaker, moderator, etc.

26 OCTOBER 2021

1000 Keynote/Opening: *Scott Kraus, NARWC Chair*

1015 **<u>Session 1: Species Status</u>**

01.01.01 North Atlantic Right Whale Catalog update and whale naming results
- *Philip Hamilton, Anderson Cabot Center for Ocean Life at the New England Aquarium*

01.01.02 Mortality update:
- *Bill McLellan, University of North Carolina, Wilmington*

01.01.03 Entanglement/injury update
- *Scott Landry, Center for Coastal Studies*
- *Heather Pettis, Anderson Cabot Center for Ocean Life at the New England Aquarium*
- *Allison Henry, Northeast Fisheries Science Center*

01.01.04 Update on the North Atlantic Right Whale Unusual Mortality Event: 2017-Present
- *Deborah Fauquier, National Marine Fisheries Service*

1100 **<u>Session 2: General Updates</u>**

01.02.01 North Atlantic Right Whale Species in the Spotlight: Overview and implementation of a NOAA Fisheries 5-year Action Plan
- *Diane Borggaard, National Marine Fisheries Service*

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01.02.02 Marine Mammal Commission general update
- *Peter Thomas, Marine Mammal Commission*

01.02.03 DFO science update
- *Angelia Vanderlaan, Fisheries and Oceans Canada*

~~**01.02.04 Orsted offshore wind – science initiatives updates**~~
- ~~*Laura Morse, Orsted, North American Offshore*~~

01.02.05 The other right whale: North Pacific right whale status update
- *Kevin Campion, Save the North Pacific Right Whale*

01.02.06 Last of the Right Whales film and impact campaign
- *Nadine Pequeneza, HitPlay Productions*
- *Joanne Jackson, HitPlay Productions*
- *Sholeh Fabbri, HitPlay Productions*

1200 <u>Session 3: Anthropogenic Event Management</u>

01.03.01 Fisheries and Oceans Canada (DFO) update on North Atlantic right whale fisheries management measures
- *Adam Burns, Fisheries and Oceans Canada*

01.03.02 Atlantic Large Whale Take Reduction Plan updates: Recent and planned modifications
- *Marisa Trego, Greater Atlantic Regional Office, National Marine Fisheries Service*

01.03.03 Implementation of reduced breaking strength vertical lines in the Massachusetts trap/pot fishery
- *Erin Burke, Massachusetts Division of Marine Fisheries*

01.03.04 Transport Canada management update
- *Michelle Sanders, Transport Canada*

01.03.05 US Vessel Strike Rule update
- *Caroline Good, National Marine Fisheries Service*

01.03.06 A multi-state mark-recapture-recovery model to estimate rates of severe injury and cause-specific mortality in North Atlantic right whales
- *Daniel Linden, National Marine Fisheries Service*

01.03.07 The (en)tangled web they weave: Stakeholder and social learning in the take reduction process
- *Kimberly Ohnemus, University of Rhode Island*

01.03.08 Shiny tools for management rules: using R and 'shiny' to inform dynamic management of North Atlantic right whales (*Eubalaena glacialis*)
- *Leah Crowe, Integrated Statistics/Northeast Fisheries Science Center*

1300 LUNCH

1330 <u>Session 4: Anthropogenic Events and Mitigation – Entanglement & Vessel Strike</u>

01.04.01 Ropeless Consortium meeting summary
- *Sean Brillant, Canadian Wildlife Federation; Dalhousie University*
- *Mark Baumgartner, Woods Hole Oceanographic Institution*
- *Michael Moore, Woods Hole Oceanographic Institution*

01.04.02 Conservation, concertation, and innovative technologies for co-existing in the Gulf of St. Lawrence: the crabbers perspective
- *Philippe Cormier, CORBO, Inc*

01.04.03 Whales and fishermen in Gaspésie: towards a coexistence on the maritime territory:
- *Lyne Morissette, M-Expertise Marine, Inc*

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01.04.04 Quantifying the effects and risk reduction of the annual Canadian North Atlantic right whale fishery closure strategies in the Gulf of St. Lawrence snow crab fishery:
- *Alexandra Cole, Canadian Wildlife Federation*

01.04.05 Elevations of lobster fishery groundlines in relation to entanglement risk to North Atlantic right whales in Atlantic Canada
- *Rhyl Frith, Canadian Wildlife Federation*

01.04.06 Quantifying rope density in the Scotian Shelf and Bay of Fundy lobster fishery considering fishing methods and effort
- *Farheen Kadwa, Canadian Wildlife Federation*

01.04.07 Documented early-stage North Atlantic right whales (*Eubalaena glacialis*) entanglements in the southern Gulf of Saint Lawrence
- *Delphine Durette-Morin, Canadian Whale Institute*

01.04.08 Marine Aquaculture: An emerging industry. An emerging threat?
- *Matt Thompson, Anderson Cabot Center for Ocean Life at the New England Aquarium*

01.04.09 Evaluation of surface-based detection performance for vessel strike mitigation of North Atlantic right whales
- *Loïcka Baille, Woods Hole Oceanographic Institution*

01.04.10 Fishing-vessel-strike risk to North Atlantic right whales in the Gulf of St. Lawrence
- *Meg Carr, Dalhousie University*

01.04.11 Navy Maritime Domain Awareness (MDA) Systems leveraged for North Atlantic right whale alerting
- *Erin Murnane, Naval Research Laboratory*

1445 Break

1500 Breakout Sessions I

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#1 Linking Drone Imagery and Catalog Data

- *Co-Chair: Philip Hamilton, Anderson Cabot Center for Ocean Life at the New England Aquarium, NARWC Identification Catalog Database Curator*
- *Co-Chair: Monica Zani, Anderson Cabot Center for Ocean Life at the New England Aquarium, NARWC Identification Catalog/Database Data Manager*

As the curators of the North Atlantic Right Whale Catalog, we are trying to make sure we have a data coding system on our end that creates the strongest links between any drone imagery submitted to the Catalog and the original field data associated with those images. We anticipate a lot more drone imagery coming into the Catalog in the future, so we want to get this right. To do this, we need to understand how drone operators are collecting and tracking their drone imagery. We want any image we have to have the strongest link to the most accurate location, date, and observer. If there is a question about an image in 20 years, how will we best be able to find the answer? We would like to invite anyone contributing drone imagery of right whales to the Catalog to discuss this. We have developed some questions to guide the discussion which we will provide before the meeting.

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#2 Student/Early Career Research "Roundtables"

- *Chair: Hansen Johnson, Dalhousie University*
- *Moderated by NARWC Members*

An informal opportunity to meet and chat with various Consortium members who represent different areas of expertise. Ask questions about their fields and how they view their role in right whale conservation.

1600 Breakout Sessions II

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#1 Using Social Movement Scholarship to Develop Strategies to Grow Support for NARW Conservation

- *Chair: Randle Hart, St. Mary's University, Sociologist*

In this breakout session, we will discuss how social movement and science communication scholarship may be employed to develop strategies to increase the effectiveness of the Consortium's efforts to publicize the plight of the North Atlantic Right Whale, to amplify the pressing need to act collectively to save the species from extinction, and to respond to, and correct, misinformation, especially on social media. There will be time for participants to share their perspectives/experiences of obstacles in effectively communicating the science and urgency of the right whale issue. The session will be led by Randle Hart, a sociologist and co-investigator on the recently awarded Genome Canada grant, *Conservation Genomics of the Endangered North Atlantic Right Whale* (PIs T. Frasier and P. Hamilton). As part of this grant, Randle and his research team are studying the collaboration networks of the North Atlantic Right Whale conservation community and will be conducting ethnographic research in the USA and Canada on efforts to protect the species.

#2 How can Offshore Wind Energy Development Advance in a Way that Protects the North Atlantic Right Whale (NARW)?

- *Chair: Michael Moore, Woods Hole Oceanographic Institution*
- *Co-Organizer: Jessica Redfern, New England Aquarium*
- *Co-Organizer: Francine Kershaw, Natural Resources Defense Council*
- *Co-Organizer: William Rossiter, NY4WHALES.*

Offshore wind energy development areas currently extend along almost the entire East coast (from Maine to North Carolina), directly coinciding with the NARW migratory corridor. Recently, NARW have favored waters off Southern New England (SNE). This distribution change is likely a result of climate change creating new thermal gradients that change the location and predictability of NARW optimal foraging. This area coincides with a high density of wind energy lease areas that will be constructed over the next two to five years. Offshore wind energy development—while necessary to meet the nation's ambitious clean energy goals—poses several potential risks to NARWs. Noise sources harmful and/or disruptive to NARW will occur during site assessment (geophysical surveys), construction (pile driving, dredging, dynamic positioning systems), and may occur during operations (broadband and tonal turbine noise) and decommissioning. Increased vessel use associated with wind energy development and operation pose the risk of NARW sublethal and lethal trauma. Large numbers of turbines may also lead to oceanographic changes, such as

increased water turbulence, that may change prey density and distribution. Prospective floating offshore wind energy development in the Gulf of Maine also poses some unique challenges, including the potential for secondary entanglement risk in the mooring lines and inter-array cables. Together, potential impacts from offshore wind—if inadequately mitigated—may lead to displacement of individuals or the following suite of effects for individuals that remain in the area: increased vessel strike and entanglement risk, disruption of foraging success and other vital behaviors, and increased stress, which, collectively, may result in reduced energy balance and reproductive success, and increased mortality. The goal of this session is to discuss these concerns, to assess the completeness of current research, including the status of baseline data collection on NARW in waters off SNE, and consider the adequacy of current mitigation plans and opportunities for improvement (e.g., new monitoring and mitigation technologies).

1715 Recap Day 1

1730 Social – Trivia Night

Following the success of last year's trivia event, we will host a **TEAM** trivia night at the 2021 meeting. Gather your team (up to 10 people), grab a beverage/food of choice, and get ready to show off how much you know about right whales, the NARWC, your colleagues, and everything in between. We will be using the platform "Wonder" for this event and will offer a tutorial as we get closer to the meeting. I the meantime – feel free to check it out! www.wonder.me. You can also get into our NARWC room passcode **NARWC2021** and play around so that you have a good feel for how it works prior to the event. Trivia night SIGN UP is open. We are also taking fun and creative right whale related questions for the event! Submit questions HERE.

1930 Screening of "The Last of the Right Whales" film

"Last of the Right Whales" will be available to screen from 7-10 pm EDT on October 26th. This virtual screening is open to registered NARWC participants only. Registrants must sign up to reserve a screening ticket with a private viewing link.

Reserve here: https://watch.showandtell.film/watch/lastoftherightwhales-narwc
A panel discussion on the film and the NARW Impact campaign will take place during the breakout sessions on October 27th (3PM EDT)

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27 OCTOBER 2021

1000 Welcome Day 2

1015 <u>Session 1: Demographics and Species Assessments</u>

02.01.01 How should we think about reproduction in North Atlantic right whales?
- *Timothy Frasier, St. Mary's University*

02.01.02 Estimating the population size of the North Atlantic right whale
- *Chongkyung Kim, Swarthmore College*

02.01.03 Multi-state modeling of true reproductive states of individual female right whales provides new insights into their decline
- *Joshua Reed, Macquarie University*

1100 <u>Session 2: Acoustics and Acoustic Detections</u>

02.02.01 North Atlantic right whale presence and vocal activity in New York waters: Implications for their protection and safe passage
- *Anita Murray, Wildlife Conservation Society; Bronx Zoo*

02.02.02 Near real-time passive acoustic monitoring for right whales on the U.S. east coast – an update
- *Mark Baumgartner, Woods Hole Oceanographic Institution*

02.02.03 Impacts of COVID-19 pandemic-related changes in shipping on the soundscape and calling behavior of right whales in the New York Bight
- *Susan Parks, Syracuse University*

02.02.04 Current NARW PAM Project updates from the NEFSC
- *Genevieve Davis, Northeast Fisheries Science Center*

02.02.05 Using sonobuoys and visual surveys to characterize North Atlantic right whale (*Eubalaena glacialis*) calling behavior in the Gulf of St. Lawrence
- *Kimberly Franklin, Dalhousie University*

02.02.06 Ambient acoustic noise with depth in the Honguedo Strait, Gulf of St Lawrence and implications for baleen whale detection
- *Romina Gehrmann, Dalhousie University*

02.02.07 The value of incorporating bearing estimation into real-time right whale mitigation systems
- *Kaitlin Palmer, SMRU Consulting*

02.02.08 Detecting and classifying right whale upcalls in Cape Cod Bay and co-locating calls with aerial observations
- *Tina Yack, Duke University*

1200 BREAK/LUNCH

LUNCH BREAKOUT SESSION

The Northeast Implementation Team for Right Whale Recovery: Informal discussion forum on team activities and future directions

- *Chair: Desray Reeb, Bureau of Ocean Energy Management*

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The Northeast Implementation Team (NEIT) is a multi-disciplinary group formed under the U.S. Endangered Species Act that advises NOAA Fisheries on issues related to the status and conservation of right whales in the Northeast U.S. (Maine to Virginia). The NEIT considers issues that are impeding right whale recovery, including (but not limited to) vessel strikes, climate change, pollution and contaminants, and acoustic threats. While the threat of entanglement is addressed through other avenues, such as the Atlantic Large Whale Take Reduction Team process, the NEIT can support the Take Reduction process, if needed, to help implement recovery goals. This breakout session will offer an opportunity for the right whale stakeholder community to learn more about what the NEIT is working on and offer feedback and suggestions for future work.

1245 **<u>Session 3: Distribution and Behavior</u>**

02.03.01 A comparison of three approaches to estimate North Atlantic right whale regional abundance
- *Nathan Crum, Fish and Wildlife Research Inst., FL Fish and Wildlife Conservation Comm.*

02.03.02 Repatriation of a historical right whale habitat and novel year-round occurrence during an era of rapid climate change
- *Orla O'Brien, Anderson Cabot Center for Ocean Life at the New England Aquarium*

02.03.03 Predicting endangered North Atlantic right whales using prey fields
- *Camille Ross, Bigelow Laboratory for Ocean Sciences*

02.03.04 Predicted distribution and abundance of zooplankton species in Cape Cod Bay in 2019
- *Robert Schick, Duke University*

02.03.05 Matrilines and migratory patterns explain high variation in the fecundity of a critically endangered baleen whale
- *Ana Bishop, University of South Carolina*

02.03.06 Residency, demographics, and movement patterns of North Atlantic right whales (*Eubalaena glacialis*) in an offshore wind energy development area in southern New England, USA
- *Ester Quintana-Rizzo, Simmons College*

02.03.07 Observations of adult-calf non-reproductive copulatory behavior in North Atlantic right whales
- *Gina Lonati, University of New Brunswick, St. John*

1345 **<u>Session 4: Feeding Ecology, Health, and Physiology</u>**

02.04.01 Variation in near-bottom aggregations of North Atlantic right whale prey in the southern Gulf of St. Lawrence in summer
- *Kevin Sorochan, Fisheries and Oceans Canada*

02.04.02 North Atlantic right whale (*Eubalaena glacialis*) habitat in the southern Gulf of St. Lawrence
- *Hansen Johnson, Dalhousie University*

02.04.03 Biogeochemical analysis of baleen as a wildlife forensic tool: Reconstructing the lives (and deaths) of North Atlantic right whales
- *Nadine Lysiak, Suffolk University*
- *Elizabeth Burgess, Anderson Cabot Center for Ocean Life at the New England Aquarium*

02.04.04 Health indicators to predict the cumulative effects of multiple stressors on the vital rates of North Atlantic right whales
- *Peter Tyack, University of St. Andrews*

02.04.05 Development of a mass spectrometry method capable of detecting and quantifying a panel of steroid hormones in right whale blow

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- *Andrew Wright, Fisheries and Oceans Canada*

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1500 Breakout Sessions I

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#1 Last of the Right Whales Film & Impact Campaign

- *Co-Chair: Nadine Pequeneza, Producer/Director, Last of the Right Whales*
- *Co-Chair: Joanne Jackson, Executive Producer/Impact Producer, Last of the Right Whales*
- *Co-Chair: Sholeh Fabbri, Impact Producer, Last of the Right Whales*
- *Panelist: Moira Brown, Senior Scientist, Canadian Whale Institute*
- *Panelist: Sean Brillant, Senior Conservation Biologist, Marine Programs, Canadian Wildlife Federation*
- *Panelist: Patrick Ramage, Senior Director of Outreach & Program Collaboration, IFAW*

With unprecedented access to film the critically endangered North Atlantic right whale from Florida to the Gulf of St. Lawrence, a new feature documentary bears witness to their challenges and offers hope for their survival. *Last of the Right Whales* had its world premiere at the Calgary International Film Festival on September 26th and will continue to screen at festivals and theatres before airing on CBC's The Nature of Things in Fall 2022. In tandem with the film's release, a 10-month impact campaign is being planned for North America in collaboration with the film's outreach partners: International Fund for Animal Welfare (IFAW), Sierra Club Canada Foundation, Canadian Wildlife Federation, Canadian Whale Institute, and Oceans North. *Last of the Right Whales* will be used to engage stakeholders – fishers, boaters, retailers, shipping and cruise lines as well as consumers – in discussions about what we can each do to ensure the survival of this great whale facing extinction. Join this breakout session to find out how you can be part of the film's impact campaign and help amplify the call to protect North Atlantic right whales.

#2 Health Indicators to Predict the Cumulative Effects of Multiple Stressors on the Vital Rates of North Atlantic Right Whales.

