

North Atlantic Right Whale Consortium 2016 Annual Report Card

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 sixteen years, there has been increasing interest in addressing the problems hampering 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 100 entities including: research, academic, and conservation organizations; shipping and fishing industries; whale watching companies; technical experts; 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 incorporating 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 Canadian Right Whale Network, the U.S. Southeast Right Whale Implementation Team, the Atlantic Large Whale Take Reduction Team, the Atlantic Scientific Review Group, and members of the U.S. Congress. The Consortium membership supports the maintenance and long-term continuity of the separate research programs under its umbrella, 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 at the Annual Meeting.

2016 ANNUAL NORTH ATLANTIC RIGHT WHALE REPORT CARD

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 entanglement 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. The 2016 annual report card includes information from 01 November 2015 – 31 October 2016.

Essential Population 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 population 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 high use habitats and migratory corridors, including, but not limited to, the southeast United States, Cape Cod Bay, Great South Channel, Bay of Fundy, Scotian Shelf, and Jeffreys Ledge, (2) Monitoring of scarring and visual health assessment from photographic data, (3) Examination of all mortalities, and (4) Continue using photo-ID and genetic profiling to monitor population structure and how this changes over time.

The Consortium Board regards the Consortium databases as essential to recovery efforts for the North Atlantic right whale population. 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 Consortium databases available) be fully funded on a stable basis.

Over the last several years, surveys in areas listed above have indicated that right whale distribution and patterns of habitat use have shifted, in some cases dramatically from expectations based on previous studies. These shifts have been observed throughout the range of North Atlantic right whales and have direct implications on research and management activities, as well as on each of the key efforts identified above. As such, the Board believes that identifying potential extralimital and new critical habitats and developing alternative survey effort strategies to respond to the distributional changes should be a priority. These strategies should include efforts to not only locate and identify individual right whales, but also to ensure that information critical to important monitoring and management efforts (i.e. health assessment, injury and scarring assessments) is effectively and efficiently collected.

Entanglement in fixed fishing gear continues to pose a significant threat to this population. Current management regulations have not been effective at reducing serious entanglement injuries (Pace et al. 2014) and since 2010, entanglement related deaths accounted for 85% of diagnosed mortalities (Kraus et al. 2016). Entanglements reduce survival probability for right whales and moderate and severe injuries from entanglement are increasing (Robbins et al. 2015; Knowlton et al. 2016). In addition to entanglement threats to this population, reproductive output has declined by 40% since 2010 (Kraus et al. 2016). The reasons for this decline are unclear. However, this trend coupled with the continued (and perhaps increasing) impact of entanglements must serve as a call to action for immediate intervention to reduce entanglement mortalities and injury in both Canada and the United States.

Population Status

Estimate of Cataloged North Atlantic Right Whales: 2015

The ability to monitor North Atlantic right whale vital rates is entirely dependent on the right whale identification database. Curated by the New England Aquarium, the database consists of over 800,000 slides, prints, and digital images collected during the 71,066 sightings of 703 individual right whales photographed since 1935. Each year, 3,000 to 5,000 sightings consisting of 20-30,000 images are added to the identification database. Due to the lag time in processing data, an estimate of the cataloged population is available through 2015.

The best estimate of cataloged North Atlantic right whales in 2015 is 524 individuals (database exported 20 October 2016). Low and high estimates were also calculated (Table 1 below). This "best estimate" is based upon the number of photographed whales, but it excludes potential unphotographed whales, and therefore should **not** be considered a "population estimate". This photo-identification estimate includes 490 cataloged whales that were presumed to be alive in 2015 because they were seen in that year, or any time in the prior five years (Knowlton et al. 1994). The estimate also includes 11 calves from 2014 or 2015 that were considered suitable for eventual inclusion in the catalog and 23 other whales that did not match the catalog, but were re-identified in at least one subsequent year (excluding sightings in field seasons that spanned the calendar year). A detailed explanation of these calculations is included at the end of this report.

Table 1. Estimates of the number of photographed whales in the North Atlantic Right Whale Identification Catalog. A detailed explanation of calculations can be found at the end of this report. Analysis completed 10/20/16.

