

North Atlantic Right Whale Consortium 2023 Annual Report Card

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SUMMARY

Started in 1986 as a collaborative data sharing group, the North Atlantic Right Whale Consortium (NARWC) has grown to include more than 200 individuals from various research and conservation organizations, shipping and fishing industries, technical experts, U.S. and Canadian government agencies, and state and provincial authorities, all of whom are dedicated to the conservation and recovery of the North Atlantic right whale. North Atlantic Right Whale Consortium members agreed in 2004 that an annual “report card” on the status of right whales would be useful. This report card includes updates on the status of the cataloged population, mortalities and injury events, and a summary of management and research efforts that have occurred over the previous 12 months.

The population estimate for 2022 using data as of October 8, 2023 is 356 (+7/-10). Additionally, the estimate for 2021 was recalculated with updated data, resulting in a 2021 estimate of 364 (+5/-4). Eleven mother calf pairs were sighted in 2023, down from 15 in 2022. Additionally, there was one lone calf observed that was later sighted dead. There were two first time mothers in 2023. Initial analyses detected at least 27 new entanglement events in 2023: six events for five whales seen with attached gear and 21 with new scarring from entanglements. That number will increase when all the data are processed and the full scar analysis completed. Additionally, there were two non fatal and one fatal vessel strikes detected. An additional mortality was detected for a calf with cause of death determined to be maternal separation. Data analyses to date (2022-2023 data are still being received and processed) indicate that surveys and opportunistic sightings in 2023 captured approximately 90% of the living population. Management measures to mitigate vessel strikes and entanglements were implemented in both the U.S. and Canada.. Lastly, a subset of publications and reports of interest is provided.

NORTH ATLANTIC RIGHT WHALE CONSORTIUM BACKGROUND

The North Atlantic right whale (*Eubalaena glacialis*) remains one of the most endangered large whales in the world. Over the past two decades, there has been increasing interest in addressing the problems hindering the recovery of North Atlantic right whales by using innovative research techniques, new technologies, analyses of existing databases, and enhanced conservation and education strategies. This increased interest demanded better coordination and collaboration among all stakeholders to ensure that there was improved access to data, research efforts were not duplicative, and that findings were shared with all interested parties. The North Atlantic Right Whale Consortium, initially formed in 1986 by five research institutions to share data among themselves, was expanded in 1997 to address these greater needs. Currently, the Consortium membership is comprised of representatives from more than 200 entities including: research, academic, and conservation organizations; shipping and fishing industries; whale watching companies; technical experts; United States (U.S.) and Canadian Government agencies; and state authorities.

The Consortium membership is committed to long-term research and management efforts, and to coordinating and integrating the wide variety of databases and research efforts related to right whales to provide the relevant management, academic, and conservation groups with the best scientific advice and recommendations on right whale conservation. The Consortium is also committed to sharing new and updated methods with its membership, providing up-to-date information on right whale biology and conservation to the public, and maintaining effective communication with U.S. and Canadian Government agencies, state authorities, the U.S. Southeast and Northeast Right Whale Implementation Teams, the Atlantic Large Whale Take Reduction Team, the Atlantic Scientific Review Group, industry, and members of the U.S. Congress. The Consortium membership supports the maintenance and long-term continuity of the separate research databases and serves as executor for database archives that include right whale sightings and photo-identification data contributed by private institutions, government scientists and agencies, and individuals. Lastly, the Consortium is interested in maximizing the effectiveness of management measures to protect right whales, including using management models from other fields.

The Consortium is governed by an Executive Committee and Board members who are elected by the general Consortium Membership.

North Atlantic Right Whale Consortium members agreed in 2004 that an annual “report card” on the status of right whales would be useful. This report card includes updates on the status of the cataloged population, mortalities and injury events, and a summary of management and research efforts that have occurred over the previous 12 months. The Board’s goal is to make public a summary of current research and management activities, as well as provide detailed recommendations for future activities. The Board views this report as a valuable asset in assessing the effects of research and management over time.

ESSENTIAL SPECIES MONITORING AND PRIORITIES

In the 2009 Report Card to the International Whaling Commission (IWC), the Consortium Board identified key monitoring efforts that must be continued and maintained in order to identify trends in the species, as well as assess the factors behind any changes in these trends (Pettis, 2009). The key efforts are: (1) Photographic identification and cataloging of right whales in historically and emerging high-use habitats and migratory corridors, which currently include, but are not limited to, the southeast United States, Cape Cod Bay, Gulf of St. Lawrence, Great South Channel, Gulf of Maine, mid-Atlantic, southern New England, and the Scotian Shelf, (2) Monitoring of scarring and visual health assessment from photographic (including drone) data, (3) Examination of all mortalities, and (4) Continue using photo-ID and genetic profiling to monitor species structure and how this changes over time.

The Consortium Board regards the availability of Consortium databases as essential to recovery efforts for the North Atlantic right whale species. In a review of the federal recovery program for North Atlantic right whales, the Marine Mammal Commission agreed with the Board’s sentiment, stating that “both databases play critical roles in right whale conservation” and that the Identification Catalog “is the cornerstone of right whale research and monitoring” (Reeves et al. 2007). The review went on to recommend that both databases (“both” here and above refers to the [Identification and Sightings databases](#); there are several other Consortium databases available) be fully funded on a stable basis. Additionally, the Board recognizes the importance that passive acoustic monitoring has played in our understanding of right whale distribution and its potential role in mitigating anthropogenic impacts on the species. The Board strongly supports and encourages efforts to maintain the comprehensive [Passive Acoustics Cetacean Map](#) that serves as an additional resource in conservation and management efforts. The ability to implement such measures is further facilitated by near real-time information on right whale distribution. To this end, the Board strongly supports the efforts to maintain the WhaleMap system (<https://whalemap.org/>) for collating and displaying near real-time whale survey and detection results.

Since 2010, right whale distribution and patterns of habitat use have shifted, in some cases dramatically. These shifts have been observed throughout the range of North Atlantic right whales and have direct implications on research and management activities, and on each of the key efforts identified above. As such, developing alternative survey effort strategies to respond to the distributional changes and identifying potential extralimital and new important habitats should continue to be a priority. These strategies should include efforts to not only locate, both visually and acoustically, and identify individual right whales, but also to ensure that information critical to important monitoring and management efforts (i.e. health, injury, and scarring assessments) is effectively and efficiently collected. **This will require a continued commitment to both aerial and shipboard photo documentation to ensure that information necessary to evaluate individuals and the species as a whole are captured.** The value of photo-identification in our ability to precisely estimate the living North Atlantic right whale population (and by extension documented and undocumented mortalities) and document changes in anthropogenic impacts cannot be overstated. Increasing the scope of monitoring throughout the species range is necessary and will require additional, and likely significant, resources which must include thorough photo-documentation.

