INCIDENT REPORT

North Atlantic Right Whale Mortality Event

Eastern Canada, 2019

CANADIAN WILDLIFE HEALTH COOPERATIVE

RÉSEAU CANADIEN POUR LA SANTÉ DE LA FAUNE

MARINE ANIMAL RESPONSE SOCIETY MARS

RÉSEAU QUÉBÉCOIS D'URGENCES POUR LES MAMMIFÈRES MARINS

Citation:

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

Cover photo: First dead right whale of 2019, 9-year old male, Wolverine, being towed to shore. © Marine Animal Response Society

Incident Report
North Atlantic Right Whale Mortality Event
In Eastern Canada, 2019

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Preface

The following incident report primarily describes history, necropsy findings, and causes of death of North Atlantic right whales which were found dead in and around the Gulf of St. Lawrence during the summer of 2019.

The necropsies were led by veterinary pathologists with the Canadian Wildlife Health Cooperative (CWHC) with assistance with logistics, coordination, and research sample collection and distribution provided by the Marine Animal Response Society (MARS) along with the Réseau québécois d'urgences pour les mammifères marins (RQUMM) and Fisheries and Oceans Canada (DFO). The results of the necropsy findings were analyzed collaboratively among the lead veterinarians of this report and also in consultation with other North American marine mammal experts. The CWHC and MARS coordinated the writing of this report.

Given the repetition of a second mortality event in the Gulf of St. Lawrence (the first being summer 2017), the current Incident report also includes a comprehensive review of surveillance effort and mitigation measures focused on right whales in Canadian waters, as well as a discussion and comparison of various aspects of mortality response between the two events.

The final thoughts and conclusions of this report reflect on the current and potential role of stranding networks in marine mammal conservation in Canada.

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Dedicated to everyone who has reminded us of the importance of challenging the status quo and aiming to set a higher standard.

Executive Summary

Sightings and identification of individual North Atlantic right whales (here after referred to as right whales) in the Gulf of St. Lawrence (GoSL) have been increasing. In 2017, an unprecedented right whale mortality event occurred in the GoSL where 12 right whales were found dead with the primary causes of death for seven whales determined to be due to vessel strike and entanglement in fishing gear. Another right whale mortality event occurred during the summer of 2019 where 9 right whales were found dead in and around the GoSL. The current incident report focuses on the necropsy results for the five right whales which received necropsy investigation in 2019, and also provides context on the other 2019 incidents, right whale conservation, mitigation efforts, and marine animal stranding networks in Canada.

Key Findings:

- From June to July 2019, nine right whales were identified dead, and four live right whales were observed to be entangled in fishing gear in Canadian waters.
- Three of the four entangled whales were responded to by experts and were partially disentangled. A response was not possible for the fourth animal and it was later found dead off New York state, US.
- Five whales received complete necropsies of which four (EG2019-01, EG2019-02, EG2019-03, and EG2019-06) had evidence of severe acute trauma.
- The cause of death for three whales (EG2019-02, EG2019-03, and EG2019-06) was considered probable vessel strike.
- The cause of death of one whale (EG2019-01) was considered suspect vessel strike.
- The cause of death of the fifth whale (EG2019-07) could not be determined.
- Fecal hormones (glucocorticoids, progesterone, estrogen, testosterone, and thyroid hormones) for three whales (EG2019-01, EG2019-02, and EG2019-06) were within normal limits. Fecal samples were not available for EG2019-07.
- Fecal glucocorticoids for one whale (EG2019-03) were significantly elevated implying this whale experienced chronic physiologic stress prior to death.
- No evidence was found to support the involvement of biotoxins, infectious diseases, or starvation as the primary causes of mortality in this investigation.
- Comparison of carcass response between the 2017 and 2019 mortality events indicates significant improvement in rapidity of towing identified carcasses to shore, but continued delay in identifying floating carcasses.
- Early carcass detection and necropsy response are required to continue to improve post mortem investigations, although valuable information can still be obtained from decomposed carcasses.
- Having trained individuals present during initial at-sea investigations of floating carcasses can provide valuable information and clarity that can assist with on shore necropsies.
- More research is needed to understand right whale habitat use in Canada, as well as the human activities in these waters to prevent further right whale deaths.
- Effort should be made to understand the differences in inter-annual mortalities and assess the efficacy of mitigation measures.
- Regional marine mammal response networks provide valuable information about marine animal health and biodiversity. Stable, sufficient, and long-term funding must target gaps and needs identified by Canada’s expert responders to establish a truly national Marine Animal Health Surveillance and Incident Response Program.

Sommaire

L’observation et l'identification de baleines noires de l'Atlantique Nord (les « baleines noires ») ont augmenté dans le golfe du Saint-Laurent (le « golfe »). En 2017, un enchaînement sans précédent de mortalités de baleines noires s'est produit dans le golfe et pas moins de 12 baleines noires ont été retrouvées mortes. Il a été déterminé que la collision avec un navire et l’empêtrement dans du matériel de pêche étaient les principales causes de la mort de sept de ces baleines. Au cours de l’été 2019, une autre suite de mortalités s’est produite, touchant cette fois 9 baleines noires retrouvées mortes dans le golfe et ses alentours. Le présent rapport d'incident porte essentiellement sur les résultats de la nécropsie des 5 baleines noires qui ont fait l'objet d'une expertise en 2019, et présente également le contexte des autres incidents de 2019, de la conservation de la baleine noire, des mesures d'atténuation et des réseaux d’intervention auprès des animaux marins échoués au Canada.

Principales constatations

- De juin à juillet 2019, neuf baleines noires mortes ont été documentés et quatre baleines noires vivantes ont été observées empêtrées dans des engins de pêche dans les eaux canadiennes.
- Des experts sont intervenus auprès de trois des quatre baleines empêtrées, qui ont pu être partiellement désempêtrées. Il n'a pas été possible d’intervenir auprès du quatrième animal, qui a été retrouvé mort au large de l'État de New York, aux États-Unis.
- Cinq baleines ont fait l’objet de nécropsies complètes, dont quatre (EG2019-01, EG2019-02, EG2019-03 et EG2019-06) présentaient des signes de trauma aigu sévère.
- La mort de trois baleines (EG2019-02, EG2019-03 et EG2019-06) a été attribué à une collision probable avec un navire.
- La mort d'une baleine (EG2019-01) a été attribué à une collision présumée avec un navire.
- La cause la mort de la cinquième baleine (EG2019-07) n'a pas pu être déterminée.
- Les hormones présentes dans les échantillons fécaux (glucocorticoïdes, progestérone, œstrogène, testostérone et hormones thyroïdiennes) de trois baleines (EG2019-01, EG2019-02 et EG2019-06) étaient dans les limites normales. Des échantillons fécaux n'étaient pas disponibles pour EG2019-07.
- Les glucocorticoïdes fécaux d'une baleine (EG2019-03) étaient élevés, ce qui permet de supposer que cette baleine a subi un stress physiologique chronique avant sa mort.
- On n’a trouvé aucune preuve de la présence de biotoxines, de maladies infectieuses ou d'inanition comme principales causes de mortalité.
- La comparaison des interventions auprès des carcasses entre les saisons 2017 et 2019 indique une nette amélioration de la rapidité de remorquage des carcasses identifiées vers le rivage, mais un retard persistant dans l'identification des carcasses flottantes.
- La détection précoce des carcasses et la rapidité de la nécropsie sont essentielles à l’amélioration soutenue des processus d’expertises post mortem, bien que des informations précieuses puissent tout de même être obtenues à partir des carcasses décomposées.
- La présence de personnes bien préparées lors d’une expertise initiale en mer sur les carcasses flottantes permet de recueillir des informations précieuses et une précision de renseignements utiles aux nécropsies effectuées à terre.
- Des recherches supplémentaires sont nécessaires pour évaluer correctement l'occupation de l'habitat de la baleine noire au Canada, ainsi que les activités humaines dans ces eaux pour prévenir d'autres décès de baleines noires.
- Il faudrait tenter de mieux comprendre les différences entre les mortalités interannuelles et évaluer l'efficacité des mesures d'atténuation.
- Les réseaux régionaux d’intervention auprès des mammifères marins fournissent des informations précieuses sur la santé des animaux marins et la biodiversité. Du financement stable, suffisant et à long terme devrait servir à combler les lacunes et les besoins exprimés par les experts en interventions du Canada, afin d'établir un véritable programme national de surveillance de la santé des animaux marins et d’intervention en cas d’incidents.

Chapter 1: Introduction

North Atlantic Right whales in Canada

North Atlantic right whales (right whales; *Eubalaena glacialis*) are one of the most endangered whales in the world. Once common in temperate waters of the western North Atlantic, the species was severely depleted by whaling. Since the cessation of whaling, right whales have struggled to recover due primarily to high levels of human-caused mortality. The population is currently estimated to be around 411 individuals, with the population trajectory declining since 2010 (Pace et al., 2017; Pettis et al., 2020). Of particular concern is the difference in trends for males and females in this species where males are more abundant than females due to a higher mortality rate in the latter after age five (Pace et al., 2017). As a result, the species has been federally listed and protected under Schedule 1, Part 2 of the *Species at Risk Act* (SARA) in Canada and the *Endangered Species Act* in the US. In addition, Canada has made numerous other national and international commitments which will benefit right whales through preservation of healthy oceans, protection of marine biodiversity and ensuring sustainability of human activities (e.g., Canada's Nature Legacy, the Oceans Protection Plan, and commitments as signatories of the United Nations Convention on Biological Diversity and the 2030 Agenda for Sustainable Development).

In 2017, an unprecedented mortality event occurred in the GoSL where 12 right whales (herein referred to as right whales) were found dead and five were identified live-entangled. In 2019, another right whale mortality event occurred in the GoSL where nine right whales were found dead and four whales were reported live-entangled. This was despite strong management measures put in place, with the support of intensive research programs. The following section provides an overview of what is known about right whale distribution in eastern Canada and reviews all of the right whale incidents that have been documented in Canadian waters to date.

North Atlantic Right Whale Distribution in Eastern Canada

Right whales are a migratory species and individuals regularly travel along the east coast of North America primarily from eastern Florida to the GoSL and Newfoundland. Despite a seemingly regular use of core habitats along this route, there is no area where all members of the population can be found at a given time (Brillant et al., 2015). As well, the abundance and distribution of whales in these core habitats changes over time, with some areas being used more or less frequently from year to year. In Canadian waters, right whales for many years were predominantly found in the Grand Manan Basin in the Bay of Fundy and Roseway Basin on the Scotian Shelf. The regular seasonal use of these specific habitats resulted in their designation as Critical Habitat (Fisheries and Oceans Canada, 2014). Since 2010, however, there has been a reduction in the sightings and acoustic detections of right whales in these habitats (Davis et al., 2017).

Prior to 2015, there were sporadic sightings of right whales in the GoSL, with fewer than a dozen individuals identified in most years (Figure 1). However, during much of this time there was relatively little dedicated survey effort, with most reports being from opportunistic sightings made by whale watch naturalists, researchers, and the public. The only long-term dedicated research has been conducted by the Mingan Island Cetacean Study (MICS) in an area north

and west of Anticosti Island. As a result, there were significant knowledge gaps regarding distribution, abundance, and threats to the species in the GoSL during this time.

From 2015 to 2017, the surveys by MICS were augmented by researchers from numerous institutions including the New England Aquarium, Canadian Whale Institute, Dalhousie University, University of New Brunswick, DFO's Science and Conservation and Protection (C&P), and the National Oceanic and Atmospheric Administration-Northeast Fisheries Science Centre (NOAA-NEFSC). Results have shown that during this time right whales were increasing their use of the GoSL habitat (data provided by researchers as reported in Fisheries and Oceans Canada, 2019a). Passive acoustic monitoring data collected from June 2010 to November 2018 also demonstrated an increase in the use of the GoSL by right whales (Simard et al., 2019). Simard et al. (2019) found the mean daily occurrence of right whales in the feeding grounds off the Gaspé quadrupled after 2015 compared to 2011-2014.

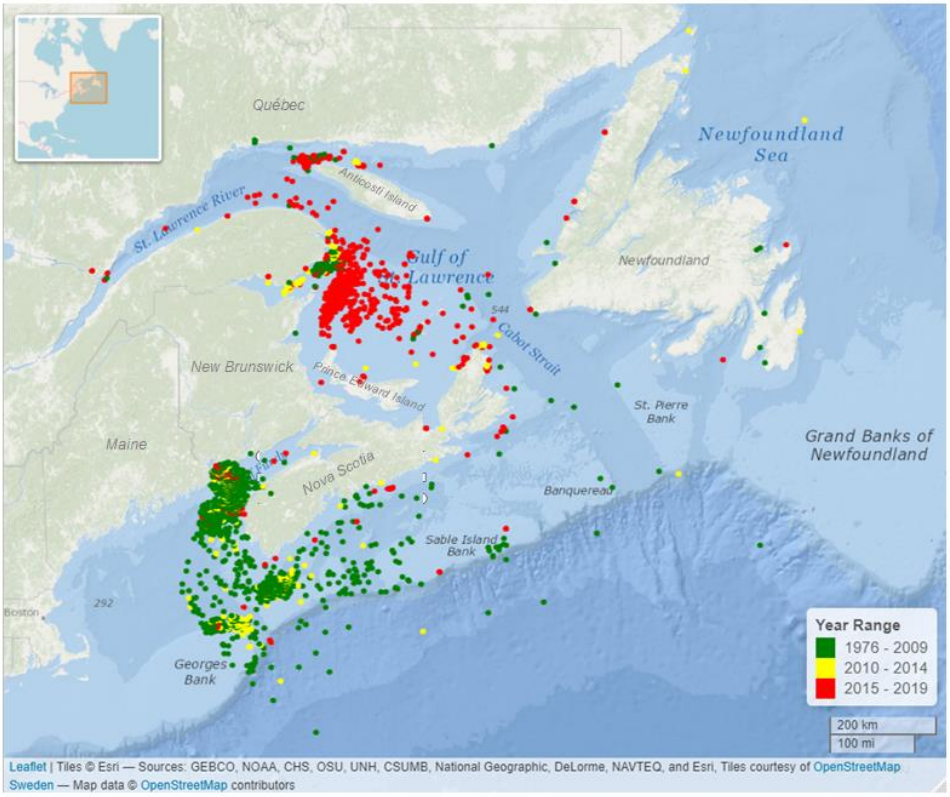


Figure 1: Sightings of North Atlantic right whales in the Gulf of St. Lawrence and Bay of Fundy from 1976 to 2009 (green dots), 2010 to 2014 (yellow dots), and 2015 to 2019 (red dots). Sightings provided by: Right Whale Consortium (2020). North Atlantic Right Whale Consortium Sightings Database 03/04/2020 (Anderson Cabot Center for Ocean Life at the New England Aquarium, Boston, MA, U.S.A.). *Disclaimer: This is a sightings map, not a distribution map. It is not known whether areas without sightings are because of whale absence or lack of surveillance. This map does not include right whale acoustic detections.*

Since the 2017 right whale mass mortality event in the GoSL (Daoust et al., 2017), research effort as well as surveillance by several Canadian federal agencies, the US government and academic institutions have increased substantially in eastern Canada. Aerial surveillance and survey effort by Canadian and US government platforms collectively increased significantly from 2017 to 2018, with similar coverage continuing from 2018 to 2019 (Figure 2). Canadian

government surveys and research (dedicated or opportunistic) from vessel-based platforms have been very similar over the three years, ranging from approximately 600 – 800 hours (Data provided by S. Ratelle, DFO- Gulf; V. Harvey, DFO-Québec; A. Vanderlaan, H. Moors-Murphy and P. Emery, DFO-Maritimes). Areas covered by government surveys and surveillance were quite broad and included the GoSL, Newfoundland, Scotian Shelf, and Bay of Fundy.

Vessel surveys conducted by MICS, New England Aquarium, Canadian Whale Institute, Dalhousie University and the University of New Brunswick in the GoSL in 2017, 2018 and 2019 were composed of 73, 91 and 108 days, respectively (Figure 2; data provided by New England Aquarium and from Johnson, 2018. WhaleMap. Available at: https://whalemap.ocean.dal.ca/. Accessed 23-02-2020)[1].

Note: The focus and objectives vary across these platforms. The presentation of information here is not meant to be a reflection of the effectiveness of the individual platforms or their personnel, but rather to give a general sense of the approximate effort in this region over this period and potential impacts on carcass or live-entangled whale detection. As well, the numbers of search hours or days have not necessarily been filtered by weather, visibility or sea state conditions. This will have an impact on the ability of personnel to detect animals. This information also does not include other platforms of opportunity which often report whale sightings or sightings of dead or distressed animals, including other government platforms and those from the public or industry.

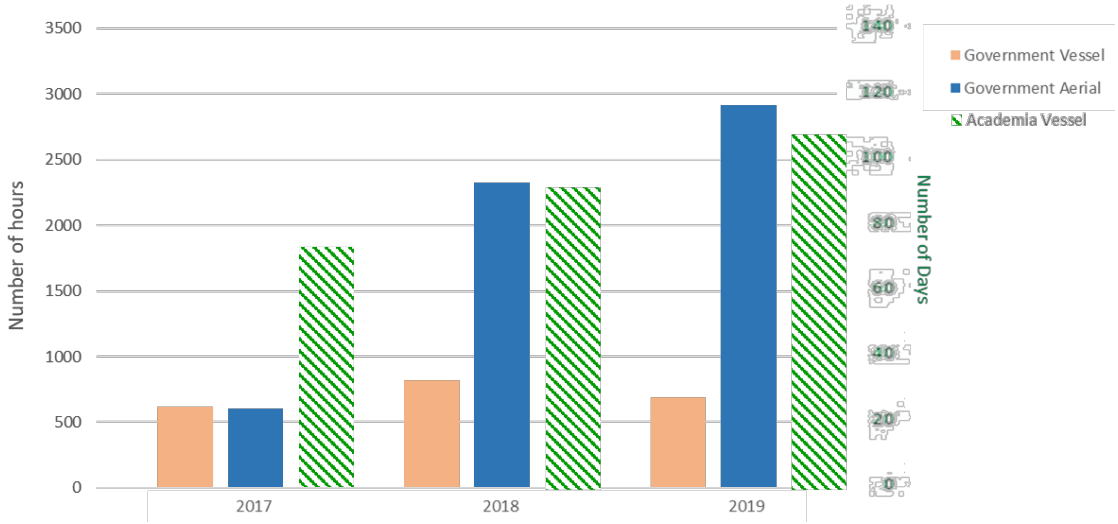


Figure 2. The collective number of surveillance and survey **hours** by government vessel (peach) and aerial (blue) platforms in eastern Canada (DFO-Science and Conservation amd Protection, Transport Canada and the NOAA – NEFSC), aligned with the left axis. The number of collective survey **days** by non-government and academic (green hatched) platforms in the Gulf of St. Lawrence (Mingan Island Cetacean Society, New England Aquarium, Canadian Whale Institute, Dalhousie University, and the University of New Brunswick), aligned with the right axis. Note: left and right axis are not equivalent (e.g. 2000 hrs ≠ 80 days).

[1] *Additional details on government and non-government surveillance and survey effort and timing are provided in Annex A.*

New England Aquarium staff tentatively identified 137, 134, and 135 individual right whales in the GoSL in 2017, 2018, and 2019, respectively[2]. Visual and acoustic surveys indicate that right whales are typically present in eastern Canada from June until January. However, the earliest detections in the GoSL have usually been at the end of April with a peak occurring from August to late October (data provided by researchers as reported in Fisheries and Oceans Canada, 2019a; Simard et al., 2019). The sex ratio of observed whales has not been different from what was expected when compared to the catalogued population (New England Aquarium, pers. comm.). In some years, large numbers of adult females and their calves have been observed, with some suggesting the area may also be important for nursing as well as feeding.