Low: 250 individuals	
250	Cataloged whales seen in 2015
Middle: 524 individuals	
490	Cataloged whales presumed alive in 2015
23	Intermatch whales likely to be added to Catalog
11	Calves from 2014 and 2015 likely to be added to Catalog
High: 716 individuals	
661	All Cataloged whales in 2015 minus those known dead
32	All active intermatch codes without 2014 & 2015 calves
23	All uncataloged 2014 and 2015 calves minus dead

Population Over Time

Assessments of the number of photo-identified right whales within the population over time based on three available methods are provided below (Figure 1). The presumed alive counts whales that have been seen at least once in the last six years. It is a consistently measureable and easily available value, but is not an accurate estimate of recent cataloged population size due to delays in data processing. The Minimum Number Alive (MNA) is the number used in the NMFS stock assessment reports and counts whales seen in a given year, plus any whale not seen that year- but seen both before *and* after. The MNA number is also not accurate for recent years for the same reason as the presumed alive, plus the fact that there have been fewer “after” years to detect a whale. The report card number is the only number that assesses animals that are not yet cataloged and is the best number for the previous year.

In the figure below, the numbers for presumed alive and MNA for all years were recalculated using data from October 20, 2016; only the numbers from past report cards were not regenerated. The report card numbers are always higher than the other two methods for the most recent two to three years. The fact that the old report card numbers for 2005 through 2008 are close to what the newly generated MNA numbers are suggests that the report card method may result in a reasonably accurate estimate, and can do so several years ahead of the MNA method (in 2010, the MNA was 20 to 60 whales less than the report card for 2005 - 2008. The MNA increases over time with the increase of more “after” years for a whale to be detected in). The report card also helps capture recent calves that have not yet been cataloged largely due to the shift in right whale distribution; this shift has resulted in fewer calves seen on the spring, summer, and fall feeding grounds with their mothers, and fewer sightings of juveniles anywhere- both of which make cataloging recent calves challenging. On the other hand, the report card does not remove a whale from the population until it goes unsighted for six years; some of these whales likely die before six years resulting in the report card potentially overestimating the population number.

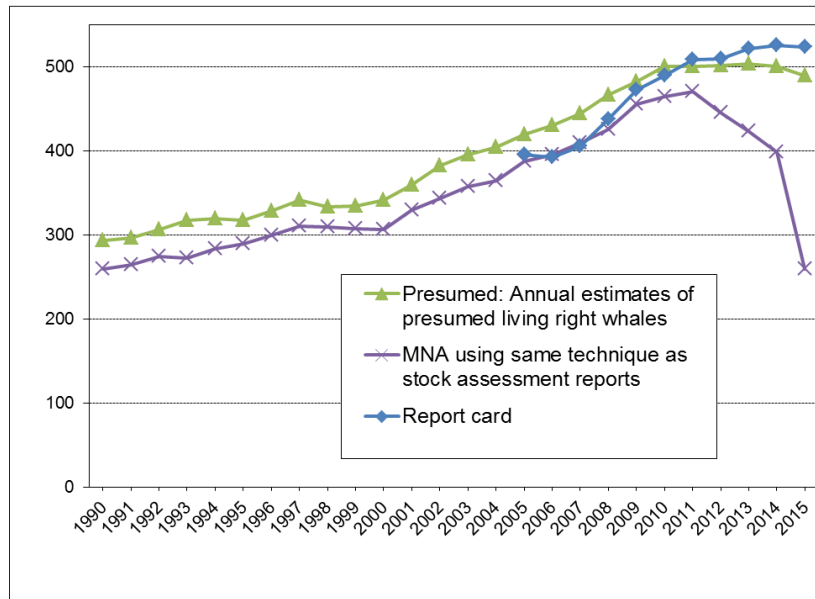


Figure 1. Assessments of the North Atlantic right whale population based on three available assessment methods.

How Well Are We Monitoring?

Below is a count of sightings, unique individuals, and whales presumed alive by year, and the number of survey miles dedicated to searching for right whales from 2000-2015. Evident from the table is that the shift in whale distribution has reduced both the number of sightings contributed to the Catalog and the percent of the population seen annually in recent years.

Table 2. Annual counts of sightings, unique individuals, presumed living whales, survey effort, and the percentage of the population seen. Survey effort from dedicated surveys only; opportunistic sightings do not record or report effort. Effort data for 2010-2014 changed slightly from the 2015 report card as additional survey data was submitted to the Sightings Database. Data as of October 20, 2016.