The dramatic shifts in distribution observed for North Atlantic right whales over relatively short periods of time highlight the need for management efforts that protect right whales not only in habitats/areas where they are currently known to frequent, but also areas to which they may shift, be it ephemeral or more stable use. Discussions and management plans for reducing anthropogenic injuries and mortalities on right whales in both Canadian and U.S. waters are ongoing and encouraging. However, despite the relative reduction in overall mortalities in 2020-2023 and increases in births over 2020 (detailed below), the detected mortalities and serious injuries are still well above the Potential Biological Removal (PBR) of 0.7/year. Additionally, the sublethal impacts of injuries on reproduction and health are becoming clearer (Stewart et al., 2021; Knowlton et al., 2022; Moore, 2023; Pirota, et al., 2023, 2024) and yet are not adequately addressed in current management and recovery plans. In addition to the management protection shortfalls outlined in last year’s NARWC Report (Pettis et al., 2023), including the congressional pause on fisheries management action in the United States and the delay in broad scale implementation of lower breaking strength rope

in Canada, at the time of this report's publication, modifications to the U.S. Right Whale Vessel Speed Rule that were proposed in July 2022 still have not been finalized/released. Since that time, at least one right whale was killed by vessel strike. **Anthropogenic mortalities and injuries that have lasting sublethal effects remain a threat to the existence of North Atlantic right whales and immediate, broad-based mitigation strategies that result in significant risk reduction throughout the right whale's range must be a priority if this species is to survive. These should include broadened mandatory speed restrictions and the transition of fixed-gear fisheries to utilize on-demand fishing technologies.**

2023 SPECIES STATUS

The ability to monitor North Atlantic right whale vital rates and anthropogenic impacts is entirely dependent on the North Atlantic Right Whale Identification Database (Catalog), curated by the Anderson Cabot Center for Ocean Life at the New England Aquarium. As of October 8, 2023, the database consisted of over two million slides, prints, and digital images collected during the 94,952 sightings of 798 individual right whales photographed since 1935. Each year, ~2,000 to 5,000 sightings consisting of 50-250,000 images are added to the identification database.

Right Whale Species Estimate 2022

Since 1990, using Catalog data, a number of methods have been employed to estimate the number of North Atlantic right whales alive annually, including the Catalog Method, Presumed Alive Number, Minimum Number Alive, and most recently, the Pace model (Pace et al., 2017; Pace, 2021). Beginning with the 2021 report card, we only present the single, most accurate assessment method, based on the Pace model. The move to present a single estimate was based on several considerations. First, previous methods suffered from uncertainties that were difficult to quantify, and frequently led to public misunderstanding about what those numbers represented. Additionally, several of the previous population estimates, such as the Minimum Number Alive, were known to be less accurate towards the end of the time series (i.e. for the previous year or two).

The Pace model “adapted a state-space formulation with Jolly-Seber assumptions about population entry (birth and immigration) to individual resighting histories and fit it using empirical Bayes methodology.” This model estimate accounts for whales that have not been photographed and the full methodology is available in the paper and subsequent technical memorandum. The model is run annually using updated Catalog data. The population estimate for a given year is an estimate of the number of whales alive at in the start of a given year between December (Year-1) and November (Year).

The Pace model estimate for 2022 (December 2021-November 2022) is **356 whales** (95% credible interval +7/-10) using data as of October 8, 2023 (Figure 1, Table 1, Linden, 2023). Additionally, the model estimate run results in slight changes to population estimates for previous years. The estimate for 2021 changed from 340 +/-7 to 364 +5/-4, primarily due to the 18 calves born in 2021, many of which were catalogued within the last year (Table 1). While the sharp population decline observed from 2015-2020 appears to have slowed, annual mortalities continue to be above population recovery thresholds. North Atlantic right whales remain red listed as critically endangered by the International Union for Conservation of Nature (IUCN). This designation is made when a species is considered at high risk for global extinction. The North Atlantic right whale is one of only two large whale species on the list.

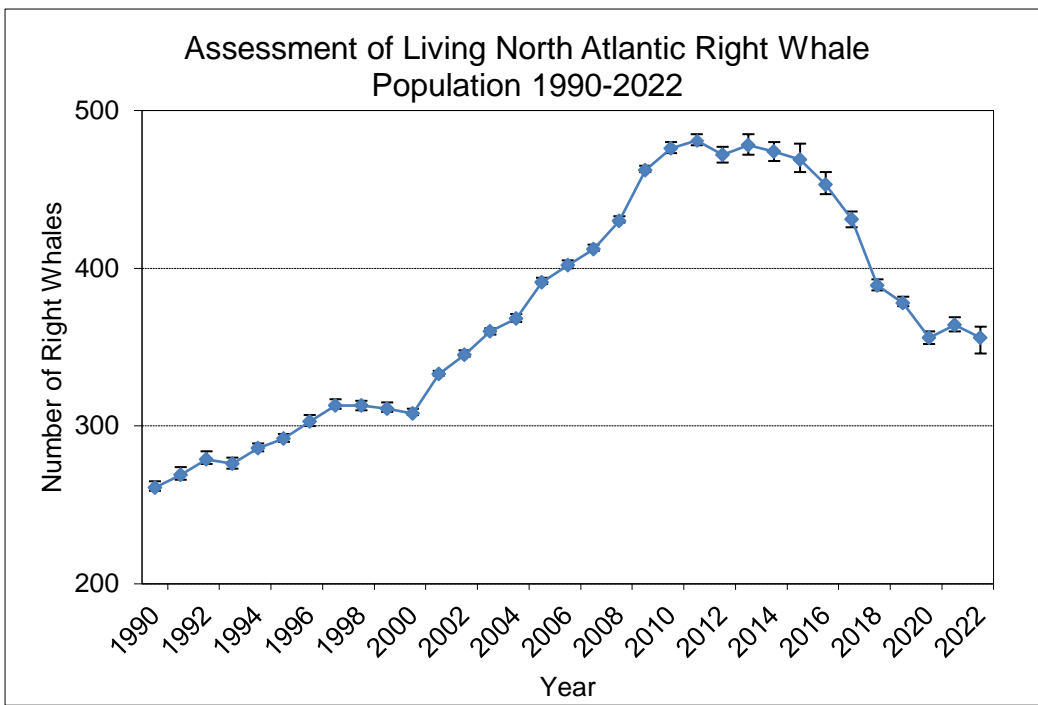


Figure 1. Assessments of the North Atlantic right whale population 1990-2022. Annual assessments are shown by a point "estimate" along with error bars which represent 95% of the posterior probability. The estimate for 2022 was 356 +7/-10. Data from the North Atlantic Right Whale Catalog as of October 8, 2023.