- *Chair: Peter L Tyack, Sea Mammal Research Unit, School of Biology, University of St Andrews*

A large research project that aims to better understand the cumulative effects of multiple stressors on marine mammals (funded by SERDP from 2021-2025) has selected North Atlantic Right Whales as an important case where the effects of multiple stressors threaten the survival of an endangered species. My talk at the consortium with the same title as the breakout session above introduces the approaches we are currently taking. One approach to understand how short-term effects accumulate to affect vital rates is to seek health indicators whose status can be estimated based on exposure to stressors and that have consequences for survival and reproduction. In our breakout session, we encourage all participants to suggest indicators for health, how to estimate them, and what their link is to survival and reproduction. We aim to develop models that help decide how much each stressor in combination with others needs to be reduced in order to reduce the risk to the species to an acceptable level. We particularly hope to hear from about ideas that we may have missed and hope to discuss how best to match our work to the highest priorities for right whale conservation.

1600 Breakout Sessions II

#1 *We Are All Whalers*

- *Chair: Michael Moore, Woods Hole Oceanographic Institution*
  https://press.uchicago.edu/ucp/books/book/chicago/W/bo113867120.html

  Discussion of consumer education and engagement in right whale conservation, in the context of the book '*We are all Whalers'*, by Michael Moore, Woods Hole Oceanographic Institution, recently published by University of Chicago Press. Michael will briefly introduce the book, and read a few key pieces from it in the context of the above. Then a discussion will follow as to how to better engage ethical consumers to seek goods shipped by sea, and caught in trap fisheries, that are provided in a manner that is sustainable to both the relevant industries and whales.

1700 Wrap Up/Meeting Close

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Evaluation of surface-based detection performance for vessel strike mitigation of North Atlantic right whales

Baille, L. M. R.[1], Zitterbart, D. P[1]

[1]*Applied Ocean Physics and Engineering Department, Woods Hole Oceanographic Institution, Woods Hole, MA, 02543*
(lbaille@whoi.edu)

The surge in marine traffic due to increasing commercial and recreational use of the world's ocean leads to growing concerns on vessel and marine mammals encounters. For endangered species, like the North Atlantic right whale, vessel strikes can be responsible for the majority of the recorded deaths. Reducing the number of vessel strikes is key to increase North Atlantic right whale protection and a number of mitigation methods have been proposed and implemented. We developed an agent-based model to assess the effectiveness of vessel-based surface whale detection methods, such as thermal imaging systems and marine mammal observers, for different vessel and animal characteristics.
Our study showed that under the right vessel's speed and maneuverability, vessel-based whale detection systems can be very effective and could lead to a significant decrease in vessel strikes when deployed at a large-scale. In particular, in speed restricted areas (10kn) any form of on-board detection system that can detect at least 1km in the distance will greatly (90+%) enhance animal protection. For faster ships, such as cruise-ships, a detection system that detects at least 3km in the distance leads to good results (~85%). Finally, fast vessels with low maneuverability, such as supertankers, cannot directly benefit from having such a system on-board but the information obtained and shared from other vessels equipped with such a system, could help estimate a near real-time distribution of whales in critical areas and improve the large-scale dynamic management efforts.

Near real-time passive acoustic monitoring for right whales on the U.S. east coast – an update

Baumgartner, M.F.[1]

[1] *Biology Department, Woods Hole Oceanographic Institution, Woods Hole, MA 02543*
(mbaumgartner@whoi.edu)

Together with partners from the NOAA Northeast Fisheries Science Center, Stellwagen Bank National Marine Sanctuary, Wildlife Conservation Society, University of Maryland Center For Environmental Science, U.S. Navy's NAVFAC Atlantic, and Rutgers University, the Woods Hole Oceanographic Institution (WHOI) deployed gliders and buoys in late 2020 and 2021 to conduct near real-time passive acoustic monitoring of baleen whales, including North Atlantic right whales, on the U.S. east coast using the digital acoustic monitoring (DMON) instrument. WHOI deployed DMON-equipped gliders in the Gulf of Maine, in the Stellwagen Bank National Marine Sanctuary, near Cox Ledge (south of Massachusetts and Rhode Island) and on the outer New England Shelf, while Rutgers University deployed a DMON-equipped glider in the nearshore waters off New Jersey. WHOI DMON buoys were deployed in the New York Bight, south of Martha's Vineyard and off the coasts of New Jersey, Maryland and North Carolina. Plans are underway to deploy two additional buoys off Norfolk, Virginia and Savannah, Georgia during 2022, bringing the total number of DMON buoys on the U.S. east coast to 8. A brief overview of these deployments will be provided.

Matrilines and migratory patterns explain high variation in the fecundity of a critically endangered baleen whale

Bishop, A.[1], Crowe, L.M.[2], Meyer-Gutbrod, E.[1]

[1] *University of South Carolina, Blossom Street, Columbia, SC, 29208, USA*
[2] *Integrated Statistics under contract to the Northeast Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, 166 Water Street, Woods Hole, MA, 02543, USA*
(cb32@email.sc.edu)

North Atlantic right whales (NARW) have recently experienced a significant decrease in reproduction, which has played a role in the overall decline of the species. However, certain mothers have still managed to remain reproductively efficient during this time. They are not alone; these individuals reflect a trend that has been observed throughout various historical periods of low reproduction. In contrast, some mothers fail to be reproductively efficient, even during historical periods of high reproduction. This study aimed to analyze these fecundity variations based on multiple variables including matriline, migratory behavior/habitat usage, age, and prior

calving history. Photo identification data collected during visual surveys of NARW were used to create a calving index for sexually mature females to serve as a proxy for calving efficiency. Subsequent analysis focused on two main subjects: fecundity variation within matrilines over time, and a recent habitat distribution shift by a NARW sub-population to the Gulf of St. Lawrence during summer and fall seasons. Analyzing the fecundity and family history of whales associated with this new migratory pattern may improve predictions of future spatial distributions and population trends. The analysis demonstrated significant relationships between the fecundity of matriline matriarchs and their progeny, individual fecundity and migratory patterns, and migratory behavior and matriline members. The results of this study have the potential to be a significant addition to the body of knowledge on NARW behavior and reproduction. Since low calving rates in the past seven years have played a major role in the species' decline, new insights into the mechanistic drivers of right whale reproduction and migration may contribute to the creation of more effective protection policies.

North Atlantic right whale Species in the Spotlight: Overview and implementation of a NOAA Fisheries 5-year Action Plan

Borggaard, D.[1]; Cholewiak, D.[2]; Good, C.[3]; Patterson, E.[3]; Trego, M.[1]

[1] Greater Atlantic Regional Office, U.S. National Marine Fisheries Service, Gloucester, Massachusetts 01930
[2] Northeast Fisheries Science Center, U.S. National Marine Fisheries Service, Woods Hole, MA 02543
[3] Office of Protected Resources, U.S. National Marine Fisheries Service, Silver Spring, Maryland 20910
(diane.borggaard@noaa.gov)

NOAA Fisheries designated North Atlantic right whales as a Species in the Spotlight (SIS) in 2019. In 2021, NOAA Fisheries completed the SIS Priority Action Plan for North Atlantic right whales as is required for species identified as among the most at-risk of extinction under this initiative. The plan builds off the North Atlantic right whale recovery plan and was developed with input from NOAA Fisheries' regional implementation teams. It identifies the following urgent actions we can take in the next 5 years 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

The action plan will help NOAA Fisheries and its partners focus resources, expand partnerships, and increase public outreach during the next five years to promote recovery of right whales. We focus on the primary threats for right whales, while also highlighting other key actions (e.g., further understand climate impacts on right whales). Partnerships are critical to North Atlantic right whale recovery and the Plan identifies many important efforts underway. We will provide an overview of the action plan, note progress NOAA Fisheries has made on these actions including work with our partners, and highlight opportunities for additional partnerships.

Implementation of reduced breaking strength vertical lines in the Massachusetts trap/pot fishery

Burke, E. K.[1], Wilson, J.[1], Glenn, R.[1]

[1]Massachusetts Division of Marine Fisheries, 836 S. Rodney French Blvd, New Bedford, MA 02740 (erin.burke@mass.gov)

In spring 2021, the Massachusetts Division of Marine Fisheries implemented new conservation measures designed to protect North Atlantic right whales in Massachusetts state waters. A crucial aspect of the regulatory package was the broad-scale adoption of reduced breaking strength buoy lines. The use of ropes with reduced breaking strength could minimize the severity of injury to large whales in the event of an entanglement. Beginning May 1, 2021, Massachusetts trap/pot fishermen are now required to equip all buoy lines with either fully formed "weak" rope that breaks at 1,700 lbs or less, or with weak contrivances that breaks at 1,700 lbs or less. The weak contrivances must be inserted every 60 feet in the upper 75% of the buoy line and fishermen can choose from a variety of NMFS-approved contrivance options. Here we report on DMF's efforts to identify a baseline of approved contrivances, outreach to the fishing industry and the status of weak rope implementation in Massachusetts.

Fisheries and Oceans Canada (DFO) update on North Atlantic right whale fisheries management measures

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In 2021, the Fisheries and Oceans Canada's (DFO) management measures continue to focus on entanglement prevention for North Atlantic right whales throughout its Canadian range. Since 2017, Canada has implemented strong measures for the protection of the North Atlantic right whale with the primary objective of the fisheries measures being the prevention of fishing gear entanglement. To prevent entanglements, the Department has consulted with industry and scientists to adjust fishing seasons to minimize co-occurrence with whales and has developed a series of near real-time area closure protocols that apply to non-tended fixed gear fisheries throughout the right whale's Canadian range. These closures are supported by the most comprehensive right whale monitoring and detection regime in the world which includes flights, vessels, and acoustic devices. Closure areas, some of which remain in place for several months, are adaptive and occur in areas where whales are found to aggregate. In addition, the Department has put in place a series of regulatory measures, including the requirement for the reporting of lost gear, accidental contact with marine mammals, and the implementation of a gear marking regime for non-tended fixed gear fisheries. Further, the Department has implemented a comprehensive ghost gear program, and has also implemented a new Whalesafe Gear Adoption Fund to support the requirements that are being phased in for whalesafe fishing gear. All Canadian measures are developed in consultation with industry and scientists, and take into consideration past confirmed NARW detections, the latest science advice, navigational safety, and economic impacts.

The other right whale: North Pacific right whale status update

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Little is known about North Pacific right whales due to their small population size. Current estimates place the Western Pacific population in the hundreds, and the Eastern Pacific population around 30 individuals. NPRWs were labeled as a separate, and endangered, species from North Atlantic right whales in 2008, and were assigned two critical habitats in Alaska based on their feeding grounds. No policy has occurred for their protection since. Research efforts to learn more about this species are conducted by only a few dedicated scientists and are primarily based on rare sightings and acoustic data. The latest sighting was off Haida Gwaii, Canada in Spring 2021.

This year, we are introducing Save the North Pacific Right Whale, an organization dedicated to increasing the protections, awareness and support for this endangered whale. We are initially focusing on education through a documentary film, social media, and outreach events. We curate an interactive map of sightings beginning in 1979 and have a website featuring individual whales in the eastern population, the history of NPRWs, and scientific research. We will discuss the current status of NPRWs, recent sightings, our work, and we invite advice and collaboration at this Annual Meeting, as we are hoping to learn from the current conservation efforts for the NARW.

Fishing-vessel-strike risk to North Atlantic right whales in the Gulf of St. Lawrence

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Vessel strikes are one of the leading identified sources of mortality for critically endangered North Atlantic right whales (*Eubalaena glacialis*; right whales). From 2017 to 2020, 32 right whales were observed dead in United States and Canadian waters. Of the 16 cases where cause of death was determined, 9 carcasses (56%) presented with injuries consistent with vessel strike, 7 of which (78%) were discovered in the Gulf of St. Lawrence (GSL). The GSL is an area with substantial shipping and fishing activities and lethal vessel-strike risk from large (>20 m) vessels that has been preliminarily quantified (same authors). However, no studies have investigated lethal vessel-strike risk derived from smaller fishing vessels in the GSL or elsewhere. The

southwestern GSL is an area of particular concern as right whales have shifted their distribution to seasonally feed and socialize in this area and a considerable portion of the GSL snow crab fishing fleet transits through and actively fishes in this area. Right whales are not only exposed to fishing gear entanglement risk but also lethal vessel-strike risk as a recent study found that smaller vessels such as 15-meter long, 45 tonne Cape Islander lobstering vessels are capable of causing lethal injury to right whales (Kelley et al. 2021; Mar. Mam. Sci. 37(1), 251-267). Our research addresses the small-vessel risk knowledge gap by quantifying lethal vessel-strike risk to right whales based on the 2017 snow crab fishing fleet using mandatory Vessel Monitoring System (VMS) data in concert with visual right whale detections. Lethality is estimated for standard-dimension GSL snow crab vessels using the Kelley 4-layer model. Areas of concentrated risk that may be the focus of future management schemes are identified.

Quantifying the effects and risk reduction of the annual Canadian North Atlantic right whale fishery closure strategies in the Gulf of St. Lawrence snow crab fishery

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Since 2018, the government of Canada has implemented time-area fishery closures in the Gulf of St. Lawrence (GSL) to mitigate entanglement risk to North Atlantic right whales. When in effect, these closures provide large gear-free areas where whales are aggregating. Using various measures such as static, dynamic, and season-long closures, closure protocols have been amended in each subsequent year to include different measure combinations. However, there are concerns about the impact these management measures have on snow crab fishery operations, and their effectiveness to mitigate entanglement risk given continued mortalities and entanglement events in the GSL. Using whale sightings during the snow crab fishing season (April 28-June 30), we simulate closures under each annual management strategy (2018-2021) to evaluate their effect on the fishery and risk reduction value. Impact to the fishery was measured as the percentage of the total average catch-per-unit-effort (CPUE) within closed fishery management grid cells, based on averaged pre-closure fishing activity (2015-2017). Whale occurrence within each grid cell was based on annual reported sightings (2015-2019) using a location uncertainty estimate, and entanglement risk was estimated as the product of this and the average fishing activity. Using 2020 whale sightings to simulate closures, preliminary results showed that the dynamic-only, GSL-wide 2020 and 2021 measures closed more grid cells throughout the fishing season than the 2018 and 2019 measures consisting of static closures and more limited management areas. As a result, a larger proportion of the CPUE was closed to fishing by the 2020 and 2021 measures. The 2018 and 2019 static closures resulted in decreased entanglement risk throughout all of May, whereas the 2020 and 2021 measures did not reach similar risk reduction values until the end of May. Each annual fishery management strategy, however, achieved similar risk reduction values by the end of the fishing season.

Conservation, concertation, and innovative technologies for co-existing in the Gulf of St. Lawrence: the crabbers perspective

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In the Gulf of St. Lawrence, crab fishermen developed, in partnership with scientists, engineers, conservation NGOs and governmental agencies, different approaches to adapt their operations and fishing gear to the presence of North Atlantic Right Whales (NARW) on fishing grounds and try to coexist on a shared territory. Since 2018, an Atlantic Fisheries Fund (AFF) project focussed on the development of new technologies of fishing gear to reduce entanglements or fatalities when fishermen and whales are occurring on the same area and at the same time. This project, testing 15 different solutions, resulted in interesting findings that could enhance our competences to find the most effective and efficient solutions to protect NARW while maintaining fisheries in the Gulf. The key findings of

this project are presented, along with the new project it allowed to create. This new 3-year project (2021 – 2023) aims to build on the knowledge gained during the last 3 years on how to coexist with NARW and developing the best working solutions for the three most promising options explored by our team, being: 1) to address issues raised by the fish harvesters who experienced the EdgeTech ropeless technology during the 2020 fishing season before recommending and promoting full commercial fishery in closed areas with this new technology; 2) to conduct a pilot tests using weak rope (less than 1,700 lbs) as vertical lines during commercial snow crab fishing in CFA12 closed areas; and 3) to combine our knowledge on 4 initiatives tested in 2018-2020 to test the feasibility of using snow crab pots throughout CFA12 as hydrophone holders to track whales and vessels. This new project will allow to strengthen the collaboration with the government, academics, and fishermen, in better understanding the fishery the whales, and our most realistic and efficient options to coexist in the Gulf.

Shiny tools for management rules: using R and 'shiny' to inform dynamic management of North Atlantic right whales (*Eubalaena glacialis*)

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Effective dynamic management for endangered species requires the ability to respond to detections by quickly implementing conservation measures. In the United States and Canada, several dynamic management strategies reactive to both visual and acoustic detections are used to mitigate threats from shipping and fishing activities to aid in the recovery of the critically endangered North Atlantic right whale (*Eubalaena glacialis*). In the last decade, right whale distribution and observed occupancy shifts have sparked renewed attention to dynamic management measures as whales and mortality events have often been detected outside of seasonal protection areas. The implementation of protection measures requires the rapid application of various calculations to near real-time detection information collated from a variety of monitoring organizations and platforms. To streamline the process of turning right whale detections into management actions in a reproducible and publicly available way, several tools have been developed in the R programming language that rely upon the 'shiny' package for interactive, web-based data visualization. Here we describe two separate suites of 'shiny' applications developed by right whale researchers that are currently used in the process of determining dynamic right whale protection zones. Features of these tools include summarizing survey detections and effort from different monitoring platforms (e.g., ocean gliders and moored buoys with acoustic sensors, aerial and shipboard surveys with visual observers) to share with managers and other stakeholders, calculations of recommended dynamic management zones (e.g., SLOW zones in the Northeast and mid-Atlantic regions of the United States) based on visual and acoustic detections, and interactive maps to visual effort and detection data. We aim to demonstrate how effective applications can be developed by researchers without formal computer science training using accessible, open source tools (R and RStudio) to minimize the time between detections and the implementation of management rules.