Contemporary Variation of Right Whale Food in Canadian and US Waters

Contributor: Dr. Kimberley T. A. Davies

North Atlantic right whales occupy several regional feeding habitats throughout their foraging range which extends from Southern New England, USA north to the GoSL, Canada (Range: 40 - 50^{o} Latitude). The distribution of right whales throughout their foraging range shifted over a period of roughly 7 years beginning in 2008 in Cape Cod Bay (Mayo et al., 2018), and later extending northward (Davies and Brillant, 2019; Fisheries and Oceans Canada, 2019; Record et al., 2019; Simard et al., 2019). Relative to the previous decades, large changes have occurred in the seasonal timing of habitat occupancy, as well as the density of animals occupying each habitat. These changes have been measured using multi-year time series of both visual and acoustic detections. Some habitats have seen dramatic seasonal increases in right whale occurrence (Cape Cod Bay, Nantucket Shoals, GoSL) (Fisheries and Oceans Canada, 2019; Mayo et al., 2018; Simard et al., 2019), whereas other habitats have seen substantial seasonal decreases in occurrence (Bay of Fundy, Great South Channel, and Roseway Basin) (Davies and Brillant, 2019; Durette-Morin et al., 2019; Record et al., 2019). The Gulf of Maine and western Scotian Shelf have seen the greatest decreases in occurrence, which have occurred during prime feeding periods in spring, summer and early autumn (Record et al., 2019). The range-scale right whale distribution appeared to stabilize around 2015 and has been fairly consistent each year since, however some inter-annual variation has been documented within some habitats (Davies and Brillant, 2019; Fisheries and Oceans Canada, 2019).

Several recent publications have begun to shed light on the causes of the distributional shift (Meyer-Gutbrod and Greene, 2018; Plourde et al., 2019; Record et al., 2019; Sorochan et al., 2019). Right whales are specialist foragers on copepods, and especially lipid rich copepods of the genus *Calanus*. Two species of *Calanus* dominate the mesozooplankton biomass within the right whale foraging range; *C. finmarchicus* and *C. hyperboreus*. Recent studies have found that the abundance of *C. finmarchicus*, which usually dominates the mesozooplankton biomass in the Gulf of Maine, has declined substantially throughout the right whale foraging range (Record et al., 2019; Sorochan et al., 2019). The decline in Jordan Basin in the Gulf of Maine is strongly correlated with the decline in right whale occurrence in the Bay of Fundy (Record et al., 2019). The decline in *C. finmarchicus* abundance occurred during an ocean heat wave that warmed the deep water of the Gulf of Maine and Scotian Shelf (Record et al., 2019; Sorochan et al., 2019), suggesting a climate-driven bottom-up driver of the *C. finmarchicus* decline. Increasing temperature could affect *Calanus* directly through thermal stress, or indirectly through changes in water mass advection or phytoplankton (food) supply.

[2] *Note: The majority of individuals were catalogued, but several uncatalogued animals were also identified in each year.* New England Aquarium, personal communication.

The reason behind the increase in right whale occurrence in the GoSL is less clear. Our research group has been sampling this region since 2017 and found that *Calanus* is abundant near right whales foraging in the region. The GoSL is a relatively cool inland sea and the oceanographic regime differs from that in the Gulf of Maine and Scotian Shelf. It supports populations of both *C. finmarchicus* and *C. hyperboreus* (Plourde et al., 2019). *C. hyperboreus* is a colder water species that is not able to survive in the warm waters of the Gulf of Maine, although it is occasionally present in high abundances on the Scotian Shelf. One hypothesis to explain the increase in occurrence of right whales in the GoSL is that the oceanography in this inland sea has been less affected by recent ocean warming elsewhere. The right whale feeding habitat in the southern GoSL contains sub-zero water temperatures below the thermocline year round, so it is possible that the *Calanus* populations in this region may not be suffering the same level of thermal stress as populations outside of this inland sea. Nevertheless, much research is ongoing and remains to be done to address these questions and their implications for right whale distribution and population trajectory.

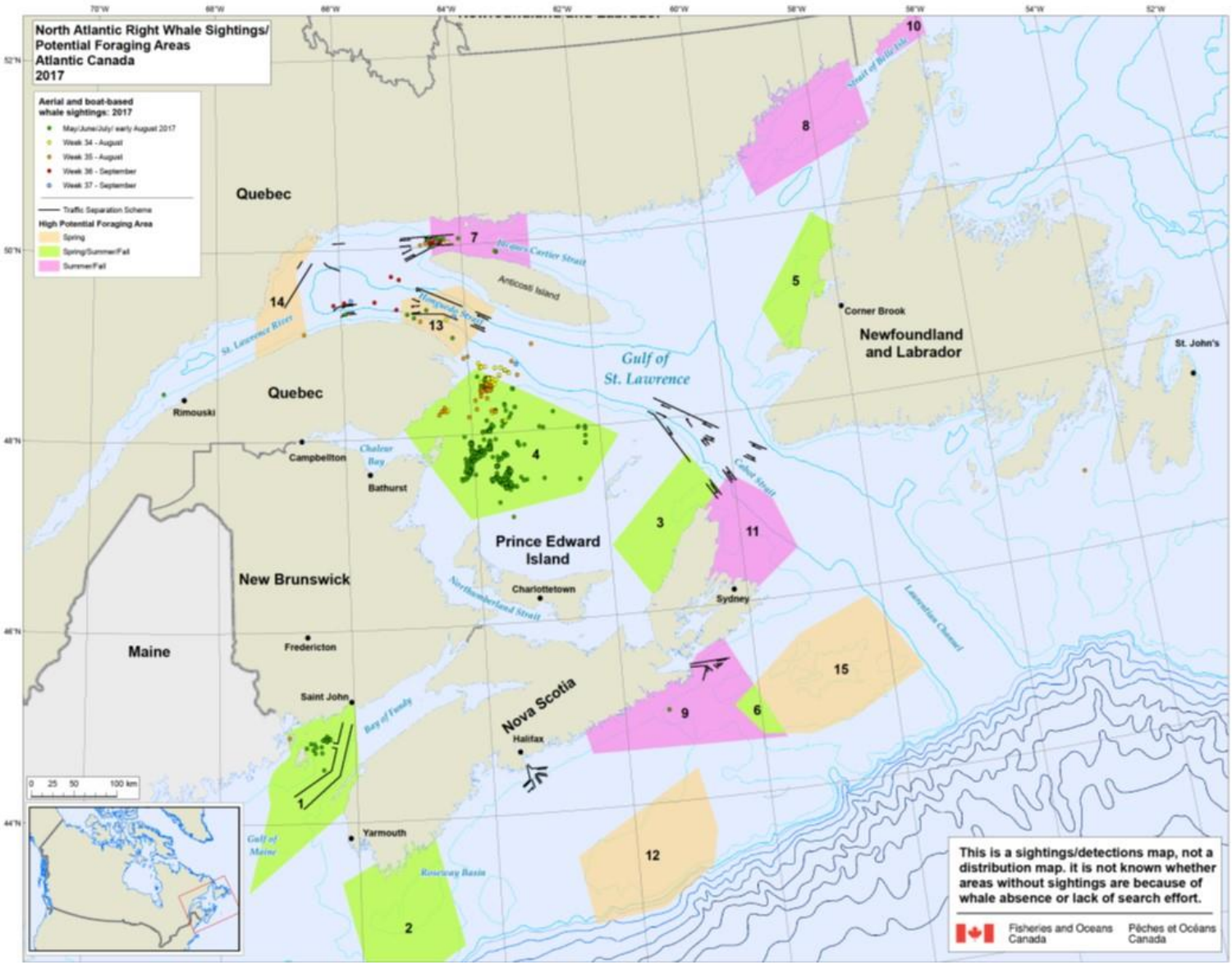


Figure 3: 2017 Sightings of North Atlantic right whales in the GoSLGSL and BoF overlying NARW foraging suitability areas. The latter were added to the map to identify other areas of interest for surveillance of NARW presence (produced by J.-F. Gosselin based on Dr. S. Plourde preliminary analysis, DFO Science). Map includes sightings information from multiple sources including NOAA, CWI, MICS, whale watching companies, for example. Disclaimer: This is a sightings map, not a distribution map. It is not known whether areas without sightings are because of whale absence or lack of surveillance. (DFO Science, unpublished data; as reported in Daoust et al 2017).

Review of Right Whale Mortalities and Entanglements/Entrapments in Canada

Throughout their range in both Canada and the US, right whales are subject to high levels of mortality caused by vessel collisions and entanglement in fishing gear (Daoust et al., 2017; Knowlton and Kraus, 2001; Moore et al., 2004; Sharp et al., 2019). The number of reported right whale mortalities, entanglements, and entrapments (animals captured in man-made structures such as weirs or fishing traps) occurring in eastern Canadian waters has changed dramatically over the past 32 years with 42 right whale mortalities occurring between 1987 to 2019 (Figure 4)[3].

Between 1987- 2014, there were a total of 17 dead right whales reported in eastern Canada, typically only one whale every two to four years with an average of 0.6 individuals annually (Table 1, Annex A; Moore et al., 2004 and Sharp et al., 2019). From 2015 to 2019, there were 25 mortalities with average annual right whale deaths increasing to 5 which is 8 times the number of deaths compared to the 1987 to 2014 time period. Most of the mortalities occurred in 2017 (12 deaths; Daoust et al., 2017) and 2019 when 9 whales died in Canadian waters (this report) and one whale died in US waters that was previously observed entangled in Canadian fishing gear (S. Sharp, Pers. Comm.). Over this 32-year period, 19 animals were male, 17 were female, and 6 were of unknown sex. Where age was known, individuals ranged from 2 – 38 years old.

Of the 42 animals that died in Canadian waters from 1987 to 2019, 26 were examined by trained responders and/or veterinarians. The level of examination varied between carcasses (determined by resource availability and carcass accessibility) and included complete or partial necropsy, photo documentation, and tissue sampling (see Table 2, Annex A). For 19 of the 26 examined mortalities, there was enough evidence to determine a suspect, probable or confirmed cause of death as follows (see Chapter 3 for case definitions):

- 13 vessel strikes (vessel class unknown)
- 6 entanglements, gear information is as follows:
    - 3 snow crab gear
    - 1 Danish seine or snow crab gear
    - 1 unknown, investigated by DFO-C&P but results were not disseminated
    - 1 unknown as no entangling gear was present

For the remaining 6 incidents where only partial examination was possible, as well as the additional 16 cases where an examination or necropsy was not possible, the cause of death could not be determined.

Note: Cases lacking evidence of human interaction cannot be interpreted to mean there were no impacts from human activities due to lack of necropsy analysis, advanced decomposition, or inadequate imagery.

Forty-five incidents involving live entangled or entrapped right whales have been reported since 1999 (Figure 4). From 1999 to 2014, twenty-five incidents involving live right whales in fishing gear and structures were reported, averaging 1.5 individuals annually (see Table 1, Annex A).

[3] *Detailed information on eastern Canadian incidents, including those discussed in the next section from 2019, is provided in Annex A.*

Since 2015, twenty additional entangled or entrapped animals have been reported which is an almost three-fold increase to 4.2 individuals annually. For many incidents, the source of the entangling gear was unknown, either due to the inability of the gear to be retrieved, identified, or the results of investigations not being disseminated. Of the 14 cases where gear was identifiable between 2015 and 2018, snow crab fishing gear was identified to be the entangling gear on half of the whales. Information on the gear involved in the 2019 incidents was not available from DFO at the time this report was being prepared.

Prior to 2015, most reported incidents occurred on the Scotian Shelf or in the Bay of Fundy (see Figure 1, Annex A). Since 2015, there has been an increased number of incidents reported in the GoSL (or related to activities there) including the 2017 and 2019 mortality events (see Figure 4, Annex A). Some of the change in incident distribution may reflect the distribution of research and whale-watch vessels, especially in early years. However, with the introduction of consistent incident reporting hotlines in the last 15-20 years and their accessibility to all marine users, reporting trends overall have plateaued and it is considered that the majority of incidents (where there is someone to observe them) are being reported to these hotlines.

It is important to note that the information presented here does not include animals which have died or were disentangled in US waters (where the cause of death was attributed to a Canadian fishery) nor live individuals who were determined to have sustained serious injuries. Under the US Marine Mammal Protection Act, serious injury is defined (50 CFR 229.2) as “any injury that is more likely than not to result in mortality" (National Marine Fisheries Service, 2012). These animals are highly likely to perish earlier than their natural lifespan and, while they continue to live, they are unlikely to significantly contribute to the right whale population in terms of reproduction (Kraus et al., 2001). The annual rate of human-caused serious injury and mortality in the US and Canada combined during the period of 2013-2017 was 6.85 whales per year for right whales (Henry et al., In Press). This is well above the Potential Biological Removal (PBR) for this species, estimated to be 0.9 individual whales/year (NOAA, 2018).

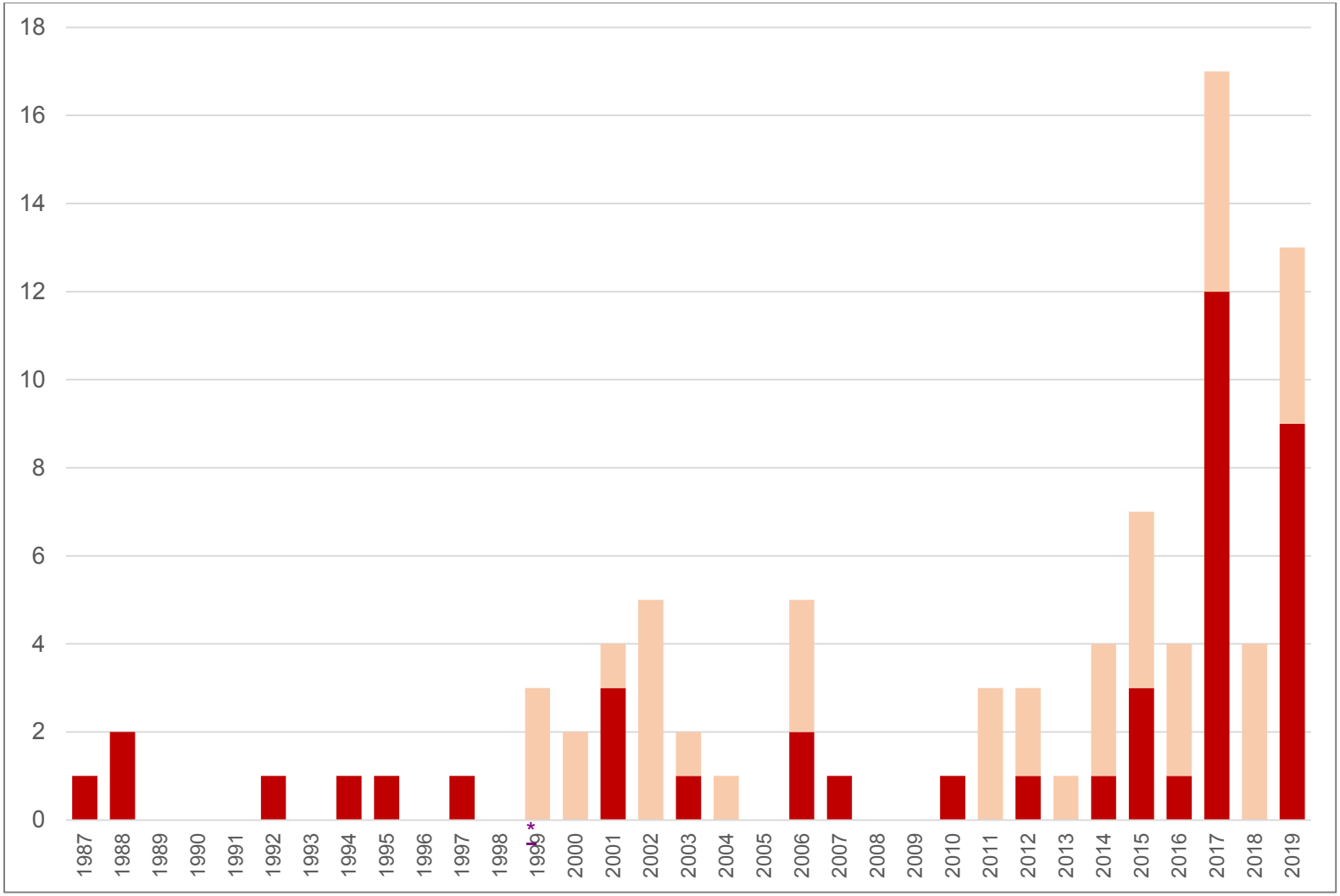


Figure 4. The annual number of reported North Atlantic right whale mortalities (red) or entanglements/entrapments (peach) in Canadian waters from 1987 to 2019. ** Reports regarding entanglements and entrapments are only available since 1999. A lack of incidents prior to this does not indicate that none occurred.*

Chapter 2:
2019 Canadian Incident Timeline

2019 North Atlantic Right Whale Incidents

From June 4th and August 6th, 2019, incidents involving nine dead and four live, free-swimming entangled right whales, were reported in the GoSL. Six dead individuals were observed floating in the GoSL, one was reported ashore on Anticosti Island (Québec), and two were observed floating off the Atlantic coast off Cape Breton Island (Nova Scotia). All four live-entangled right whales were initially reported in the GoSL (Figure 5).

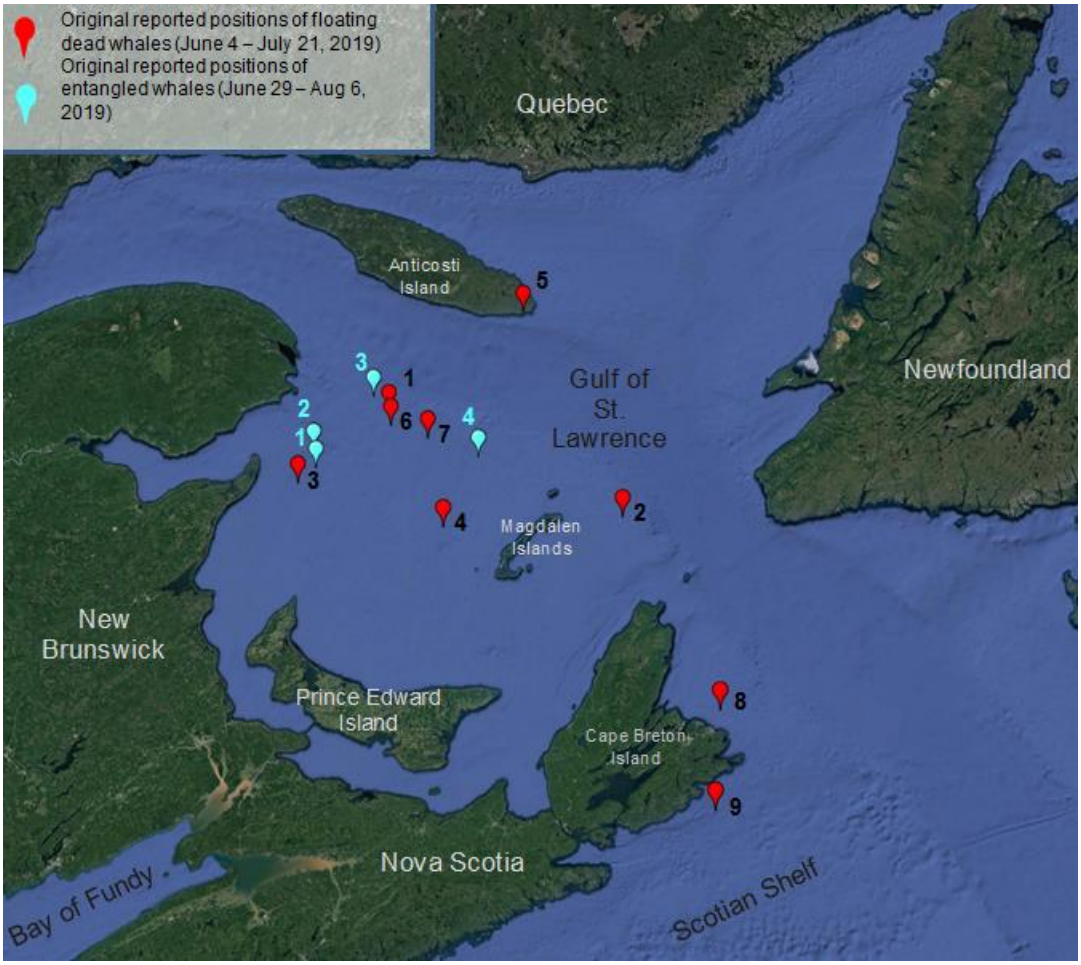


Figure 5. Locations of reported incidents involving dead (red marker, numbered 1-9) and live-entangled (blue marker, numbered 1-4 in blue) North Atlantic right whales in eastern Canada between 4 June – 6 August 2019.