Table 1. Summaries of estimated North Atlantic right whale population sizes 1990-2022. Tabular data presented in figure 1. Median estimates are given for each year, with lower and upper bounds for the 95% credibility range.

| Year | Lower | Median | Upper | Year | Lower | Median | Upper |
|------|-------|--------|-------|------|-------|--------|-------|
| 1990 | 259 | 261 | 265 | 2007 | 411 | 412 | 415 |
| 1991 | 266 | 269 | 274 | 2008 | 429 | 430 | 433 |
| 1992 | 276 | 279 | 284 | 2009 | 461 | 462 | 465 |
| 1993 | 273 | 276 | 280 | 2010 | 473 | 476 | 480 |
| 1994 | 284 | 286 | 289 | 2011 | 478 | 481 | 485 |
| 1995 | 290 | 292 | 295 | 2012 | 467 | 472 | 477 |
| 1996 | 300 | 303 | 307 | 2013 | 472 | 478 | 485 |
| 1997 | 311 | 313 | 317 | 2014 | 468 | 474 | 480 |
| 1998 | 310 | 313 | 316 | 2015 | 461 | 469 | 479 |
| 1999 | 309 | 311 | 315 | 2016 | 447 | 453 | 461 |
| 2000 | 307 | 308 | 311 | 2017 | 426 | 431 | 436 |
| 2001 | 332 | 333 | 335 | 2018 | 386 | 389 | 393 |
| 2002 | 344 | 345 | 348 | 2019 | 376 | 378 | 382 |
| 2003 | 358 | 360 | 362 | 2020 | 352 | 356 | 360 |
| 2004 | 366 | 368 | 371 | 2021 | 360 | 364 | 369 |
| 2005 | 390 | 391 | 394 | 2022 | 346 | 356 | 363 |
| 2006 | 400 | 402 | 405 | | | | |

How Well Are We Monitoring?

Table 2 is an annual count of sightings, unique individuals, estimated population size, kilometers of effort that have been submitted to the sightings database at the University of Rhode Island, and percent of the estimated population that is identified each year from 2000 onward (Table 2).

Table 2. Annual counts of photo-ID sightings, unique individuals, presumed living whales, survey effort (in Beaufort conditions ≤ 4), and the percentage of the population seen. Survey effort from dedicated surveys only; opportunistic sightings do not have associated effort. Additionally, the NARWC does not currently receive effort data for surveys completed by the Department of Fisheries and Oceans Canada or Transport Canada. All reported fields are updated annually with the most available Sighting and Identification/Catalog Databases data. At the time of reporting, data for 2022 were still being received, processed, and analyzed. Data as of October 8, 2023.

| Year | Sightings | Unique IDs | Population Estimate | Survey Effort (1,000 km) | % of Estimated Population Seen* |
|------|-----------|------------|---------------------|--------------------------|---------------------------------|
| 2000 | 3315 | 246 | 308 | 125 | 80 |
| 2001 | 3983 | 286 | 333 | 127 | 86 |
| 2002 | 2725 | 315 | 345 | 248 | 91 |
| 2003 | 2406 | 315 | 360 | 178 | 88 |
| 2004 | 1841 | 299 | 368 | 280 | 81 |
| 2005 | 3408 | 364 | 391 | 350 | 93 |
| 2006 | 2806 | 348 | 402 | 313 | 87 |
| 2007 | 3771 | 384 | 412 | 266 | 93 |
| 2008 | 4164 | 408 | 430 | 253 | 95 |
| 2009 | 4698 | 429 | 462 | 246 | 93 |
| 2010 | 3236 | 432 | 476 | 270 | 91 |
| 2011 | 3479 | 444 | 481 | 233 | 92 |
| 2012 | 2127 | 384 | 472 | 269 | 81 |
| 2013 | 1904 | 296 | 478 | 214 | 62 |
| 2014 | 2404 | 379 | 474 | 200 | 80 |
| 2015 | 1842 | 270 | 469 | 183 | 58 |
| 2016 | 2225 | 328 | 453 | 155 | 72 |
| 2017 | 3126 | 380 | 431 | 179 | 88 |
| 2018 | 3833 | 363 | 389 | 191 | 93 |
| 2019 | 4944 | 361 | 378 | 221 | 96 |
| 2020 | 2336 | 314 | 356 | 171 | 88 |
| 2021 | 4205 | 347 | 364 | 296** | 95 |
| 2022 | 3502 | 321 | 356 | 324 | 90 |

*In previous Report Cards, the population estimate and resulting % presumed alive seen were based on the Catalog Method (see previous report cards for explanation). Starting with the 2020 report card, we used the Pace model results as the population estimate and as the denominator for the calculation of the % estimated population seen. The population estimates are updated annually with a model run using all available data.

**One set of aerial survey data from southeast U.S. EWS program has not yet been received

Reproduction

Eleven mother/calf pairs and **one** lone neonate were sighted in the 2023 calving season, down from 15 mother/calf pairs in 2022 (Table 3). The lone calf was first sighted on January 3, 2023, inside of the Beaufort Inlet, North Carolina. An aerial effort was launched to try to locate the calf's mother, but no other right whales were sighted in the area. On January 7, 2023, the calf's carcass surfaced under a dock at Moorehead City Port, North Carolina. A necropsy was performed and the cause of death is suspected to be maternal separation. Genetic evidence indicates that the mother of the lone calf was right whale #3194 (T. Frasier, personal communication). Right whale #3194 was not a previously known mother and was never seen with a calf in 2023. She was, however, seen on multiple occasions in the southeast U.S. during the calving season between January 27 and March 3, 2023.

Right whale births remain significantly below what is expected and the average inter-birth interval remains high (Frasier et al, 2023). Additionally, there were two first-time mothers in 2023 (including #3194), underscoring recent research findings that fewer adult, nulliparous females are becoming reproductively active (Reed et al., 2022).

Table 3. Summary of mother/calf pairs sighted and associated inter-birth interval times for North Atlantic right whales from 2009-2023. The number of available cows, defined as females who have given birth to at least one previous calf, were seen in the last 6 years, have not given birth in previous two years, or gave birth in that year, are followed by the percentage of available cows to successfully calve.

| Year | Calf Count | Available Cows/ % that calved | Average Interval (yrs) | Median Interval (yrs) | Min/Max Interval (yrs) | First time Moms |
|------|------------|----------------------------------|------------------------|-----------------------|------------------------|-----------------|
| 2009 | 39 | 59/66.1% | 4.0 | 4 | 2/6 | 8 |
| 2010 | 19 | 46/41.3% | 3.3 | 3 | 2/5 | 4 |
| 2011 | 22 | 49/44.9% | 3.7 | 3 | 2/6 | 3 |
| 2012 | 7 | 65/10.8% | 5.4 | 4 | 4/10 | 2 |
| 2013 | 20 | 84/23.8% | 4.6 | 4 | 2/8 | 7 |
| 2014 | 11 | 86/12.8% | 4.4 | 4.5 | 2/7 | 1 |
| 2015 | 17 | 82/20.7% | 5.5 | 6 | 4/7 | 4 |
| 2016 | 14* | 84/16.7% | 6.6 | 7 | 4/9 | 4 |
| 2017 | 5 | 74/6.8% | 10.2 | 8 | 7/20 | 0 |
| 2018 | 0 | 78/0.0% | - | - | - | - |
| 2019 | 7 | 89/7.9% | 7 | 7 | 3/10 | 1 |
| 2020 | 10** | 80/12.5% | 7.6 | 7 | 4/11 | 1 |
| 2021 | 18 | 72/25.0% | 9.2 | 10 | 5/11 | 6 |
| 2022 | 15 | 56/26.8% | 7.7 | 8 | 2/13 | 0 |
| 2023 | 12*** | 46/26.1% | 7.8 | 7.5 | 4/12 | 2 |

*There were 14 mothers seen with calves in the 2015/2016 season, however, due to a three-way calf switch that included the presumed loss of one calf that was never photographed, only 13 calves were photographed.