Year	Sightings	Unique IDs	Presumed Living Population	Survey Effort (1,000 km)	% of population seen
2000	3084	236	342	125	69%
2001	3848	281	360	127	78%
2002	2709	303	383	217	79%
2003	2401	314	396	180	79%
2004	1804	286	405	259	71%
2005	3397	352	420	340	84%
2006	2799	344	431	316	80%
2007	3736	379	445	267	85%
2008	4147	388	467	254	83%
2009	4634	421	483	246	87%
2010	3221	418	501	271	83%
2011	3462	435	501	234	87%
2012	2126	370	502	271	74%
2013	1905	293	504	215	58%
2014	2389	361	501	200	72%
2015	1766	250	490	183	51%

Reproduction

The calving calculation for 2016 is a complicated one. There were 14 mothers seen with calves in 2016 (Table 3), 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. The average calving interval of 2016 moms was 6.6 years and there were four first-time moms in 2016.

Table 3. Summary of calving events and associated interval times for North Atlantic right whales 2007-2016.

Year	Calf Count	Available Cows/ % Available to calve	Average Interval	Median Interval	First time Moms
2007	23	49/46.9%	4.5	3	10
2008	23	59/39.0%	3.2	3	7
2009	39	58/67.2%	4.0	4	8
2010	19	45/42.2%	3.3	3	4
2011	22	48/45.8%	3.7	3	3
2012	7	64/10.9%	5.4	4	2
2013	20	83/24.1%	4.6	4	7
2014	11	85/12.9%	4.4	4.5	1
2015	17	80/21.3%	5.5	6	4
2016	14*	81/17.3%	6.6	7	4

* Only 13 calves were photo-documented during the 2015-2016 calving season.

Mortalities

Between 01 November 2015 and 31 October 2016, four right whale mortalities were documented (Table 4). The Consortium Board 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 01 November 2015 - 31 October 2016

Whale #	Date	Location	Sex	Age	Necropsy Field #	Cause	Comments
2016 Calf of 1281	5/5/2016	Monomoy, MA	M	Calf	IFAW16- 082Eg	Vessel Strike	Full necropsy performed. Last sighted alive 04/28/2016 in Cape Cod Bay with mother (Eg #1281). Eg #1281 re-sighted alive 08/01/2016 Anticosti, QC in the Gulf of St. Lawrence
	9/1/2016	Sable Island, Canada	Unk	Unk		Likely Entanglement	Decomposed carcass with attached line and buoy embedded in flipper. Limited samples taken.

Table 4 (cont'd). Documented right whale mortalities 01 November 2015 - 31 October 2016

Whale #	Date	Location	Sex	Age	Necropsy Field #	Cause	Comments
	9/22/2016	Mt. Desert Rock, Gulf of Maine	Unk	Unk		Undetermined	Code 4 carcass. Carcass last sighted 9/26/2016. Not retrieved or sampled.
3694	9/23/2016	Boothbay Harbor, ME	F	10	MME-16-249Eg	Chronic Entanglement	Full necropsy performed. Last sighted alive 02/12/2016 in Florida.

Entanglements, Entrapments, and Vessel Strikes

Entanglement and Entrapments

There were seven active entanglement/entrapment cases reported between 01 November 2015 and 31 October 2016. Of these, six were new cases, two of which resulted in mortality. Table 5 includes newly reported cases as well as pertinent updates to previously reported cases.

Table 5. Right whale entanglements and status updates 01 November 2015 – 31 October 2016. Newly reported entanglements (carrying gear) are bolded and those cases resulting in mortality are italicized.

Whale#	Date of First Entanglement Sighting	First location	Sex	Age (current)	Comments
1306	9/13/2015	Roseway Basin	Male	Adult. 32+ yo	Green line exiting the left side of the mouth, possibly going to the flipper. Resighted in and around Cape Cod Bay in March and May 2016. Line remains fouled on right side of mouth. Sighting 8/16/2016 in the Bay of Fundy. Skin and body condition declined markedly since spring sightings. Line exiting right mouth remains.
4057	8/13/2016	Bay of Fundy	Male	6	Previously entangled and partially disentangled in 2014. Was sighted gear free in October 2015. Sighted with new and extensive entanglement in the Bay of Fundy on 8/13/2016. Whale had extensive cyanid coverage on head and in entanglement wounds (both new and old) and the whale was thin. A lengthy disentanglement operation removed most of the entangling line, at least a short length of line remained in the baleen and the right flipper was not seen. Fate is uncertain because of his poor condition.