2019 Known Dead Whale Incidents

Nine incidents involving dead right whales were reported from June 4th to July 21st, 2019. Reports were obtained from various sources including DFO and/or NOAA-NEFSC's Aerial Science Surveys, Transport Canada's National Aerial Surveillance Program, DFO Québec's Science Seal Surveys, DFO C&P Aerial Surveillance Program, and local fishermen. The first seven animals were individually identified by colleagues with the New England Aquarium (NEA) and included in the Right Whale Catalog. The last two animals could not be individually identified. There were three males, five females, and one animal of unknown sex. Where known, these animals ranged in age from 9 – 38 years old. Several of the animals had been previously sighted in many of the other core habitats in the US and Canada. Additional information, including the last known sighting prior to death, if known, is provided in Table 1[4].

Eight animals were initially reported floating while one (EG2019-05) was initially reported ashore on Anticosti Island. Whale EG2019-05 was minimally sampled (blubber and baleen samples) by a DFO Science Seal Survey team who was surveying the island at the time.

Five of the eight dead, floating animals were necropsied (see Chapter 3 and Annex C). One other whale, EG2019-04, was not towed ashore for necropsy but several opportunistic samples (vertebrae and bone fragments) were obtained when the carcass came ashore a week later on Îles de la Madeleine on July 31th, 2019.

The final two floating carcasses were reported off northern (EG2019-08, June 24th) and eastern (EG2019-09, 21-July) Cape Breton Island (Figure 5), respectively, but were subsequently lost. Whale EG2019-08 was relatively fresh (External Decomposition Level 1, see Annex I for level definitions), while EG2019-09 was in an advanced state of external decomposition (Level 4). There was very little documentation of these two whales, especially the individual observed on June 24th (EG2019-08). Upon review of available information, experts were not able to conclusively determine that these two whales were the same individual. Thus, following a precautionary approach utilized by global response and research communities, these two animals are considered **separate** individuals[5].

Based on these data, a total of nine individual right whales were reported dead in eastern Canadian waters in 2019.

An additional whale, NEA #1226 (Snake Eyes), was reported live-entangled while in Canadian waters but later is believed to have succumbed to his injuries and died upon his return to US waters (see below). Thus, he represents a 10th whale which most likely either died in Canadian waters or died due to Canadian activities.

The External Decomposition Level (EDL) for reported carcasses ranged from fresh (Level 1) to advanced (Level 4) decomposition (see Annex I for EDL classification). Genetic samples were obtained from all animals that were necropsied as well as from the animal that came ashore on

[4] *Additional details on these individuals is provided in Annex B1.*

[5] *For more details on available information for EG2019-08 and EG2019-09 and the expert determination see Annex D.*

Anticosti Island (EG2019-05). Phalangeal bones and skin were collected from 5 carcasses (EG2019-01, EG2019-02, EG2019-03, EG2019-06 and EG2019-07) while only skin was collected for the animal sampled on Anticosti Island (EG2019-05). A vertebra and various bone fragments were collected from EG2019-04 when it came ashore on Îles de la Madeleine. At the time of report preparation, the samples from EG2019-05 were not processed and those from EG2019-04 were not yet available (it is also unknown if they will be sufficient for genetic analysis). In total, 6 genetic samples were submitted to the North Atlantic Right Whale DNA Bank at Saint Mary's University in Halifax (NS) and analyses conducted by Brenna McLeod and Tim Frasier. Genetic analyses confirmed that the individual whale identifications provided by the New England Aquarium were correct, with no mismatching sexes, haplotypes, or microsatellite loci (see Annex E for complete details).

Table 1. Reported dead North Atlantic right whales in Eastern Canada, June 4th – July 21st, 2019.

Field Number	Response Network Identification Code (if exist)	Date Observed/ Reported	NAEA ID (Name)	External Decomposition Level at Initial Sighting+	Sex	Age	Location	Recovered	Necropsied	Necropsy Date	Last sighting alive prior to death (location)*
EG2019-01	MARS2019-130	04/06/2019	4023 (Wolverine)	1	M	9	48.2500, -63.1383	Y	Y	07//06/19	21/08/2018 (GoSL)
EG2019-02	MARS2019-146	20/06/2019	1281 (Punctuation)	1	F	38+	47.6139, -60.7675	Y	Y	25/06/19	07/06/2019 (GoSL)
EG2019-03	MARS2019-161	25/06/2019	1514 (Comet)	2	M	33+	47.8346, -64.0524	Y	Y	28/06/19	07/06/2019 (GoSL)
EG2019-04	MARS2019-168	25/06/2019	3815	4	F	11	47.5475, -62.5600	N (came ashore)	N	Not examined	07/06/2019 (GoSL)
EG2019-05	MARS2019-169	26/06/2019	3329	3	F	16	49.0777, -61.7912	N (came ashore)	N	Minimal sampling	25/04/2019 (CCB)
EG2019-06	MARS2019-170	27/06/2019	3450 (Clipper)	3	F	16+	48.3493, -63.1655	Y	Y	01/07/19	10/06/2019 (GoSL)
EG2019-07	MARS2019-223	18/07/2019	3421	3	M	15	48.1640, -62.7512	Y	Y	21/07/19	10/06/2019 (GoSL)
EG2019-08	MARS2019-202	24/06/2019	unknown	1	Unk	Unk	46.3250, -59.8750	N	N	Not examined	Unk
EG2019-09	MARS2019-232	21/07/2019	unknown	4	F	Unk	45.6881, -59.9561	N	N	Not examined	Unk

* CCB = Cape Cod Bay and GoSL = Gulf of St. Lawrence

+ See discussion section and Annex A I for level definitions

2019 Known Live-Entangled Whale Incidents

From June 29th to August 6th, four live-entangled right whales were also documented in the GoSL (Figure 5, Table 2) and each whale was individually identified by colleagues with the New England Aquarium. All individuals were male, with ages ranging from 5 to 40 years old. Again, as with the dead animals, many of the individuals had been previously sighted in many of the other core habitats in the US and Canada, including the GoSL. Additional information, including the last known sighting prior to entanglement, if known, is provided in Table 2[6].

Whale #2 (NEA#4423) was known to already be entangled prior to its observation in the Gulf of St. Lawrence on July 4th, 2019. It was previously observed entangled since at least April 25, 2019 in the Great South Channel, though the source of the gear is not known to report authors. Prior to this, the animal was last sighted gear free in the Gulf of St. Lawrence on August 20, 2018. Thus, for the purposes of this report four live-entangled whales were observed in the GoSL in 2019, though only three were reported in the GoSL in 2019 with an entanglement for the first time.

The Campobello Whale Rescue team was deployed to the GoSL to relocate and attempt to disentangle each of these animals, with the assistance of the New England Aquarium/Dalhousie University/University of New Brunswick boat-based research team, DFO/NOAA Aerial surveillance plane, and DFO C&P. The team was able to partially disentangle #4440, #4423 and #3125. Tangly Whales from Newfoundland were deployed to take over disentanglement efforts for #3125 when the animal moved out of the Gulf and onto the Scotian Shelf headed toward the US and they were able to make a series of cuts to loosen the gear on this whale. Once #3125 entered US waters and became accessible, the disentanglement team from the Center for Coastal Studies (assisted by the NEFSC Aerial Surveillance plane) was also able to make a subsequent series of cuts. At last sighting, there was some line remaining on #3125 and it was in poor condition.

Distance from shore and poor sea conditions hindered search and disentanglement efforts for #1226 (Snake Eyes). He was not re-sighted following the initial entanglement report until his carcass was reported off Long Island, New York. A necropsy was performed and his death was determined to be due to entanglement. This animal was last sighted gear free in the GoSL on July 16, 2019. In the interim period between this and the date it was sighted entangled in the GoSL, it is unlikely the animal left Canadian waters.

There currently is no information available from DFO on the origin of the gear on each of the 2019 entangled whales.

[6] *Additional details and images of each whale are provided in Annex B*.

Table 2. Reported live entanglements of North Atlantic right whales in Eastern Canada, June 29 – Aug 6, 2019.

Field Number	Response Network Identification Code	Date observed entangled	NEA ID	Sex	Age	Location	Last seen not entangled+	Documented?	Fishing Gear Identity (if known)	Disentanglement Attempt(s)?	Subsequent sighting date and status
1	MARS2019-171	29/06/2019	4440	M	**5**	47.9452 -63.8808	17/08/2018 (GoSL)	Y	Unknown	Yes – Partially disentangled	14/08/2019 Sighted Gear Free by NOAA/DFO (GoSL)
2*	MARS2019-188	04/07/2019	4423	M	5	48.0666 -63.9180	20/08/2018* (GoSL)	Y	Unknown	Yes – Partially disentangled	29/10/2019 Sighted Gear Free by NOAA/DFO (GoSL)
3	MARS2019-184	04/07/2019	3125	M	18	48.4583 -63.3350	20/03/2019 (CCB)	Y	Unknown	Yes – Partially disentangled~	02/08/2019 Line remaining Poor Condition
4	MARS2019-258	06/08/2019	1226 (Snake Eyes)	M	40+	48.0347 -62.2273	16/07/2019 (GoSL)	Y	Unknown	No	16/09/2019 **Died^**

* This animal was known to already be entangled since at least April 25, 2019 in the Great South Channel. This date represents the first time this individual was observed in Canadian waters. Experts noted that there was no observed change in the configuration of the entangling gear since the initial entanglement report

+ CCB = Cape Cod Bay and GoSL = Gulf of St. Lawrence

~ A satellite monitored telemetry buoy was attached to the trailing gear by the CWI/NEA/Dal/UNB research team on 19 July 2019. Center for Coastal Studies (CCS) monitored the satellite telemetry enabling two disentanglement attempts east of Cape Breton, Canada on July 25 and 26th by Tangly Whales with the assistance of DFO-C&P. The satellite tagged whale then moved into US waters where a disentanglement attempt was made on Aug 2nd about 60 miles east of Cape Cod MA by CCS with the assistance of the NOAA-NEFSC Aerial Surveillance plane and the US Coast Guard
^ #1226 was later found dead off Long Island. He was necropsied with the probable cause of death determined to be due to the entanglement

Chapter 3:
Analysis of 2019 Necropsy Response

In 2019 there were nine right whales reported floating dead or beached in and around the Gulf of St. Lawrence (GoSL), Canada. Of these nine whales, five were available for necropsy and were towed to one of four different on-shore locations which usually corresponded to the closest coastline but also depended on securing permission to perform on site necropsy from local authorities. Details on the signalment and necropsy location for each whale are listed in Table 3. The necropsy numbers are listed as EG2019 followed by the sequential sightings numbers (order in which they were first reported) and New England Aquarium individual identification numbers are listed as "NEA" followed by the catalog number and the whale's given name (if available).

Table 3: Whale identification, signalment, and necropsy date and location for 2019 necropsies.

Whale identification	Sex	Age	Necropsy date and location
EG2019-01, NEA #4021, ("Wolverine")	Male	9	June 7, 2019, Miscou Island, NB
EG2019-02, NEA #1281, ("Punctuation")	Female	38+	June 25, 2019, Petit Étang, NS
EG2019-03, NEA #1514, ("Comet")	Male	33+	June 28, 2019, Norway, PEI
EG2019-06, NEA #3450 ("Clipper")	Female	16+	July 1, 2019, Grand Étang, QC
EG2019-07, NEA #3421 (unnamed)	Male	15	July 21, 2019, Grand Étang, QC

Large Whale Necropsy: The Investigative Process

A necropsy (i.e., autopsy) is defined as a post mortem examination of an animal carcass which systematically identifies lesions (abnormal tissue change) and determines the most likely cause of death. Each lesion is given a morphological diagnosis based on its anatomical location (e.g., hemothorax) which may or may not relate to the cause of death (incidental). When an etiology (defined as the cause of a lesion or condition) cannot be determined with absolute certainty, a list of differential diagnoses may be proposed for each lesion (or spectrum of lesions) which are qualified by their overall probability of occurrence in the context of the case history. For the purposes of this report, the authors have adapted the "confirmed, probable, and suspect" definitions as laid out by Moore et al. (2013) as follows:

- **Confirmed:** Cases where the cause of death (COD) has been witnessed, or cases which display an incontrovertible spectrum of lesions at necropsy where the most parsimonious explanation is consistent with a particular mechanism of serious injury or cause of death.

- **Probable:** Cases which have been found dead (i.e., death is unwitnessed) and which display lesions which are highly consistent with a particular COD but for which the pathogenesis is somewhat unclear due to lack of some critical evidence.

- **Suspect:** Cases which have been found dead and that display lesions consistent with a COD but for which the pathogenesis is substantially unclear due to lack of critical evidence or confounding factors (e.g., advanced post mortem decomposition, no or incomplete necropsy).

- **Open diagnosis:** Cases which have been found dead and have either not received a necropsy, or which have received a complete necropsy but during which no obvious lesions were identified that could be assigned to a particular cause of death.

We added the last definition, open diagnosis, to those of Moore et al. (2013) to take into account one of the following cases (EG2019-07) for which a cause of death could not be identified. The outcome of each necropsy is one or more morphologic diagnoses describing the most significant lesions, an etiologic diagnosis describing the agent(s) that caused the lesions, and an interpretation which explains how and why investigators reached their conclusions. In most cases, the etiologic diagnosis also corresponds to the cause of death. Table 4 details the final and most significant morphologic and etiologic diagnoses that were assigned to each whale.

Table 4: Morphologic diagnoses and associated etiologies related to the cause of death for five of the North Atlantic right whales that died during the 2019 mortality event.

Whale ID	**Morphologic Diagnosis**	**Cause of Death**
EG2019-01, NEA #4021, (“Wolverine”)	1. Abrasion, focally extensive (presumptive) 2. Contusion, focally extensive (presumptive)	Suspect vessel strike
EG2019-02, NEA #1281, (“Punctuation”)	1. Dorsolateral body wall laceration, focally extensive, severe, acute	Probable vessel strike
EG2019-03, NEA#1514, (“Comet”)	1. Internal hemorrhage, severe, acute, (thoracic and intracranial) 2. Tympano-periotic fracture, unilateral, severe, acute, with hemorrhage 3. Contusion, focally extensive, severe, acute	Probable vessel strike
EG2019-06, NEA #3450, (“Clipper”)	1. Hemothorax, severe, acute	Probable vessel strike
EG2019-07, NEA #3421, (unnamed)	1. Open diagnosis	No cause of death identified

These diagnoses were reached through extensive discussions among the pathology and marine mammal experts listed as collaborators on the report. The following synopsis describes the

processes involved in reaching each of the above diagnoses and other considerations pertinent to interpretation of large whale necropsies. Incidental findings (necropsy findings and lesions unrelated to the cause of death) and lesion descriptions for each whale are detailed in the individual necropsy reports provided in Annex C.

Probable Vessel Strike as a Cause of Death in EG2019-02, EG2019-03, and EG2019-06

Necropsy investigations revealed evidence that supports a probable vessel strike as the most likely cause of death in three of the investigated right whales (EG2019-02, EG2019-03, and EG2019-06). All three of these whales were in good body condition based on average annual blubber thickness measurements described by Miller et al. (2011). In the case of EG2019-03 ("Comet") and EG2019-06 ("Clipper"), there was no external evidence of trauma in the form of lacerations or abrasions, and all significant lesions were identified internally. Both of these whales had a large amount of what has been termed "black putty-like material" within and coating the surfaces of the thoracic cavity. This putty is consistent with "cooked" (i.e., has been exposed to markedly elevated heat and pressure within the body cavity), decomposed blood and its presence in large quantities within the thorax implies a perimortem traumatic event (i.e., hemothorax). It has been speculated among some pathologists that this putty material may be consistent with congestion of the thoracic *rete mirabile* (a complex of arteries and veins in close proximity), and therefore represents a normal anatomical structure (Figure 6 shows an example of a *rete* from a bowhead whale). If this were the case, then it would be expected that this putty should be admixed with vascular remnants (which it typically is not) and also be found in equal quantities in non-vessel strike mortalities. Necropsies of whales that have died from non-blunt force trauma causes (e.g., entanglement) do not have similarly abundant putty within the thorax and at most exhibit a thin layer of putty coating thoracic surfaces as might be expected with normal accumulation of blood in the *retia mirabile*. Therefore our interpretation is that large accumulations of black putty-like material within the thorax are consistent with antemortem hemorrhage. Similar hemothorax was observed in three of four right whales necropsied during the 2017 mortality event that had a final etiologic diagnosis of death from suspected or probable vessel strike (Daoust et al., 2017).

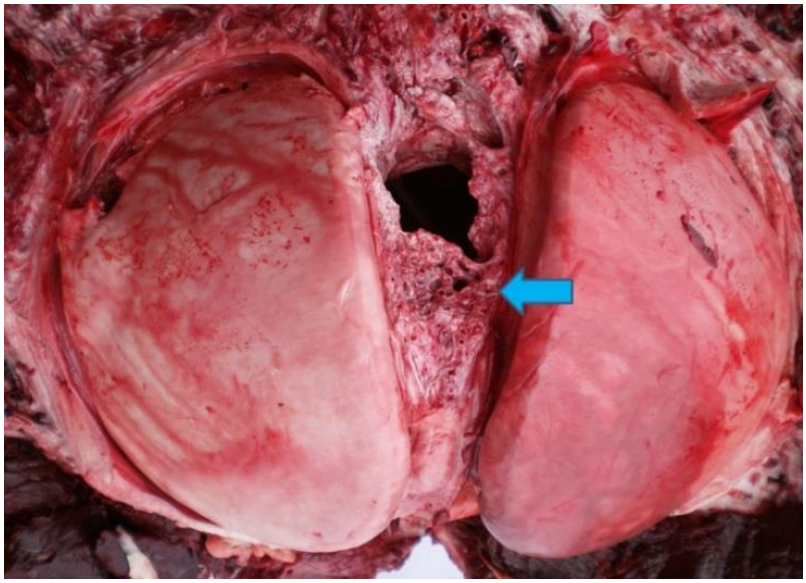


Figure 6. Image of the foramen magnum from the head of a bowhead whale harvested during the annual Inuit bowhead whale hunt in northern Canada showing the *foramen magnum* with

the associated abundant vascular tissue of the epidural *rete mirabile* (blue arrow). The thoracospinal *rete* is believed to be the source of hemorrhage in the thorax and calvarium in cases of vessel strike (Photo curtesy of Simeonie Keenainak and Pierre-Yves Daoust).

Along with the hemothorax, EG2019-03 also had other traumatic lesions including hemorrhage within the cranial vault, fracture of the right tympano-periotic complex, and a severe focally extensive contusion extending along the right mandible and surrounding the caudal skull. The fact that ear bone fracture and mandibular contusion were both on the right side indicates that this was the site of impact.

The necropsy findings of EG2019-02 ("Punctuation") were consistent with antemortem sharp trauma rather than blunt force trauma. From first sighting at sea, it was evident that EG2019-02's carcass had a large laceration/chop wound across its dorsum from which abundant loops of intestine protruded. Previous studies from smaller marine mammals have indicated that careful measurements and analysis of the lacerations can help determine which vessel structure (e.g., propeller, rudder, skeg, keel) caused the laceration and the approximate vessel size (Rommel et al., 2007). Typically, propeller strikes result in multiple parallel cuts which may have an S or Z shape (Rommel et al., 2007). EG2019-2's laceration was a single large (5 m in length) cut that extended cranially along the caudal dorsal region of the peduncle to the left craniolateral abdominal wall. A single cut like this could be generated by either a fixed protruding structure such as a rudder, keel, or skeg, or by a large diameter propeller with a correspondingly large effective pitch (distance traveled in a single revolution of the propeller). Punctuation's laceration had a slight sigmoid curve, suggesting a propeller blade as the lacerating object; however, this is not possible to confirm. Regardless of the impacting structure, the size of the vessel that could cause such a large and deeply penetrating laceration would have to be a category four vessel (> 65 feet) which includes mega yachts, tug boats, ferries, cruise ships, and large shipping vessels (Rommel et al., 2007).