**There was one lone calf observed on December 22, 2020, off of the Canary Island El Hierro. It was not resighted. As the calf was not observed with a mother and the calf was not genetically sampled, it is not included in the table above.

***There were 11 mother/calf pairs sighted in 2023. Additionally, a lone calf was sighted alive on January 3, 2023, and subsequently dead on January 7, 2023. All 11 known mothers of the year were excluded as the potential mother of this lone calf. Genetic evidence indicates that the mother of this lone calf was #3194, and this would have been her first known calf.

Mortalities

In 2023, **two** right whale mortalities were **detected** (Table 4, Figure 2). Necropsies were conducted for both of the mortality cases and the Consortium Board reiterates that it recognizes necropsies as significant data collection events that provide valuable information on which management and conservation measures can be (and have been) based. The Board views consistent necropsy response and support (both financial and personnel) as critical to monitor both right whale recovery and the efficacy of management actions.

Table 4. Documented right whale mortalities 2023. Right whale mortalities detected in 2023 are listed with information on whale, location, and cause of death when determined.

| Whale # | Date | Location | Sex | Age | Field # | Necropsied? | Cause | Comments |
|-----------|------------|----------------|-----|------|---------------|-------------|-----------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2023 Calf | 01/07/2023 | North Carolina | M | Calf | VGT 449 Eg | Yes | Perinatal mortality | Calf was seen alive on 01/03/2023 swimming alone off of Morehead City Port, North Carolina. No other right whales were seen in the area. Later in the day on 01/03/2023 the calf was seen swimming under a pier at the Port. The calf was not resighted until 01/07/2023 when its carcass was found floating under the pier. All other known calves of the year were sighted after 01/07/2023. Genetic analysis indicates that Eg #3194 is the mother of this calf. |
| 3343 | 02/12/2023 | Virginia Beach | M | 20 | | Yes | Vessel Strike, blunt force trauma | Whale seen alive on 12/26/2022 (GA). No external evidence of trauma noted on whale prior to necropsy. Internal examination revealed catastrophic blunt force traumatic injury, which impacted a large portion of the spinal column. The injuries are consistent with a vessel strike. They included multiple spinal fractures and separations that would have resulted in death shortly after the injury. There was no obvious external evidence of the trauma. |

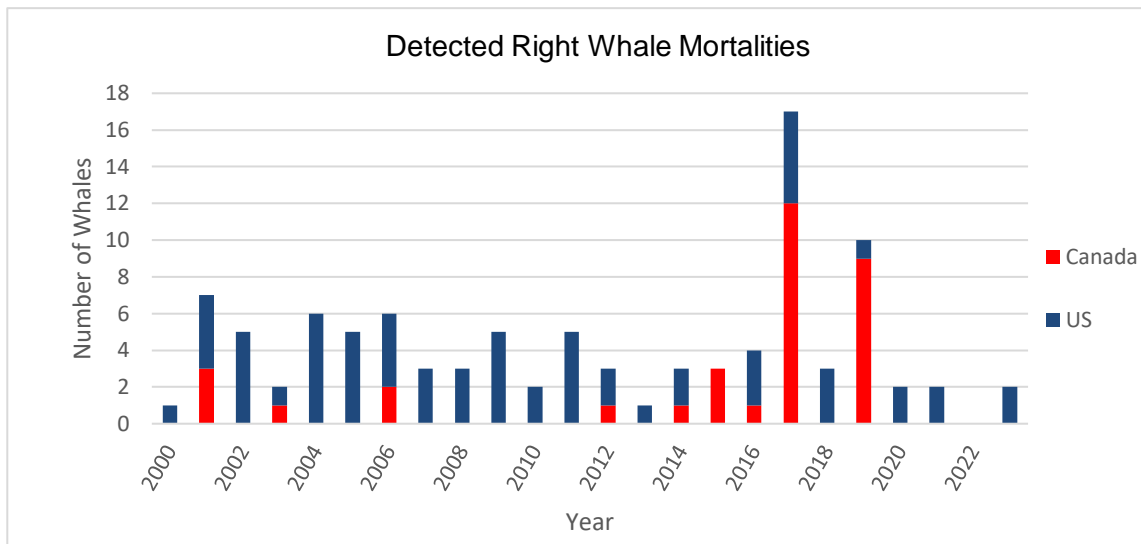


Figure 2. Number of right whale mortalities detected by year. Detections are summarized by the country in which they were made. Detected right whale mortalities represent a fraction of true mortalities (see Pace et al. 2021) and therefore, these annual values are known to be underestimates.

Vessel Strikes, Entanglements, and Entrapments

Vessel Strikes:

There was **one** vessel strike injury documented in 2023 that was not immediately lethal (Table 5). The whale, a 2022 calf, was sighted off Florida in February 2023 with two propeller cuts on its left flank, with one of the wounds filled with orange cyamids. The whale was resighted in Cape Cod Bay in April 2023, though images were aerial and the wounds could not be fully assessed. Additionally, there was a second whale with a suspected vessel strike injury; right whale #3460 seen on March 31, 2023, in Cape Cod Bay, with cuts to its right flank. The wounds were difficult to assess given available images. Follow up assessments are planned if/when the whale is resighted.

Table 5. Right whale vessel strikes 2023. Newly reported vessel strikes with whale, location, and injury information. These data include reports received to date and do not include a full assessment of all 2023 sightings as many have not yet been received and/or processed. Dead whales first sighted with vessel strikes are not included here.

| Whale #/Name | Date of First Injury Sighting | First location | Sex | Age (2023) | Comments |
|----------------|-------------------------------|----------------|-----|------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2022Calfof3220 | 02/14/2023 | Florida | Unk | 1 | Two prop marks left flank. Larger of the two has orange cyamids. |
| 3460/Havana | 03/31/2023 | Cape Cod Bay | M | 19 | New wounds right ped/flank visible on 03/31/23. Wounds were not visible on 03/13/2023 sighting. Suspected vessel strike but need additional images to assess. |

Entanglement and Entrapments

There were eight active entanglement/entrapment cases reported between January 1 and December 31, 2023, six of which were new (for five whales as one whale was entangled twice in 2023) and two were known cases from 2022 (Table 6). At least four of the whales are presumed to still be entangled and their fate is uncertain.