Table 5 (cont'd). Right whale entanglements and status updates 01 November 2015 – 31 October 2016. Newly reported entanglements (carrying gear) are bolded and those cases resulting in mortality are italicized.

Whale#	Date of First Entanglement Sighting	First location	Sex	Age (current)	Comments
1152	8/16/2016	Off Baccaro Point, southern Nova Scotia	Male	Adult, 34+ yo	Trailing line and a buoy. Attachment points unknown. Last sighted gear free in Cape Cod Bay in April 2016.
2608	8/28/2016	Bay of Fundy	Male	20	Heavy tan line around rostrum, right flipper and possibly tailstock. Whale was in poor condition (thin and head lesions). Whale previously sighted in the Bay of Fundy on 8/1/2016 with new, severe entanglement scars but no visible gear. Unclear if gear present on 8/28 was also present on 8/1 (albeit in a very different configuration) or not. Last sighted injury free 8/26/2015 in the Gulf of St. Lawrence.
Unk	9/1/2016	Sable Island, Canada	Unk	Unk	Decomposed carcass with attached line and buoy. Limited samples taken.
3823	9/22/2016	Stellwagen Bank	Female	8	Whale carried line (including rostrum wrap), buoys and weighted gear. Partial disentanglement that likely cut the rostrum wrap. Telemetry buoy attached, found drifting not attached to whale on 9/26/2016.
3694	9/23/2016	Boothbay Harbor, ME	Female	10	Floating dead with extensive entanglement wraps around body, flippers and in mouth. Full necropsy performed. Last sighted alive 02/12/2016 in Florida.

Vessel Strikes:

There was one lethal right whale vessel strike documented between 01 November 2015 – 31 October 2016 (Table 6).

Table 6. Vessel strike wounds reported 01 November 2015 – 31 October 2016. Cases resulting in mortality are italicized.

Whale#	Date of First Sighting with Strike	First location	Sex	Age (current)	Comments
2016 Calf of 1281	5/5/2016	Monomoy, MA	Male	Calf	Full necropsy performed. Last sighted alive 04/28/2016 in Cape Cod Bay with mother (Eg #1281). Eg #1281 re-sighted alive 08/01/2016 Anticosti, QC in the Gulf of St. Lawrence

Monitoring Health of Injured Right Whales

Efforts to better track and monitor the health of anthropogenic injury on North Atlantic right whales were initiated in January 2013. These efforts aim to support annually mandated human induced serious injury and mortality determinations, to reduce the likelihood of undetected and unreported events, and to better assess both short and long term impacts of injury on right whale health. Biannually, previously and newly injured right whales with vessel strikes, attached fixed gear, or with moderate to severe entanglement

injuries in the absence of attached gear (see Knowlton et al 2016 for review of injury types) are flagged for monitoring. Their pre- and post-injury health conditions are evaluated using the visual health assessment technique (Pettis et al. 2004) and a determination of the impact of injury on health is made. Based on the available sighting and health information, whales are assigned to one of four categories: 1) Evidence of declining health coinciding with injury; 2) Inconclusive (this determination was assigned to animals when a: evidence of declining health exists but it was unclear whether or not it was linked to injury and/or b: images/information were inadequate to fully assess health condition visually); 3) No indication of declining health caused by injury based on available images/information; and 4) Extended Monitor - no indication of declining health or whale's condition has improved but whale will remain on monitoring list because of injury severity and/or is still carrying gear. This last category was created to capture whales without current health impacts related to injury, but with injuries that have the potential to negatively impact future health condition (i.e. some severe vessel strikes, whales carrying gear, etc.).

As of June 2016, the Serious Injury/Human Impact list includes 60 whales with injuries documented from March 2004 through 31 May 2016 (Table 7). This is up one whale from the previous report in December 2015. The majority of documented injuries are entanglement related (49/60, 81.7%) followed by vessel strikes (10/60, 16.7%; Table 8). There is one whale on the list with an injury of unknown origin.

Table 7. Since the inception of the injured right whale monitoring protocol, the number of injured whales and newly reported injuries has varied by year. The number of whales included on the injured whale list is given for each biannual report and is followed parenthetically by the number of new injuries detected for the corresponding report. There are whales (four as of June 2016) on the injured list with multiple injuries.