External lacerations may be caused either antemortem or post mortem by vessels impacting the carcass, which makes the determination of the incident timeline particularly important. Unfortunately in partially decomposed carcasses with no antemortem history, it is often only possible to place the time line of lesions within the perimortem interval (either several hours before or after the time of death) (Brooks, 2016). When lacerations occur dorsally (as in the case of EG2019-02), it is suggestive of an antemortem incident, as dead whales quickly turn belly up due to the internal accumulation of gases. With large vessels that have more draft, the blades of the propeller could turn the carcass over, or potentially cut underneath the floating carcass, thereby creating dorsal lacerations post mortem (Alex Costidis, personal communication). Given the large size of EG2019-02's laceration (indicating large vessel size), it is not possible to use only the dorsal positioning of the laceration to indicate an antemortem vs. post mortem strike. Despite this, the tissues protruding from the laceration were still bright red when the whale was first sighted, and there was evidence of hemorrhage coating the exposed surfaces of the epaxial muscles at the margin of the laceration. These findings indicate that EG2019-02's soft tissues were very fresh when the laceration occurred and therefore this laceration occurred either before death or very shortly after (which would be a highly improbable coincidence). Samples of the muscle from the margins of the laceration were unfortunately decomposed and did not reveal any histologic evidence of degenerative changes as has been observed in some experimental studies (Stacy et al., 2015).

We classified each of the above cases as "probable" rather than the more definitive "confirmed" even though significant evidence points to vessel strike in these cases. After careful consideration of the available information, it is our opinion that the more conservative

classification of “probable” is warranted as absolute certainties rarely exist when the mortality events are unwitnessed (or at least unreported) or when carcasses are significantly decomposed. This is consistent with the current literature and best practices concerning interpretation of results from large whale necropsies (Moore et al., 2013; Sharp et al., 2019). Even so, there is strong evidence presented here that supports vessel strike as the most likely cause of death in EG2019-02 (“Punctuation”), EG2019-03 (“Comet”), and EG2019-06 (“Clipper”). Vessels strikes have historically been a significant cause of death in right whales, and were the main cause of death identified in the 2017 right whale mortality event in the GoSL (Daoust et al., 2017; Sharp et al., 2019).

Suspect Vessel Strike in EG2019-01: Pathogenesis of Lethal vs. Sublethal Vessel Strike

EG2019-01(“Wolverine”) was the first right whale to be necropsied in 2019, and its cause of death was initially considered to be “open”, as significant lesions that could have resulted in its death were not immediately identified during its necropsy. Further analysis of necropsy images, and discussion among the attending veterinary pathologists, veterinarians, and biologists, have revealed a pattern of lesions which are considered to be suspicious of a vessel strike. These lesions were focused on a dorsolateral area just caudal to the left eye and included a superficial, hemorrhagic skin abrasion running perpendicular to the long axis of the whale, multiple coalescing areas of reddening of the underlying blubber, and a large focally extensive contusion underneath the aponeurosis and extending into the adjacent epaxial muscle (see necropsy report #1, Annex C). Taken together, this spectrum of lesions strongly suggests that EG2019-01 experienced a traumatic impact just behind the blowhole close to the time of its death. We consider this to be a suspect vessel strike, rather than probable, as histologic support for these lesions was not obtained, and it is possible that some or all may be either mimicked by post mortem change or caused by some other type of trauma. In fresh carcasses, histology can be used to differentiate between contusions and lividity, however EG2019-01’s samples from this area were non-diagnostic (hence the use of “presumptive” in the morphologic diagnosis of Wolverine’s contusion). EG2019-01 was otherwise in good body condition and did not exhibit elevated fecal glucocorticoids, findings that are supportive of an acute cause of death (see Fecal Hormone Analysis section below).

Unlike the previously described right whale mortalities (EG2019-02, EG2019-03, and EG2019-06) where the lesions identified at necropsy were severe enough (e.g., massive hemothorax) to directly result in death, the lesions identified in EG2019-01 were not severe enough to have resulted in death on their own. We are therefore faced with the conclusion that EG2019-01 was an otherwise healthy young whale (in good body condition and not experiencing chronic stress) that died acutely either due to a cause unrelated to vessel strike, or due to an unknown complication of the suspected strike. The location of EG2019-01’s contusion has led to some speculation of neuro-trauma in its case, and so the pathogenesis of neuro-trauma is briefly reviewed here.

The pathophysiology of concussion (defined as a transient loss of consciousness following a sudden injury to the head) is well documented in humans and in non-human primates, in which the ratio of mass of the entire head compared to that of the brain is very low (compared to large whales) (Miller and Zachary, 2017). This low ratio, in combination with a relatively mobile neck, permits relatively mild head trauma (i.e., trauma causing minimal damage to the skull and soft tissues) to transmit kinetic energy into the brain resulting in a variety of pathophysiologic changes that lead to temporary or permanent loss of consciousness and reflex activity (Cantile and Sameh, 2016). If the same processes occurred in large whales, possible complications of “mild” head trauma could therefore theoretically involve temporary loss of consciousness with

subsequent drowning. However, in our opinion, the unique cranial anatomical characteristics of large whales make this scenario unlikely (Figure 7). Unlike humans who have a low head to brain mass ratio, large whales (and in particular right whales) have a comparatively very large skull with abundant skeletal muscle, fibroelastic tissue, and thick blubber. This means that kinetic energy generated by mild trauma is more likely to be absorbed into the surrounding soft tissues before it reaches their relatively small cranium (Miller and Zachary, 2017). As a consequence, significantly greater force would be required for kinetic energy to reach the whale's nervous system which would make any intervening soft tissues or bone more likely to evidence severe damage grossly (fractures, contusions).

With the exception of shock waves caused by intrathoracic grenade detonation during commercial whaling activities, convincing cases of neuro-trauma lacking significant associated skull fractures have not been described in large whales to our knowledge (Knudsen, 2005). It is possible that a spectrum of lesions exists (ranging from mild contusions to severe musculoskeletal fractures) which may result in neuro-trauma, however where on this spectrum EG2019-01's lesions lie is not known. Currently, answering questions related to concussion in large whales is next to impossible as there is almost never any intact brain tissue available for assessment at necropsy (as was the case in all whales examined in 2019). Computer models that simulate the biomechanical forces acting on whales during vessel strikes would greatly advance our understanding of the pathogenesis and various sequelae of vessel strike. It must be stated that even if EG2019-01 could have died as a result of concussion, it should not be immediately assumed that this is what occurred without concrete evidence to support it.

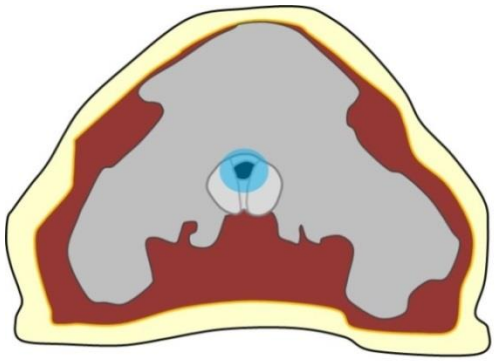


Figure 7: This figure was drawn to scale from an image taken from the caudal surface of EG2019-03 ("Comet") skull. It is meant to demonstrate the relative ratios of the soft tissues and skull that surround the comparatively small cranial vault that contains the right whale brain (indicated by the blue circle). The yellow, red, and gray colours correspond to blubber, skeletal muscle, and skull bone respectively.

Open Diagnosis and Incidental Findings in EG2019-07 (NEA#3421)

A cause of death could not be determined for EG2019-07 despite a complete necropsy investigation. EG2019-07 was in good body condition, implying that it did not suffer from chronic conditions that could impair its ability to forage. Unfortunately its entire gastrointestinal tract was missing and so feces were not available for fecal steroid or biotoxin analysis (although baleen and blubber will be analyzed for this purpose at a later date). Regardless, it is likely that EG2019-07 experienced an acute death, rather than a prolonged illness which would have been indicated by reduced blubber thickness. EG2019-07's entire carcass was dissected and its skeleton disarticulated (including the head) and did not exhibit any evidence of possible trauma such as lacerations, contusions, internal hemorrhage, or bone fractures. An important

differential diagnosis to consider in any whale with no obvious lesions at necropsy is peracute underwater entrapment secondary to entanglement. It is known that three other whales became entangled in 2019, likely in the same region where EG2019-07 was found dead. Typically entanglement of right whales is a chronic process that culminates in eventual emaciation and drowning (van der Hoop et al. 2017). It is possible that a whale's ability to drag gear could be impaired (i.e., disease, emaciation, heavy gear, etc.) and result in more rapid drowning, however this would be unlikely in an apparently healthy adult like EG2019-07 that had no gear on its body when he was first sighted. It is also unlikely for gear in a severely entangled whale to fall off unless removed by mechanical means. Other causes of acute death for EG2019-07 could include infectious disease, biotoxin exposure, and/or metabolic or physiologic abnormalities. It is almost always impossible to rule out these diagnoses during large whale necropsies due to the confounding issues of decomposition and rapid expulsion of internal organs through the oral cavity and anus.

At the time of this report, there is no evidence to indicate any differential diagnosis as being more likely than the others in EG2019-07's death. An interesting yet incidental lesion identified during EG2019-07's necropsy was an area of marked periosteal proliferation (new bone growth) that encased the 12th and 13th lumbar vertebrae, resulting in the complete fusion of their vertebral bodies. This is an unusual lesion, and has been identified in right whales, once previously in a juvenile which had been suspected of suffering from chronic entanglement that resulted in deformation of the vertebral column (Sharp et al., 2019). The linear symmetry of EG2019-07's vertebral column was not disrupted by this lesion and it is therefore unlikely that it significantly impacted its locomotory capacity or in any way led to its death. Possible causes of this lesion include localized infection, past trauma, or degenerative disease (see EG2019-07 necropsy report for further discussion and images of this lesion, Annex C).

Body Condition and Emaciation/Starvation Analysis

The evaluation of the body condition of these whales was based on systematically measured blubber thicknesses as described by McLellan et al. (2004). Assessment of blubber thicknesses was based on annual seasonal blubber measurements from free-ranging right whales as described by Miller et al. (2011). All five whales were determined to be in seasonally robust body condition as indicated by convex epaxial muscles and blubber thicknesses taken at the mid-dorsal and mid-ventral regions (see Table 5 below). This indicates that emaciation/starvation was not a factor in the deaths of any of these whales.

Table 5: Mid dorsal and mid ventral blubber thicknesses measured during necropsy.

Whale ID	Blubber thickness, mid-dorsal (cm)	Blubber thickness, mid-ventral (cm)
EG2019-01, #4021, "Wolverine"	15	14.5
EG2019-02, #1281, "Punctuation"	15	22
EG2019-03, #1514, "Comet"	13.8	18.5
EG2019-06, #3450, "Clipper"	13	18
EG2019-07, #3421, (unnamed)	14	18.5

Fecal Hormone Analysis – Stress, Reproduction, and Nutrition

Several important hormones accumulate in the feces of large whales, which can be sampled and analyzed to draw conclusions about the overall physiologic, nutritional, and reproductive state of whales in the days prior to death (Rolland et al., 2017, 2005). Results of the following hormonal analyses were kindly provided by the Anderson Cabot Center for Ocean Life at the New England Aquarium and the original report is available in Annex G. Table 6 lists the fecal concentrations of various hormones as determined through radioimmunoassay and enzyme-linked immunoassay.

Table 6: Fecal hormone concentrations provided by the New England Aquarium.

Whale ID	Progesterone (ng/g)	Testosterone (ng/g)	Estrogens (ng/g)	GCs* (ng/g)	Thyroid (ng/g)
EG2019-01, #4021, “Wolverine”	265.2	3505.9	72.78	33.1	30.9
EG2019-02, #1281, “Punctuation”	362.1	137.3	19.50	26.2	9.5
EG2019-03, #1514, “Comet”	370.3	175.5	33.92	272.6	23.6
EG2019-06, #3450, “Clipper”	266.2	56.2	61.00	12.5	8.8

*Glucocorticoids

For EG2019-01, EG2019-02, and EG2019-06, fecal glucocorticoids (a marker of physiologic stress) were within the normal limits expected for healthy, free ranging right whales, as well as whales that died acutely due to vessel strike (normal range = 13–112 ng/g, n = 5) (Rolland et al., 2017). This is consistent with the diagnoses of suspect and probable vessel strike in these whales. For EG2019-03 however, fecal glucocorticoids were significantly elevated (272.6 ng/g) above that which is observed in whales that died acutely. This result indicates, despite this whale’s probable acute death due to vessel strike, that it experienced increased physiologic stress within the days leading up to its death or over a longer period of time due to some unknown cause. An interesting observation that may explain this finding is the presence of several poorly healing wounds located on the leading edges of each fluke and on the leading edge of the left flipper. The location and nature of each of these lesions is consistent with a previous episode of entanglement. Retrospective analysis of images of this whale at the New England Aquarium demonstrates similar fluke ulcers have been present at these locations since 2005 when an entanglement event was documented Amy Knowlton, personal communication). Similar ulcers were identified in 2006, 2009, 2017, and 2018 (see Annex H for images). No entanglements have been observed in this whale since 2005, although it had obtained numerous other entanglement scars on its body wall, peduncle, oral cavity which were well healed. Given how well right whales are able to heal superficial wounds, it is unusual for wounds like these to remain open for a prolonged period of time (years). In general, causes of poor wound healing can be due to anatomical locations where tissues experience recurrent strain and stretching that prevents re-epithelialization and closure of the wound bed (as would occur on the flukes). It can also be caused by underlying health factors such as prolonged stress and poor nutrition causing immune suppression and subsequent poor wound healing. In this case, it is therefore possible that the increased fecal glucocorticoids for EG2019-03 could have been caused by a number of factors including pain from chronically open wounds, poor health, or potentially due to an undocumented entanglement in the recent past.

EG2019-02 (“Punctuation”) was a very productive female during her long life and there was some question of whether or not she was pregnant at the time of her death. Fecal progesterone levels for both EG2019-02 and EG2019-06 were within the limits of non-reproductive/non-lactating adult female right whales (295 ± 145 ng/g), and well below those of confirmed pregnant females (201,240 ± 27,025 ng/g; Rolland et al. 2005), indicating that neither whale was pregnant at the time of death. All four whales had fecal thyroid hormone levels below average levels that have been recorded for right whales (~50-60 ng/g) which are consistent with a newly observed trend in the population that may be reflective of an overall reduction in nutritional state for the population. Feces from EG2019-07 (NEA#3421) were not available for fecal hormone testing as the gastrointestinal tract was absent at necropsy although other samples were collected (baleen, skin) which will be analyzed for hormone concentrations in the future.

Fecal Algal Biotoxin Analysis – Paralytic Shellfish Toxins, Amnesic Shellfish Toxins, and Lipophilic Shellfish Toxins

Harmful algal blooms produce a wide array of biotoxins which can cause mass mortality events in marine species. Feces from EG2019-01, EG2019-02, EG2019-03, and EG2019-06 were screened by the Canadian Food Inspection Agency (CFIA) for several different groups of algal biotoxins (paralytic shellfish toxins, amnesic shellfish toxins (domoic acid), and lipophilic shellfish toxins) to rule out these agents as factors involved with the 2019 right whale mortality event in the GoSL. The original CFIA reports are available in Annex F. Feces from whales EG2019-01, EG2019-02, and EG2019-03 were negative for all tested biotoxins. Feces from EG2019-06 (“Clipper”) contained a low concentration (0.09 µg STXdiHCl eq/g feces) of a single paralytic shellfish toxin, Neosaxitoxin. Low concentrations (0.165 ± 0.24 µg STXeq./g feces) of paralytic shellfish toxins are commonly identified in the feces of free swimming right whales, and it is unknown at this time what their long term significance may be for population health (Doucette et al., 2012). It is unlikely however, that the low concentration identified in the feces of EG2019-06 had any impact on its cause of death (probable vessel strike). Feces from EG2019-07 (NEA#3421) were not available for fecal biotoxin testing as the gastrointestinal tract was absent at necropsy.

Right Whale Carcasses That Were Not Necropsied – EG2019-04, EG2019-05, EG2019-08, and EG2019-09

Whales EG2019-04, EG2019-05, EG2019-08, and EG2019-09 were not available for necropsy for different reasons. EG2019-02 through EG2019-06 were first observed dead in and around the GoSL within the same time frame (three days, June 25th to June 27th). Although it is preferred that all identified right whale carcasses (regardless of state of decomposition) receive complete necropsies, the logistical reality of having to assess and necropsy five dead right whales that are simultaneously identified floating offshore demanded that each carcass be ranked and prioritized according to it respective degree of decomposition. To put this need for prioritization into perspective, necropsy response for dead floating whales requires at a minimum three days (assuming weather and towing condition are optimal) and typically involves necropsy personnel traveling to the necropsy site (which may occur anywhere around the GoSL)on day 1, the necropsy taking place and hopefully being completed on day 2, and then the necropsy team traveling home for sample processing on day 3. If there are any complications in securing any number of the resources necessary for necropsy (such as necropsy location, excavators, towing vessels, disposal facilities, and necropsy personnel), or if there are adverse weather conditions or any other conditions which render necropsy procedures unsafe, then more time (days to weeks) will be required.

Accordingly, as EG2019-04 was in a significantly advanced state of decomposition compared to the other whales (flattened with no adherent skin), it was elected to be left floating to allow resources and personnel to focus on the better preserved whales. After floating in the GoSL for a month, EG2019-04 was subsequently lost, and then later found beached on the Îles de la Madeleine where several bones were collected. EG2019-05 was first sighted beached on the south shore of Anticosti Island (located in the mouth of the St. Lawrence River estuary) by a DFO Science team that discovered the whale during an aerial seal survey of the island. This team then landed on the island to document the whale and to collect images and samples of skin and baleen. This carcass was deemed inaccessible for complete necropsy and subsequently could not be relocated. EG2019-08 was originally sighted by a fisherman on June 24 floating off Glace Bay (Cape Breton Island, NS) however it was initially not identified as a right whale until subsequent imagery was available, at which point it was lost. EG2019-09 was sighted off Eastern Cape Breton Island on July 21 and was in an advanced state of decomposition (flat carcass with no skin). Minimal at sea sampling was attempted for EG2019-09 by DFO C&P, however bone from the flipper was not obtained due to sampling error and so genetic analysis could not be performed. Towing and complete on shore necropsy were not pursued for this whale due to its advanced state of decomposition (see Annex D for complete descriptions of EG2019-08 and EG2019-09).

At Sea Assessment and Sampling of Floating Right Whale Carcasses

There will always be a delay between first carcass sighting and necropsy, due to weather and logistics associated with carcass towing and preparing the necropsy site preparation, including personnel, location identification, and necessary equipment. Even under the best circumstances, a delay of at least 2 to 3 days is inevitable, during which a significant amount of decomposition can develop. Ideally all carcasses (regardless of level of decomposition) should be tagged or marked and sampled for DNA (skin or finger bones/phalanges) as soon after they are first located as possible to prevent later confusion when/if carcasses become lost. However, there is potentially much more to be gained from initial at sea assessment of carcasses and so it is therefore worthwhile discussing what types of assessment and sampling can be performed during this period when carcasses are in their freshest state. This is **not** to suggest that at sea investigation should replace a complete on land necropsy, but it can provide insurance against those carcasses which become lost prior to towing for necropsy, as well as providing important information that can assist the necropsy investigation.

Three of the right whales that died in 2019 (EG2019-01, -02, -09) provide important examples of why at sea investigations performed by experienced personnel should be made a priority during any future right whale mortality events. Descriptions of these cases are as follows:

1. **EG2019-01 (“Wolverine”):** Communication with the initial observers in the surveillance plane indicated that there was a large amount of red fluid colouring the water surrounding the head of this whale when it was first identified. A large amount of red fluid may be suggestive of hemorrhage from the oral cavity and possible rupture of the oral vascular *rete*, however this may also be mimicked by post mortem decomposition fluids escaping the body via the oral cavity. Unfortunately, photo documentation failed to convey the colour of the liquid surrounding this whale which appeared more dark brown than red. Despite this, those who first observed the animal maintain that photo documentation did not accurately represent what was observed in real life.

2. **EG2019-02 (“Punctuation”):** From first sighting it was apparent that this whale had a large penetrating laceration in its side from which abundant soft tissues and intestine

protruded. Assessment and sampling of the wound margins in cases of sharp trauma is essential as it can provide evidence that supports antemortem rather than post mortem trauma. At sea sampling was attempted by DFO-C&P officers but unfortunately the obtained specimens were non-diagnostic, despite the officers' best efforts. This type of sampling necessarily requires an understanding of anatomy and the sampling methods needed to achieve optimal histopathology, and so it is not surprising that this would have proven challenging for individuals unfamiliar with the process.

3. **EG2019-09 (unidentified):** This whale was first sighted on July 21 in an advanced state of decomposition. Because of its relative position to EG2019-08, it was suspected to be the same whale (see Annex D for details). Genetic sampling was recommended for this whale to attempt identification; however, experts were not consulted prior to sampling and samples of bone (necessary for genetic analysis in decomposed carcasses) were not obtained during sampling.