Whales with attached gear tell only part of the entanglement story. Annual assessments of scarring show that interactions with fishing gear often occur without detection of the actual entangling gear. Ongoing efforts to monitor anthropogenic injuries to right whales in near real time provide an assessment of the minimum number of new entanglement events seen annually without attached gear but with injuries of concern. While still in preliminary analyses, there were at least **21** additional entanglement events in Canadian and U.S. waters in 2023 resulting in notable wounds/scars only, highlighting the ongoing nature of this anthropogenic threat to the species throughout its range and the shortcomings of current management strategies. While the precise location for these events cannot be determined, the locations of, and timeframe between, pre-injury sightings and injury detections do provide useful information on the area/region where events may have occurred (Table 7).

Table 6. Right whale active entanglements and status updates 2023. Newly reported active entanglements (carrying gear) and updates to previously reported entanglements are in **bold**. Dead whales first sighted entangled at death are not included here. However, whales sighted alive as entangled and later dead are included.

*Prior to the publication of this report, right whale 5120 was sighted dead on January 28, 2024. That mortality will be reported in the 2024 NARWC Report Card.

| Whale #/Name | Date of First Entanglement Sighting | First location | Sex | Age (2023) | Comments |
|----------------------------|-------------------------------------|----------------------|-----|------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5120* (2021 Calfof3720) | 08/20/2022 | Gulf of St. Lawrence | F | 2 | Whale sighted entangled ~50miles east of Shippagan, NB. The whale appears to have been free-swimming with its entanglement. Documentation indicates that the whale has at least one wrap of line around the peduncle and fluke blade, two small floats and perhaps 200' of line in tow. The trailing line appears to be at the surface when the whale is at the surface. The whale may have been feeding at the time of the sighting and wounds at the peduncle indicate that this is not likely a fresh entanglement. Previously sighted gear free on 03/11/2022 in Cape Cod Bay. Whale was resighted multiple times, still entangled, in January 2023 in Cape Cod Bay and in February 2023 south of Nantucket. No trailing line was observed, but the whale maintains at least four wraps around the peduncle and buoys were attached. On 06/12/2023, the whale was resighted, still entangled, in the Gulf of St. Lawrence. The buoys appear to have shed or are at least no longer visible. The wounds at the peduncle have worsened, as has the overall condition of the whale, with progressing lesions on both sides of the head and decline in body condition. Whale catalogued as Eg #5120. |
| 4501 | 08/24/2022 | Gulf of St. Lawrence | M | 7 | Whale entangled with at least one wrap around the body and another forward of the peduncle. The entanglement likely occurred very recently (that day or the previous day) given its behavior (very fast swimming, partial rolls, fluking frequently) and evidence of blood at the wound on the peduncle. By the end of the initial sighting, the two body wraps are gone and the whale continues very fast swimming. There is no way to determine whether it was still entangled (the flipper and mouth were not seen). It had very minor abrasions on the body and peduncle. – whales often have extensive grey skin abrasions and peduncle abrasions from struggling against gear. Its behavior of surfacing and sinking or fluking in the same area suggests there may still be weighted gear attached. Previously seen gear free on 08/06/2022 in the Gulf of St. Lawrence. On 03/31/2023 Eg #4501 was sighted south of Nantucket gear free. |
| 4904 | 01/08/2023 | North Carolina | F | 4 | Last sighted gear free on 05/06/2022 in Massachusetts Bay. The whale appeared to have a relatively complex entanglement. There is at least one wrap of the rostrum with line exiting each side of the mouth, both leading to wraps at the tail, essentially hogtying the whale. At the tail, it appears that there are wraps of the peduncle as well as wraps of the fluke blades with numerous short loops trailing. From the tail, one line leads to a bitter end that can be seen about 1-2 whale lengths aft of the whale. Another line trails aft an unknown distance sinking into the water column likely attached to weight or a long portion of sinking line. The whale has significant wounds on the peduncle, flukes, head, left flipper and there are several wounds across the body. |
| 3812/Nimbus | 01/20/2023 | Georgia | M | 15 | Previously seen gear free on 08/08/2022 in the Gulf of St. Lawrence. The whale was sighted free-swimming with heavy rope (~11/16”) rope caught in the mouthline. Rope exited both sides of the mouth and appeared to consist of both sinking and float line. Injuries to the whale, including the peduncle and mouth were extensive. A disentanglement effort was successful in removing ~370ft of the entanglement. There remained a short length of rope caught in the mouthline. On 03/10/2023 the whale was sighted gear free south of Martha’s Vineyard. Bilateral gear analyses determined the entanglement to be from Canadian snow crab – Area 12 in the Gulf of St Lawrence. NOAA Report DFO Report |

Table 6 cont'd. Right whale active entanglements and status updates 2023. Newly reported active entanglements (carrying gear) and updates to previously reported entanglements are in **bold**. Dead whales first sighted entangled at death are not included here. However, whales sighted alive as entangled and later dead are included.

| Whale #/Name | Date of First Entanglement Sighting | First location | Sex | Age (2023) | Comments |
|--------------|-------------------------------------|--------------------------------------------------|-----|------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1218/Argo | 01/27/2023 | North Carolina | M | >42 | <p>The whale was free-swimming with its entanglement with weighted line and what appeared to be at least one trap in tow. Previously seen gear free on 05/26/2022 in the Great South Channel. The entanglement configuration appeared to involve the flukes and peduncle only. The whale was free-swimming but appeared to be moving very slowly, perhaps aided by sculling with the flippers. A short length of line from the flukes led to what appeared to be a pot directly under the flukes. Another, longer length of line, trailed further aft of the whale but sunk steeply into the water. The overall condition of the whale is quite poor and the line around the base of the flukes appeared to be embedded.</p> <p>On 01/29/2023 responders successfully cut and removed nearly all trailing line and two attached pots. There was a small segment of rope remaining near the fluke notch. Preliminary bilateral gear analysis determined the gear to be from Canadian lobster trap/pot gear from the east coast of Nova Scotia, LFA 33.</p> <p>NOAA Report DFO Report</p> |
| 4545 | 02/09/2023 07/30/2023 | Southern New England Gulf of St. Lawrence | F | 8 | <p>Last sighted gear free on 07/28/2022 in the Gulf of St. Lawrence. First sighted entangled on 02/09/2023 with thick green line exiting the right mouth and trailing at least five body lengths. A resight of the whale on 03/28/2023 showed a significant change in the entanglement configuration that now consisted of line exiting both sides of the mouth leading to three body wraps and at least one long length of line (300-400ft). The body wraps were embedded along some of their lengths. Approximately 200ft of line was removed during one disentanglement effort and another 100ft during the most recent attempt on 04/04/2023. The body wraps remain. Gear analyses indicate that the gear was from Canadian Snow Crab Area 12. On 07/20/2023 the whale was resighted in the Gulf of St. Lawrence, still entangled, and in deteriorating condition.</p> <p>NOAA Report DFO Report</p> <p>Eg #4545 was sighted on 07/30/2023 in the Gulf of St. Lawrence carrying a second set of entangling gear in addition to the gear reported above. The new entanglement appears to be centered within the mouth, with line likely sinking off its left and right sides an unknown distance. The whale was visibly agitated, spending much of its time at the surface pumping its flukes. Resighted on 08/24/2023 in the Gulf of St. Lawrence still entangled, Eg #4545's condition has declined significantly. Body condition is emaciated, skin is pale, and there are large patches of cyanids on her head and body.</p> |
| 4042/Martini | 07/15/2023 | Gulf of St. Lawrence | M | 13 | <p>Last sighted gear free on 07/08/2023 in the Gulf of St. Lawrence, Eg #4042 was sighted in the Gulf of St. Lawrence on 07/15/2023 with attached gear with line exiting the left mouth and trailing ~50 meters. The whale has not been resighted.</p> |