	June	December
2013	33*	32 (2)
2014	45 (16)	50 (6)
2015	51 (4)	59 (9)
2016	60 (4)	

*The first injured whale monitoring report was distributed in June 2013 and therefore does not include a comparative number of newly reported injuries.

Table 8. Impact of anthropogenic injury on right whale visual health by injury type based on assessments of photographs pre- and post-injury for all North Atlantic right whales on the Serious Injury/Human Impact list as of 31 May 2016.

	Entanglement		Vessel Strike	Other	Total
	With Attached Gear	Without Attached Gear			
Decline in Condition	10	13	2	1	26
Inconclusive	8	11	6	0	25
No Decline in Condition	0	4	1	0	5
Extended Monitor	1	2	1	0	4
Total	19	30	10	1	60

Aerial and Vessel-based Sightings November 2015 – October 2016

Cataloged sighting information through 31 October 2016 is summarized below and includes survey, research, and opportunistic sightings. Months with sightings and major contributing organizations (>10% total sightings for region) are listed after total number of sightings. Summaries of survey type (if available) are listed below each region. Not all data have been received and/or entered. Survey platforms and sighting totals may change.

Major Contributing Organizations and Individuals ():*

BOSH: Boston Herald	LG: Laura Ganley*
CCS: Center for Coastal Studies	MICS: Mingan Island Cetacean Study
CWI: Canadian Whale Institute	NEAq: New England Aquarium
DFO: Fisheries and Oceans Canada	NEFSC: Northeast Fisheries Science Center
DN: Doug Nowacek*	PCAN: Parks Canada
FWRI: Fish and Wildlife Research Institute	S2S: Sea to Shore Alliance
GDNR: Georgia Department of Natural Resources	WHOI: Woods Hole Oceanographic Institution

Southeast United States (sightings: 348, December - March; FWRI, GDNR, S2S, DN)

- Aerial and vessel surveys, biopsy darting, tagging

Mid-Atlantic (includes south of Cape Cod) (sightings: 14, November - March; NEFSC, CCS)

- Aerial surveys

Great South Channel (sightings: 54, January - May, August; NEFSC, CCS)

- Aerial and vessel surveys

Massachusetts Bay/Cape Cod Bay (sightings: 768, November – May; CCS, LG, NEFSC, WHOI)

- Aerial and vessel surveys, habitat sampling, drone based photogrammetry

Gulf of Maine (sightings: 94, April - June; CCS, NEFSC)

- Aerial and vessel surveys

Bay of Fundy (sightings: 311, November, July - October; NEAq)

- Vessel surveys

Roseway Basin (sightings: 1, August; DFO)

- Vessel surveys

North (sightings: 110, July - August; CWI, MICS)

- Vessel surveys

East (sightings: 4, April, September; CCS, NEAq, BOSH, PCAN)

- Vessel surveys

Partial Listing of Research Analyses Underway in 2016

- Analysis of North Atlantic right whale social behavior
- Acoustic detections of North Atlantic right whale presence in Massachusetts Bay, 2007 - 2013
- Examining the correlation between winter flounder body condition and North Atlantic right whale calving rate
- Spatially-explicit capture-recapture modeling (SECR) of North Atlantic right whale density in Cape Cod Bay and the Nantucket Wind Energy Area
- Variation in diving behavior in North Atlantic right whale mother/calf pairs increases risk for vessel strike
- Characterize number of individual right whales in SEUS
- Integrating photogrammetry from manned and unmanned aircraft to monitor the growth of North Atlantic right whales
- The behavioral ecology of North Atlantic right whale (*Eubalaena glacialis*) mother-calf pairs
- How and why is the timing and occurrence of seasonal migrants in the Gulf of Maine changing due to climate?
- Movement of North Atlantic right whales in the waters of the mid-Atlantic

- The relationship between maternal experience and calf survival outcomes in North Atlantic right whales, *Eubalaena glacialis*
- Fecal stress hormones and anthropogenic injury and mortality in North Atlantic right whales (*Eubalaena glacialis*)
- Vocal development in Right Whales
- Building a Reproducible R Package to Facilitate Dynamic Generation of a Population-Wide Report Card for Right Whales
- Predicted suitable habitat of cetaceans in the North West Atlantic Ocean (NWAO)
- Investigating seasonal prevalence of large whale mortalities in US and Canadian east coasts.
- Assessment of potential missed mortalities to better inform SAR estimates

Management and Mitigation Activities

United States

- On January 27, 2016 NOAA Fisheries announced the expansion of critical habitat for endangered North Atlantic right whales to cover northeast feeding areas in the Gulf of Maine/Georges Bank region and southeast calving grounds from North Carolina to Florida.