Each of the above whales represents a situation during initial at sea responses which would benefit from having trained personnel present to assist with the data and sample collection. Trained personnel would be able to oversee and assist with species identification, photo documentation, and sampling for a variety of purposes including genetics, histopathology, and research. As large whale mortality response improves, and more carcasses are detected in a fresher state, it is probable that more situations will arise that would benefit from the presence of specialists during initial at sea investigations. Fresher carcasses tend to have intact skin which more readily exhibits lesions that may become lost with decomposition, towing, and gear removal. For example, acute entanglement impressions and abrasions are subtle and may require trained personnel for interpretation. In other situations when gear is present on the animal, trained personnel are required for appropriate gear, entanglement, and lesion documentation. Although at times logistically challenging, every effort should be made to include trained personnel on board vessels involved with at sea investigations, especially prior to gear being removed or animals towed.

Necropsy Analysis Concluding Statement

Vessel strikes were identified as the probable cause of death in 3 of the 5 whales examined, and as the suspect cause of death in a fourth whale. These findings suggest that vessel strikes were a major cause of mortality in North Atlantic right whales that died in the GoSL in 2019. Mitigation measures aiming at decreasing the risks of fatal vessel interaction should be pursued in order to minimize the impact of anthropogenic mortality on this critically endangered population. It should be remembered that, although a cause of death (probable or suspect) was determined for four whales, a cause of death was not determined in the remaining five whales and so causes of death (vessel strike, entanglement, infectious disease etc.) cannot be ruled out for these whales.

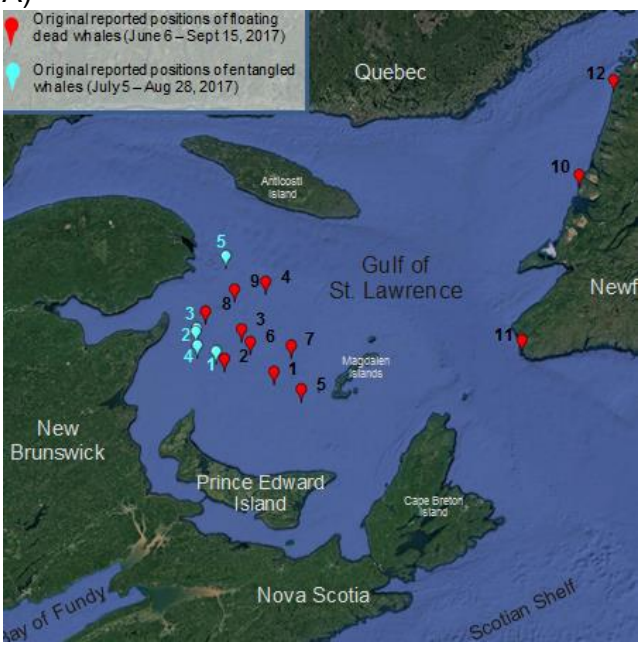
Chapter 4:
Comparison of 2017 and 2019 Incidents

The increasing trends in anthropogenic causes of mortality in this species are alarming and unsustainable given that the Potential Biological Removal (PBR) limit for right whales is less than one per year (NOAA, 2018). Canada has invested significantly in the implementation of mitigation measures to improve right whale protection in our waters and prevent further mortalities and entanglements (Brillant et al., 2017; Davies and Brillant, 2019). Since 2017, mitigation measures have been implemented each year with varying success in preventing right whale mortalities and entanglements. It therefore behooves federal departments and regional response groups to review various aspects of previous mortality events to determine effectiveness of mitigation measures, surveillance, and response efforts to ensure continued improvement in right whale conservation moving forward. The following sections compare various aspects of the 2017 and 2019 mortality events including surveillance effort, carcass detection, and necropsy response.

Carcass Distribution, Timeline, and Cause of Death

The majority of incidents that were reported in eastern Canada in both 2017 and 2019 occurred in the GoSL (Figure 8), with 12 dead animals reported in 2017 and 9 in 2019. The observed sex ratio of the dead animals was opposite in 2019 (33% males, 56% females) to that observed in 2017 (67% males, 33% females). There was one animal in 2019 for which the sex could not be determined.

A)



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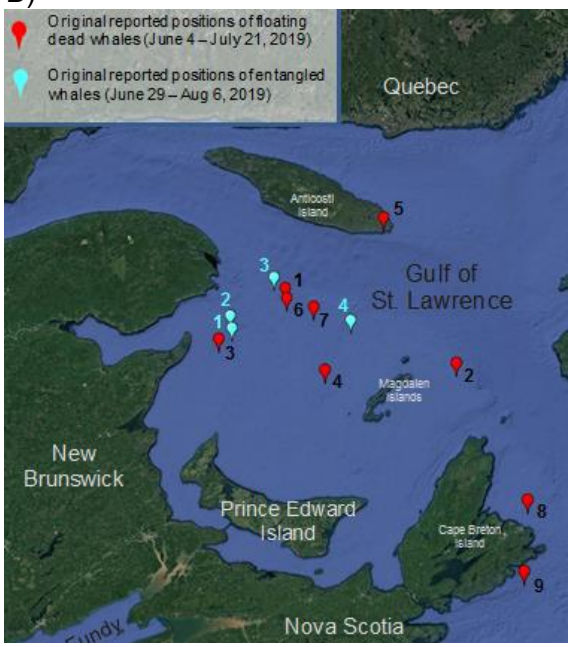

Figure 8. Reported mortalities (red) and entanglements (blue) of North Atlantic right whales in eastern Canadian waters during the (A) 2017 and (B) 2019 mortality events in eastern Canada.

The onset of the mortality incidents was almost identical in both years with the first carcass in 2017 reported on June 6th whereas in 2019 it occurred on June 4th. The duration of reported mortalities in 2017 extended to September 15th whereas in 2019, the final detected mortality occurred on July 21st (see Table 2, Annex A). In both years, the majority of deaths occurred from June 18 to the 27th.

In 2017, most of the reported mortalities were centered on an area in the southern GoSL. The exceptions to this were the carcasses which came ashore in western Newfoundland, all of which were in a very advanced state of decomposition. One of these carcasses was genetically determined to be the same as a carcass that was initially reported floating in the southern Gulf. In 2019, carcasses were spread out over a wider area of the Gulf and extended into both northern and eastern regions including the Cabot Strait and the Scotian Shelf off eastern Cape Breton (Figure 8).

Of the 12 carcasses discovered in 2017, seven were necropsied. Findings indicated that four animals died due to trauma from vessel strikes and two from entanglement in snow crab fishing gear. For one animal necropsied, the cause of death could not be determined. In 2019, five of the nine animals were necropsied. Of these, four animals were determined to have died due to trauma from vessel strikes. The cause of death of the remaining necropsied animal could not be determined.

Surveillance and Survey Effort

Since 2018, both Canadian and American governments as well as non-government and academic institutions have invested considerable time and financial support into surveillance and surveys of right whales in the GoSL, particularly aerial surveillance (see Annex A). This surveillance effort is critical and is the primary means for determining the population size and distribution, and estimating the annual mortality rate. Survey and surveillance effort can be assessed in a variety of ways including spatial distribution, number of dedicated days/hours on the water, as well as time of year.

Since the 2017 mortality event, the spatial distribution of survey and surveillance effort for right whales in the GoSL has varied, often with large regions lacking coverage at any given time (see Figures 10 and 11, Annex A). Government aerial surveys have tended to have broader coverage as compared to boat-based government and non-government/academic research efforts which predominantly focused on the Shediac Valley off northern New Brunswick, as well as regions north and south of Anticosti Island (see Figure 9, Annex A). Seasonal efforts by government platforms has varied as well, with some being year-round (e.g., surveillance efforts) and some concentrated during the times when whales are known to occur in large numbers (e.g., June – October; Figure 8, Annex A).

The number of dedicated hours by government platforms was considerably less in 2017 compared to subsequent years, as the bulk of survey and surveillance activities (especially those directly targeting the detection of right whales) did not begin in the GoSL until later that year, following the deaths of most of the whales (see Figure 13, Annex A). Canadian and US government aerial and vessel surveillance and survey effort for right whales were approximately the same in 2018 and 2019, with over 3000 hours (see Table 4, Annex A). Boat-based non-government research days increased slightly over the three-year period (see Table 5, Annex A) and tended to primarily occur in July and August (see Figure 7, Annex A).

Carcass Detection and External Decomposition Level at First Sighting

As mortality events are becoming more common in the GoSL, there is a need to assess the effectiveness of carcass detection from year to year in order to both ensure accurate estimates of annual mortality rates and identify causes of death in individual whales. To our knowledge, there is no consistent system for estimating the annual effectiveness of carcass detection by surveillance and survey efforts. Effectiveness of carcass detection relies on being able to rapidly identify carcasses soon after death occurs. Although it is difficult to assess our ability to detect the true number of mortalities in the GoSL given its massive expanse, it is possible to make some comment on the rapidity with which carcasses are being detected by assessing the degree of external decomposition of carcasses at first sighting. Carcasses which have been floating longer should exhibit a greater degree of external post mortem decomposition. It is ***not*** possible to determine a specific post mortem interval (i.e., how much time has passed since the mortality event) for right whales in this manner due to their rapid post mortem decomposition and impacts of confounding environmental variables such as high ambient temperatures and rough ocean conditions. However, it is possible to discern broad categories of external decomposition in floating carcasses during initial at sea sightings which can be used to indirectly indicate which carcasses have been floating longer than others.

To our knowledge there is currently no effective system for assessing the level of external decomposition in floating right whale carcasses. Typically, floating carcasses are described in subjective terms such as mild, moderate, and advanced to indicate their relative level of decomposition. The condition code system developed by Geraci and Lounsbury (1993) has been applied to floating carcasses, however this system is designed for onshore evaluation, usually with an examination of the viscera, and does not conform well to the unique scenario presented by floating right whale carcasses which are evaluated from a distance and only "externally". To address this need, we developed a system for objectively evaluating the External Decomposition Level (EDL) of floating right whale carcasses (see Annex I). This system describes four general levels where Level 1 is a “fresh” carcass with minimal signs of external decay (skin sloughing, scavenging, bird droppings, livor mortis, etc.), and Level 4 is a “flat” carcass with no adherent skin.

With two right whale mortality events having occurred in 2017 and 2019, it is possible to use the EDL system to compare carcass detection between the events. Since all carcasses start out fresh (Level 1), a surveillance system that is 100% effective should theoretically detect all carcasses when they are at Level 1. This has not been the case in practice as indicated by Figure 9 which outlines the various EDLs that were observed in right whale carcasses at first sighting during both the 2017 and 2019 mortality events. Although there is considerable variation in both years, it is encouraging to note that there were more level 1 carcasses in 2019 (3) compared to 2017 (1). Despite this, more than half of the carcasses in both the 2017 and 2019 mortality events were in a state of advanced decomposition (level 3 and 4) suggesting these carcasses were floating for a considerable period of time (days to weeks) prior to first sighting. Nevertheless, surveillance efforts should continue to work towards rapid identification of dead right whales to inform ongoing management and mitigation measures, ensure accurate estimation of annual mortality rates, and facilitate necropsy investigations which in general are most effective in better preserved carcasses.

Continued improvement of effective carcass detection will require a diversity of surveillance methods to better cover the entire range of right whales in eastern Canada. Passive acoustic monitoring devices (via buoys and oceanic gliders) have great promise for improving the detection of live, vocalizing right whales in eastern Canada, however they cannot be used to

locate dead right whales which is critical if an accurate annual mortality rate is to be obtained. One possible solution to this would be near real-time satellite imaging targeting eastern Canada (particularly the GoSL) which could then be digitally analyzed in real-time for detection of floating carcasses. Satellite imaging has recently been used to detect live free-ranging Southern right whales and it is hoped that it will become more widely available as the technology advances (Borowicz et al., 2019; Cubaynes et al., 2019). Other at sea surveillance modalities which are currently being investigated that could potentially be adapted for carcass detection include the use of unmanned aerial vehicles (drones) and infra-red imaging (right whale carcasses hold considerable heat) which have been shown to be as effective as traditional surveillance methods, both at sea and onshore in some situations (Aniceto et al., 2018; Hodgson et al., 2017; Smith et al., 2020). Every surveillance modality has its strengths and weaknesses, and it is likely that a combination of both old (marine mammal observers, manned aerial surveillance) and new technologies will be needed to effectively monitor right whale habitat in the GoSL. Enhancing programs to encourage mariners and communities to report incidents, as well as coordinated beach surveillance programs, could also improve carcass detection.

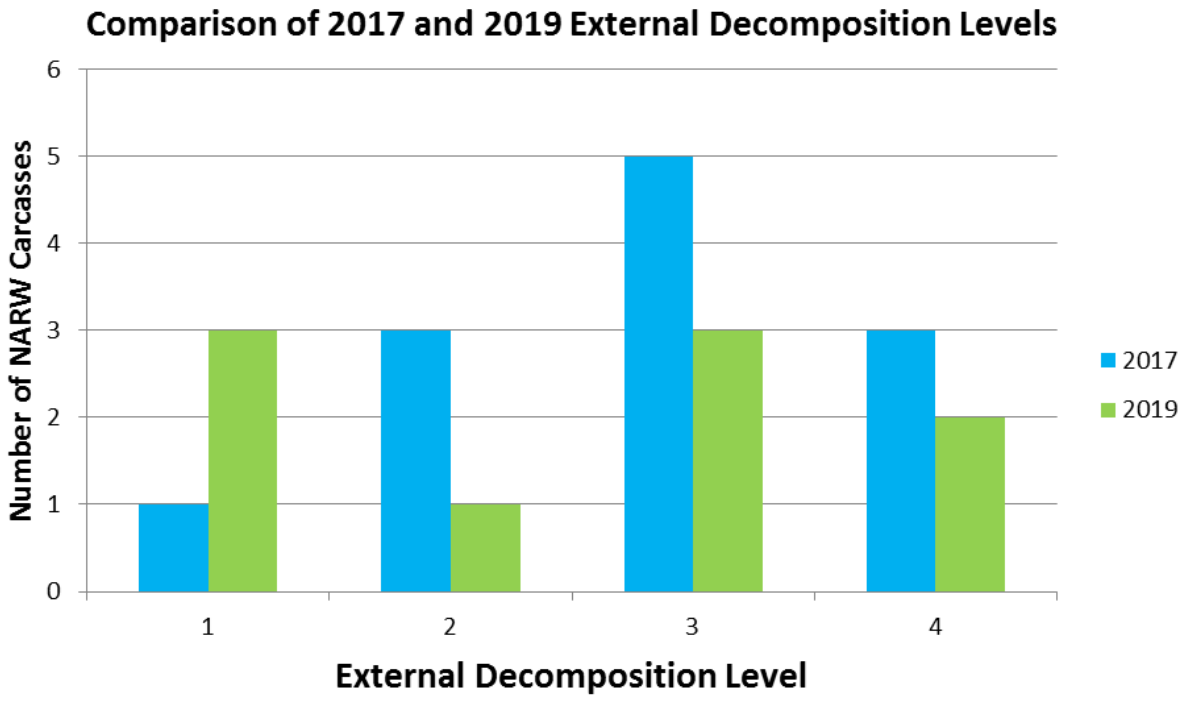

Figure 9. Comparison of External Decomposition Level (EDL) of North Atlantic right whale carcasses when first sighted during the 2017 (blue) and 2019 (green) mortality events in the Gulf of St. Lawrence. EDLs are represented on the x axis and range between freshly dead (level 1) and advanced decomposition with internal organ liquefaction (levels 3-4). The number of carcasses is represented on the Y axis.[7] See Annex I for further description of the EDL system.

[7] Note: images taken during the 2017 event were reassessed to reflect the current EDL system for purposes of comparison with 2019 carcasses in this report.

Number of Days at Sea

Once carcasses are detected, another important variable to assess is the length of time carcasses are left floating at sea prior to being towed to land for necropsy. Compared to rapidly detecting carcasses, this is a variable which responders have considerably more control over and has shown marked improvement between the 2017 and 2019 mortality events (Figure 10). In 2017, of the carcasses that were towed to shore, the majority spent well over 5 days at sea prior to necropsy (average 8 days at sea), whereas in 2019 the majority of carcasses spent less than 5 days at sea with the average dropping from 8 to 4. There will always be some delay in towing carcasses, which reflects the need to organize the onshore necropsy location and response team, as well as factors like weather and sea state. In some situations a delay in carcass towing until land based activities are prepared may even be preferred as carcasses are preserved better at sea than on land.

The importance of the improvement in necropsy response time cannot be overstated and is well demonstrated by the case of EG2019-01 ("Wolverine"). EG2019-01 had relatively subtle yet significant lesions which were eventually determined to be consistent with vessel strike, but that would have been easily masked by post mortem changes had response time for this carcass been slower. The freshness of EG2019-01 therefore played a key role in determining its suspected cause of death (vessel strike). In general, Level 1 and Level 2 carcasses generate the most data at necropsy and so by improving both the effective surveillance and response time we also ensure the greatest probability of determining a cause of death to inform subsequent mitigation measures. However, necropsy of Level 3 and even Level 4 carcasses can still provide important information on cause of death as indicated by the successful investigations in several whales in 2017 which were in an advanced state of decomposition (Daoust et al., 2017). Therefore, although rapid carcass recovery and response is an important goal to pursue, the level of external carcass decomposition should not deter responders from pursuing complete necropsy investigations where possible.

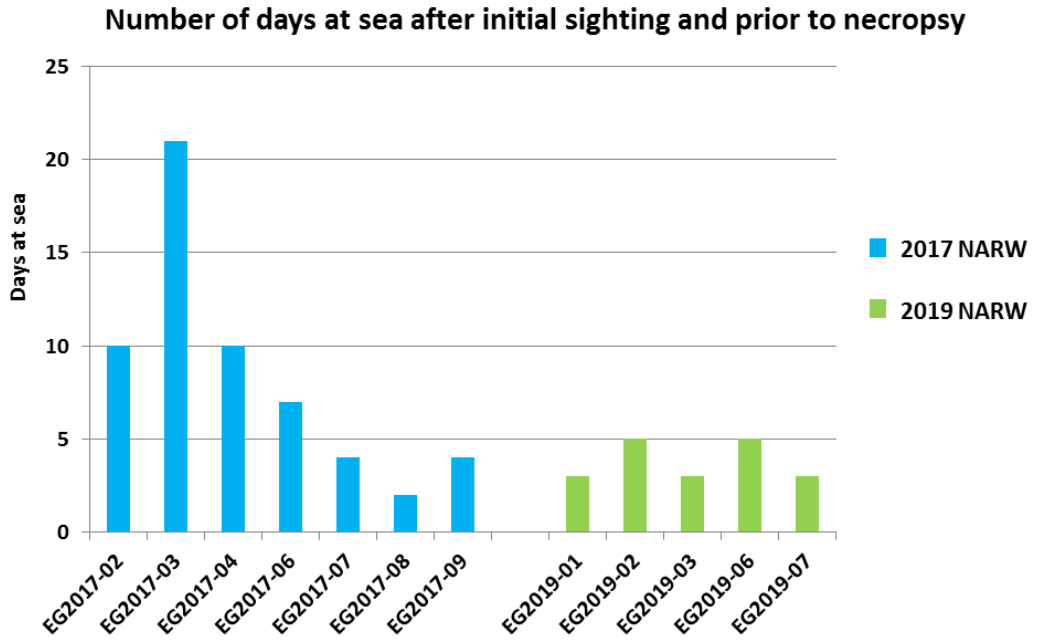

Figure 10. Comparison of the number of days at sea between first sighting and necropsy day between the 2017 (blue) and 2019 (green) mortality events. Individual whales are identified along the x axis.

Chapter 5:

Inter-Annual Variation in Right Whale Mortality

Over the last three years, mortality of right whales has varied considerably in Canadian waters with 12 found dead in 2017, 0 in 2018 and then 9 in 2019. One critical question to be answered regarding the 2019 mortality event is: Why did nine right whales die in Canadian waters in 2019 but none died in 2018? An answer to this question is not yet definitively known and may relate to a number of factors including right whale distribution, efficacy of mitigation measures, and surveillance and survey effort.