A comparison of three approaches to estimate North Atlantic right whale regional abundance

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A wealth of data have been collected documenting when and where North Atlantic right whales have been observed. These data are indicators of how right whales are distributed through time and space but are biased by the uneven distribution of survey effort and variation in right whale behavior. Taken alone these raw data may provide a misleading picture of right whale distribution and demographics and therefore misinform management actions. Statistical models, such as distance sampling, mark-recapture, and spatial capture-recapture, can account for such biases while estimating abundance, spatial patterns of density, and demographic rates. Each type of model has strengths and weaknesses and produces estimates that may be appropriate for informing some management plans and actions and not others. For instance, distance sampling can estimate spatial patterns of density, which are well-suited to be used in ship strike and entanglement risk analyses. However, distance sampling has difficulty estimating demographic rates such as survival and

fecundity because it does not use photo-ID data that tracks individuals through time. Conversely, mark-recapture uses photo-ID data to robustly estimate demographic rates and regional or total population abundance, making it a good approach to track population trends over time. However, mark-recapture does not use the fine scale location data associated with individuals' sightings and therefore cannot estimate spatial patterns of abundance. Spatial capture-recapture combines the important aspects of distance sampling and mark-recapture by integrating photo-ID and sighting location data to estimate demographic rates, individual movement, abundance, and spatial patterns of density. We will present an example spatial capture-recapture analysis of right whale aerial survey data in the Southeastern US. Additionally, we will discuss the data required for these three models, the estimates that they produce and their utility for informing management actions.

Current NARW PAM Project Updates from the NEFSC

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The passive acoustic research group at the Northeast Fisheries Science Center continues to expand its passive acoustic monitoring (PAM) program and develop new approaches for using PAM data to address science and management needs. Currently, PAM recorders are deployed along the Northwestern Atlantic, focused on areas such as inshore Gulf of Maine (with Maine DMR), the Massachusetts/Rhode Island wind energy lease areas, and National Marine Sanctuaries. Since early 2020, 15 continuous archival bottom-mounted recorders, in addition to numerous real-time gliders and surface-buoys, have been deployed and results on NARW detections will be presented. We have started to produce reports on the NARW detections across our PAM monitored areas once or twice a year. Recently, we released a public online web application that displays PAM detections (Passive Acoustic Cetacean Map; https://apps-nefsc.fisheries.noaa.gov/pacm) from our data and that of a wide number of collaborators. We have also collaborated with GARFO to create and support the implementation of NOAA Slow Zones when triggered by real-time acoustic detections. Lastly, with our colleagues at NOAA and BOEM, we created PAM recommendations, with specific focus on monitoring for NARWs in areas before, during, and after wind farm construction. We will introduce all of these innovative, collaborative ways that we use to display, process, and serve up passive acoustic data, allowing for improved data exploration and understanding.

Documented early-stage North Atlantic right whales (*Eubalaena glacialis*) entanglements in the southern Gulf of Saint Lawrence

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At least 86% of North Atlantic right whales (*Eubalaena glacialis*) have been documented with entanglement scars. Most of these individuals have never been observed with attached gear, suggesting that many of these whales may "shed" entangling ropes, but at what cost? Using vessel and drone-based photographs and video, we describe two instances during which circumstances indicate the whales were reacting to new or recent entanglements. On July 13th, 2021, a 5-year-old male right whale (#4615) was observed at 12:05 in the southern Gulf of Saint Lawrence (sGSL) without evidence of entanglement. At 16:30 the same day, #4615 was observed with gear through his mouth and four body and peduncle wraps. The whale was repeatedly thrashing its tail and had severe, open wounds on the peduncle and the fluke's leading edge. During the next six hours of prolonged thrashing behavior, the gear shifted on the whale's body and a telemetry buoy was attached to

the trailing line. The whale was observed the next morning with only one rope through its mouth, no telemetry buoy, and has not been observed since. On August 20th, 2018, at 17:49, a 9-year-old male right whale (#3960) was observed entangled in the sGSL, with multiple head and body wraps. Only fourteen days earlier, #3960 had been seen without gear. Similar to #4615, the animal's behaviour was very violent, including tail slashes and spiraling dives. He had extensive bleeding injuries on the tailstock and damaged baleen. During the next hour and a half, the gear shifted numerous times on the whale's body. He then travelled away quickly, gear free. He has been seen in subsequent years with healing wounds. These shocking events are but two examples showing the stress and energetic costs, in addition to the physical wounds, these animals must undergo when faced with an entanglement.

Update on the North Atlantic right whale Unusual Mortality Event: 2017-Present

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An Unusual Mortality Event (UME), which is defined under the U.S. Marine Mammal Protection Act as "a stranding that is unexpected, involves a significant die-off of any marine mammal population, and demands immediate response" was declared by the National Marine Fisheries Service for North Atlantic right whales (*Eubalaena glacialis)* starting in 2017, due to elevated numbers of dead or seriously injured whales along the Northwest Atlantic Ocean coast. This is a transboundary event and the investigation includes whales stranding in both Canada and the United States. The UME is ongoing with 50 known cases, including 34 dead and 16 seriously injured individuals to date. Of the 34 confirmed dead whales, 21 were first documented in Canada and 13 were first documented in the United States. The breakdown of known mortalities by year includes: 17 whales in 2017 (12 in Canada; 5 in the U.S.); 3 in 2018 (all in the U.S.); 10 in 2019 (9 in Canada; 1 in the U.S.); 2 in 2020 (both in the U.S.); and 2 in 2021 (both in the U.S., as of 20 August). Of the 24 whales that were necropsied, 20 (83%) were confirmed, probable, or suspect deaths as a direct result of human activities: entanglements (9) or vessel strikes (11). Of the 16 serious injury cases, which involve live free-swimming non-stranded whales, 14 had serious injuries from entanglements

and 2 from vessel strikes. Therefore, of the 40 cases examined (both live and dead), 90% (36/40) were impacted by entanglements (23) or vessel strikes (13). Given there are fewer than 400 individual North Atlantic right whales remaining, these 50 individuals in the UME represent at minimum 12.5% of the population, which is an extremely significant impact on such a critically endangered species.

More information can be found at the National Marine Fisheries Service UME website: (https://www.fisheries.noaa.gov/national/marine-life-distress/2017-2021-north-atlantic-right-whale-unusual-mortality-event).

Using sonobuoys and visual surveys to characterize North Atlantic right whale (*Eubalaena glacialis*) calling behavior in the Gulf of St. Lawrence

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The appropriate use and interpretation of passive acoustic data for monitoring the North Atlantic right whale (*Eubalaena glacialis:* hereafter right whale) relies on knowledge of their calling behavior and how it varies with respect to time, space, age, sex, and physical behavior. To assess these relationships in a habitat of increased management importance, sonobuoys (disposable, drifting hydrophones) were deployed in the Gulf of St. Lawrence, Canada, to record sounds produced from aggregating right whales during visual aerial surveys in the summers (June through August) of 2017 (n = 8), 2018 (n = 13) and 2019 (n = 16). Acoustic data from each sonobuoy deployment were manually reviewed for right whale upcalls, gunshots, and various mid-frequency (250-800 Hz) tonal calls. The calls were quantitatively compared to concurrently collected demographic and observed behavior variables obtained through photo-identification data using correlation matrices, linear regressions and generalized linear models. Our results show: 1) call rates increased from June to August for all call types; this is the first known report of a temporal trend in right whale mid-frequency tonal calls; 2) calling rates were associated negatively with observed foraging behavior, and positively with observed socializing behavior; 3) upcalls were occasionally produced at higher rates (> 20 calls h^{-1}) when in association with gunshot and tonal calls; 4) acoustic monitoring did not always detect right whale presence at fine timescales (2 – 6 h), but presence estimates were improved when multiple calls types were considered; and 5) calling rates were too variable to provide reliable count estimates of observed right whales. These results have important implications for the interpretation of passive acoustic monitoring in this habitat and provide evidence that some whale behaviors (e.g., socializing) may be reliably inferred from acoustics alone.

How Should We Think About Reproduction in North Atlantic Right Whales?

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Although much of the conservation concerns related to North Atlantic right whales deal with anthropogenic mortalities, reproductive success is also compromised and substantially lower than their known potential. However, this “reproductive problem” is often overshadowed by mortality issues, except in years when few calves are born. In such years alarm bells go off in the North Atlantic right whale community, but these eventually wane when calf numbers increase. My concern is that we do not yet have a good metric by which to judge and quantify reproduction in this species, and that this void is masking the degree, and trends associated with, this reproductive problem. As a contrast, with anthropogenic mortalities we have a clear target of zero. How “bad” a year has been can therefore be quantified by the degree to which such mortalities exceeded this target. However, we have no such reference or target for reproductive success. For example, was 2021 a “good” year for reproduction, given that there were 18 calves born? How few

calves need to be born to qualify as a "bad" year, and why? I argue that we currently have no scientific way to evaluate these questions, but that such a method is sorely needed. Instead, we tend to compare calf counts to previous years, and therefore our assessment of what is good or bad is only relative. If reproduction has been compromised since studies began (which seems likely), then this comparison is flawed. Here, I describe and propose some different ways to quantify reproductive success that can be used to develop absolute evaluations of reproductive performance, with the goal that these will be useful additions to the Report Card or other monitoring/evaluation efforts. I also highlight how these different metrics capture different aspects of the reproductive problem.

Elevations of lobster fishery groundlines in relation to entanglement risk to North Atlantic right whales in Atlantic Canada

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Elevations of groundlines for fixed-gear fisheries along the Scotian Shelf and the Gulf of St. Lawrence have not been studied. Calibrated depth recording sensors were used to measure the elevations of groundlines above the seafloor for 34 floating and 4 neutrally buoyant groundlines on 10 different lobster trawls in four areas along the Scotian Shelf and Gulf of St. Lawrence for at least 24 hours/ 2 tidal cycles each, resulting in 21,423 elevation measurements. The trawls consisted of between 4 and 15 traps and were deployed in depths between 4.8 and 73.2 m. Elevations of floating line between traps ranged from 0 to 6.8 m. Using a combinatorial test, we rejected the hypothesis that floating groundlines remain below 1 m most of the time ($P < 0.01$; 45% of observations) but also rejected that they exceed 3 m most of the time ($P < 0.01$; 10% of observations). The neutrally buoyant groundlines between traps ranged from 0 to 2.0 m above the bottom. Factors affecting these elevations (e.g. trawl configurations, environmental conditions) were also examined to identify factors within control of fish harvesters that could reduce groundline elevations. We briefly address the relative conservation value of groundline management with respect to mitigating entanglement risk to NARW.

Ambient acoustic noise with depth in the Honguedo Strait, Gulf of St Lawrence and implications for baleen whale detection

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Endangered whales, such as the North Atlantic right whale (NARW) and blue whale rely on the Honguedo Strait to transit between the eastern and western regions of the Gulf of St Lawrence, Canada. The strait between the Gaspé Peninsula and Anticosti Island is a minimum of 70 km wide, and as a busy shipping corridor represents an area of increased risk of vessel strike and noise impacts to these whale species. From 4th September through 30th October 2019, an experiment was conducted to evaluate the impacts of noise on the performance of near real-time acoustic detection of whales, especially NARW. The experiment used a digital acoustic monitoring (DMON) instrument on a profiling Slocum glider and two fixed autonomous multichannel acoustic recorders (AMAR) on the seabed. The glider travelled between 30 and 210 m water depth 14 times back and forth along a programmed transect and recorded flight, hydrographic and acoustic data. The depth profile of ambient sound power spectral density is analysed with respect to glider flight data, vessel traffic from AIS data as well as weather data. At frequencies below about 50 Hz, which includes most calls by blue and fin whales, flow noise masks the true ambient sound and increases in power with increasing glider vertical velocity. The observed relative noise profile with depth at frequencies greater than 200 Hz, which includes the majority of NARW calls, agree with predictions from a wind-wave driven sound field model, consisting of homogeneously distributed noise sources placed close to the sea surface. The difference between the observed and predicted noise-depth profile is further exploited to determine the prevailing contribution of ship generated noise.

North Atlantic right whale vessel strike mitigation in U.S. waters - Assessment of current efforts and next steps for change

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North Atlantic right whales continue to experience elevated risk of mortality and serious injury from vessel collisions in their primary U.S. habitats. To better understand and address this risk, the National Marine Fisheries Service (NMFS) Office of Protected Resources (OPR) is leading a series of efforts to evaluate the effectiveness of current vessel strike mitigation programs, identify opportunities to enhance whale protection, and implement changes where needed. In January 2021, OPR released an assessment evaluating the efficacy of NMFS vessel strike risk reduction programs for North Atlantic right whales, including the mandatory speed rule. The assessment found that while progress has been made to reduce the risk of death and serious injury from vessel strikes, additional measures were needed to meet right whale conservation goals. The assessment recommended modifying the boundaries and timing of Seasonal Management Areas to better reflect current vessel strike risk dynamics, expanding the scope of vessels subject to mandatory speed restriction to include those smaller than 65 feet in length, and enhancing enforcement and outreach efforts to increase vessel compliance. In light of the assessment findings, and considering public comments received, NMFS is investigating modifications to the current right whale speed regulations and anticipates issuing a proposed rule in spring 2022 and final rule in fall of 2022.

North Atlantic right whale Catalog update and whale naming results

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Each year the New England Aquarium provides an update of the status of the photo-identification Catalog which they manage for the Consortium. This update will include: the number of animals currently in the Catalog, their age and sex and whether they are presumed alive or dead; the number of sightings and images contributed in the last year; new animals added to the Catalog; the matching status of the data by year; and an overview of recent births, mortalities and entanglements (although details of the latter two will likely be provided by other presenters). Also, comparisons of data submission and number of whales alive historically will be presented. To ensure that the most up-to-date data are provided, these numbers will be calculated in mid-October and therefore the results are not provided in this abstract. Given the large number of researchers that utilize the Catalog data, it is important to provide annual summaries of the status of available data so that these researchers can determine appropriate research objectives. Lastly, the final results of the Consortium whale naming effort will be presented.

North Atlantic right whale (*Eubalaena glacialis*) habitat in the southern Gulf of St. Lawrence

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The distribution of North Atlantic right whales has shifted in the last decade, perhaps best exemplified by the decreased use of several well-characterized habitats in the Gulf of Maine and Scotian Shelf and an increased occupancy of a relatively unknown

habitat in the southern Gulf of St. Lawrence (GSL). The goal of this project was to characterize right whale feeding habitat in the GSL region. We conducted opportunistic oceanographic sampling during daylight hours from visual survey vessels in the presence and absence of right whales in July and August over three years (2017 – 2019). Oceanographic stations (n = 115) were typically comprised of a depth-integrated oblique ring net tow that was preceded and followed by a vertical profile with a conductivity-temperature-depth (CTD) instrument and optical plankton counter (OPC; 2018/2019 only). Small copepods (e.g., *Centropages*, *Psuedocalanus*) were numerically dominant at all stations. Of the *Calanus* species, *C. finmarchicus* was typically most abundant but *C. hyperboreus* appeared to comprise the majority of total *Calanus* biomass based on their abundance and relative body size (biomass estimation is pending). Physical and biological variables were derived at each station and logistic regressions were used to quantify right whale habitat associations. Results suggested a higher probability of right whale presence was associated with a shallow bottom mixed layer characterized by relatively warm saline water, and abundant patches of late-stage *Calanus* near the seafloor. Further research is underway to better characterize the deep *Calanus* layer and explore the potential role of alternative foraging strategies (e.g., feeding on other taxa). These results offer insights into the quantity of the prey and quality of the GSL as a right whale foraging habitat and the associated implications for right whale recovery.

Quantifying rope density in the Scotian Shelf and Bay of Fundy lobster fishery considering fishing methods and effort

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The Canadian lobster fishery is a fixed-gear fishery that occurs within North Atlantic right whale (NARW) habitat. Knowledge of fishing methods and effort distribution can be used to identify patterns of rope density, and thus, areas of increased entanglement threat and priority for management. To estimate rope densities, we consolidated data on fishing methods from a Fisheries and Oceans Canada (DFO) survey with 350 Maritime fishers, and data on effort distribution from commercial fishing logbooks from 2015-2018. Endline, groundline, and surface line densities were estimated by management grid cell for each month of the fishing season across lobster fishing areas (LFA) 27 through 38B. DFO permitted 2,997 fishing licenses in 2018, resulting in 1,349,525 traps and 512,000 endlines in the water. Harvesters in shallower areas (LFAs 28-32; 22 m depth average) fished entirely with singles and shorter endlines while harvesters in deeper areas (LFAs 33- 38B; 74 m depth average) placed 71% of traps in trawls, and 29% as singles and used longer endlines. Considering variation in length and scope, we standardized the number of endlines by creating a unit of depth-equivalent endlines to allow density comparison within LFAs. High endline density areas included Cabot Strait (LFA 27) in June, and Grand Manan Island (LFAs 36 and 38) in May. Endline density was low in other summer and fall months. We also developed a preliminary model to compare the entanglement threat value of different line types by considering time spent by whales at certain depths of the water column. In addition to an improved method of estimating rope densities in the Canadian inshore lobster fishery along the Scotian Shelf and Bay of Fundy, this work provides important progress in the use of fishing methods and effort distribution data to evaluate entanglement threat to NARW.

Estimating the population size of the North Atlantic right whale

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We propose to estimate the population size of the North Atlantic right whale using a Bayesian statistical method. Two challenges in estimating population size are (1) some whales that have been sighted are now dead, and (2) some living whales may never have been sighted. We account for the first issue by estimating the probability that each sighted whale is currently alive, given its sighting record in the NARWC sighting database. Based on these probabilities, we randomly simulate a dataset consisting of whales thought to be alive. We then

apply to this dataset a method from statistical ecology for estimating the number of never-sighted individuals. This estimate is added to the number of whales thought to be alive to arrive at an estimate of population size. We then repeat this process 1000 times total, each time simulating a different dataset of whales thought to be alive and applying the method for estimating never-sighted individuals. We thus arrive at a posterior distribution of estimated population sizes that accounts for uncertainty in both the current status of sighted whales, and the number of never-sighted whales. Our work is in progress, and our team (mostly composed of statisticians and computer scientists, including six undergraduate students) is eager to receive feedback from the North Atlantic right whale community.