- NMFS initiated a 5-year review of the North Atlantic right whale (*Eubalaena glacialis*) under the Endangered Species Act of 1973, as amended (ESA). The purpose of these reviews is to ensure that the listing classification of a species is accurate. The 5-year review will be based on the best scientific and commercial data available at the time of the review; therefore, NMFS requests submission of any such information on the North Atlantic right whale that has become available since the last 5-year review on August 28, 2012. The deadline to submit new information was October 27, 2016.

- On August 15, 2016, NMFS published a final rule to implement provisions of the MMPA that aim to reduce marine mammal bycatch associated with international commercial fishing operations, by requiring nations exporting fish and fish products to the United States to be held to the same standards as U.S. commercial fishing operations.

- On September 15, President Obama designated the first marine national monument in the Atlantic Ocean, the Northeast Canyons and Seamounts Marine National Monument, using his authority under the Antiquities Act of 1906. Commercial fishing and other resource extraction activities will be prohibited within the monument boundaries. A 60-day transition period is in effect for all commercial fisheries. The red crab fishery and the American lobster fishery will continue under existing permits for up to seven years. The proclamation allows NOAA and US Fish and Wildlife Service three years to prepare a joint management plan. Some implementing regulations related to prohibited and restricted activities may be issued prior to the completion of the management plan.

-NOAA called for 4 Dynamic Management Area (DMA) voluntary speed reduction zones between 01 November 2015 and 31 October 2016:

04/12/2016	25nm NE Boston	04/28/2016	49nm ESE Atlantic City, NJ
04/19/2016	Nahant, MA	08/23/2016	55nm SE of Nantucket
04/28/2016	20nm SU Portsmouth, NH		

Canada

- Environmental Assessment -Sydney Basin and Orpheus Graben Offshore Cape Breton, Nova Scotia

- The Minister of Fisheries and Oceans Canada proposed a Critical Habitat Order under Section 58 of the *Species at Risk Act* (SARA) to protect the critical habitat (Grand Manan and Roseway Basins) of the North Atlantic Right Whale (NARW). A Critical Habitat protection order makes it illegal to destroy critical habitat that is identified in a recovery strategy or action plan. The protection order was posted for

public comment in the spring of 2016. The public comment period is over and awaiting posting of Final Critical habitat protection order.

- The Report on the Progress of Recovery Strategy Implementation for the North Atlantic Right Whale (*Eubalaena glacialis*) in Canadian Waters for the Period 2009-2014 was published.

-The Minister of Fisheries and Oceans posted the Proposed Action Plan for the North Atlantic Right Whale in Canada: Fishery Interactions on the Species at Risk Public Registry for public comment which is now complete.

2016 North Atlantic Right Whale Publications/Reports

Reports and publications that utilized NARWC databases in 2016 are listed and hyperlinked below.

DFO. 2016. Preliminary Estimates of Human-Induced Injury to and Mortality of Cetaceans in Atlantic Canada. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2016/029.

Farmer, N. A., Gowan, T. A., Powell, J. R., & Zoodsma, B. J. 2016. Evaluation of Alternatives to Winter Closure of Black Sea Bass Pot Gear: Projected Impacts on Catch and Risk of Entanglement with North Atlantic Right Whales *Eubalaena glacialis*. *Marine and Coastal Fisheries*, 8(1), 202-221.

Fisheries and Oceans Canada. 2016. Report on the Progress of Recovery Strategy Implementation for the North Atlantic Right Whale (*Eubalaena glacialis*) in Canadian Waters for the Period 2009-2014. Species at Risk Act Recovery Strategy Series. Fisheries and Oceans Canada, Ottawa. iii + 48 pp.

Fleishman, E., Burgman, M., Runge, M.C., Schick, R.S. and Kraus, S. 2016. Expert Elicitation of Population-Level Effects of Disturbance. In *The Effects of Noise on Aquatic Life II* (pp. 295-302). Springer New York.