There is some evidence to suggest that right whales occupied different areas of the GoSL between 2018 and 2019 with whale distribution appearing to have been more widespread in 2019 (Figure 11 a and c). However, caution should be used when assessing these data as there currently are only two years upon which to make inferences, survey effort is still largely focused on specific regions, and sightings and habitat data have yet to be fully scrutinized. For large, dynamic marine animals, data over additional years will be required to gain a full appreciation for how they may utilize the waters of eastern Canada, and, even then, their distribution may continue to shift with the impacts from warming waters and global climate change.

There were slightly more surveillance hours in 2019 (~2900 hrs in 2019 versus ~2300 hrs in 2018; see Annex A) and the minimal variation in spatial coverage between the two years (Figure 11). However, when one looks at smaller timescales, during the peak week when whale deaths were detected in 2019, variation in surveillance coverage was apparent between the events (Figure 12). This does not mean that surveillance effectiveness varied from year to year (the primary means of detecting floating carcasses and entangled whales) but it could affect the number and spatial distribution of carcasses detected from year to year.

The 2018 mitigation measures were modified slightly for 2019, though the timing of implementation remained the same (see Annex A). In both years, dynamic and static measures were utilized to reduce the risk to whales from vessels and fishing gear. At the moment, data are not currently available to evaluate the differences observed between the years in relations to the spatial and temporal implementation of measures and the speed with which they were implemented and so it is not currently known whether the recurrence of mortalities in 2019 was a result of these changes.

In order to evaluate these potential hypotheses regarding interannual variation of right whale mortalities, information on both the whale sightings and the various human activities needs to be readily available on appropriate spatial and temporal scales. The majority of data on right whale sightings in Canada are available from the Right Whale Consortium (upon request and depending on whether all Canadian researchers and institutions are contributing their sightings information to this collaborative database). However, the spatial-temporal information on surveillance at relevant scales is not readily available. For example, information was obtained regarding the total hours flown by various government platforms, but this information was not easily available monthly or weekly.

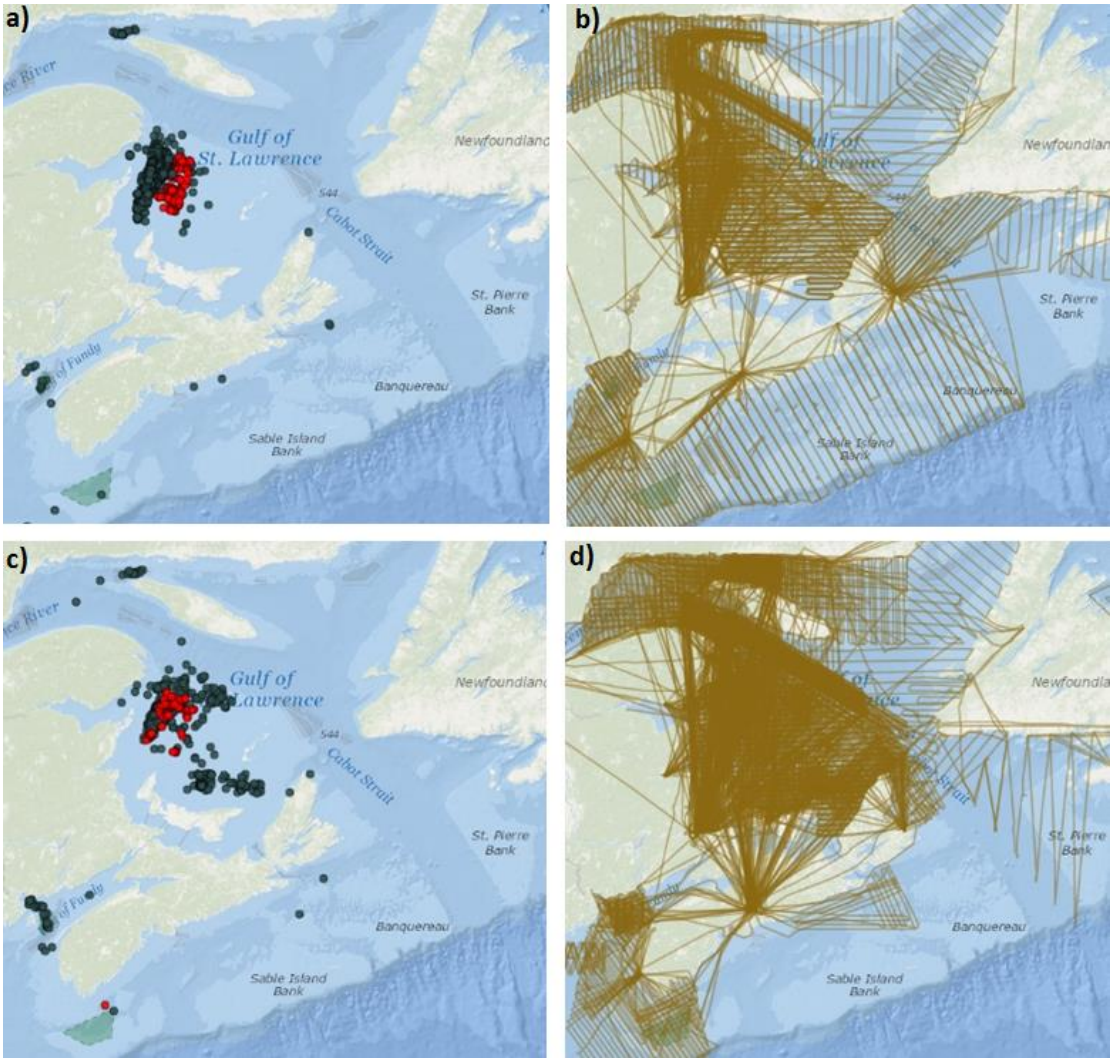

Figure 11. Sightings of North Atlantic right whales and government aerial surveillance survey tracks in 2018 (a and b, respectively) and 2019 (c and d, respectively). Green dots represent visual sightings, and red dots represent acoustic recordings. Source: Johnson 2018. WhaleMap. Available at: https://whalemap.ocean.dal.ca/. Accessed 06-08-2020.

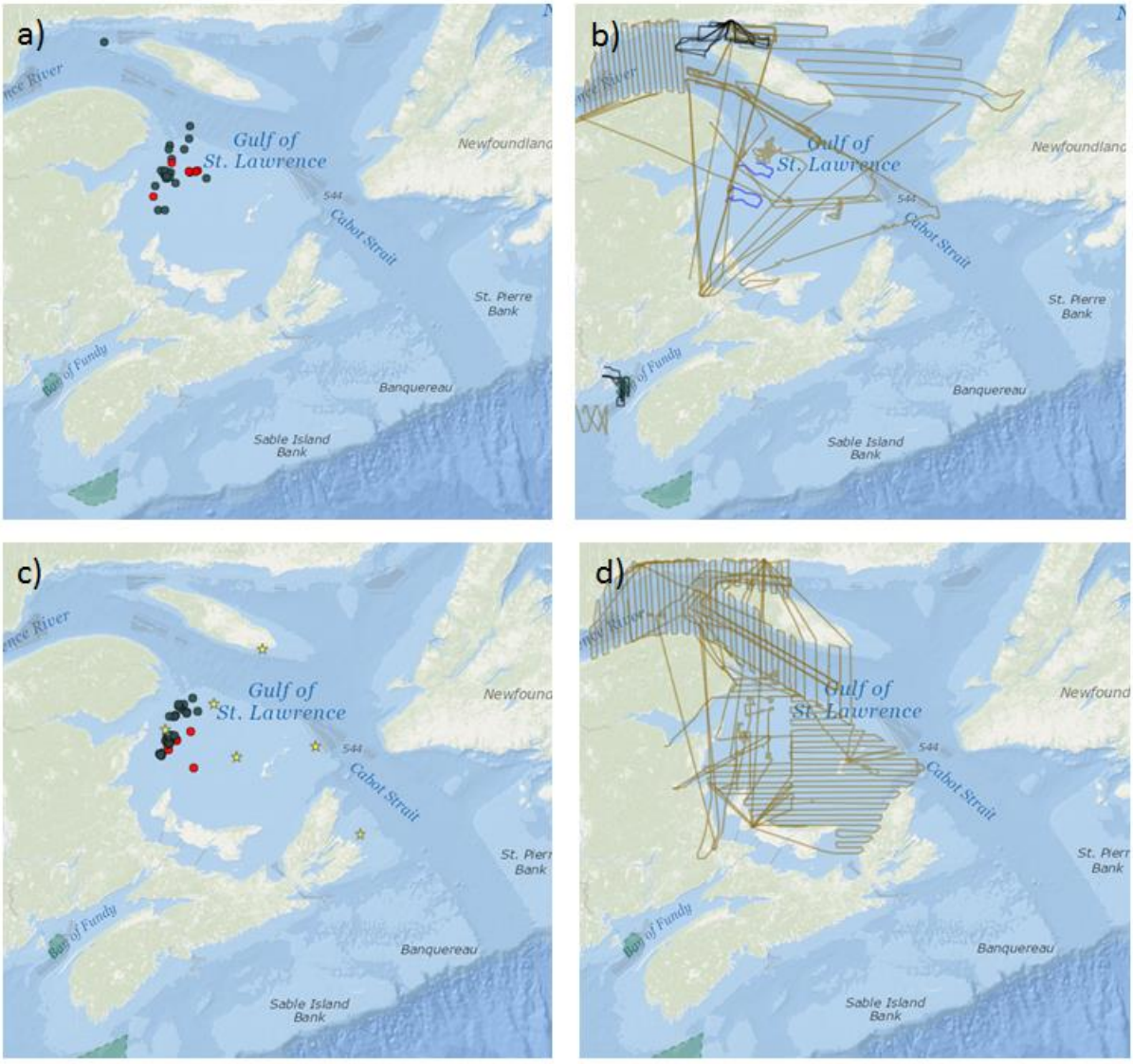

Figure 12. Sightings of North Atlantic right whales and government aerial surveillance and survey tracks between June 18 – 29 in 2018 (a and b, respectively) and 2019 (c and d, respectively). Source: Johnson 2018. WhaleMap. Available at: https://whalemap.ocean.dal.ca/. Accessed 06-08-2020. The approximate locations of the dead whales during this period in 2019 (EG2019-02, 03, 04, 05, 06 and 08) are indicated on the map with yellow stars. Green dots represent visual sightings, and red dots represent acoustic recordings.

Another question relates to why right whales died in 2019 of vessel strikes if speeds in much of the GoSL were restricted to 10 knots (either in the static or dynamic zones when whales were observed there, Figure 13). A reduction in speed to 10 knots has been the “typical” management benchmark and utilized by Canadian and US governments and international regulating bodies to reduce the risk of lethality to right whales from vessel strikes. Research related to this reduction in speed acknowledges that the reduction in risk is not 100% and can vary substantially with some risk of lethality remaining (Conn and Silber, 2013; Vanderlaan et al., 2008).

The initial reported location of many of the dead right whales in 2019 was within the static shipping zones, where vessels over 13m could only go a maximum 10 knots (a measure which had been in place since April 28, 2019). These measures have largely stayed the same for 2020 (see Annex A). This raises the question of whether vessels going at speeds 10-knots or less can still cause mortality or, as we do not know the size of the vessels which resulted in these mortalities, whether the vessel size to which the restriction needs to be applied should be reduced. Again, these are aspects which should be evaluated to determine if implemented mitigation measures are effective or whether other elements are involved in this complex issue.

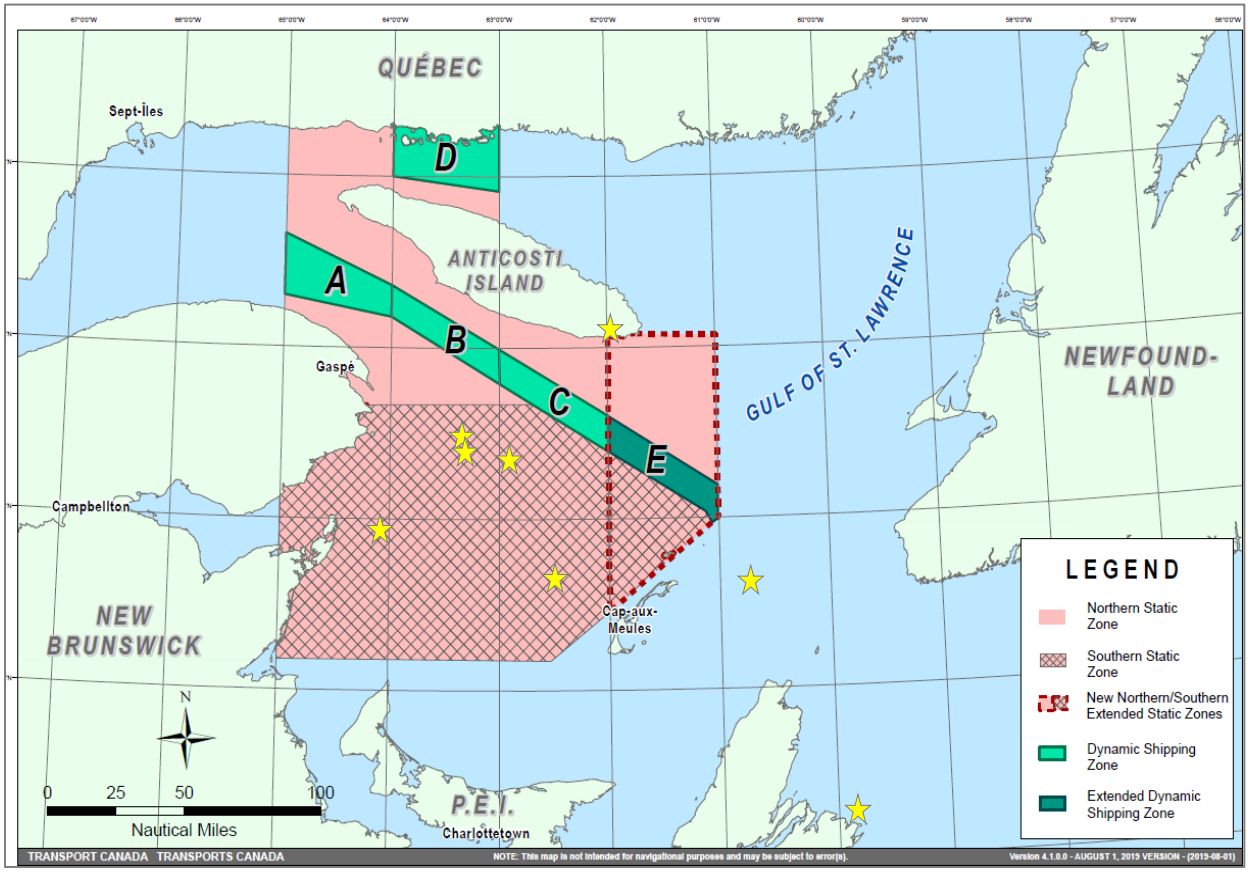

Figure 13. Vessel management measures to be implemented by Transport Canada in 2019. The approximate locations of dead whales during 2019 are indicated on the map with yellow stars. A ninth carcass located south of Cape Breton Island is not shown on this map. The Transport Canada mitigation measures map can be accessed at the Transport Canada website as follows: https://www.tc.gc.ca/en/services/marine/navigation-marine-conditions/protecting-north-atlantic-right-whales-collisions-ships-gulf-st-lawrence.html.

The other outstanding concern is the fate of right whales outside of the static and dynamic management zones. For example, EG2019-02, EG2019-08 and EG2019-09 were all found outside these areas and in areas which often receive less surveillance than the majority of the GoSL. Though the exact locations where EG2019-02 and EG2019-08 died are not known, both whales were very fresh (EDL 1) which suggests they died close their first reported locations which were outside the identified fishing and shipping management mitigation zones.

In 2020, Transport Canada announced a voluntary speed restriction zone in the inner part of the Cabot Strait (i.e., inner part of the entrance to the GoSL), however, it will only be in place during the periods of April 28th to June 15th and October 1st to November 15th. This timeframe does not encompass the dates when whales EG2019-02, EG2019-08, and EG2019-09 were reported dead (between June 20th to the 24th). As well, available research suggests that right whales enter the GoSL via the Cabot Strait throughout the period when they are found within the GoSL (end of May through to January) meaning that there is no gap in their transit of this area during the period when the voluntary slow down would not be in place (Durette-Morin, Pers. Comm.).

The efficacy of implemented management measures must be subjected to ongoing evaluation to ensure they maximize the ability to protect right whales (and other species) throughout their range in eastern Canada, particularly the GoSL. As mortalities and serious injury far exceeds PBR, stronger conservation actions and effective mitigation efficacy monitoring are needed in both countries to recover this species from extinction.

Chapter 6:
Review of Right Whale Protection in Canada

The role of Canada in protecting right whales and promoting their recovery is crucial as most of the extant population spends all or part of the summer and autumn months in Canadian waters (DFO 2014). The following is a brief review of the measures currently in place to protect right whales in Canada.

Right whales are protected under Schedule 1, Part 2 of the *Species at Risk Act* (*SARA*) in Canada. Under *SARA*, section 32 states that it is not only illegal to kill but also to harm, harass, or capture species that are listed under this Act (SARA, 2002). Both the *SARA* Recovery Strategy (DFO 2014) and the proposed *SARA* Action Plan (DFO 2020) for right whales state the need to identify and evaluate the effects of human activities using a variety of methods, including by supporting necropsies of dead animals in Canadian waters. Four federal agencies in Canada share the legal responsibility to protect and recover right whales (DFO, Transport Canada, Environment and Climate Change Canada, and Parks Canada). Fishing and shipping activities in Canadian waters are subject to the provisions of various acts which govern the impact of their activities on the marine environment (e.g., *Fisheries Act, Oceans Act, Canada Shipping Act, Marine Mammal Regulations*) as permitted, managed, and enforced by DFO and Transport Canada. Despite the growing evidence of the presence of, and danger to, right whales in the GoSL prior to 2017, no mitigation measures were implemented by these federal agencies.

Davies and Brillant (2019) provide an overview of the measures implemented in Canada since 1993 (see Figure 12 in Annex A). During this time, response and rescue operations to marine mammal incidents (e.g., live stranded individuals, disentanglement of free-swimming animals, collection of biological samples, necropsies) were primarily carried out by non-government organizations and their partners, many of which have been in operation for over 20 years but have only limited staff to draw upon. Mid-way through the 2017 mass mortality event, DFO and Transport Canada implemented measures to reduce the mortalities of right whales, which included exclusion of the snow crab fishery from some areas, and closure of the fishery several days earlier than scheduled. Transport Canada implemented voluntary, then mandatory, slow down speed zones for large (> 20 m) vessels in parts of the GoSL. For 2018, these mitigation measures were strengthened with static and dynamic fisheries management measures put in place between April 28th and Jun 30th and static and dynamic measures for vessels put in place between April 28th and November 15th. There were no reported mortalities of right whales in 2018, though 4 whales became entangled.

Though the timing of implementation remained the same, the 2018 mitigation measures were modified slightly for 2019.The key changes were that the static closure fishing area was reduced to be approximately 60% smaller than it was in 2018 (see Figure 15b, Annex A) and measures to reduce the risk of vessel strikes applied to vessels 13 metres or longer (was 20m and longer in 2018). The area that was removed from the static fishing closure area was subject to dynamic fishing management measures.

See Annex A for additional information on right whale incidents and mitigation measures implemented between 2017-2019.

Chapter 7:
Marine Mammal Conservation and Response in Canada

Although this report is primarily focused on the health and conservation of right whales, we feel there is a need to address issues relating to other marine mammal species in Canada. With the One Health Initiative becoming globally adopted (Gibbs, 2014), it is critical to move away from single to multispecies approaches if ecosystems, and consequently biodiversity, are to be preserved. Right whales are part of a complex marine ecosystem, and to truly address threats to their conservation, one must also monitor and address the threats to other marine mammals that share their waters. For example, vessel strikes and entanglements have significant negative health impacts on other large whale species in the GoSL besides right whales. Consequently, investigation into causes of death in these other species could also provide important insight pertaining to right whale conservation. Analysis of stranding records has shown that while 25 right whale mortalities occurred in Canadian waters between 2015 and 2019, there were an additional 240 incidents involving beached or floating large whales reported to just the Québec and Maritime Provinces response networks alone (MARS and the Réseau Québécois d'Urgences pour les Mammifères Marins, unpublished data)[8]. Most of these animals were not necropsied or sampled in any significant way which represents a significant loss of conservation data.