North Atlantic right whale entanglement and serious injury update, November 2020 – October 2021

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Since the last consortium meeting there were 18 sightings of entangled right whales, involving five individuals: #3920 (Cottontail), #1803, #3466, #3560 (Snow Cone) and #4615. These sightings ranged from the Gulf of St. Lawrence to Florida. Three cases were newly discovered for the time period, and two were re-sightings of ongoing cases reported at prior consortium meetings. This is below the average of 5.2 during the last decade for newly discovered cases. One ongoing case, #3466, was confirmed to have shed his entanglement while the other ongoing case was confirmed to have died from his entanglement (Cottontail). Of the three new cases, all but one (Snow Cone) is likely to be carrying a lethal entanglement. Ten on-water operations were mounted to tag, attempt disentanglement or document a carcass. Atlantic Large Whale Disentanglement Network members are urged to keep watch for these individuals and report any sightings immediately.

In 2021, six new injured whales were added to the Right Whale Injury Monitoring list. Additions included three whales carrying gear (#1803, #3560, and 4615), two whales with entanglement wounds but not carrying gear (#2223 and #3510), and one whale with a vessel strike (#3230). Of these whales, one was determined to be in declining condition coinciding with its injuries (#1803) and the impact of injury on whale health was inconclusive for the remaining five whales. An updated report on all injured whales currently on the monitoring list (including new and previously detected injuries) will be released in December 2021. Additionally, a new web portal for anthropogenic events was developed in 2021 with the goal of streamlining data entry and access for injury and monitoring events. We will engage with various stakeholders in the upcoming year to develop extraction routines and visual outputs to better support management and conservation efforts.

Preliminary serious injury determinations were made for the six new injured whales. #1803 and #4615 are both determined to have serious injuries. #3560 and #3230 have prorated injuries. #2223 and #3510 have non-serious injuries. When assigning numerical values to these injuries to compare to PBR (0.8), the total is 3.27 seriously injured whales to date. These determinations are subject to change. Official determinations will be published in annual Stock Assessment and Serious Injury reports.

A multi-state mark-recapture-recovery model to estimate rates of severe injury and cause-specific mortality in North Atlantic right whales

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Recent decline of North Atlantic right whales over the past decade has been attributed to high rates of mortality and low rates of reproduction. The former has been driven by human-related causes including entanglement and vessel strike, though cause-specific mortality rates have been difficult to estimate due to uncertain variation in carcass detection and a large proportion (>60%) of cryptic mortality. Here we present a multi-state mark-recapture-recovery model that leverages the sightings of individuals with severe injuries and recovered carcasses of known

individuals to estimate rates of injury and mortality during 1990–2019. Annual variation and decadal trends in injury and mortality rates were accommodated, as well as the effect of mature females recovering from the physiological stress of reproduction. Model results suggest that while just under half of vessel strike mortalities may result in recovery, entanglement mortalities are recovered at a much lower rate. Population-wide apportionment of mortality suggests a ~2:1 ratio of entanglement to vessel strike deaths. Females with a recently weaned calf had higher rates of severe injury and, consequently, a higher proportion of mortalities due to entanglement. By integrating observations of severe injuries with carcass recoveries, our modeling approach provides a novel framework for estimation of cause-specific mortality.

Observations of adult-calf non-reproductive copulatory behavior in North Atlantic right whales

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Non-reproductive copulatory behavior occurs when individuals engage in sexual behavior, but their sex and/or age precludes reproduction. Such behavior has been reported in primates and some cetacean species, suggesting a correlation with complex social structures. In Eubalaenids, non-reproductive copulatory behavior between adult males is often observed in surface active groups. Additionally, one instance of non-reproductive copulatory behavior involving a southern right whale (*Eubalaena australis*) adult male and calf was documented via underwater video on a calving/mating ground in Argentina in 2015. Here we report two similar events in North Atlantic right whales (NARWs), which both involved an adult male and a calf in the Shediac Valley of the southwestern Gulf of St. Lawrence, Canada. On 18 July 2021, a NARW mother (catalog #3720) and her calf (possibly female, to be confirmed by genetics) were initially observed from a research vessel. While the mother was diving, a drone captured video of an adult male (#3442) engaging in non-reproductive copulatory behavior with the calf for ~9 minutes. Specifically, #3442 was positioned ventrum-up under the calf with his flippers on either side of the calf. His penis was extended, and there appeared to be intromission during part of the video. In August 2020, drone video was collected of an adult male (#1429) interacting in a similar manner with the female calf of #2642. In this video, the male's genitalia could not be seen, but the mother can be observed interacting with the male and her calf. To the best of our knowledge, these videos represent the first documentation of non-reproductive copulatory behavior involving NARW adults and calves. Reasons for such behaviors could include practice, play, or some role in establishing social relationships. The unique aerial perspective of drones can provide greater insight into the [unexpected] behaviors of these large whales.

Biogeochemical analysis of baleen as a wildlife forensic tool: Reconstructing the lives (and deaths) of North Atlantic right whales

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Baleen is a remarkable structure. In addition to being a highly adaptive filter feeding apparatus, it is an accreting, metabolically inert matrix holding a myriad of compounds that reflect a whale's physiological state at the time of tissue formation. Our research team is measuring biogeochemical compounds - including stable isotopes ($\delta^{13}C$, $\delta^{15}N$, compound specific) and hormones (reproductive, glucocorticoid, metabolic) – to build retrospective

endocrine and ecological histories of North Atlantic right whales using necropsied baleen (currently n=30 individuals collected between 1975-2020). The goals of this study are to reconstruct patterns and individual variability in (1) parameters of reproductive cycles including gestation period, interbirth interval, reproductive rate, male seasonality, and sexual maturity; (2) incidences and severity of natural and anthropogenic stressors; (3) migration behavior, foraging ecology, and nutritional responses; and (4) long-term shifts in the aforementioned factors due to climate change. Measured biogeochemical profiles will be chronologically matched with data on whale life-history, visual health and field observations to provide insights into long-term trends. Here, we report preliminary endocrine data from five individuals that died in Canadian waters during the 2019 Unusual Mortality Event. Adult females (Eg1281, *Punctuation* and Eg3450, *Clipper*) exhibited prolonged elevations in progesterone with brief increases in cortisol, indicating pregnancy events. Adult males (Eg1514, *Comet* and Eg3421) exhibited prominent, multi-year cyclical, seasonal patterns in testosterone across their baleen record. In two males (Eg3421 and Eg4023, *Wolverine*), testosterone production showed significant increases by age 8 and 7, respectively, younger than available estimates of male age at sexual maturity for this species. Thus far, elevations in cortisol in these samples can be linked to stress events (i.e., pregnancy or breeding season), lowered visual health scores, or potential periods of food limitation (indicated by elevated thyroid hormones). Future work includes high resolution sampling of baleen plates in pursuit of the project objectives.

Update on three North Atlantic right whale mortalities in the U.S. Oct 2020 – Sept 2021

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As part of the ongoing Unusual Mortality Event (UME) impacting North Atlantic right whales (NARWs) that began in 2017, there were three confirmed North Atlantic right whale (NARW) mortalities within US waters in the southeast between October 2020 and September 2021. The first was an unidentified male perinate reported 20 November 2020 on North Core Banks, North Carolina in a state of moderate decomposition. Significant necropsy findings included: extensive bilateral contusions in muscles in the neck; axial muscle pallor; two rib fractures (one ante- and one post-mortem); patent ductus arteriosus, dark red lungs that barely float; patent umbilical vessels; meconium in the large intestine; and empty stomach chambers. Dystocia was the most likely cause of death. The second case was a male calf (2021 calf of Catalog #3230, "Infinity") that stranded fresh dead on 13 February 2021 in Anastasia Island State Park, St. Augustine, FL. Law enforcement had received a report of a vessel striking a whale prior to the animal stranding and the necropsy and histology findings were consistent with cause of death due to vessel induced trauma. The calf had numerous chop wounds extending into the thoracic cavity with a probable hydropneumothorax; numerous chop wounds extending into the oral cavity lacerating the oral rete and bisecting the blowhole; and acute fractures of vertebral ribs, premaxilla and maxilla. The final case was a 12 year old male, Catalog #3920, "Cottontail" that had been first observed with a chronic entanglement on 19 October 2020 south of Nantucket. Multiple efforts had been made to disentangle the whale, removing only portions of the gear. Cottontail was observed alive in poor condition off southeast Florida on 18 February 2021 and his carcass was subsequently found floating 27 February off Myrtle Beach, SC. An at-sea exam was performed, which found chronic entanglement

involving the oral cavity and emaciation. Much of the gear was removed while the tagged carcass drifted south. These three whales are included in the UME (50 known cases to date) and continue to demonstrate the urgent need for additional mitigation measures to prevent vessel collisions and fishing gear entanglements, which are the primary causes of the current UME and are driving NARWs to extinction.

Whales and fishermen in Gaspésie: towards a coexistence on the maritime territory

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Since 2017, we are experiencing in the Gulf of St. Lawrence a major crisis related to the North Atlantic Right Whale, a species increasingly present in our waters. Beyond the stakes related to the spatio-temporal distribution of this endangered species in a Gulf, there are some specific, finer scale concerns relative to the zones that overlap fishing areas and the challenges of coexistence that this entails. This is especially true for coastal areas (less than 20 fathoms), where an important lobster fishery takes place, and for which almost no information was available to implement the NARW protection measures. This project is the first of its kind in Canada and is based on the expertise and interdisciplinarity of experts in ecology, economics, social sciences, and fishermen. It is a project made FOR and WITH fishers, who are adapting to a changing and challenging future. Our project allowed us to meet fishermen to collect their opinion on the NARW crisis, to produce a social analysis on the history and social context of this fishery in Gaspésie and its evolution in recent years, and to propose a series of recommendations to fishermen, scientists, and the governments regarding this fishery. Moreover, the vessel-based surveys of the coastal zone during the lobster fishing season covered more than 1000 km^2 each year and allowed to assess the biodiversity of an area that is important for both fishers and marine mammals. No NARW was observed in shallow areas, and no species typically known to be associated to NARW were seen either. These results will improve the level of confidence of fishermen in the management measures (based on better data, involving fishermen), and measures the level of compliance and respect for the measures to protect right whales in this part of the Gulf.

Orsted offshore wind: North Atlantic right whale science initiatives updates

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In 2016 Orsted entered the U.S. market and now owns multiple offshore wind leases along the east coast as well as the Block Island Wind Farm. In support of our offshore development efforts, Orsted is investing in multiple science initiatives specific to the North Atlantic Right whale (NARW) (*Eubalaena glacialis*). We are focusing on developing and adapting technologically innovative and verifiable solutions to mitigate and monitor our activities impacts in a practical manner as well as support efforts to advance predictive habitat models and add to the general baseline knowledge of NARW's. We have invested over 6 million dollars to date in support of these efforts. I will provide an update of the utilization of real-time data sharing and integration efforts that has substantially increased the collective situational awareness of protected species in the area of operations and summarize the right whale sighting contributions to date. I will briefly review the status and 2020/21 learnings from our ECO-PAM project, summarize additional NARW studies commencing in the fall of 2021 and anticipated research and monitoring initiatives anticipated for 2022 and beyond. Finally I will highlight the expanding offshore wind industry regional research efforts for consortium community awareness.

Navy Maritime Domain Awareness (MDA) systems leveraged for North Atlantic right whale alerting

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NRL hosts an unclassified MDA system, Proteus, which provides a common operational picture of vessels worldwide. Proteus contains a fusion engine that forms tracks via various data sources: land based sensors (RADAR and AIS), space based sensors (Polar, Epsilon, NOAA VIIRS, and Hawkeye 360), OSINT, airborne sensors (USCG and CB Minotaur), cargo, and other assets. A capability included in Proteus is user-defined area of interest alerting. Seasonal and Dynamic Management Areas for North Atlantic right whales have been layered into Proteus to generate automatic alerts on management area violators. NOAA and USCG users are undergoing a pilot programming for this system and may set and test these aforementioned alerts. A data source currently being investigated for Proteus ingest is commercial high resolution imagery for dark vessel tracking. The dark target vessel tracking effort has synergy with another effort ongoing at NRL, Geospatial Artificial Intelligence for Animals (GAIA). With funding through Office of Naval Research and NOAA Northeast Fisheries, GAIA is workflow being developed to automatically detect marine mammals in commercial imagery using COTS/GOTS machine learning products. In collaboration with NOAA, Bureau of Ocean Energy Management, and University of Cambridge, a training data set of commercial imagery containing Southern right whales and manual annotations have been leveraged to test detection performance. We will first provide a demonstration of current North Atlantic right whale situational awareness measures in Proteus and how imagery may use to enrich situational awareness. We will then provide current workflow and detection performance for the identification of Southern right whales and how this work may be applied to North Atlantic right whales.

North Atlantic right whale presence and vocal activity in New York waters: Implications for their protection and safe passage

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Since 2010, North Atlantic right whales (NARWs) have undergone large-scale distribution shifts moving into areas with limited or no protection from vessel strikes. Our current understanding of NARW presence in New York (NY) waters is limited given these large-scale distribution shifts. Thus, the extent to which the Port of New York-New Jersey Seasonal Management Area (SMA) overlaps with current NARW distribution is also currently not well understood. To determine the acoustic presence and vocal activity of NARWs in NY waters, particularly while the SMA was inactive, we analyzed acoustic recordings from July 2016 – January 2020. The recordings were collected via a buoy moored ~30km from the SMA. The acoustic recordings were analyzed using a two-step process: 1) automatic detection of NARW calls via the low-frequency detection and classification system (LFDCS) and 2) human verification and augmentation. Daily vocal behavior was categorized into distinct vocal states by a hidden Markov model; peak, high, medium, low and no vocal activity. The diel pattern of vocal activity was determined by calculating average number of calls per hour and fitting a generalized additive model to the data. We acoustically detected NARW outside the SMA over several years, and medium or high vocal states occurred while the SMA was inactive suggesting whales were present when the SMA implicitly assumes whales are absent**.** We also found that NARW calling activity was greatest at night when NARW cannot be visually sighted, and we acoustically detected NARWs when concurrent aerial surveys did not visually detect them. The results of our study indicate additional protections are needed beyond the current SMA, as its spatio-temporal boundaries do not fully coincide with NARW presence. Dynamic management approaches activated by acoustic detections of NARWs may be a promising mitigation measure particularly at times when NARWs can be acoustically but not visually detected.

Repatriation of a historical right whale habitat and novel year-round occurrence during an era of rapid climate change

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Climate change is affecting species distributions in space and time. Rapid warming in the Gulf of Maine has altered the distribution of the critically endangered North Atlantic right whale (*Eubalaena glacialis*). Right whales have returned to historically inhabited areas such as southern New England shelf waters (SNE), an area known to have been a whaling ground, but one that has not been known to host large numbers of right whales in modern times. While right whales are known to occur in SNE, the relative importance of this region is still being assessed. We compared aerial survey data from two time periods (2013-2015; 2017-2019) to assess the trends in right whale abundance in the region using distance sampling techniques. We also explored the annual and seasonal use of this habitat by different age and sex classes using photographically identified individuals. A generalized linear model of abundance ($\beta_{year} = 1.48$, $p < 0.01$) and a linear model of the number of unique individuals (IPUE; $\beta_{year} = 2.25$, $r^2 = 0.66$, $p < 0.001$) showed significant increasing trends in right whale use of the area. We estimated zero abundance and IPUE during summer and fall of 2013-2015, but non-zero abundance or IPUE during the summer and fall of 2017-2019. A *G*-test of independence showed significantly different proportions of adults to juveniles between seasons pooled across years ($G = 20.61$, $df = 3$, $p < 0.001$), and a *G*-test goodness of fit of pooled seasons from 2017 to 2019 showed significantly higher proportions of juveniles during two seasons (Bonferroni p-values < 0.05). Our results show the current importance of this habitat and suggest that importance may vary seasonally by age class. Management options must evolve as right whales repatriate historical habitats and potentially expand to new habitats as they adapt to climate change.

The (en)tangled web they weave: Stakeholder perceptions of the large whale take reduction planning process

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Negotiated rulemaking is a decision-making process that has been integrated into U.S. regulatory processes within the last three decades. Amendments to the Marine Mammal Protection Act in 1994 mandated the creation of Take Reduction Teams, stakeholder committees that use negotiated rulemaking to develop regulations to reduce marine mammal interactions with commercial fishing operations. The largest and least successful of these teams is the Atlantic Large Whale Take Reduction Team (ALWTRT), which is tasked with developing regulatory measures to protect the highly endangered North Atlantic right whale, as well as other large whale species. This study used semi-structured interviews with members of the ALWTRT to gain insight into the aspects of the take reduction process that limit the team's ability to reach consensus and limit stakeholder satisfaction. While some aspects of the process are effective at promoting agreement, respondents revealed many factors that make consensus agreements difficult and the overall process unrewarding. Results suggest that the malaise that negotiated rulemaking was intended to remedy is still prevalent and that legislative action may be required to create more collaborative, legitimate, and successful participatory process.