Table 7. Newly detected right whale entanglement events evidenced by wounds/scars only. These cases represent a **minimum** number of new events detected in 2023 and are meant to inform near real time monitoring efforts for injury impacts on right whale health, stock assessment reports, and morbidity information for the Unusual Mortality Event. A full injury analysis of all right whale sightings for the year will be completed once all data are received and processed.

| Whale #/Name | Pre-Injury Date | Pre-Injury Location | Injury Detection Date | Injury Detection Location | Sex | Age (2023) |
|----------------|-----------------|---------------------|-----------------------|---------------------------|-----|------------|
| 5143 | 04/13/22 | SNE | 01/08/23 | CCB | M | 2 |
| 2021Calfof3860 | 08/06/22 | GSL | 02/09/23 | SNE | F | 2 |
| 4146 | 09/21/22 | GSC | 02/09/23 | SNE | F | 12 |
| 4080 | 05/01/22 | CCB | 03/01/23 | SNE | F | 13 |
| 5104 | 08/16/22 | GSL | 03/13/23 | CCB | M | 2 |
| 4640/Wishbone | 08/26/22 | GSL | 03/13/23 | CCB | F | 9 |
| 4145 | 10/10/22 | GB | 03/18/23 | SNE | M | 12 |
| 4446 | 11/11/22 | GSL | 03/22/23 | SNE | M | 9 |
| 3845/Mogul | 07/07/22 | GSL | 03/24/23 | SNE | M | 15 |
| 2950 | 01/20/23 | NC | 03/29/23 | SNE | M | >24 |
| 4510/Shelagh | 07/14/22 | GSL | 04/09/23 | CCB | F | >8 |
| 2022Calfof1515 | 03/21/23 | CCB | 05/15/23 | GSC | F | 1 |
| 2930/Specs | 08/28/21 | GSL | 06/12/23 | GSL | M | >24 |
| 2022Calfof4180 | 02/19/23 | SNE | 06/12/23 | GSL | Unk | 1 |
| 2642/Echo | 04/09/23 | CCB | 06/12/23 | GSL | F | 27 |
| 2022Calfof1817 | 04/03/23 | CCB | 06/12/23 | GSL | M | 1 |
| 2022Calfof3157 | 03/13/23 | CCB | 06/12/23 | GSL | Unk | 1 |
| 3390/Uca | 05/30/22 | GSL | 07/20/23 | GSL | F | >20 |
| 4040/Chimineia | 04/07/23 | SNE | 07/21/23 | GSL | F | 15 |
| 4605 | 04/09/23 | CCB | 08/20/23 | SNE | M | 7 |
| 2022Calfof2753 | 06/12/23 | GSL | 09/24/23 | GSL | Unk | 1 |

AERIAL AND VESSEL-BASED SIGHTING SUMMARY: 2022

Prior to the 2017 Report Card, sighting information was reported for the time period following the previous NARWC Annual Meeting. However, that reporting included the current year for which not all data has necessarily been received and/or processed. Therefore, beginning with the 2017 Report Card, sighting summaries will be presented for the *previous* calendar year. Cataloged sighting information for the year 2022 (data as of October 8, 2023) is summarized below (Table 8) and includes survey, research, and opportunistic sightings. Months with sightings, survey types, and major contributing organizations (>10% total sightings for region) are listed.

*Major Contributing Organizations (*Indicates individual contributor)*

AMTU*: Amy Tudor
AS: Associated Scientists
BOS: Blue Ocean Society
CCG: Canadian Coast Guard
CCS: Center for Coastal Studies
CMARI: Clearwater Marine Aquarium Research Institute
CWI: Canadian Whale Institute
DFO: Fisheries and Oceans Canada

FTR: Fundy Tide Runner
FWRI: Florida Fish and Wildlife Research Institute
GDNR: Georgia Department of Natural Resources
NEAq: New England Aquarium
NEFSC: Northeast Fisheries Science Center
QLM: Quoddy Link Marine
TC: Transport Canada
WHOI: Woods Hole Oceanographic Institution

Table 8. Summary of 2022 right whale sightings by habitat region as defined in the North Atlantic Right Whale Identification/Catalog Database. Analyses for 2022 data are ongoing and therefore the data presented here should not be considered complete.

| Region | # Sightings | Sighting Months | Survey types/activities | Organizations |
|--------------------------------------------------------------------------------------------|-------------|----------------------------|----------------------------------------------------------------------------------------------------------|-----------------------|
| Bay of Fundy | 8 | Aug-Oct | Opportunistic, whale watch | AMTU*, DFO, FTR, QLM |
| East (East of Mainland US (Azores, Nova Scotian Shelf, Spain, Bermuda, Canary Islands)) | 2 | Mar, Jun | Opportunistic | NEAq, WHOI, CCG |
| Gulf of Maine | 79 | Jan, Mar-Jun, Aug, Oct-Nov | Aerial and vessel surveys | CCS, NEAq, NEFSC |
| Great South Channel | 213 | Mar-Jun, Aug-Sep | Aerial and vessel surveys | CCS, NEFSC |
| Jeffreys Ledge | 37 | Apr-Jun, Nov-Dec | Aerial surveys, Whale Watch, Opportunistic | BOS, CCS, NEFSC |
| Mid-Atlantic (includes south of Cape Cod) | 193 | Jan-May, Jul, Sep-Dec | Aerial and vessel surveys, drone photography | CMARI, NEAq, NEFSC |
| New England (Massachusetts Bay/Cape Cod Bay) | 1704 | Jan-May, Oct, Dec | Aerial and vessel surveys, biopsy and habitat sampling, drone photogrammetry, whale watch, opportunistic | CCS, NEAq, WHOI |
| North (North of latitude 46 degrees including Newfoundland, Gulf of St. Lawrence, Iceland) | 926 | May-Nov | Aerial and vessel surveys | CWI, DFO, NEAq, TC |
| Southeast United States | 354 | Jan-Mar, Dec | Aerial and vessel surveys, biopsy and drone sampling | AS, CMARI, FWRI, GDNR |

MANAGEMENT AND MITIGATION ACTIVITIES

The following management summaries were submitted by the National Marine Fisheries Service (NMFS), Department of Fisheries and Oceans Canada (DFO), and Transport Canada (TC) for inclusion in the 2023 NARWC Annual Right Whale Report Card.