Large whales play a significant role in capturing carbon from the atmosphere and so monitoring their health and addressing threats to their populations could also have positive repercussions not only on species biodiversity but also on climate change (Chami et al., 2019; Roman et al., 2014). The following sections review the commitments of the Canadian government towards conservation of all marine mammal species and the role of response networks in achieving these commitments.

Federal Commitments for Preserving Marine Biodiversity in Canada

The strongest elements of species and critical habitat protection under the *Species at Risk Act (SARA)* are focused on Endangered and Threatened species, but it also aims to protect species of Special Concern from further risk, and to protect not-at-risk species from ***becoming*** listed. Canada therefore has a legal responsibility to protect all its species in its water and has consequently made important commitments toward preserving ecosystem health and biodiversity for present and future generations. Commitments such as Canada's Nature Legacy and the Ocean Protection Plan (http://dfo-mpo.gc.ca/campaign-campagne/oceans/index-eng.html) aim to ensure human activities and industries are sustainable and that their impacts on species and habitats are minimized. Canada's Federal Sustainable Development Strategy outlines the government's plan and vision for a more sustainable Canada while ensuring that ecosystems are and stay healthy (ECCC 2019). Fisheries and Oceans Canada's Departmental Sustainable Development Strategy states that this includes ensuring there aren't significant impacts to other species, especially those considered at risk (Fisheries and Oceans 2017).

[8] *Note, this does not include animals reported in Newfoundland waters and there is potential that a small number of these reports are duplicates*

Internationally, Canada is a signatory of the United Nations Convention on Biological Diversity and the 2030 Agenda for Sustainable Development. In addition to these sustainability commitments, monitoring and addressing industry impacts on marine mammals will also be required for Canada to continue to trade fish products with the USA, Canada's primary trade partner. Existing regulations that had previously not been implemented under the *US Marine Mammal Protection* Act (MMPA 1972) related to the import of seafood into the US and requirements for quantification and reduction of marine mammal bycatch in those fisheries will come into effect in January 2022 (the MMPA Import Provisions; NOAA, 2016). As a result, Canada will be required to quantify the bycatch of all marine mammal species and to demonstrate the implementation of comparable mitigation measures to reduce this threat.

Despite the above listed commitments, Canada is not making enough progress to protect marine species, including many at risk cetacean populations. In 2018, a report from the Office of the Auditor General examined Canada's progress to protect marine mammals and concluded that Fisheries and Oceans Canada, in collaboration with Parks Canada, Transport Canada, and Environment and Climate Change Canada, had not adequately protected marine mammals from threats posed by marine vessels and commercial fishing (Auditor General of Canada, 2018). In addition, legal prohibitions on harm, harassment, and capture of species (i.e., non-lethal and sub-lethal impacts) are often overlooked. For many large whales, non-lethal impacts from human activities (e.g., entanglements, noise pollution) can significantly affect individual health and overall population trends. For example, Christiansen et al. (2020) demonstrated that poor body condition and sublethal stress of North Atlantic right whales could suppress their growth, survival, age at sexual maturation, and calving rates.

Since the 2018 Canadian Auditor General's report was released, Canada has invested considerable funding and resources into marine mammal conservation, however this has focused primarily on only a few species (including right whales). The national and international commitments stated above are intended to protect all species and populations thereby ensuring that none become at risk of endangerment or extinction. Therefore, in order to meet these commitments, accurate information on the health of individuals and populations (size, fecundity, distribution, disease, rates and causes of injury and mortality, etc.) of all marine mammal species will be needed to inform policy and mitigation measures moving forward.

Role of Response Networks in Protecting Marine Mammal Species in Canada

The above stated commitments made by the Government of Canada provide the foundation and requirement for effective preservation of all marine wildlife in our waters for future generations. Non-governmental marine mammal response networks are natural allies in meeting Canada's marine biodiversity commitments. Canada is fortunate to have dedicated groups of response experts distributed across the country who are deeply connected to their communities. These highly trained experts assist with the many issues related to these incidents, including animal welfare assessment, incident investigation, human interaction assessment, documentation, and sample collection, as well as conduct and contribute to valuable research projects.

In eastern Canada, effective response and its impacts were exemplified by the 2017 right whale mortality event, following which aggressive mitigation measures to reduce the impacts from fishing and shipping activities were implemented (Daoust et al 2017). As well, during both the 2017 and 2019 right whale incidents alone, samples and data were collected to support a large number of research projects in Canada and the US including, but not limited to, the New England Aquarium, Fisheries and Oceans Canada, National Oceanic and Atmospheric

Administration, Canadian Wildlife Federation, Dalhousie University, University of New Brunswick, Saint Mary's University, University of Prince Edward Island, Suffolk University and the Oceanographic Environmental Research Society. As well, samples and data were distributed to numerous educational, archival, and outreach initiatives with museums, governments, non-governmental organizations and a variety of other agencies (New Brunswick Museum, Nova Scotia Museum of Natural History, Royal Ontario Museum (ROM), including the collection of 2 whole skeletons for the ROM and DFO-Gulf Region). Collection and distribution of data and samples to these organizations, along with hundreds of media interviews, public and industry outreach events and participation in several documentaries, were all supported by dedicated non-governmental responders.

Despite this demonstrated value, response in Canada is still currently coordinated and conducted by only a few organizations and dedicated individuals, most of whom have limited personnel and lack long-term funding. Response networks are therefore not able to fully implement a truly systematic and coordinated approach to assessing and monitoring marine animal health and incident response. If we are to meet our commitments for protecting Canada's oceans and all the species inhabiting them, collaboration between government agencies and non-governmental response networks (with funding for increased network capacity) will be essential.

Support for implementing a national marine animal health and incident surveillance program is needed if we are to understand and monitor marine species and ecosystem health in Canada. Canada's marine animal response networks generate large amounts of data and samples which serve as a valuable resource for monitoring marine animal health, supporting research, and advising government policy on marine mammal protection. Currently only a small fraction of data generated by response networks are used by government for advising policy and setting and monitoring management and conservation targets. Where response data are used, it is typically focused primarily on specific at-risk species. Surveillance data generated by response organizations during their operations can significantly contribute to our national commitments for protecting biodiversity in Canada's oceans. If our ultimate goal is to ensure that our oceans and the species living within them are healthy, then governmental and non-governmental organizations must work together to monitor the health of all marine wildlife.

Chapter 8:
Conclusions and Recommendations

Over the course of 2019, nine dead right whales were discovered floating at various locations around the GoSL and eastern Nova Scotia. Necropsy investigations of five whales revealed vessel strike to be the probable or suspect cause of death in four whales, and the cause of death was undetermined in the fifth. The remaining four whales were not necropsied and consequently the cause of death was unknown. During the same time period, four live right whales in the GoSL were observed to be live-entangled in fishing gear, one which was previously known to be entangled (NEA 4423) and one which was later discovered dead off the eastern seaboard of the US (NEA 1226). From the investigations recorded in this report, it was determined that, similar to 2017, the major causes of mortality and injury of right whales in the GoSL in 2019 were vessel strikes and entanglement in fishing gear.

Several aspects of the response to the 2017 and 2019 events were compared in order to identify areas requiring improvement to prevent future right whale mortalities. It was determined that overall rapidity of response to identified carcasses had improved between the two events. The average number of days carcasses were left floating at sea in 2019 was reduced by half, resulting in significant improvements to carcass preservation by the time of necropsy. The ability to rapidly detect floating carcasses soon after death remains largely unchanged between both years, as indicated by the advanced state of decomposition in which many of the carcasses were first reported. Rapid detection of carcasses is a variable that is difficult to address, given the challenges inherent in identifying floating carcasses as well as the vastness of the GoSL. Research into advanced surveillance technologies such as satellite imagery, unmanned aerial vehicles, and thermal imaging should be pursued to improve our ability to detect live whales as well as floating carcasses in the GoSL. Improving carcass detection and limiting the number of days carcasses spend at sea will improve both the accuracy of annual mortality rate estimates and our ability to examine health factors and determine causes of death during necropsy investigation.

The right whale mortality events in the GoSL in 2017 and 2019 are deeply concerning for the survival of the species. Significant mitigation measures have been enacted in the GoSL since the 2017 event which, given the occurrence of a second mass mortality event, would seem to have had variable success at preventing right whale mortalities and entanglements. The importance of preventing right whale injury, morbidity and mortality cannot be overstated, and it is to be hoped that new mitigation measures put in place for the 2020 season will prevent further entanglements and mortalities from occurring. To better protect right whales, there is a need to move away from single-species reactive approaches and towards proactive health surveillance of ecosystems as a whole. As many threats (including fishing and shipping) affect multiple marine mammal species and not just those at-risk, multi-species health surveillance will be needed to ensure the preservation of other at-risk species and overall biodiversity in our waters. This is especially pertinent in this era of climate change, when warming oceans will have increasingly negative impacts on marine species, as is suspected to have caused the recent shift in summer distribution of right whales into the GoSL (Davies and Brillant, 2019).

There is a clear need to prevent catastrophic mortality events, not just enact reactionary measures once they occur. Failure to prevent these catastrophes will threaten species survival not just for higher priority species such as right whales, but also for species currently considered

to be not threatened and which receive comparatively little monitoring or study. A broader, systematic approach to monitoring marine animal health is needed with the consideration of the many objectives of multiple collaborators related to response, research, education, and training.

The right whale mortality events of 2017 and 2019 demonstrate the need to have groups of trained marine mammal specialists available to coordinate and conduct both necropsy response and sample collection for research projects during these events. Although certain aspects of marine mammal response were supported by funding from the Government of Canada, particularly since 2018, many operational and logistical challenges remain. The support that these non-governmental groups receive tends to be incident or species specific, does not provide for much response to non-priority species and does little to contribute to the long-term enhancement and sustainability of response operations, particularly for maintenance and building of human resources. Moving forward, more broad based support is needed to maintain the day to day working capacity of response groups as well as their ability to collaborate on essential research projects with outside groups. The value of the services and contributions by response groups cannot be overstated and is essential for implementation of the numerous national and international commitments Canada has made for ensuring marine animal conservation for the future.

Key Issues and Recommendations:

- To effectively meet Canada's commitment to understanding, monitoring and protecting biodiversity and ecosystem health, **a comprehensive and collaborative *Marine Animal Health Surveillance and Incident Program* must be developed for Canada.**

- Stability and long-term sustainability remain a serious threat to regional response organizations and networks. **Support must target gaps and needs identified in collaboration with Canada's response experts with the intent to support a comprehensive, collaborative and coordinated approach to marine animal health surveillance and incident response.**

- **People and human resources are critical for present and future functioning of response networks.** This is the largest deficiency for many response organizations yet, despite improved funding, it remains one of the most difficult elements to get supported. In most regional response networks, the responsibility for the majority of responses lies on the shoulders of only a few people which is not sustainable. **Additional investment into existing and training future personnel is needed.**

- Valuable information on the health of marine animals is often lost as the majority of mortality events are not investigated. **Enhanced support for the examination of lower priority or non-priority species is needed**, both to ensure their continued survival and also with the view to monitor broader ecosystem issues. **As well, enhanced support is needed for at sea investigation of large whale mortalities.**

- Investigation of marine animal incidents presents an opportunity to gather valuable data and samples for research and management. **Support is needed for research related to marine animal health, threats, investigative procedures and incident response.**

Acknowledgements

Response to marine animal incidents in Canada requires the collaboration and coordination of many individuals, organizations, and agencies.

In eastern Canada, incidents of dead, entangled, or distressed marine animals are reported to either the Marine Animal Response Society (MARS) for waters around the Maritime Provinces, the Group for Research and Education on Marine Mammals (GREMM) for the Réseau Québécois d'Urgences pour les Mammifères Marins (RQUMM) in Québec managed waters or Whale Release & Strandings for Newfoundland and Labrador waters. All organizations work in cooperation with industry, federal and provincial agencies, other non-governmental organizations, scientists, and local communities to respond to all incidents of dead and distressed marine animals in a timely, effective, and safe manner.

For the incidents discussed in this report, MARS, RQUMM, the Canadian Wildlife Health Cooperative (CWHC) and the DFO marine mammal coordinators from Gulf (Isabelle Elliot) and Quebec (Antoine Rivierre) coordinated and conducted the necropsies in New Brunswick, Prince Edward Island, Nova Scotia, and Québec in 2019. Members of the Atlantic and Québec regional nodes of the CWHC were the leads for all five of the necropsies conducted. Without these incredibly dedicated and hardworking people, these necropsies would not have been possible.

Necropsies of large whales cannot be completed by these individuals and organizations alone. These efforts take a village and we'd like to thank everyone who assisted with every aspect of the necropsies in 2019, from those reporting the animals to those relocating them, towing them to the coast, bringing them ashore and assisting with the various aspects of conducting necropsies and collecting valuable research samples. All of these people dropped everything they were doing to help, and many are the same people who did so in response to the 2017 right whale mass mortality incident.

For support to report, facilitate, coordinate and conduct necropsies as well as to assist with clean up and sample processing, many heartfelt thanks to:

CWHC – Atlantic Region, Atlantic Veterinary College
Laura Bourque, Megan Jones, Pierre-Yves Daoust, Fiep de Bie, Darlene Weeks, Amanda Clark, Ashley Powell, Hanna Ruark, Tessa McBurney, Jenna Kenney

CWHC – Quebec Region, Faculté de Médecine Vétérinaire de l'Université de Montréal
Stephane Lair, Benjamin Lamglait, Marion Jalenques, Judith Viau, Kathleen Brown, Sarah Bosisio, Juliette Raulic, Karine Béland

Marine Animal Response Society and volunteers:
Andrew Reid, Tonya Wimmer, Mili Sanchez, Gally Renaud, Amanda Babin, Danielle Pinder, Lindsay Randell, Katie Kowarski, Meg Carr, Elizabeth Zwamborn, Nicole Ure, Delphine Durette-Morin

RQUMM and volunteers:
Anthony François, Melissa Tremblay, Sylvie Boulé, Priscilla Gingras, François Tremblay, Marie-Josée Guillet, Eric Smith, Stacey Cassivi, Marie-Josée Roy, Michele Van de Kaa,

DFO – Resource Management:
Isabelle Elliot, Antoine Rivierre, Siobhan Curry, Remi Brine, Steve Hachey, Etienne Chiasson, Daniel LaPierre, Stacey Bieren, Kelsey Hayden

DFO – Science:
Stephanie Ratelle, Stéphanie Côté, Rachel DeJong, Karen Robertson, Sylvie Robichaud, Mylène Dufour, Jason Harasimo, Kate Gingles, Renée Allain, Katherine Landry, Stephanie Boudreau, Nicolas Rolland, Charlotte Ward, Mikio Moriyasu, Marie-France Robichaud, Shelley Lang, Angelia Vanderlaan, Elizabeth Thompson, Kari Underhill, Michael Elliott, Jenni McDermid, Matthew Hardy, Philip Byrne, Arnaud Mosnier, Anne Provencher St-Pierre, Isabeau Pratte, Rachel Brien-Lavergne, Antoine Dispas, Ole Nielsen

Personnel aboard the CCGC Arthur LeBlanc and CCGC Corporal Teather

DFO – C&P:
Stéphane Boulay, Jacques Boudreau , Luc Bouvier, Maxime St-Louis, Jean-Mathieu Plante, Corey Webster, Raoul Bourgeois, Guillaume Lapierre, Antoine Théberge-Fortin, Allen Langlais, Bobby Guillemette, Jean-David Blanchette, Allain Landry, Paul Arsenault, Julien Roussel, Joel Leger, Caroline Savoie, Jean-Michel Dignard, Alban Lanteigne, Philippe Chiasson, Maxime Gagnon, Adam Theriault, Jonathan Gallant, Arthur LeBlanc, Kelly Lynch, Trevor Coffin, Anthony Cheverie, Brian Leger, Stephane Thibodeau, Glen Gillespie, Cody Pleshka, DFO-Maritimes Region Eastern Nova Scotia C&P Fishery Officers

Additional support for necropsies and sample processing provided by:
Dave McRuer **(Parks Canada),** Nesime Askin and Meredith Foley **(OERS),** Audrey Fournes, Maxime Gaudet-Boulay, Heather Fenton (Ross University, St. Kitts & Nevis), Stephen Raverty (**Animal Health Center BC**), **AVC Diagnostic Services, Province of New Brunswick, Province of Nova Scotia, Province of Prince Edward Island, Ministère de l'Environnement et de la Lutte contre les changements climatiques, Association des capitaines propriétaires de la Gaspésie,** Michel Cotton and Alain Dunn **(ville de Gaspé), Chiasson Brothers Ltd., Christian Laroque Services Ltee., Duffy Construction Ltd.** and the Commissionaires who provided onsite security.

Surveillance and research teams and those reporting incidents:
Canadian Whale Institute, Dalhousie University, DFO-C&P and Science, Mingan Island Cetacean Study, New England Aquarium, NOAA-Northeast Fisheries Science Center, Transport Canada National Air Surveillance Program, University of New Brunswick and Atlantic Canadian fishermen who reported incidents and assisted with response.

We were very honoured for the blessing **Elder Noel Milliea (joined by Patrick Goguen) of Elsipogtog First Nation and Keptin Jim Bernard with Lennox Island First Nation** provided prior to the necropsies of Wolverine and Comet. Their words provide much needed support to the teams facing these daunting tasks.

We would also like to thank our all colleagues in the US for their incredibly kind words of support and offers of necropsy support, especially those who attempted to or made the trek north for necropsies (Kim Durham, Lynda Doughty, Bill McLellan and Misty Niemeyer).

We would also like to thank those who provided information or assistance with the 2019 Incident report: Phillip Hamilton, Marianna Hagbloom, Amy Knowlton, Monica Zani, Rosalind Rolland, Katherine Graham, Elizabeth Burgess **(Anderson Cabot Center for Ocean Life at the New**

England Aquarium), Tim and Brenna Frasier and Sonya Radvan **(Saint Mary's University)**, Wade Rourke **(Canadian Food Inspection Agency),** Alex Costidis **(Virginia Aquarium and Marine Science Center)**, Michael Moore **(Woods Hole Oceanographic Institution)**, Kim Davies **(University of New Brunswick)**, Moira Brown **(Canadian Whale Institute/Campobello Whale Rescue)**, Bill McLellan **(University North Carolina Wilmington)**, Allison Henry **(NOAA-NEFSC)**, Laurie Murison **(Grand Manan Whale and Seabird Research Institute)**, Sean Brillant **(Canadian Whale Institute)**, Erin LaBrecque and Maureen Hughes.

We'd like to acknowledge the incredible efforts of our disentanglement colleagues who dealt with the daunting task of helping the live, entangled whales reported in Eastern Canada during this incident: **Campobello Whale Rescue, Tangly Whales, Center for Coastal Studies** and all those who supported them.

To protect and recover this species takes a global community, one that we are very honoured to be part of and have support from. Words cannot express how grateful we are to each and everyone one of you.

Partial response support for MARS and RQUMM provided by the Fisheries and Oceans Canada Marine Mammal Response Program. Additional support for right whale necropsies and subsequent analyses was provided by Fisheries and Oceans Canada Marine Mammal Response Program - Necropsy Fund and DFO-Maritimes, Species at Risk.

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Annexes

ANNEX A: North Atlantic right whale incidents, whale research and surveillance and threat mitigation measures in Canada, 1987 – 2019

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Information provided by: Laura Bourque, Sean Brillant, Moira Brown, Pierre-Yves Daoust, Kim Davies, Pam Emery, Valerie Harvey, Phil Hamilton, Amy Knowlton, Michael Moore, Hilary Moors-Murphy, Stephanie Ratelle and Angelia Vanderlaan

Reported North Atlantic right whale incidents in Canadian waters, 1987 - 2019

The number of reported North Atlantic right whale (here after referred to as right whales) mortalities, entanglements and entrapments (animals captured in man-made structures such as weirs or fishing traps) occurring in eastern Canadian waters changed significantly over the past 32 years (timeframe over which reports of mortalities or entanglements exist, though this does not necessarily mean that these incidents did not occur prior to this time). More comprehensive information and data from incidents involving right whales, as well as many other species, have been collected, particularly during the last 10-15 years. This is due to the establishment of response and rescue organizations in eastern Canada and their collaborative efforts to receive reports, document and investigate incidents.

Forty-two right whale mortalities have been reported in Canadian waters between 1987 to 2019 (Table 1). In addition, 45 entangled or entrapped right whales have been reported during this time period. These numbers are minimum estimates of mortalities and entanglements. Not all incidents of right whales are observed or reported, as evidenced by the over 80% scarring rate on whales, most of which were not observed to be entangled (Knowlton et al 2012).