The value of incorporating bearing estimation into real-time right whale mitigation systems

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There is a need to implement effective conservation measures for right whales while minimizing negative impacts on stakeholders including the fishing, shipping, and burgeoning offshore wind industry. Exclusion and mitigation zones are a common conservation method that limits potentially harmful activities such as pile driving or ground fishing when right whales are in the area. SMRU Consulting has built the Coastal Acoustic Buoy for Offshore Wind (CABOW) to address the need for exclusion zone mitigation. Each CABOW consists of a bottom lander with three hydrophones; data acquisition system; and onboard computer running PAMGuard. The CABOW detects potential calls and relays clips to a base station for classification, bearing estimation, and validation. Bench testing characterized detector performance and measured bearing accuracy as a function of SNR. Field trials used playbacks of real and simulated right whale upcalls to evaluate the detection probability with respect to the range and signal excess of the call; estimate bearing accuracy; and test the range and stability of the radio communications. Field trials indicated a maximum detection range of 4-12km under high and very low noise levels, respectively. Last, we used a simulation to compare true and false alarm rates of the CABOW to an equivalent single sensor system for monitoring a fixed area. Simulations show that incorporating bearings to calling animals could provide a substantial improvement in false alarm rates relative to single sensors if properly placed with respect to potential noise sources.

Impacts of COVID-19 pandemic-related changes in shipping on the soundscape and calling behavior of right whales in the New York Bight

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Public health measures in response to the COVID-19 global pandemic led to significant changes in human activities across the globe. As vehicle and airplane traffic decreased in April and May 2020, scientists documented notable reductions in the overall noise levels in many terrestrial habitats and in some marine habitats. Global commercial shipping patterns were also impacted by the pandemic. For the Ports of New York and New Jersey, these changes included a slow decline in the volume of large commercial vessel traffic that reached a minimum of ~16% lower traffic in 2020 than in 2019 between May and June. The objective of this study was to use passive acoustic monitoring data to explore regional changes in background noise and North Atlantic right whale (*Eubalaena glacialis*) calling behavior in response to these changes in shipping. An array of bottom-mounted passive acoustic recorders collected data in the New York Bight from October 2017-October 2020. Changes in vessel traffic patterns were reflected in changes to the ambient noise levels in the New York Bight during the spring of 2020 when compared to 2018 and 2019. This included reduction of the highest noise levels (95% levels), while average noise levels (50% levels) remained virtually unchanged across years. Right whale calling behavior across the three years was investigated to assess whether individual whales showed vocal modifications in response to the changes in background noise associated with the pandemic. Soundscape-related impacts from the pandemic and, in turn, to the vocal behavior of low frequency baleen whales in this coastal urbanized environment highlight the persistence of low-frequency noise from commercial shipping, which showed only modest changes to average background noise in this habitat despite major changes to human activity.

Last of the Right Whales film & impact campaign panel

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LAST OF THE RIGHT WHALES, by filmmaker Nadine Pequeneza, is the story of a disparate group of people - a wildlife photographer, a marine biologist, a whale rescuer, and a crab fisher - united in their cause to save the North Atlantic right whale. By joining forces these formidable allies are determined to stop the world's first great whale extinction. The film combines the 4K cinematography of a blue-chip nature film with the character-driven, vérité storytelling of a high-stakes drama. With unprecedented access to film the migration of the North Atlantic right whale from their calving ground off the coast of Florida to their new

feeding area in the Gulf of St. Lawrence, this feature documentary brings a message of hope about the most at-risk, great whale on the planet.

Residency, demographics, and movement patterns of North Atlantic right whales (*Eubalaena glacialis*) in an offshore wind energy development area in southern New England, USA

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One of the largest commercial offshore wind energy farms in the USA will be constructed off southern New England, in an area used by the critically endangered North Atlantic right whale *Eubalaena glacialis*. Prior to 2011, little was known about the use of this area by right whales. We examined aerial survey data collected between 2011−2015 and 2017−2019 to quantify right whale distribution, residency, demography, and movements in the region. Right whale occurrence increased during the study period. Since 2017, whales have been sighted in the area nearly every month, with peak sighting rates between late winter and spring. Model outputs suggest that 23% of the species' population is present from December through May, and the mean residence time has tripled to an average of 13 d during these months. Age and sex ratios of the individuals present in the area are similar to those of the species as a whole, with adult males the most common demographic group. Movement models showed that southern New England is an important destination for right whales, including conceptive and reproductive females, and qualitative observations included animals feeding and socializing. Implementing mitigation procedures in coordination with these findings will be crucial in lessening the potential impacts on right whales from construction noise, increased vessel traffic, and habitat disruption in this region, and has the potential to set a precedent for stewardship standards for an industry that is quickly developing throughout much of the right whales' range.

Multi-state modeling of true reproductive states of individual female right whales provides new insights into their decline

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Abundance and population trends of the Critically Endangered North Atlantic right whale (*Eubalaena glacialis*, NARW) have traditionally been estimated using mark-recapture analyses with an underlying stage-structured population where an individual's stage is based upon arbitrary delineations of age. Here we assigned individual females to stage based upon their reproductive experience, rather than age. We developed a Bayesian mark-recapture-recovery model to investigate how survival, recapture, site fidelity and dead recovery probabilities vary for female NARW in different states, using data collected from 1977-2018. States were assigned as calves for individuals in their first year; pre-breeder for individuals greater than one year of age who had yet to produce a calf, or breeder if an individual had reproduced. A decline in abundance of female NARW was seen starting in 2013, with the estimated 185 females declining yearly to 142 by 2018. The largest decline was seen in breeding females, with only 72 estimated to be alive at the beginning of 2018, while the abundance of pre-breeding females plateaued at around 70 between 2011 and 2018. Females born from 2000 onwards had an average 4% (95% CI: 0.03-0.06) chance of transitioning from pre-breeder to breeder, compared to 8% (95%CI: 0.06-0.1) for females born prior. This delay in age of first reproduction for the current cohort of young females resulted in breeding females constituting only 51% of the female population by 2018, compared to 61% in 2010. Our analysis shows not only a collapse in the fecundity of breeding females, but a failure of pre-

breeders to recruit to breeders, is driving this population decline.

Predicting endangered North Atlantic right whales using prey fields

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Predictions of North Atlantic right whale distributions form an increasingly important tool used in policy and management decisions for this endangered species. Incorporating plausible prey fields into right whale models has the potential to improve predicted whale distributions, and by implication the decisions based on them. We statistically modeled distributions of *Calanus finmarchicus*, *Centropages typicus*, and *Pseudocalanus* spp. with the goal of incorporating these prey fields into a right whale density surface model that is part of the National Oceanic and Atmospheric Administration's (NOAA's) North Atlantic right whale decision support tool. We used a Random Forest model with a subset of the environmental covariates used in the density surface model, combined with copepod data from NOAA's Ecosystem Monitoring Program (EcoMon) survey, to create prey fields for these three species. We then incorporated these prey fields into the right whale density surface model and evaluated whether they improve right whale predictions. We investigated the effect of a range of covariate configurations on model skill. Results of the experiment indicate that prey fields improve predictions, but have variable contributions throughout the year.

Transport Canada (TC) update on North Atlantic right whale vessel management measures

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The Government of Canada's vessel management measures for the 2021 season to reduce the risk of vessel collisions with North Atlantic right whales (NARW) in Canadian waters came into effect on April 28, 2021. The 2021 measures build off the measures from the previous year, and were developed in consultation with industry and scientists, taking into consideration past confirmed NARW detections, the latest science advice, navigational safety, and economic impacts. In addition to the large mandatory slowdown area covering much of the Gulf, new measures introduced in 2020, including a restricted area in and near the Shediac Valley and a trial voluntary slowdown in Cabot Strait, were implemented once again in 2021 with modifications based on lessons learned in 2020. Surveillance technologies incorporated into the dynamic management of vessel measures in 2020, namely a Remotely Piloted Aircraft System (RPAS) and an underwater acoustic glider, were once again deployed, with additional acoustic monitoring in Cabot Strait to build on our understanding of where, when and how NARW travel through the area.

Predicted Distribution and Abundance of Zooplankton Species in Cape Cod Bay in 2019

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Center for Coastal Studies has collected systematic zooplankton samples in Cape Cod Bay since 1984. Samples are collected on myriad species using 4 different collections methods at a variety of geographic locations, and at a range of proximities to right whales. To better understand how right whales may respond to the distribution and abundance of their prey, we need predictions of prey across space and time to co-locate with right whale distribution as observed from planes or vessels and detected from passive acoustic monitoring. In 2019, CCS sampled 558 separate locations from 18 January through 9 June. As part of an exploratory effort, we fit a Gaussian spatial regression model to these point-referenced data, where the dependent variable was log-transformed total zooplankton / m^3 and the

predictors were water temperature and bathymetry. The model accounts for spatial random effects within the sampled data. We found a significant, though moderate, negative effect of both temperature and bathymetry on zooplankton abundance. Using the fitted model, we predict both the point-wise mean for log total zooplankton with median = 6.96 / m^3 and credible interval (5.73, 7.83), as well as the total surface abundance in Cape Cod Bay in 2019 5,839,965 / m^3 (4,452,337, 8,149,468). We present maps for predicted distribution and abundance of total zooplankton, as well as each of three specific zooplankton taxa: *C. finmarchicus*, *Pseudocalanus spp.*, and *Centropages spp*. We show how these results will be incorporated into the two scales of modeling within the Population Consequences of Multiple Stressors project, as well as how we will extend this modeling approach to account for multiple years' worth of data to account for variability both within and across years.

Variation in near-bottom aggregations of North Atlantic right whale prey in the southern Gulf of St. Lawrence in summer

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North Atlantic right whales (NARWs) have been observed congregating in the southern Gulf of St. Lawrence (sGSL), where they feed and socialize in summer, since 2015. Observations of prey concentrations at scales relevant to NARWs are scarce in this area, limiting direct assessment of foraging habitat suitability and its drivers. We quantified variation in the vertical distribution of *Calanus* (identified to genus) at 3-m resolution using a Video Plankton Recorder (VPR) and depth-integrated species-specific abundance using a plankton net (35 sampling events from 9 August to 1 September 2019). Depth-integrated abundance estimates from the two instruments were comparable, indicating measurements from the VPR were accurate. Maximum prey concentrations ranged from 1000-10000 ind m^{-3} (n = 12) in the Shediac Valley (SV) from 9 to 15 August, when NARWs were observed congregating in the area, and up to 2000 ind m^{-3} elsewhere (n = 13). In SV, maximum prey concentrations declined markedly between 9 to 15 August and 24 to 30 August (n = 10), when they ranged from 300 to 1000 ind m^{-3}. The ratio of *Calanus hyperboreus: Calanus finmarchicus* in net samples was far greater in SV than in the Chaleur Trough, indicating elevated suitability of foraging conditions in SV, as *C. hyperboreus* are larger and more energy-rich than *C. finmarchicus*. Overall, the highest prey concentrations occurred between 70 and 90 m depth, ~10 to 15 m above the seafloor, and likely supported energy requirements of NARWs. We hypothesize that near bottom aggregations form when ontogenetic vertical migration of prey is blocked by the seafloor. Peak abundance above the seafloor may due to a bottom mixed layer or elevated near-bottom predation rate. Variations in magnitude of prey aggregations in SV indicate that NARW foraging habitat may be dynamic on the scale of weeks in the sGSL in summer.

Marine Mammal Commission general update

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The Marine Mammal Protection Act established the Marine Mammal Commission to provide oversight and recommend to other federal agencies actions and policies to further the purposes and policies of the Act. The Commission is working to address a host of threats to marine mammals and their ecosystems, including several that apply to right whales, such as fisheries entanglement, vessel collisions, potential disturbance from offshore energy development, and climate change. The Commission engages in North Atlantic right whale conservation through hosting workshops and meetings, providing grant funding, working with other agencies, communicating with Congress, and providing policy recommendations, as it has done for decades. The agency appreciates the difficulty of the work that our partners in other agencies are doing to reduce threats, but we have recommended that they implement stricter fishery, vessel speed, and routing measures to conserve this imperiled species and to fulfill the federal government's legal obligations. Looking forward, we have identified four major areas, under management, monitoring, gear innovations, and international collaboration, where we think the Commission, in conjunction with the Consortium, can improve the outlook for right whales.

Marine Aquaculture: An emerging industry. An emerging threat?

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There is significant interest in growing responsible marine aquaculture industry in New England. Marine aquaculture offers benefits to coastal communities through job opportunities and the production of local food. The growth of seaweed and shellfish aquaculture in particular has been a particular focus, since these sectors may provide additional ecosystem benefits, such as improving water quality by filter feeding organic matter out of the water column, or local reductions in ocean acidification impacts due to carbon uptake from photosynthesis. However, a key issue is the potential risk of harmful interactions between aquaculture gear and marine wildlife, including critically endangered North Atlantic right whales (NARW). The growth of current types of aquaculture production systems, such as longlines used for shellfish and seaweed culture, would increase the number of vertical and horizontal lines in the water column and may add to the cumulative risks of trap fisheries that are already driving right whales to the point of extinction. Approaches and methods to reduce the risk that marine aquaculture may pose to NARW are nascent, and dialogue between the NARW Consortium community and the aquaculture industry may be limited. This presentation is an introduction to the types of aquaculture production systems that have already been introduced in New England waters, as well as potential future gear types. It will include information on rare but documented harmful interactions between large whales and global marine aquaculture, while also touching on current measures being proposed to reduce the risk of harmful interactions. Finally, it will outline opportunities for NARW consortium members to engage in the dialogue regarding the expansion of marine aquaculture within the right whale range.

Atlantic Large Whale Take Reduction Plan updates: Recent and planned modifications

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NOAA's National Marine Fisheries Service (NMFS) published a Final Rule on September 18, 2021 to modify the Atlantic Large Whale Take Reduction Plan (Plan) to reduce the risk of entanglements of right whales in Northeast lobster and Jonah crab trap/pot gear by greater than 60 percent. The rule includes changes to existing seasonal closures and new seasonal restricted areas (effective October 18, 2021) as well as gear modifications including weak rope, weak insertions, minimum trap/trawl modifications, and gear marking changes (required by May 1, 2022). This rule implements Phase 1 of modifications that were initiated to address the right whale population decline that started in or around 2010 and has been exacerbated by high mortalities documented since 2017.

NMFS recently finished scoping on Phase 2 modifications to the Plan, which aim to reduce the remaining risk of mortality and serious injury of right whales by entanglement from fixed-gear fisheries throughout the entire U.S. East Coast. Input received during scoping will be used to inform the Atlantic Large Whale Take Reduction Team's discussions of potential measures that NMFS should analyze during the rulemaking process. Early in 2022, the Team will develop recommendations to NMFS to help shape the alternative measures that will further reduce the risk of right whale entanglements in fixed-gear fisheries coast-wide. We anticipate a proposed rule in late 2022 or early 2023.

Health indicators to predict the cumulative effects of multiple stressors on the vital rates of North Atlantic right whales

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Indicators of marine mammal health, which are measured on short time scales, were recommended by a 2017 US National Research Council report as an intermediate stage in modeling the effects of multiple stressors on vital rates, which are measured over the lifespan. A Visual Health Assessment has proven useful for estimating trends in reproduction and survival of North Atlantic Right Whales. Here we report on a project to develop a Population Consequences of Multiple Stressors model that starts with the Visual Health Assessment, whose long time series provides great value, and that will explore novel sources of information about health that may improve predictions and our understanding of the mechanisms by which stressors affect survival and reproduction. A goal of the model is to incorporate indicators of health such as body condition (energy stores), stress levels, immune status, and parasite load. Additional measures we are exploring to improve our health indicators include microbiome, photogrammetric information about lipid-store body condition. The long term goal of this project will be to develop models to suggest how much specific stressors will need to be reduced, in combination with other stressors, to reduce the risk of extinction of these endangered whales.

Fisheries and Oceans Canada: an update on research and monitoring activities for North Atlantic right whales (*Eubalaena glacialis*)

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Fisheries and Oceans Canada (DFO) continues to conduct research on the critically endangered North Atlantic right whale (NARW) with initiatives including aerial surveys, passive acoustic monitoring, habitat and prey studies, noise analyses and modelling, and other studies. Systematic aerial surveys to document the seasonal distribution of NARWs in Canadian waters started in mid-April. Multiple passes of the southern Gulf of St. Lawrence (GSL) were conducted to document NARW distribution in this area throughout the season. Additional surveys were undertaken in the northern GSL, southern Scotian Shelf, and off Newfoundland and Labrador. Photographs and videos of NARWs were collected by a variety of platforms and preliminary identifications of individuals and documentation of injuries are underway. Research to improve the ability to monitor NARWs acoustically, especially in areas with high levels of shipping noise is ongoing and soundscape modelling is underway. Passive acoustic monitoring using bottom-mounted acoustic recorders and gliders continued at a number of sites across Atlantic Canada including seven near real-time detection systems in the GSL and the Whale Binaural Rings Project, which uses pairs of coastal circular arrays for real-time NARW detection and localization over large areas. Foraging-habitat

and prey studies continue with the processes driving *Calanus* availability in southern GSL foraging areas assessed through the analysis of 3-D distributions of *Calanus* spp. and coupled bio-physical *Calanus* simulations. A species distribution modelling framework which can integrate presence-only datasets with sightings from systematic surveys to improve overall predictions of suitable habitat is currently under development. *Fisheriescape*, a comprehensive spatio-temporal distribution and intensity layer for fixed-gear fishing activity in the GSL is being developed. A new mass-spectrometry method for quantifying hormone levels in NARW blow samples provided promising initial results. This presentation will summarize the NARW focused research undertaken by DFO and its collaborators.