Henry A.G., Cole T.V.N., Hall L., Ledwell W., Morin D., Reid A. 2016. Serious injury and mortality determinations for baleen whale stocks along the Gulf of Mexico, United States East Coast and Atlantic Canadian Provinces, 2010-2014. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 16-10; 51 p.

Hunt, K.E., Lysiak, N.S., Moore, M.M., Rolland, R.M. 2016. Longitudinal progesterone profiles in baleen from female North Atlantic right whales (*Eubalaena glacialis*) match known calving history. *Conservation Physiology* 4, no. 1: cow014.

Knowlton, A.R., Robbins, J., Landry, S., McKenna, H., Kraus, S.D., and Werner, T.B. 2016. Effects of fishing gear strength on the severity of large whale entanglements. *Conservation Biology* 30: 318-328.

Kraus S.D., Kenney R.D., Mayo C.A., McLellan W.A., Moore M.J., Nowacek D.P. 2016. Recent Scientific Publications Cast Doubt on North Atlantic Right Whale Future. *Front. Mar. Sci.* 3:137. doi: 10.3389/fmars.2016.00137

McDonald, S.L., Lewison, R.L., Read, A.J. 2016. Evaluating the efficacy of environmental legislation: A case study from the US marine mammal Take Reduction Planning process. *Global Ecology and Conservation*, 5, pp.1-11.

McCordic, J.A., Root-Gutteridge, H., Cusano, D.A., Denes, S.L., Parks, S.E. 2016. Calls of North Atlantic right whales *Eubalaena glacialis* contain information on individual identity and age class. *Endangered Species Research* 30: 157-169.

Monsarrat, S., Pennino, M. G., Smith, T. D., Reeves, R. R., Meynard, C. N., Kaplan, D. M., Rodrigues, A. S.L. 2016. A spatially explicit estimate of the prewhaling abundance of the endangered North Atlantic right whale. *Conservation Biology*, 30: 783–791. doi:10.1111/cobi.12664

Oedekoven C., Fleishman E., Hamilton P., Clark J.S., Schick R.S. 2015. Expert elicitation of seasonal abundance of North Atlantic right whales *Eubalaena glacialis* in the mid-Atlantic. *Endang Species Res* 29:51-58

Parks, S.E., Groch, K., Flores, P., Sousa-Lima, R. and Urazghildiiev, I.R. 2016. Humans, Fish, and Whales: How Right Whales Modify Calling Behavior in Response to Shifting Background Noise Conditions. In *The Effects of Noise on Aquatic Life II* (pp. 809-813). Springer New York.

Julie Reimer, Caroline Gravel, Moira W. Brown, Christopher T. Taggart, Mitigating vessel strikes: The problem of the peripatetic whales and the peripatetic fleet, *Marine Policy*, Volume 68, June 2016, Pages 91-99

Rolland R.M., Schick R.S., Pettis H.M., Knowlton A.R., Hamilton P.K., Clark J.S., Kraus S.D. 2016. Health of North Atlantic right whales *Eubalaena glacialis* over three decades: from individual health to demographic and population health trends. *Mar Ecol Prog Ser* 542:265-282

Schick, R.S., Kraus, S.D., Rolland, R.M., Knowlton, A.R., Hamilton, P.K., Pettis, H.M., Thomas, L., Harwood, J., Clark, J.S., 2016. Effects of model formulation on estimates of health in individual right whales (*Eubalaena glacialis*). In *The Effects of Noise on Aquatic Life II* (pp. 977-985). Springer New York.

Schweikert, L. E., Fasick, J. I., Grace, M. S. 2016. Evolutionary loss of cone photoreception in balaenid whales reveals circuit stability in the mammalian retina. *Journal of Comparative Neurology*.