NMFS Submission for the North Atlantic Right Whale Consortium Report Card 2023

As North Atlantic right whale (*Eubalaena glacialis*) science and management activities continue to increase, the National Marine Fisheries Service (NOAA Fisheries) remains dedicated to providing the public with the latest information on our activities. NOAA Fisheries' *North Atlantic Right Whale Road to Recovery* describes our ongoing efforts to halt the North Atlantic right whale decline and encapsulates all of our ongoing work across the agency in collaboration with our partners and stakeholders to conserve and rebuild the population. The framework is built on the foundation of the statutory requirements that NOAA Fisheries is charged with implementing under the Endangered Species Act and the Marine Mammal Protection Act. The *Road to Recovery* complements the [North Atlantic Right Whale 2021-2025 Priority Action Plan](#) by identifying two related, overarching goals: (1) Address Threats to the Species and (2) Monitor Recovery Progress. Each goal has three associated objectives. Goal 1 aims to (1.1) Address Vessel Strikes; (1.2) Address Fishing Gear Entanglements; and (1.3) Address Potential and Emerging Threats, including impacts from climate change, new and expanded ocean uses, and ocean noise. Goal 2 aims to (2.1) Monitor Population and Health, (2.2) Monitor Threats, and (2.3) Monitor Effectiveness of Conservation. Through this framework, NOAA Fisheries is demonstrating and communicating progress on major activities and associated milestones to help conserve and recover the North Atlantic right whale population.

A few highlights NOAA Fisheries accomplished in 2023 include announcing and planning for the [2024 Vessel Strike Risk Reduction Technology workshop](#), completing peer review and a summary report of the [Decision Support Tool](#), co-hosting a [tagging workshop](#), reviewing retrospective North Atlantic right whale sightings to include morbidity cases in the ongoing [Unusual Mortality Event](#), releasing the interactive [Speed Zone Dashboard](#), and releasing the [Population Viability Analysis](#). The *Road to Recovery* is a living resource that is updated regularly. To view the latest North Atlantic right whale updates from NOAA Fisheries you can visit our [Road to Recovery webpage](#). Archived information is available upon request.

DFO and TC Submission for the North Atlantic Right Whale Consortium Report Card 2023

Below is the combined submission from Fisheries and Oceans Canada (DFO) and Transport Canada (TC) identifying management measures enacted by the Government of Canada for the protection and recovery of the North Atlantic right whale. General information is available online for [fisheries management measures](#) and [vessel management measures](#). Additional and updated information on ongoing research and management efforts in Canada can be found [HERE](#). Below we have summarized 2023 activities only.

Input from Fisheries and Oceans Canada

- Building on the success of previous funding initiatives including the five year, \$167M Whales Initiative in Budget 2018, Canada's Budget 2023 provided \$151.9 million over three years to Fisheries and Oceans Canada, Transport Canada, Environment and Climate Change Canada, and Parks Canada to continue to protect endangered whales and their habitats. This includes targeted funding for NARW protection.
- From April to November 2023, up to six planes from DFO and Transport Canada monitored the Gulf of St. Lawrence, Bay of Fundy, Roseway Basin, and Newfoundland and Labrador for right whales and their co-occurrence with fishing activity and vessel traffic. During this time, over 2,200 hours of flights were designated for NARW monitoring.
- From April to November 2023, temporary and season-long closures, triggered by single whale detections, covered a total 68,518.10 km² within Canadian waters. A total of 951 verified NARW sightings were recorded during this time, with 1,217 whales sighted (including duplicates). Additionally, there were 83 total days of acoustic detections with 2,098 definite NARW acoustic detections recorded.
- In 2023, three NARW entanglements first reported in the U.S. have been linked to Canadian fisheries based on Canadian gear analysis. DFO's investigation into these entanglements have verified that two of the entanglements were the result of ghost gear and did not occur during the fishing season. Two new NARW entanglement cases were first sighted in Canadian waters; in one case the whale was resighted gear-free later in the season. The fishery of origin of the two new entanglements cannot be confirmed as no gear was retrieved. No NARW mortalities were reported in Canadian waters, for the fourth year in a row (last observed mortality occurred in 2019).
- Fisheries and Oceans has been working with the fishing industry and partners to identify gear solutions to prevent and alleviate harm to right whales from entanglements. The Department's objective is to protect right whales while also supporting sustainable fisheries. Since 2018, the Department has supported industry trials of whalesafe fishing gear, including low breaking-strength gear, and on-demand gear that can be used in areas closed to traditional fixed gear fishing because of right whale detections. In March 2023, DFO's \$20 million Whalesafe Gear Adoption Fund (WSGF) concluded, having provided support to 34 projects in eastern Canada. On September 14 and 15, 2023, DFO held a Whalesafe Gear Trials Results Symposium in Moncton, N.B. where recipients of funding programs including the WSGF, such as research groups, fishery associations and Indigenous partners, shared and discussed the results of their gear trials. DFO is using the information gathered at the Symposium to identify the safest and most effective whalesafe gear options to use in each fishery. In December 2023, DFO announced that the use of low breaking-strength gear will be authorized for use on a voluntary basis in fisheries in which gear trials have shown that such gear can operate safely and with no added risk of gear loss. DFO is developing a five-year whalesafe gear strategy, for finalization in 2024, that will guide the broader implementation of both lower-breaking strength and on-demand fishing gear in Canada.
- Harvesters continue to successfully land and sell snow crab caught using on-demand gear in the Gulf of St. Lawrence, authorized with an experimental fishing permit. In 2024, Canada will be working with fish harvesters to expand testing and support operationalization of on-demand fishing gear, such as in Area 12 snow crab. In 2023 Canada amended the Fisheries (General) Regulations, providing Fisheries and Oceans with greater flexibility to allow fisheries to operate without surface buoys and vertical lines, when it is for the purpose of mitigating marine mammal entanglement. The Department will be able to use the licence

conditions of individual fisheries to authorize the use of on-demand gear as well as novel gear configurations to reduce entanglement risk.