Development of a mass spectrometry method capable of detecting and quantifying a panel of steroid hormones in right whale blow

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Quantification of steroid hormones in biological materials (e.g., blubber and feces) is increasingly being used to study stress responses and reproductive patterns in various cetacean. Unfortunately, blood is hard to obtain for free-swimming animals, the collection of feces is largely opportunistic, and baleen can only be obtained from dead animals. Biopsies provide a means to assess skin and blubber hormone levels over longer timeframes, leaving only blow as a possible matrix for assessing hormones over shorter timeframes. This is important when attempting, for example, to isolate the stress responses to acute noise events. Attempts to quantify blow hormones to date use off-the-shelf immunoassay-based kits, which have relatively high detection thresholds that require a certain amount of blow. Given the increasing anthropogenic (noise, entanglement) and environmental (changing prey resources and climate) pressures on critically endangered species such as the North Atlantic right whale, we sought to develop tools to effectively monitor the physiology and health of whales to help advance conservation and mitigation strategies. To address many of the existing laboratory limitations, we developed and validated extraction methods together with a liquid chromatography-tandem mass spectrometry (LC-MS/MS) method to simultaneously measure glucocorticoids (cortisol and corticosterone) and the reproductive hormone, progesterone. This was done initially for blow collected from a Pacific white-sided dolphin at Vancouver Aquarium before being applied to samples from right whales. Other potentially stress-related steroid hormones were also monitored. To increase the amount of material collected, an existing drone-based design was adapted, placing a servo-mounted petri-dish on a custom built high-speed racing drone. This was piloted through the blow of individuals multiple times in a surfacing bout by a world-class racing pilot using first person view technology. Together, these approaches elevate blow collection as a promising tool for the non-invasive, systematic study of stress responses and reproduction in large cetaceans.

A method for acquiring, extracting and quantifying stress and reproductive hormones in whale blow was created involving world-class drone racers and liquid chromatography-tandem mass spectrometry to maximise blow amount and minimise detection thresholds.

Dolphin blow collectors:
Leonora Marquez
Rachel Nelson
Tianna Steel
Nadine Trottier

Detecting and classifying right whale upcalls in Cape Cod Bay and co-locating calls with aerial observations

Yack, T.M.[1], Kaney, N.A.[1], Yu, N.[1], Clark, C.W.[2], Gillespie, D.M.[3], Mayo, C.[4], McKenna, B.[4], Nowacek, D.P.[5], Palmer, K.J.[6], Tyack, P.L.[3], Schick, R.S.[1]

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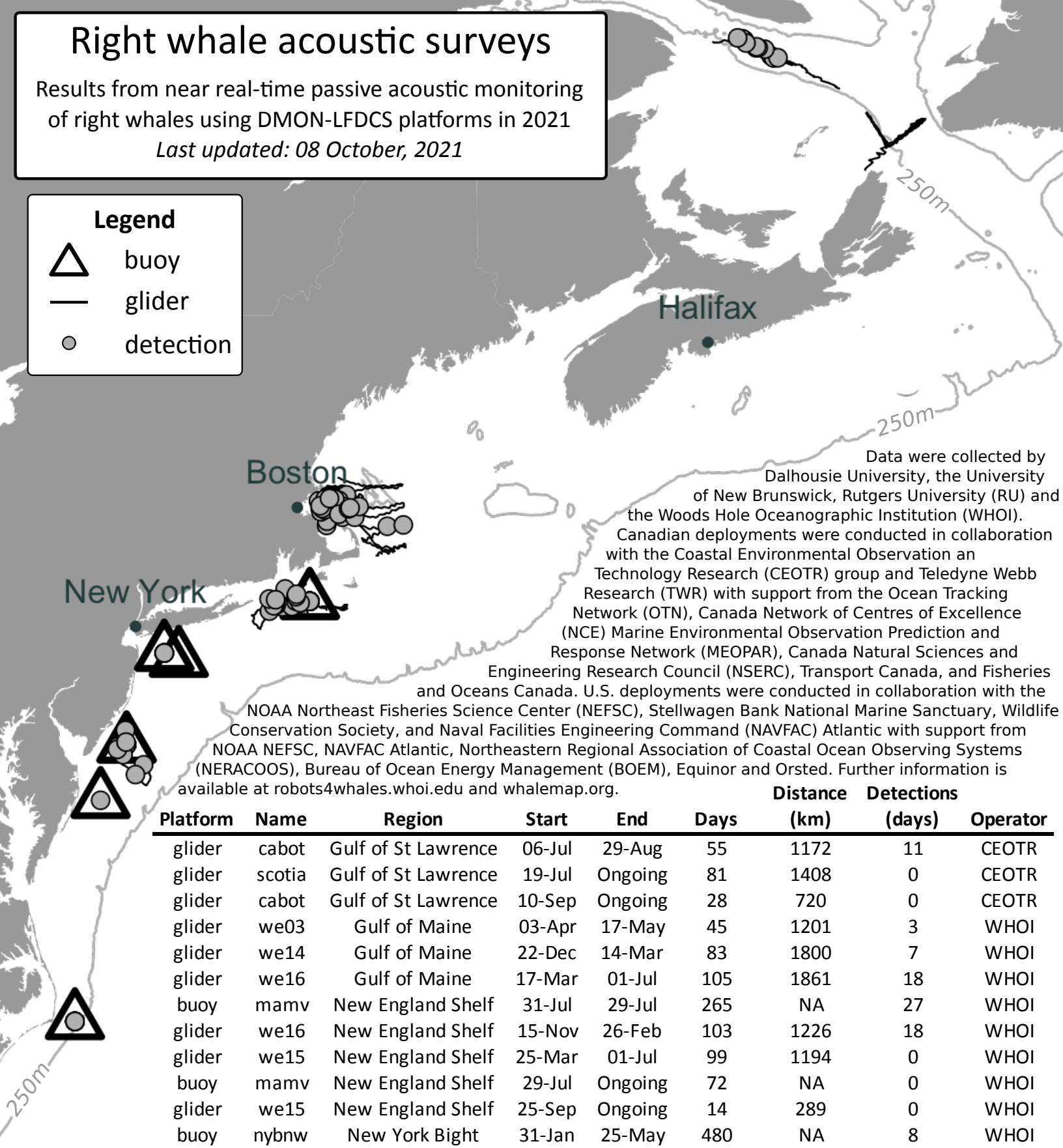
NARW are threatened throughout their range, and knowing where animals are distributed is critical to reduce impacts of multiple stressors. Researchers use myriad techniques to detect NARW including line transect surveys and passive acoustic monitoring. Better understanding of NARW distribution depends on assimilating these data. Center for Coastal Studies has conducted aerial surveys in Cape Cod Bay since the 1990's for visual detection, and from 2001-2018, Cornell University deployed arrays of bottom-mounted MARU's in CCB for acoustic detection, location and tracking. These data have not been analyzed jointly, and here we present an initial view using some of these co-located data from 2008-2009. We used PAMGuard to analyze seventeen days' worth of acoustic data. For each 24-hour period, we identified right whale upcalls using an edge detector, and we used a neural-net classifier to assign a classification score to each upcall. We retained calls with edge detection score >= 9 (0-12 range) and classification score >= 0.8 (0-1 range). Retained upcalls ranged from a low of 219 on 2008-03-11 to 8,654 on 2008-04-08, comprising a total of 50,410 upcalls. We then used a simplex algorithm to localize these calls, and unique localizations ranged from 8 on 2009-05-08 to 382 on 2008-04-08. We compare sighting positions from the line-transect effort with acoustic locations from the array. In addition, we summarize ambient noise level metrics throughout the hydrophone array as long-term spectral averages, third-octave band summaries, and estimated sound exposure levels. Each observation method has advantages and disadvantages, but together they provide us with more information about the distribution of right whales over space and time. The effort here provides an important proof of concept of assembling multiple observation types to jointly model disparate data to improve our understanding of the spatiotemporal dynamics of NARW.

Right whale acoustic surveys

Results from near real-time passive acoustic monitoring of right whales using DMON-LFDCS platforms in 2021

Last updated: 08 October, 2021



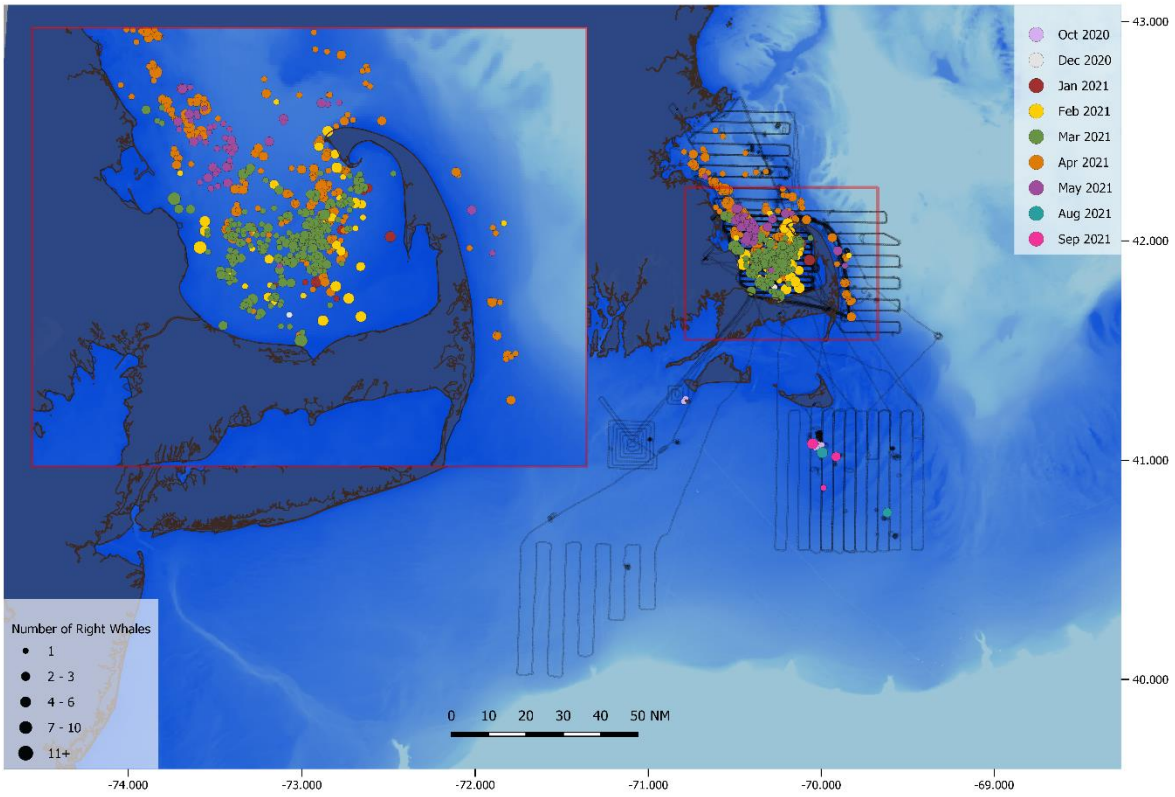
Data were collected by Dalhousie University, the University of New Brunswick, Rutgers University (RU) and the Woods Hole Oceanographic Institution (WHOI). Canadian deployments were conducted in collaboration with the Coastal Environmental Observation an Technology Research (CEOTR) group and Teledyne Webb Research (TWR) with support from the Ocean Tracking Network (OTN), Canada Network of Centres of Excellence (NCE) Marine Environmental Observation Prediction and Response Network (MEOPAR), Canada Natural Sciences and Engineering Research Council (NSERC), Transport Canada, and Fisheries and Oceans Canada. U.S. deployments were conducted in collaboration with the NOAA Northeast Fisheries Science Center (NEFSC), Stellwagen Bank National Marine Sanctuary, Wildlife Conservation Society, and Naval Facilities Engineering Command (NAVFAC) Atlantic with support from NOAA NEFSC, NAVFAC Atlantic, Northeastern Regional Association of Coastal Ocean Observing Systems (NERACOOS), Bureau of Ocean Energy Management (BOEM), Equinor and Orsted. Further information is available at robots4whales.whoi.edu and whalemap.org.

Platform	Name	Region	Start	End	Days	Distance (km)	Detections (days)	Operator
glider	cabot	Gulf of St Lawrence	06-Jul	29-Aug	55	1172	11	CEOTR
glider	scotia	Gulf of St Lawrence	19-Jul	Ongoing	81	1408	0	CEOTR
glider	cabot	Gulf of St Lawrence	10-Sep	Ongoing	28	720	0	CEOTR
glider	we03	Gulf of Maine	03-Apr	17-May	45	1201	3	WHOI
glider	we14	Gulf of Maine	22-Dec	14-Mar	83	1800	7	WHOI
glider	we16	Gulf of Maine	17-Mar	01-Jul	105	1861	18	WHOI
buoy	mamv	New England Shelf	31-Jul	29-Jul	265	NA	27	WHOI
glider	we16	New England Shelf	15-Nov	26-Feb	103	1226	18	WHOI
glider	we15	New England Shelf	25-Mar	01-Jul	99	1194	0	WHOI
buoy	mamv	New England Shelf	29-Jul	Ongoing	72	NA	0	WHOI
glider	we15	New England Shelf	25-Sep	Ongoing	14	289	0	WHOI
buoy	nybnw	New York Bight	31-Jan	25-May	480	NA	8	WHOI
buoy	nybnw	New York Bight	25-May	Ongoing	131	NA	0	WHOI
buoy	nybse	New York Bight	25-May	Ongoing	137	NA	0	WHOI
buoy	njatl	New Jersey Shelf	30-Jul	27-Jul	258	NA	14	WHOI
glider	ru34	New Jersey Shelf	08-Feb	08-Mar	29	390	7	RU
buoy	njatl	New Jersey Shelf	27-Jul	Ongoing	74	NA	0	WHOI
buoy	ncch	Mid-Atlantic Bight	03-Dec	28-May	137	NA	9	WHOI
buoy	mdoc	Mid-Atlantic Bight	27-May	Ongoing	56	NA	1	WHOI

19 deployments, 2252 days, 11261 kilometers, and 123 days with detections

Aerial right whale surveys in Cape Cod Bay and adjacent waters by the Center for Coastal Studies Right Whale Ecology Program

October 2020 to September 2021



Month	No. of aerial surveys	Trackline miles (nm)	No. right whales identified	No. of new individuals for season
October	3	n/a*	6	6
November	0	0	0	0
December	1	306	0	0
January	1	279	29	29
February	5	1174	73	64
March	8	1500	140	77
April	9	2500	174	47
May	4	1320	53	12
June	0	0	0	0
July	1	278	0	0
August	3	1070	8	2
September	1	300	8	3
	36	**8727**	**491**	**240**

**directed flights to resight EGNOs 4680 and 3920, respectively*

- CCS conducted aerial surveys aboard Cessna 337 & O-2 Skymaster from 19 October 2020 to 11 September 2021
- Observed right whales on 30 of 36 aerial survey days
- Habitat team collected 549 zooplankton samples on 20 research cruises in Cape Cod Bay
- Across all platforms CCS documented at least 244 individual right whales, including:

Age Class	**Female**	**Male**	**Unknown Sex**
Adult	72	113	6
Juvenile	14	16	10
Calf	0	0	13

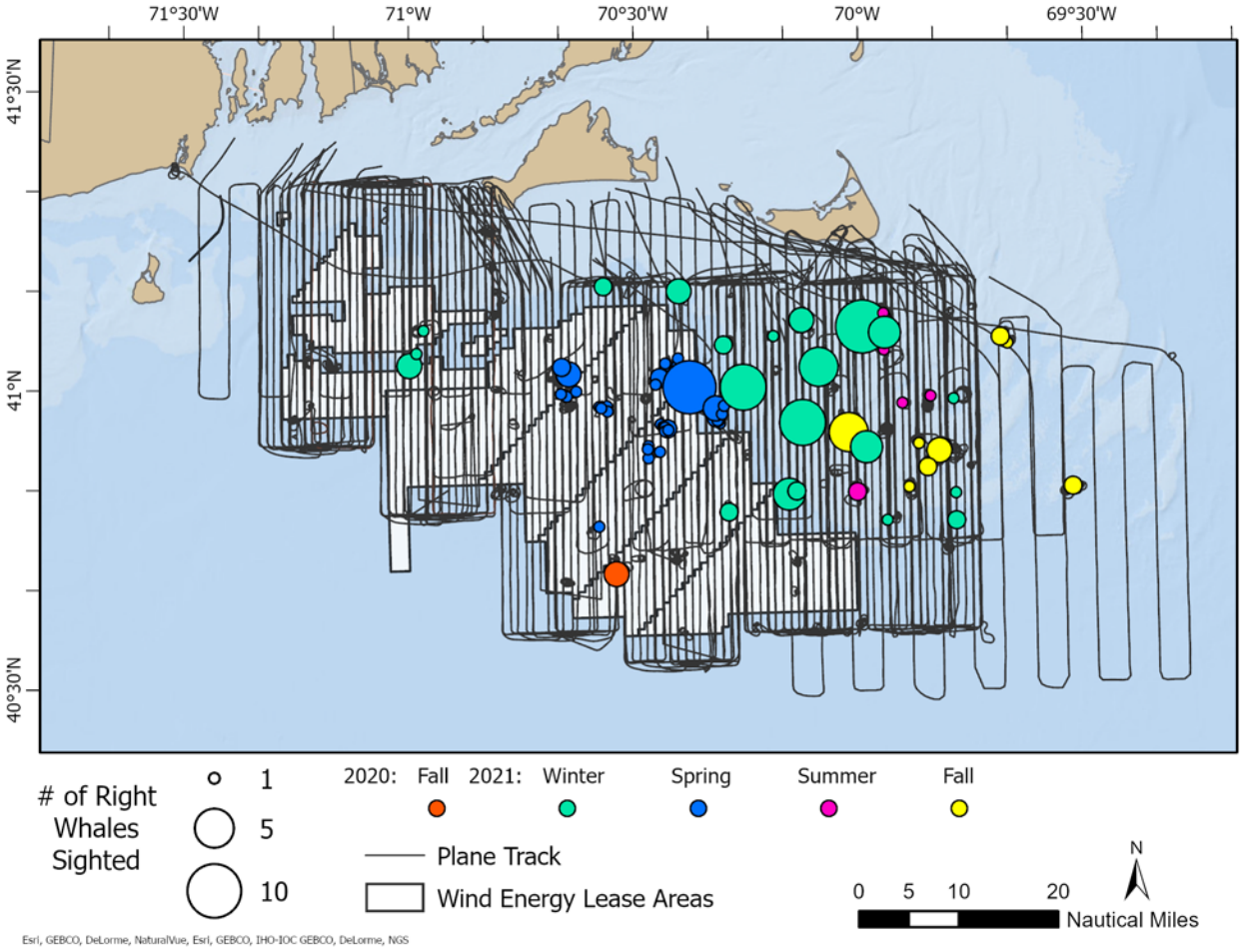
RWEP team: Stormy Mayo, Christy Hudak, Sharon Hsu, Amy James, Brigid McKenna, Natasha Telschow, Qiyah Williams