Tennessen J.B., Parks S.E. 2016. Acoustic propagation modeling indicates vocal compensation in noise improves communication range for North Atlantic right whales. *Endang Species Res* 30: 225-237. doi:10.3354/esr00738

Waring G.T., Josephson E., Maze-Foley K., Rosel, P.E., editors. 2016. US Atlantic and Gulf of Mexico Marine Mammal Stock Assessments -- 2015. NOAA Tech Memo NMFS NE 238; 501 p

Wiley, D. N., Mayo, C. A., Maloney, E. M., Moore, M. J. 2016. Vessel strike mitigation lessons from direct observations involving two collisions between noncommercial vessels and North Atlantic right whales (*Eubalaena glacialis*). *Mar Mam Sci*. doi:10.1111/mms.12326

REFERENCES

- Knowlton, A.R., S.D. Kraus, and R.D. Kennney. 1994. Reproduction in North Atlantic right whales (*Eubalaena glacialis*). Canadian Journal of Zoology. Vol. 72:1297-1305.
- Knowlton, A.R., Robbins, J., Landry, S., McKenna, H., Kraus, S.D., and Werner, T.B. 2016. Effects of fishing gear strength on the severity of large whale entanglements. *Conservation Biology* 30: 318-328.
- Kraus S.D., Kenney R.D., Mayo C.A., McLellan W.A., Moore M.J., Nowacek D.P. 2016. Recent Scientific Publications Cast Doubt on North Atlantic Right Whale Future. *Front. Mar. Sci.* 3:137. doi: 10.3389/fmars.2016.00137
- Pace, R. M. I. I., Cole, T. V. N., Henry, A. G. 2014. Incremental fishing gear modifications fail to significantly reduce large whale serious injury rates. *Endang. Spec. Res.* 26, 115–126. doi: 10.3354/esr00635
- Pettis H.M., Rolland R.M., Hamilton P.K., Brault S., Knowlton A.R., Kraus S.D. 2004. Visual health assessment of North Atlantic right whales (*Eubalaena glacialis*) using photographs. *Can J Zool* 82:8-19
- Pettis, H.M. 2009. North Atlantic Right Whale Consortium Annual Report Card (01 November 2007 – 30 April 2009). International Whaling Commission Annual Meeting, May 2009. Reference Document *SC/61/BRG1*.
- Reeves, R.R., Read, A.J., Lowry, L., Katona, S.K., Bonnes, D.J. 2007. Report of the North Atlantic Right Whale Program Review. Marine Mammal Commission. Bethesda, Maryland.
- Robbins, J., Knowlton, A.R., Landry, S. 2015. Apparent survival of North Atlantic right whales after entanglement in fishing gear. *Biological Conservation* 191: 421-427.

Population Estimate Calculation

We have developed standardized criteria that can be applied each year to get a low, middle (best estimate) and upper number of photographed whales in the population as determined from Catalog data. One term needs to be explained to understand these numbers. Whales are given temporary intermatch codes if 1) two or more sightings match each other, and 2) neither have been matched to a catalog whale. Some of these whales will eventually be matched to existing cataloged whales and others will be determined to be “new” to the Catalog and assigned a number. Once an intermatch whale is given a Catalog number, or matched to another intermatch code whale, the intermatch code is made inactive.

LOWER

To determine the lower bound, we simply count the number of unique cataloged whales identified the year before. Because of delays in processing data, this number is generally lower than the eventual total number of whales seen alive in that year.

MIDDLE

The middle bound is determined by summing three categories:

- 1) All whales presumed to be alive in that year (i.e., seen in the last six years),
- 2) Intermatch whales that are likely to be added to the Catalog. This is calculated by first finding all intermatch codes that span two or more years (both those that are active and those that were matched and made inactive), removing all calves and any SEUS whales whose sightings span two years only because they are seen in December and January of the same field season. Then, we determine which of those intermatch whales have Catalog numbers and what percent of those were new to the catalog (i.e. had not been matched to an existing cataloged whale). The remaining, unidentified intermatch whales are then multiplied by that fraction to determine how many are likely new to the Catalog (e.g., if only 20% of the matched intermatch whales were new, then 20% of the unmatched intermatched whales are likely new). That number is then added to the count of calves born more than two years earlier that are unmatched with active intermatch codes (indicating there is enough information to potentially match them in the future). Process changed Oct. 2009.
- 3) Calves from the last two years that have not been cataloged. We make an assessment of whether there is enough photographic information to match them to future sightings and thus assign them a Catalog number. We then sum those that will likely be cataloged.

UPPER

The upper bound is also the sum of three categories:

- 1) All Cataloged whales minus those whose carcasses were identified.
- 2) All active intermatch whales minus calves from the last two years.
- 3) All calves from the last two years minus those known to be dead.