- Fisheries and Oceans has continued its annual investment of over \$1 million for marine mammal response organizations, as well as investments in science to better understand threats to right whales, and to inform future management measures. The Department has also delivered \$5.5 million over five years to build capacity across Canada for safe and effective marine mammal incident response, and new funding provided in Budget 2023 includes an additional \$2.7M for 2023-2026 to continue this work. These funds are used to support necropsies, build Indigenous community response capacity, and in particular increase large whale disentanglement response capacity. Additionally, the Large Whale Disentanglement Advisory Committee has been created to discuss actions underway and planned by Fisheries and Oceans Canada (DFO) and disentanglement experts regarding the disentanglement of large whales, and to allow participants to provide advice on government decision-making, such as disentanglement training and succession planning.
- DFO received official requests for information from the Committees conducting the Regional Assessments (RA) of Offshore Wind Development in Nova Scotia and in Newfoundland and Labrador for high level summaries of existing information related to the department's mandate. The information will be used by the Committees to inform future recommendations on potential suitability of offshore wind in the waters of DFO Maritimes (including a portion of the Gulf of St. Lawrence) and Newfoundland and Labrador regions, as well as potential mitigation measures, among other topics. RAs are overseen by the Impact Assessment Agency of Canada (IAAC), but two independent Committees have been tasked with carrying out the RAs themselves along with the necessary engagement. In response to the requests, DFO provided information for consideration in the fall of 2023 which included general information on fish and fish habitat, fisheries, marine mammals (including North Atlantic right whales), commercial, recreational, and Indigenous fisheries. Information from the Regional Assessment will be posted on the [public registry](#)
- On November 15, 2023, Fisheries and Oceans Canada held the annual North Atlantic Right Whale Advisory Committee meeting with Indigenous groups, the fishing industry, provinces, and marine mammal experts. The advisory committee meeting and other discussions with harvesters and Indigenous groups, non-government organizations and academic institutions plays an important role in the preparation of Canada's measures to protect right whales and to support sustainable fisheries for 2024 and beyond.

Input from Transport Canada

- In 2023, to reduce the risk of vessel collisions with the North Atlantic right whale, Transport Canada once again implemented a large mandatory static speed restriction zone covering much of the Gulf of St. Lawrence, as well as dynamic speed restriction zones in the shipping lanes north and south of Anticosti Island. These measures, applicable to all vessels longer than 13 m, came into force on April 19, 2023, and were in place until November 15, 2023.
- Additionally, Transport Canada instituted Seasonal Management Areas from April 19 to June 27, 2023, which serve to expand the static speed restriction zone for a part of the season.
- A mandatory restricted area covering 4,000 km² in and near the Shediac Valley to protect aggregating North Atlantic right whales was in effect from June 21 to September 11, 2023 – the area was closed to all vessels longer than 13 m with exceptions for fishing vessels and certain other activities. Vessels permitted to transit in or through the restricted area were limited to speeds of no more than 8kn over ground.
- Transport Canada also put in place a voluntary seasonal slowdown in Cabot Strait from April 19 to June 27, 2023, and again from September 27 to November 15, 2023.
- With regard to whale detection, Transport Canada once again incorporated an acoustic underwater glider into its surveillance technologies to detect North Atlantic right whales to inform active management of dynamic vessel speed management measures. This technology complemented the surveillance flights flown by Transport Canada's National Aerial Surveillance Program (NASP).
- Transport Canada began evaluating the 2023 measures before the conclusion of the season, and continues to engage with the marine transportation industry, fishers, scientists, and other stakeholders to refine and develop measures for 2024.

2023 NORTH ATLANTIC RIGHT WHALE PUBLICATIONS/REPORTS

Reports and publications that utilized NARWC databases in 2023 and/or those of general interest to the right whale community are listed and hyperlinked (when available) below.

[Brilliant, S., 2023. The Future of North Atlantic Right Whales and Fishing and Shipping Interactions. *Ocean Yearbook Online*, 37\(1\), pp.207-220.](#)

[Brown, M.W. and Sironi, M., 2023. Right whale sexual strategies and behavior. *Sex in cetaceans*.](#)

[Ceballos, V., Taggart, C. and Johnson, H., 2023. Comparison of visual and acoustic surveys for the detection and dynamic management of North Atlantic right whales \(*Eubalaena glacialis*\) in Canada. *Conservation Science and Practice*, 5\(2\), p.e12866.](#)

[Crossman, C.A., Fontaine, M.C. and Frasier, T.R., 2023. A comparison of genomic diversity and demographic history of the North Atlantic and Southwest Atlantic southern right whales. *Molecular Ecology*.](#)

[Crowe, L.M., Foley, H.J. and Cholewiak, D.M., 2023. Shiny tools for management rules: interactive applications that aid in conservation strategies for North Atlantic right whales. *Journal of Open Source Software*, 8\(88\), p.5436.](#)

[Crum, N.J., Gowan, T.A. and Ramachandran, K.M., 2023. Forecasting wildlife movement with spatial capture–recapture. *Methods in Ecology and Evolution*, 14\(11\), pp.2844-2855.](#)

[Davis G, Van Parijs S., 2023. North Atlantic right whale passive acoustic detections report: January 2020 - June 2022. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 23-07; 10 pp.](#)

[Davis, G.E., Tennant, S.C. and Van Parijs, S.M., 2023. Upcalling behaviour and patterns in North Atlantic right whales, implications for monitoring protocols during wind energy development. *ICES Journal of Marine Science*, p.fsad174.](#)

[Forbes, R., Nakamoto, B., Lysiak, N., Wimmer, T. and Hayden, B., 2023. Stable isotope analysis of baleen from North Atlantic right whales *Eubalaena glacialis* reflects distribution shift to the Gulf of St. Lawrence. *Marine Ecology Progress Series*, 722, pp.177-193.](#)

[Frasier, T.R., Hamilton, P. and Pace III, R., 2023. How compromised is reproductive performance in the endangered North Atlantic right whale? A proposed method for quantification and monitoring. *bioRxiv*, pp.2023-11.](#)

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[Hütt, J.C., Corkeron, P., van der Hoop, J.M. and Moore, M.J., 2023. Uncertain bioenergetics of North Atlantic right whales. *Marine Ecology Progress Series*, 725, pp.167-184.](#)

[Linden D.W., 2023. Population size estimation of North Atlantic right whales from 1990-2022. US Dept Commer Northeast Fish Sci Cent Tech Memo 314. 14 p.](#)

[Linden, D.W., Hostetler, J.A., Pace III, R.M., Garrison, L.P., Knowlton, A.R., Lesage, V., Williams, R. and Runge, M.C., 2023. A multistate capture-recapture model to estimate cause-specific injury and mortality of North Atlantic right whales. *bioRxiv*, pp.2023-10.](#)

[Meyer-Gutbrod, E.L., Davies, K.T., Johnson, C.L., Plourde, S., Sorochan, K.A., Kenney, R.D., Ramp, C., Gosselin, J.F., Lawson, J.W. and Greene, C.H., 2023. Redefining North Atlantic right whale habitat-use patterns under climate change. *Limnology and Oceanography*, 68, pp.S71-S86.](#)

Pettis, H.M. and Hamilton, P.K. 2024. North Atlantic Right Whale Consortium 2023 Annual Report Card. Report to the North Atlantic Right Whale Consortium.
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[Moore, M.J., 2023. Policy enabling North Atlantic right whale reproductive health could save the species. *ICES Journal of Marine Science*, 80\(2\), pp.237-242.](#)

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[Ross, C.H., Runge, J.A., Roberts, J.J., Brady, D.C., Tupper, B. and Record, N.R., 2023. Estimating North Atlantic right whale prey based on *Calanus finmarchicus* thresholds. *Marine Ecology Progress Series*, 703, pp.1-16.](#)

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