Research conducted under NMFS Permit #19315-01

New England Aquarium
Protecting the blue planet

Anderson Cabot Center for Ocean Life
at the New England Aquarium

Aerial surveys of the MA/RI Wind Energy Areas: 2020-2021 Field Season
EcoMap Group - Anderson Cabot Center for Ocean Life at the New England Aquarium

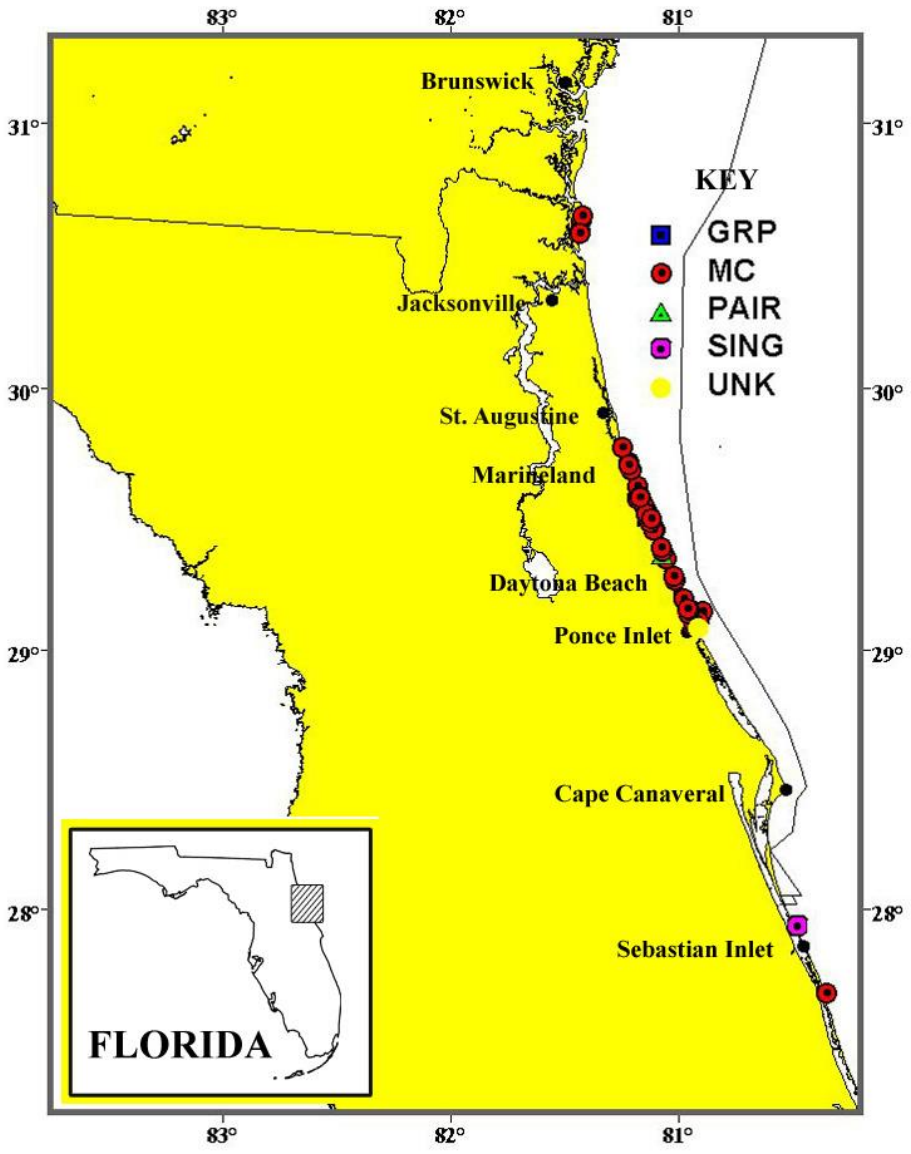


Month	# survey days	Survey mileage (nm)	# right whale sightings	# right whales	# unique whales
Fall (2020)	2	656	1	3	3
Winter	9	4,564	20	63	52
Spring	8	3,643	40	54	41
Summer	6	3,148	9	13	9
Fall (2021)	3	1,607	12	21	15
Total	28	13,618	82	154	104

Survey team: Orla O'Brien, Katherine McKenna, and Laura Ganley

Funding by: Wind energy developers via Massachusetts Clean Energy Center

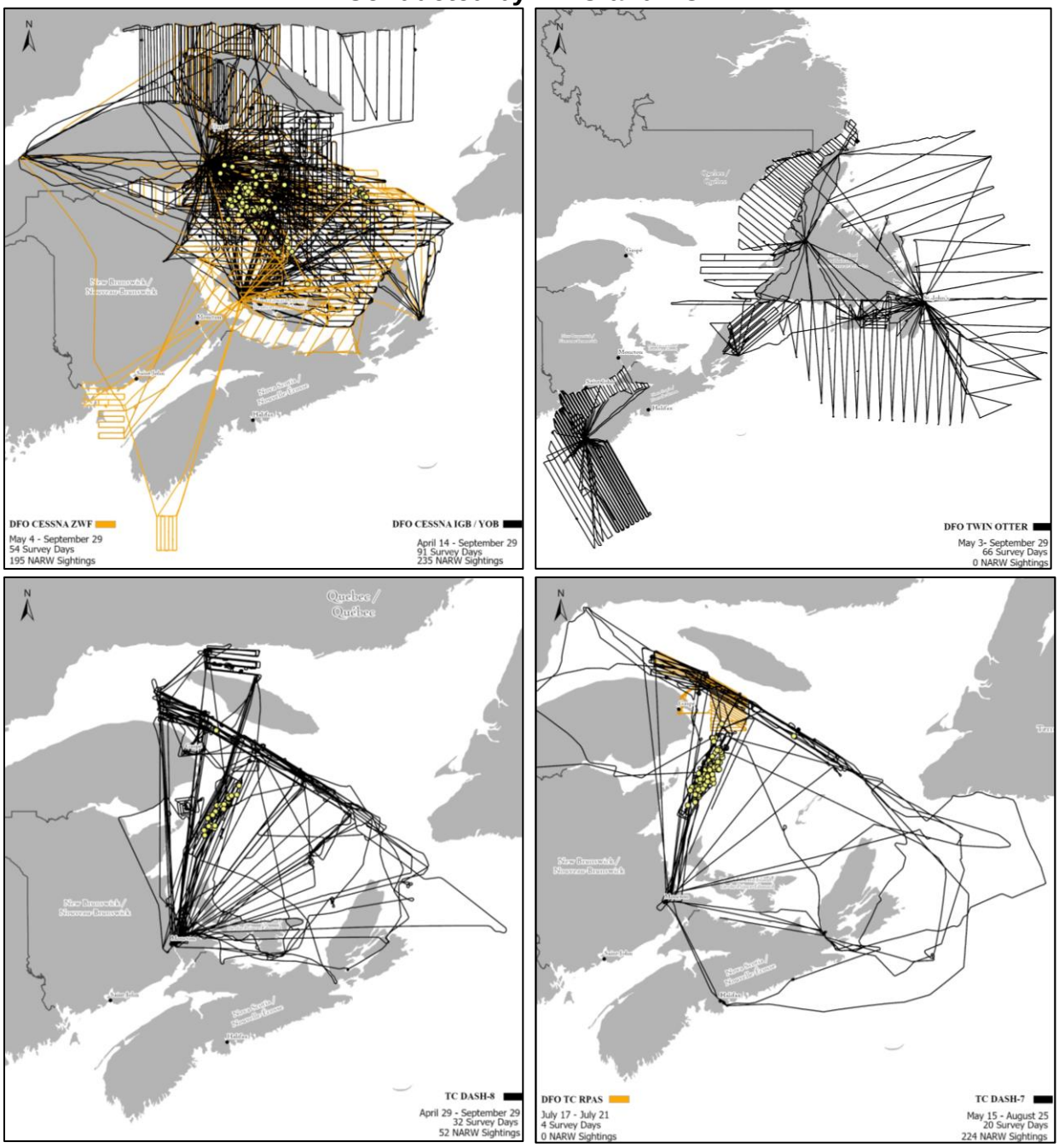
Surveys conducted under NMFS research permit 19674.



Verified right whale sightings by the Volunteer Sighting Network (VSN) during the 2020–21 southeastern U.S. (SEUS) season. Sightings resulted from a collaborative effort between the Marineland Right Whale Project and the Marine Resources Council, and included assistance from the Florida Fish and Wildlife team. The total n = 50. Most sightings were mother-calf pairs. The use of shore-launched drones considerably enhanced the efficacy of the shore-based sighting network. The black line off the coast is the boundary of the right whale critical habitat.

2021 Marine mammal aerial surveys in eastern Canadian waters

Conducted by: DFO and TC



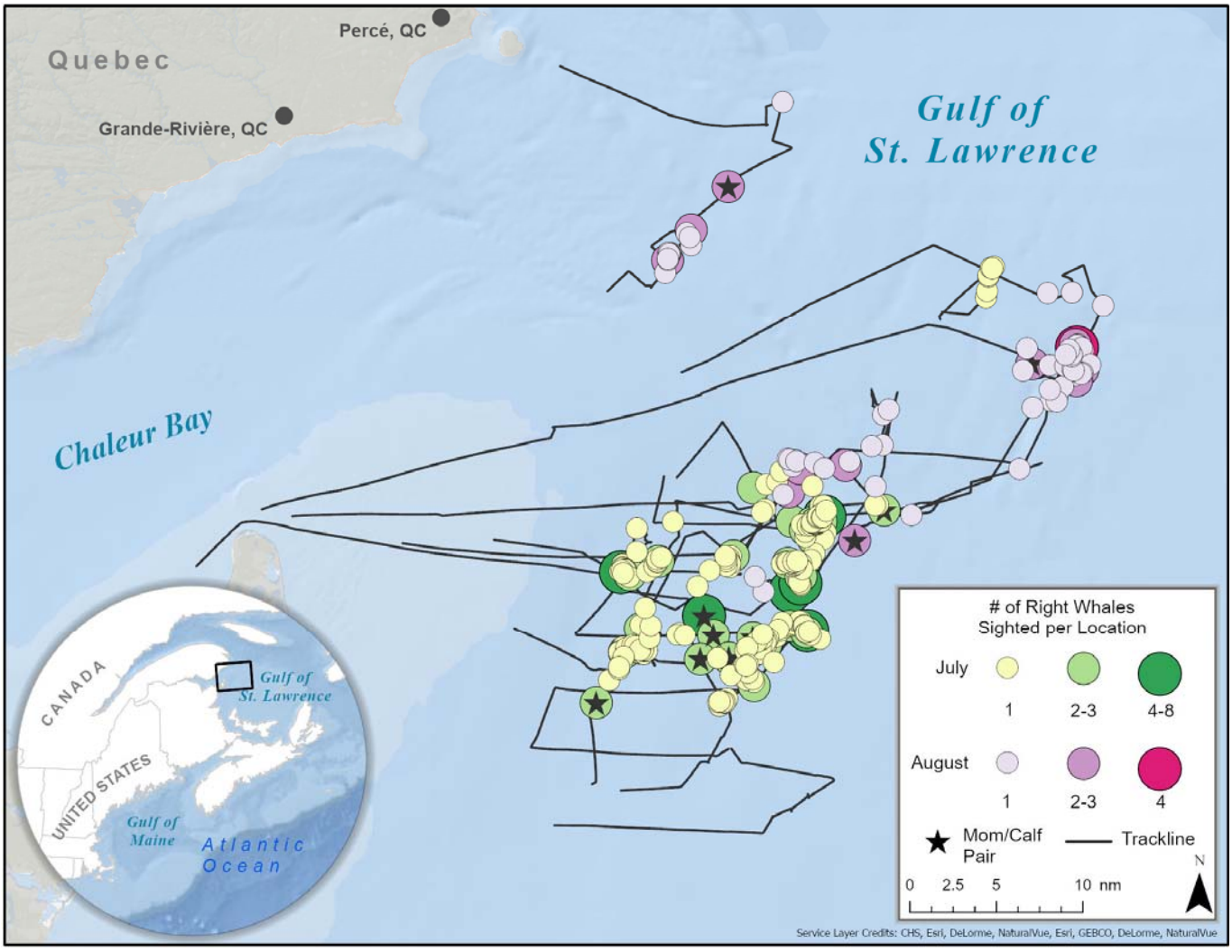
- Survey data collected up to and including Sept 30.
- All surveys except DFO-Twin Otter (Oct 1) and TC-RPAS (Jul 21) extend beyond September 30
- Fisheries surveillance flights conducted by DFO- Conservation and Protection not included and efforts extends beyond September 30.
- Sightings in map (yellow circles) represent either single or multiple individuals.
- Imagery continues to be collected and submitted to the Right Whale Consortium. Photo-identification have not been completed.

*Fisheries and Oceans Canada (DFO) Science Program- Twin Otter, Cessna 1 (ZWF) and Cessna 2 (YOB **or** IGB)*
TC National Aerial Surveillance Program- Atlantic (Dash-8) and Central (Dash-7)
TC Aircraft Services Directorate - Remotely Piloted Aircraft System (RPAS) *Project*

Anderson Cabot Center for Ocean Life at the New England Aquarium | CANADIAN WHALE INSTITUTE | DALHOUSIE UNIVERSITY | UNB EST. 1785 UNIVERSITY OF NEW BRUNSWICK

Vessel-based right whale surveys in the Gulf of St. Lawrence

Anderson Cabot Center for Ocean Life at the New England Aquarium, Canadian Whale Institute, Dalhousie University, and the University of New Brunswick



	Cruise 1	Cruise 2	Total
Cruise Dates	08 July – 20 July	04 August – 16 August	
No. of survey days	8	9	**17**
Track line Miles (NM)	245	455	**700**
No. of photo-documented sightings	301	90	**391**
No. of Unique Individuals	98	44	**108**
No. of Mom/calf pairs	6	4	**7**

Survey Team:

New England Aquarium: Kelsey Howe, Amy Warren
Canadian Whale Institute: Moira Brown, Delphine Durette-Morin
Dalhousie University: James Vlasic
University of New Brunswick: Kim Davies, Natasha Hynes, Galina Klymentieva, Gina Lonati

Funding by: Canada Space Agency, Canadian Foundation for Innovation, Fisheries and Oceans Canada, Habitat Stewardship Program for Aquatic Species at Risk, Irving Oil, Island Foundation, Marine Environmental Observation Prediction and Response Network of Centres of Excellence, and NSERC.

Research conducted under section 73 SARA permit issued by Department of Fisheries and Oceans to the NEAq (permit no. DFO-MAR-GLF-QUE-2021-11 and DFO-MAR-GLF-QUE-2021-11a) and UNB (permit no. DFO-GLF-QUE-MAR-2021-04). Map by Brooke Hodge.

2021 NARWC Annual Meeting Participants

Last Name	First Name	Affiliation
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Andrews	Russel	Marine Ecology & Telemetry Research
Asaro	Michael	NEFSC
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Borggaard	Diane	NOAA/GARFO/PRD
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Burton	Steve	FAU Harbor Branch
Burton (Giffin)	Melanie	PEI Fishermen's Association
Cabana	Nicole	NOAA Northeast Fisheries Science Center
Cameron	Sarah	Oceana Canada
Cammen	Kristina	University of Maine
Campion	Kevin	Save the North Pacific Right Whale
Capauno	Benjamin	College of the Atlantic
Capotosto	David	Ropeless Systems, Inc.
Carduner	Jordan	Equinor

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Cho	Michelle	New England Aquarium
Cholewiak	Danielle	NEFSC
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Clark	Christopher	Cornell University
Clark	Olivia	College of the Atlantic
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Cole	Tim	NEFSC
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Coolen	Lesley	Conservation and Protection
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Côté	Jean	RPPSG
Cramer	Deborah	none
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Crossman	Carla	Saint Mary's University
Crowe	Leah	Integrated Statistics/NEFSC
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Daves	Nancy K	Tybee Island Marine Science Center
Davis	Genevieve	NEFSC
Dean	Nicholas	Spindrift Images
DeAngelis	Monica	Naval Undersea Warfare Center
Deneault-Tremblay	Laurence	Pêches et Océans Canada
Deuel	Katharine	The Pew Charitable Trusts
Dickson	Jessica	Fisheries and Oceans Canada
DiMonti	Anne	Audubon Society of Rhode Island
Dion	Danielle	Quoddy Link Marine
Dobbin-Vincent	Connie	Fisheries and Oceans Canada
Downing	Nicole	The Blue Ocean Society for Marine Conser
Driscoll	Cindy	MD DNR
Driscoll	Sonya	Fisheries and Oceans Canada
Dufour	Mylene	Department of Fisheries and Oceans
Dufresne	Christiane	Arctus
Duley	Peter	NEFSC
Dupuis	Pierre	Homarus Inc
Durazo	Rosa	Center for Coastal Studies

2021 NARWC Annual Meeting Participants

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Elliott	Isabelle	Fisheries and Oceans
Ellis	Sara	Associated Scientists at Woods Hole
Elmslie	Kim	Oceana Canada
Engelhaupt	Dan	HDR
Engleby	Laura	SERO, National Marine Fisheries Service
Esch	Carter	NMFS
Evers	Clair	Fisheries and Oceans Canada (DFO)
Fabbri	Sholeh	HitPlay Productions
Fagan	Connor	Oceana
Fasick	Jeffry	The University of Tampa
Fauquier	Deborah	National Marine Fisheries Service
Ferron	Stephane	Équipe de désempêtrement du Golfe
Fink	Sheryl	IFAW
Fleming	Roger	Blue Planet Strategies
Flood	Peter	Green Seal Environmental
Foley	Heather	NOAA NMFS NEFSC
FRANCO	CRYSTAL	NOAA NMFS
Franklin	Kimberly	Dalhousie University
Frasier	Brenna	Saint Mary's University
Frasier	Tim	Saint Mary's University
Frith	Rhyl	Canadian Wildlife Federation
Fuller	Erica	Conservation Law Foundation
Gahm	Meghan	NOAA Affiliate
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Gallardo	Samantha	Whale and Dolphin Conservation
Ganley	Laura	Anderson Cabot Center for Ocean Life at the New England Aquarium
Garron	Mendy	NOAA/GARFO/PRD
Gatzke	Jennifer	NOAA NMFS WCR
Gehrmann	Romina	Dalhousie University
Genoways	Jack	College of the Atlantic
George	Clay	GADNR
Gerrior	Pat	NOAA Fisheries Retired
Gilchrist	Brett	Fisheries and Oceans Canada
Gillett	Roxanne	Fisheries and Oceans Canada
Gingras	Mireille	Pêches et Océans Canada
Giugni	Laurent	Canadian Space Agency
Glass-Hill	Hermina	Susie King Taylor Women's Inst/Ecology C
Goebel	Jen	NOAA/GARFO/PRD
Gomez	Andrea	DOC/NOAA
Good	Caroline	National Marine Fisheries Service
Graham	Katie	Anderson Cabot Center for Ocean Life at the New England Aquarium
Gray	Laura	NOAA NMFS
Greene	Charles	Ocean Visions
Grewal	Corie	NMFS
Guenther	Carla	Maine Center for Coastal Fisheries
Guerra	Olivia	International Fund for Animal Welfare
Haché	Robert	Acadian Crabbers' Associatioon
Hain	Jim	Associated Scientists at Woods Hole
Hall	Lanni	National Marine Fisheries Service
Halpin	Patricia	UNH at Manchester

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Hart	Randle	Saint Mary's University
Harvey	Valérie	Fisheries and Oceans Canada
Hastings	Nina	Whale and Dolphin Conservation
Hawk	Marin	Marine Stewardship Council
Hayden	Kelsey	Fisheries and Oceans Canada, Maritimes
Hayes	Sean	NEFSC
Heinemann	Dennis	Marine Mammal Commission
Henninger	Heidi	Atlantic Offshore Lobstermen's Assn
Henry	Allison	NEFSC
Higgins	Jean	NOAA/GARFO/PRD
Hodge	Brooke	Anderson Cabot Center for Ocean Life at the New England Aquarium
Hoppe	Jane	International Fund for Animal Welfare
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Howe	Merra	Marine Mammal Commission
Howes	Laura	UMASS Boston/Boston Harbor City Cruises
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Hudak	Christy	Center for Coastal Studies
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Hunter	Nicole	IFAW
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Isnor	Holly	Ecology Action Centre
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Jackson	Joanne	HitPlay Productions
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Jakush	Jen	Florida Fish & Wildlife (FWC)
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Jeans	Meghan	Broad Reach Fund
Jewett	Libby	DOC/NOAA/NMFS/NEFSC
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Johnson	Chris	WWF
Johnson	Hansen	Dalhousie University
Jones	Lindsey	Allied Whale, College of the Atlantic
Jubinville	Isabelle	Oceana Canada
Kadwa	Farheen	WWF-Canada
Kean	Jackie	Fisheries and Oceans Canada
Keane	Ellen	NOAA/GARFO/PRD
Keats	Adam	Law Office of Adam Keats
Kelley	Kevin	Maine Lobstermen's Association
Kelliher	Peter	NOAA/GARFO/PRD
Kelly	Emily	Center for Coastal Studies
Kennedy	Jennifer	Blue Ocean Society for Marine Conservati
Kenney	Adam	
Kenney	Bob	URI Graduate School of Oceanography
Kershaw	Francine	Natural Resources Defense Council
Khan	Christin	NEFSC

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Last Name	First Name	Affiliation
Khan	Sulmaan	N/A
Kiewiet de Jonge	Sil	College of the Atlantic
Kilchenmann	Joelle	University of Maine
Kilgour	Taylor	Saint Mary's University
Kim	Chongkyung	Swarthmore College
King	Paul	SMRU Consulting LLC
King Johnston	Angi	Bar Harbor Whale Watch
Kirby	Mike	Canadian Space Agency
Kirkpatrick	Cara	Genome Atlantic
Kiseliova	Olga	Fisheries and Oceans Canada
Klyver	Zack	Blue Planet Strategies
Knorr	Victoria	WA Department of Fish and Wildlife
Knowlton	Amy	Anderson Cabot Center for Ocean Life at the New England Aquarium
Kochanowicz	Zuzanna	Transport Canada
Kolkmeyer	Trip	GADNR
Koopman	Heather	Grand Manan Research Station/UNCW
Kraus	Scott	
Kreuser	Abigail	University of South Carolina
Kropornicka	Anna	New England Aquarium
Labbe	Adele	DFO
LaBrecque	Erin	Marine Mammal Commission
LaCroix	Marianne	Maine Lobster Marketing Collaborative
Lacroix-Lepage	Claudie	Department of Fisheries and Oceans
Lafrance	Patrick	WSP Canada
Landry	Melissa	Fisheries and Oceans Canada
Landry	Samuel	Fisheries and Oceans Canada - C&P
Landry	Scott	Center for Coastal Studies
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Lang	Jon	RIMAP/Maritime Whale
Lang	Shelley	Fisheries and Oceans Canada
Langlois	Annie	Canadian Wildlife Federation
Lanteigne	Jean	FRAPP
Lapointe	Geneviève	Fisheries and Oceans Canada
Laurent	Jérôme	Merinov
Le Mer	Charline	Pêches et Océans Canada
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LeBlanc	Carole	Fisheries and Oceans
Leblanc	Venyse	DFO
Lecavalier	Laurence	Transport Canada
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Levine	Daniel	International Fund for Animal Welfare
Limpert	Katy	JASCO Applied Sciences
Linden	Daniel	NOAA Fisheries
Litz	Jenny	NOAA, SEFSC
Lonati	Gina	University of New Brunswick Saint John
London	Evelyn	
Long	Kristy	National Marine Fisheries Service
Lucas	Charles	BROAD REACH FUND
Lucas	Charles	BROAD REACH FUND
Ludtke	Allison	Animal Welfare Institute
Lynch	Bob	Center for Coastal Studies

2021 NARWC Annual Meeting Participants

Last Name	First Name	Affiliation
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MacDonald	Jason	
MacDougall	Jordan	
Maclellan	Cole	
Magee	Jennifer	Self
Manley	Stephen	National Marine Fisheries Service
Markovich	Karlee	SeaScapes Marine Center
Martin	Mackenzie	College of the Atlantic
Martin	Rob	NOAA
Marx	Marilyn	Anderson Cabot Center for Ocean Life at the New England Aquarium
Matus	Suzanne	New England Aquarium
Matzen	Eric	NEFSC
Mayo	Stormy	Center for Coastal Studies
McCarron	Patrice	Maine Lobstermen's Association
McClenahan	Shasta	DOC/NOAA/NMFS
McCosker	Christina	University of Maine
McKenna	Brigid	Center for Coastal Studies
McKenna	Katherine	Anderson Cabot Center for Ocean Life at the New England Aquarium
McLellan	William	UNC Wilmington
McPherson	Kate	Anderson Cabot Center for Ocean Life at the New England Aquarium
McRory	Jody	Fisheries and Oceans Canada
McWeeny	Bill	The CALVIN Project
Melone	Tom	Allco Renewable Energy Limited
Merriman	Catherine	Fisheries and Oceans Canada
Messina	Marianne	MTSU
Meyer-Gutbrod	Erin	University of South Carolina
Mihalik	Katie	Sustainable Fisheries Partnership
Millan	Ashley	Clearwater Marine Aquarium Research Inst
Miller	Carolyn	Woods Hole Oceanographic Institution
Miller	Christina	Author
Miller	Jacqueline	Royal Ontario Museum
Milliken	Henry	NEFSC
Milliken	Henry	NMFS/NEFSC
Milne	Stephanie	RPS
Mitchell	Vanessa	Maritime Aboriginal Peoples Council
Moise	Meredith	NMFS GARFO
Monsell	Kristen	Center for Biological Diversity
Montello	Maxine	New York Marine Rescue Center
Moore	Katie	United States Coast Guard
Moore	Michael	Woods Hole Oceanographic Inst.
Moors-Murphy	Hilary	Fisheries and Oceans Canada (DFO)
MORGAN	ALEXIA	Sustainable Fisheries Partnership
Morin	Dave	NOAA/GARFO/PRD
Morissette	Lyne	M - Expertise Marine
Morris	Lorraine	Maine Department of Marine Resources
Morse	Laura	Orsted US Offshore Wind
Mueller Thomson	Claudia	SMELTS
Murnane	Erin	Naval Research Lab
Murphy	Tammy	NEFSC
Murray	Anita	Wildlife Conservation Society
Myers	Hannah	University of Alaska Fairbanks
Napier	Brent	Conservation and Protection

2021 NARWC Annual Meeting Participants

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Niemeyer	Misty	IFAW
Noel	Martin	APPCA
Noel	Mathieu	The Maritime Fishermen's Union
Nolet	Veronique	Transport Canada
Noriega	Rudy	BBC Radio 5 Live
O'Brien	Orla	Anderson Cabot Center for Ocean Life at the New England Aquarium
OConnell	Kate	Animal Welfare Institute
ODonnell	Brady	Marine Mammal Commission
O'Hanley	Nicholas	Department of Fisheries and Oceans
Ohnemus	Kimberly	University of Rhode Island/RI Sea Grant
Onens	Phinn	National Marine Fisheries Service
Orphanides	Christin	NEFSC
Orton	Richard	Saint Mary's University
Ouellet	Pier-Luc	Fisheries and Oceans Canada
Pace	Richard	NEFSC
Palmer	Danielle	NOAA/GARFO/PRD
Palmer	Kaitlin	SMRU Consulting, North America
Parks	Susan	Syracuse University
Patterson	Eric	National Marine Fisheries Service
Peck	Nicole	EA Engineering
Pelisson	Suzanne	Woods Hole Oceanographic Institution
Pellerin	Mathieu	Pêches et Océans Canada
Pepe	Monica	Whale and Dolphin Conservation
Pequeneza	Nadine	HitPlay Productions
Perry	Andrea	Broad Reach Fund
Pettis	Heather	Anderson Cabot Center for Ocean Life at the New England Aquarium
Pigeon-Dubeau	Catherine	Marine Stewardship Counci
Pirie-Hay	Donald	Fisheries and Oceans Canada
Pisano	Olivia	Dalhousie University
Pitchford	Tom	Florida Fish & Wildlife (FWC)
Powell	Jessica	SERO, National Marine Fisheries Service
Procopio	Maria	Tybee Island Marine Science Center
Psutka	Corry	Whale and Dolphin Conservation
Pyc	Cynthia	Vineyard Wind
Quintana	Ester	Simmons University
Rae	Jaime	Dalhousie University/Canadian Wildlife Federation
Ramage	Patrick	International Fund for Animal Welfare
Rankin	Andy	
Ratelle	Stephanie	Department of Fisheries and Oceans
Redfern	Jessica	Anderson Cabot Center for Ocean Life at the New England Aquarium
Reeb	Desray	Bureau of Ocean Energy Management
Reed	Joshua	Macquarie University
Reeve	Molly	JASCO Applied Sciences
Reiser	Craig	Smultea Environmental Sciences
Rexing	Soph	College of the Atlantic
Rickard	Meghan	New York State DEC
Roberts	Jason	Duke University
Robertson	Matt	Vineyard Wind
Robichaud	Paul	APPCA
Robinson	Elizabeth	Save the North Pacific Right Whale

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Last Name	First Name	Affiliation
Rolland	Roz	
Rose	Kathryn	IFAW
Rosenbaum	Howard	Wildlife Conservation Society
Rosner	Allison	NOAA/GARFO/PRD
Ross	Camille	Bigelow Laboratory for Ocean Sciences
Rossiter	William	NY4WHALES
Rowles	Teri	National Marine Fisheries Service
Salinger	Audrey	Saint Mary's University
salvo	flora	MERINOV
Sampino	Francesca	International Fund for Animal Welfare
Sanders	Emma	Saint Mary's University
Sanders	Michelle	Transport Canada
Sandilands	Doug	Center for Coastal Studies
Saulnier	Hubert	
Sauvé	Caroline	Fisheries and Oceans Canada
Schick	Rob	Duke University
Schuler	Alicia	NOAA/GARFO/PRD
Schulte	Dianna	Blue Ocean Society
Sefah-Twerefour	Amadi Afua	University of South Carolina
Seton	Rosemary	Allied Whale, College of the Atlantic
Shanahan	Emma	University of Rhode Island
Sharp	Brian	International Fund for Animal Welfare
Sharp	Rhod	BBC Sounds
Sharp	Sarah	International Fund for Animal Welfare
Shervanick	Kara	NOAA NMFS SERO/ERT
Siemann	Liese	Coonamessett Farm Foundation, Inc.
Silva	Michelle	Center for Coastal Studies
Silva	Tammy	NOAA SBNMS
Singer	Julia	Oceana
Sisson	Nick	NOAA/NMFS
Smith	Ainsley	NOAA/GARFO/PRD
Smith	Dan	WHOI/NOAA (contractor)
Smith	Jamison	Blue World Research Institute Inc
Sonnenberg	Melanie	Grand Manan Fishermen's Association
Sorochan	Kevin	Fisheries & Oceans Canada
Sowder	Brenna	Maine Coalition for NARW
Spradlin	Trevor	National Marine Fisheries Service
Srinivasan	Mridula	NOAA Fisheries
Staples	Kevin	Maine Department of Marine Resources
Stein	Peter	Scientific Solutions, Inc.
Stewart	Susan	Jacksonville Port Authority
Stokes	Ashley	Seacoast Science Center
Stoni	Taylor	MA Division of Marine Fisheries
Summers	Erin	Maine Department of Marine Resources
Tackaberry	Jenn	Center for Coastal Studies
Tausen	Bailey	College of the Atlantic
Taylor	Jaclyn	National Marine Fisheries Service
Taylor	Julianne	Bar Harbor Whale Watch
Teunissen	Sebastian	Canadian Whale Institute
Theriault	Kim	Fisheries and Oceans Canada
Theriault	Yvon	Corbo Engineering
Thibault	Guy	Pêches et Océans Canada

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Last Name	First Name	Affiliation
Thomas	Peter	Marine Mammal Commission
Thomas	Richard	Tracta Engineering Inc.
Thompson	Elizabeth	Department of Fisheries and Oceans
Thompson	Matthew	Anderson Cabot Center for Ocean Life
Thurston	Sayara	Oceana Canada
Tilas	Kim	MET
Todd	Sean	College of the Atlantic
Trego	Marisa	NOAA/GARFO/PRD
Trippel	Ed	Fisheries and Oceans Canada
Tritt	Max	NOAA/GARFO/PRD
Tucker	Molly	College of the Atlantic
Tyack	Peter	University of St Andrews
Van Bemmel	Alexis	Fisheries and Oceans Canada
van Berkel	Joshua Jon	DHI Water & Environment, Inc.
Vanderlaan	Angelia	Fisheries and Oceans Canada
Vinodh	Shreya	College of the Atlantic
Volgenau	Lisa	Volgenau Foundation
Volker	Kristy	IFAW
Wainwright	Hillary	Fisheries and Oceans Canada
Walde	Kirsty	Conservation and Protection
Walker	Mark	Florida FWC
Wang	Steve	Swarthmore College
Ward	Leslie	FWC
Warren	Amy	Anderson Cabot Center for Ocean Life at the New England Aquarium
Watwood	Stephanie	Naval Undersea Warfare Center
Webber	Whitney	Oceana
Weinrich	Mason	CCS
Welsh	Haley	Transport Canada
Whaling	Melissa	Southern Environmental Law Center
White	Melanie	Clearwater Marine Aquarium Research Inst
Wilding	Sam	Monterey Bay Aquarium
Wiley	Dave	NOAA/Stellwagen Bank NMS
Wilkin	Sarah	National Marine Fisheries Service
Willett	Ian	Department of Fisheries and Oceans
Wilson	Brittany	Whale and Dolphin Conservation
Wimmer	Tonya	Marine Animal Response Society
Wood	Lindsay	Canadian Wildlife Federation
Wright	Andrew	Fisheries and Oceans Canada - Maritimes
Wright	Debbie	Volusia Co. Marine Mammal Standing Team
Yack	Tina	Duke University, MEGEL
Yetman	Dana	Fisheries and Oceans
Yoder	Tate	Maine Center for Coastal Fisheries
Young	Sharon	Pegasus Foundation
Yurasits	Brian	Seacoast Science Center
Zani	Monica	Anderson Cabot Center for Ocean Life at the New England Aquarium
Zeddies	David	JASCO Applied Sciences
Zitterbart	Daniel	Woods Hole Oceanographic Institution
Zoodsma	Barb	SERO, National Marine Fisheries Service
Zou	Chao	NOAA Fisheries/GARFO PRD
Zoutis	Thomas	SMCC Marine Science Program