Prior to 2015, most reported incidents occurred on the Scotian Shelf or in the Bay of Fundy (Figure 1). Since 2015, however, there has been an increase in the number of incidents reported in the Gulf of St. Lawrence or related to activities there, including many of the incidents during the 2017 and 2019 mass mortality events.

Between 1987 - 2014, there were a total of seventeen dead right whales reported in eastern Canada, typically only one whale every 2-4 years with an average of 0.6 individuals annually (Table 1; Figure 2). Between 2015 – 2019, there were an additional 25 mortalities with average right whale deaths increasing to 5 individuals annually (Table 1; Figure 2). **This is over an 8 times increase in the number of mortalities in the last 5-year timeframe.**

Table 2 summarizes information regarding the reported mortalities of right whales in eastern Canadian waters between 1987 to 2019. Nineteen animals were male, seventeen were female and six were of unknown sex. Where known, individuals ranged in age from 2 – 38 years old.

Additional information for pre-2019 incidents is available in Moore et al (2004), Daoust et al (2017) and Sharp et al (2019). For the purposes of this report, type of examination is defined as:

- Necropsy or Partial Necropsy: Cases where, respectively, a complete or partial external and internal examination was conducted
- Examined or Sampled: Cases where a necropsy was not performed (due to inaccessibility of carcass, carcass being too decomposed, etc.) but where external documentation and/or minimal onshore or at sea sampling was completed
- Not examined: Cases where the carcass was inaccessible, not recovered, lost or not examined beyond basic documentation and sampling*

* Basic documentation and sampling include only the identification of the species and sex, and the collection of images, a length measurement, and a small skin sample for genetics.

Of the 42 reported mortalities which occurred in Canadian waters over the past 32 years, 26 were necropsied or examined by experts (including partial necropsies, advanced examinations, or sampling). For 19 incidents, there was enough evidence to determine a suspect, probable, or confirmed cause of death (see pages 25-26 of the 2019 Incident Report) for the criteria and case definitions):

- 13 died due to vessel strikes (class size of the vessels is unknown)
- 6 died due to entanglement
    - 3 in snow crab gear
    - 1 in either Danish seine or snow crab gear
    - 1 where an investigation was completed by DFO C&P but results were never disseminated
    - 1 unknown as no entangling gear was present

For the remaining 6 incidents where an examination of some sort was possible as well as the additional 16 cases where an examination or necropsy was not possible, the cause of death could not be determined (Table 2).

Note: A lack of signs of human interaction should NOT be interpreted to mean there were no impacts from human activities. Some carcasses were not examined while others were in an advanced state of decomposition or the visual materials obtained were not adequate to determine absence or presence of signs of human interaction.

Of the 25 right whales found dead since 2015 in eastern Canada, 22 were in the Gulf of St. Lawrence proper while one was found on Sable Island (in 2016) and two others were found off the Atlantic coast of Cape Breton Island (both in 2019, Figure 1). The animal found on Sable Island in 2016 was determined to be entangled in snow crab gear originally set off the Gaspé Peninsula in Quebec.

Forty-five incidents involving live-entangled right whales have been reported since 1999 (Table 1, Figure 2). Between 1999-2014, twenty-five live right whales were reported entangled in fishing gear or entrapped in fishing structures (i.e. weirs or fishing traps). The average during this period was 1.5 individuals annually. Since 2015, twenty additional entangled or entrapped animals have been reported, an almost three-fold increase to 4.2 individuals annually (Table 1, Figure 2).

Table 3 summarizes information regarding the reported entanglements and entrapments of right whales in eastern Canadian waters between 1999 to 2019. Information was obtained and/or confirmed from the Atlantic Large Whale Disentanglement Network or from response teams directly (e.g. Campobello Whale Rescue, Tangly Whales). *Note: due to the death of Joe Howlett, disentanglement efforts were suspended by DFO from July 5, 2017– March 2018.*

For the purposes of this report, type of response is defined as:

- Disentangled / Released: Cases where response was mounted, and the animal was completely disentangled or successfully released from structure
- Partial Disentanglement: Cases where response was attempted, and gear was partially removed
- Lost: Cases where the animal was searched for by response or survey teams but could not be relocated and the animal was subsequently lost
- No Action: Cases where response was not legally permitted, teams were on standby but bad weather prohibited action or response was not possible due to lack of team

Seventeen whales were partially or completely disentangled or released from structures by rescue teams (Campobello Whale Rescue team / Canadian Whale Institute, Whale Release and Strandings, Center for Coastal Studies, New England Aquarium, Grand Manan Whale and Seabird Research Station, International Fund for Animal Welfare, Marine Animal Response Society and local fishermen) with support from other partners (Fisheries and Oceans Canada, National Oceanic and Atmospheric Administration / Northeast Fisheries Science Center, Canadian Coast Guard, Dalhousie University,

Memorial University, University of New Brunswick, Transport Canada, whale watches and local fishermen). An additional twenty-eight entangled animals were either lost or no action could be undertaken or were allowed (Table 3).

For many incidents, the source of the entangling gear was unknown, due to the inability of the gear to be retrieved, identified or the results of investigations not being disseminated. Of the cases where gear was identifiable between 2015-2018, snow crab fishing gear was identified to be the entangling gear on many right whales. Information on the gear involved in the 2019 incidents was not available from DFO at the time this report was being prepared.

It is important to note that the information presented here *does not* include animals which have serious injuries. Under the US Marine Mammal Protection Act, serious injury is defined (50 CFR 229.2) as "any injury that is more likely than not to result in mortality" (NMFS, 2012). These animals may perish, but while they continue to live, they are also unlikely to significantly contribute to the right whale population in terms of reproductive contributions (Kraus et al. 2001). The annual rate of human-caused serious injury and mortality in the US and Canada combined (i.e. the entire range of right whales) during the period of 2013-2017 was 6.85 for North Atlantic right whales (Henry et al., In Press). This is significantly greater than the Potential Biological Removal (PBR) for this species (0.9 individuals/year, NOAA 2018).

In the last 5 years, the majority of the 25 mortalities and 20 entanglements/entrapments in Canadian waters were reported in June and July (Figure 3), representing 36% and 44% of incidents, respectively. Most of these incidents (80%) were either reported in the Gulf of St. Lawrence or were determined to be related to activities conducted there (one case of an entangled whale and one case of a dead whale - each were entangled in fishing gear that was traced back to fishing gear set in the Gulf of St. Lawrence; Figure 4).

*Note: The information presented here does not include animals which died or were disentangled in US waters where the cause of death was attributed to a Canadian fishery nor individuals who are alive and determined to have sustained a serious injury as per NOAA criteria. Where it exists, information on these incidents can be found in the annual Right Whale Consortium Report Cards (*https://www.narwc.org/report-cards.html*), in NOAA's Baleen Whale Mortality and Serious Injury Reports (*https://www.fisheries.noaa.gov/resource/publication-database/marine-mammal-mortality-and-serious-injury-reports*) or from response or disentanglement organizations directly.*

Table 1. Number of reported North Atlantic right whale mortalities (1987-2018) and entanglements /entrapments (1999-2019*) reported in eastern Canadian waters.

Year	Mortalities	Entanglements / Entrapments*
1987	1	-
1988	2	-
1989	0	-
1990	0	-
1991	0	-
1992	1	-
1993	0	-
1994	1	-
1995	1	-
1996	0	-
1997	1	-
1998	0	-
1999	0	3
2000	0	2
2001	3	1
2002	0	5
2003	1	1
2004	0	1
2005	0	0
2006	2	3
2007	1	0
2008	0	0
2009	0	0
2010	1	0
2011	0	3
2012	1	2
2013	0	1
2014	1	3
2015	3	4
2016	1	3
2017	12	5
2018	0	4
2019	9	4
TOTAL	**42**	**45**

* information only available from 1999 - present

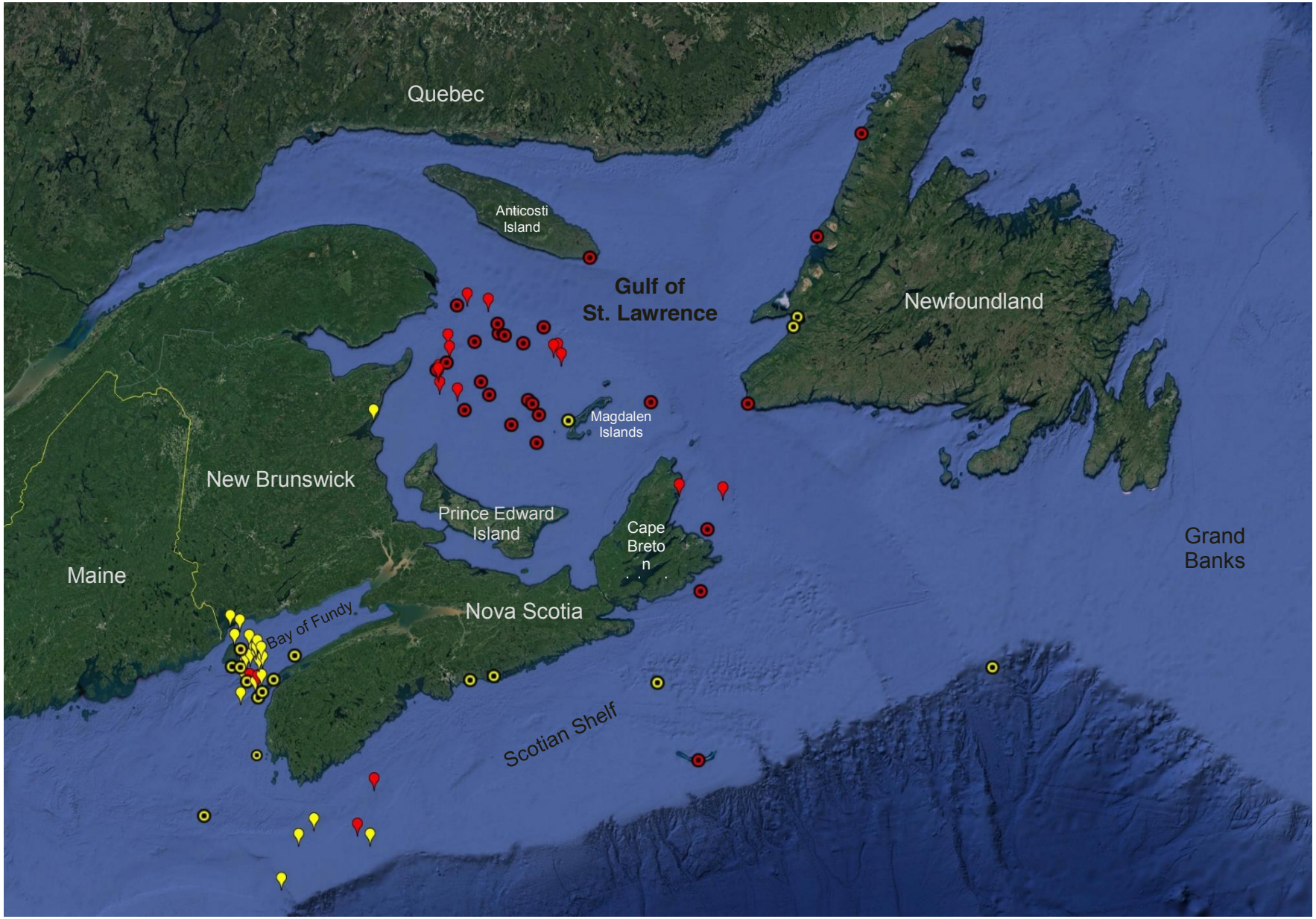


Figure 1. Locations of *reported* incidents involving dead (⊙) and live-entangled or entrapped ( ) North Atlantic right whales in eastern Canada from 1987 – 2014 (yellow) and 2015-2019 (red). Note information on entanglements and entrapments are only available from 1999 – 2019.

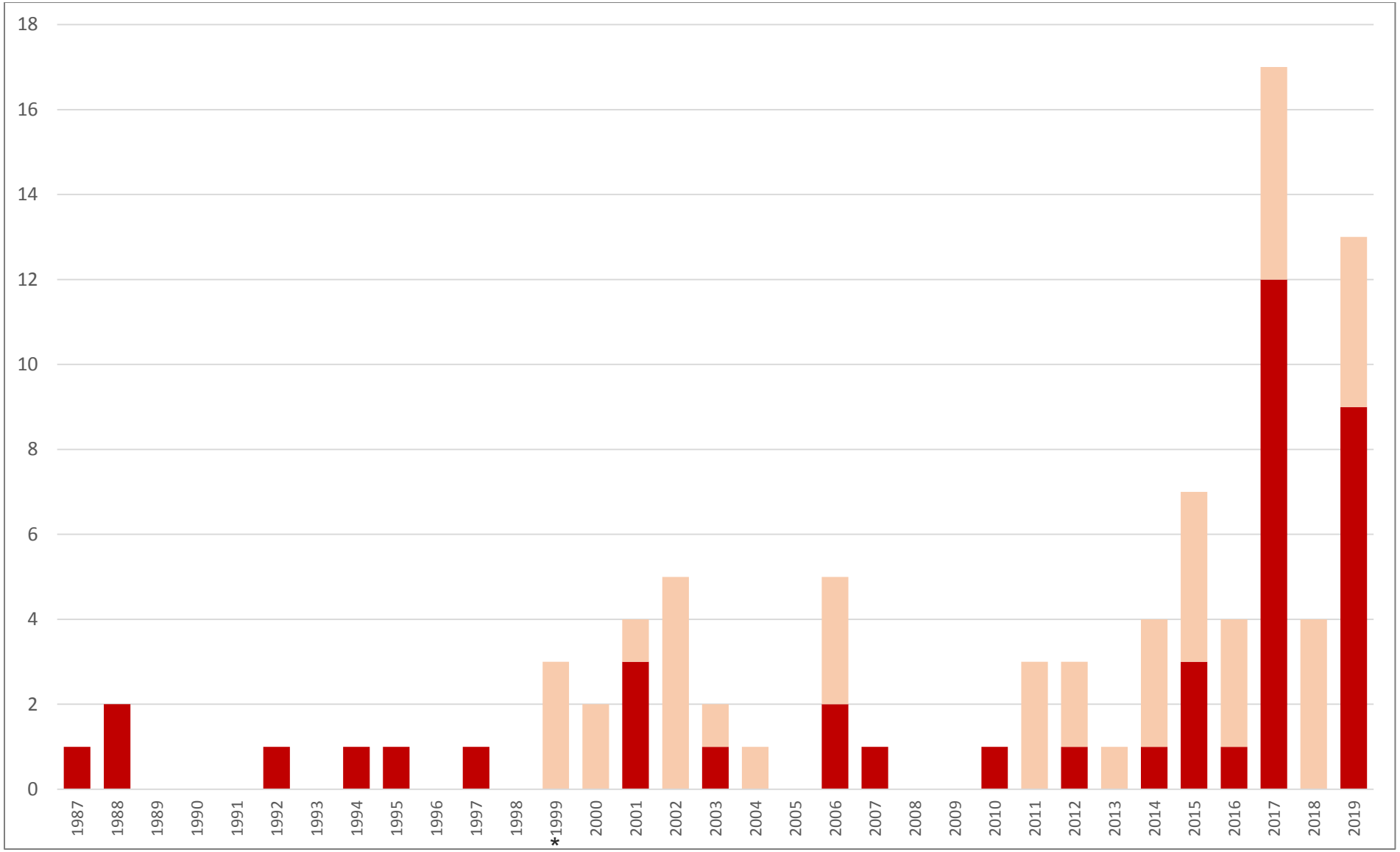


Figure 2. Annual number of reported North Atlantic right whale mortalities (red) or entanglements / entrapments (pink) in Canadian waters between 1987-2019. **Reports regarding entanglements and entrapments are only available since 1999. A lack of incidents prior to this does not indicate that none occurred.*

Table 2. Reported mortalities of North Atlantic right whales in eastern Canadian waters between 1987 to 2019. Additional information for pre-2019 incidents available in Moore et al 2004, Daoust et al 2017 and Sharp et al 2019. *Note: A lack of signs of human interaction should not be interpreted to mean there were no impacts from human activities. Some carcasses were not examined while others were in an advanced state of decomposition or the visual materials obtained were not adequate to determine absence or presence of signs of human interaction.*

Year	Incident #(s)	Field or Necropsy #(s)	Report Date	NEA # (Name)	Sex	Age	Initial Location Reported	DFO Region	Type of Examination^	Cause of Death (COD)	If not necropsied, signs of Human Interaction?*
1987			09-Jul-87		M	Unk	Seaforth, NS	Mar	Not examined	Unknown COD	
1988			15-Mar-88		Unk	Unk	Black Duck, NF		Not examined	Unknown COD	
1988			17-Nov-88		Unk	Unk	Bay of Fundy, NS		Not examined	Unknown COD	Yes, entangled in fishing gear
1992	EglaMARS92-09-08	NEAq 1223	05-Sep-92	1223	F	12	Bay of Fundy, NS	Mar	Necropsy	Vessel (blunt, confirmed)	
1994	GM-94-01		13-Jul-94		M	Unk	Kent Island, Bay of Fundy, NB	Mar	Examined or Sampled	Unknown COD	
1995		NEAq 2250	20-Oc-95	2250	M	4	Long Island, NS	Mar	Partial necropsy	Vessel (probable)	
1997		NEAq 2450	20-Aug-97	2450	F	4	Long Island, NS	Mar	Necropsy	Vessel (blunt, confirmed)	
2001			01-Jul-01		M	Unk	St. Theresa's, NF	NF	Not examined	Unknown COD	
2001	EglaMARS 01-12-03		03-Dec-01		Unk	Unk	Middle Bank, Scotian Shelf, NS		Not examined	Unknown COD	
2001		Eg 1238	04-Nov-01	1238	M	19	Magdalen Islands, Qc	QC	Necropsy	Entanglement (acute, confirmed)	
2003	EglaMARS03-10-03	MJM03-01	02-Oct-03	2150	F	12	Digby, NS	Mar	Necropsy	Vessel (blunt, confirmed)	
2006		DVS2006-04745	24-Jul-06	3595	F	1.5	Grand Manan, Bay of Fundy, NS	Mar	Necropsy	Vessel (sharp, confirmed)	
2006	EglaMARS06-09-02	MJM9406Eg	24-Aug-06	1267	F	24	Yarmouth, NS	Mar	Necropsy	Vessel (blunt, confirmed)	

2007	EglaMARS07-03-25	NEAq 1424	25-Mar-07	1424	M	27	Near Hague Line, Canadian waters	Mar	Examined or Sampled	Unknown COD	Yes, signs of entanglement
Year	**Incident #(s)**	**Field or Necropsy #(s)**	**Report Date**	**NEA # (Name)**	**Sex**	**Age**	**Initial Location Reported**	**DFO Region**	**Type of Examination^**	**Cause of Death (COD)**	**If not necropsied, signs of Human Interaction?***
2010	MARS2010-069	X22447-10	13-Aug-10	1113	M	29	Sandy Cove, Bay of Fundy, NS	Mar	Necropsy	Entanglement (acute, suspect)	
2012	MARS2012-084	CWHC 86957	19-Jul-12		F	Unk	Clam Harbour Beach, NS	Mar	Examined or Sampled	Entanglement (acute, confirmed)	
2014	MARS2014-113		04-Sep-14		Unk	Unk	120nm SW Burrin Peninsula, NF	NF	Not examined	Unknown COD	Yes, signs of entanglement
2015	QC2015028	Eg_2015-01	24-Jun-15	2320 (Piper)	F	24	Gaspe, QC	Qc	Partial necropsy	Unknown COD	
2015	QC2015046/ MARS2015-179		09-Jul-15		Unk	Unk	Floater, GoSL	Qc	Not examined	Unknown COD	
2015	QC2015049/ MARS2015-174		13-Jul-15	3923	F	6	Floater, GoSL	Qc	Not examined	Unknown COD	
2016	MARS2016-175		02-Sep-16	4320	M	3	Sable Island, NS	Mar	Examined or Sampled	Entanglement (acute, probable)	
2017	MARS2017-136	Eg-01	06-Jun-17	3746	M	100	Floater, GoSL	Gulf	Not examined	Unknown COD	
2017	MARS2017-144	Eg-03	18-Jun-17	3190 (Panama)	M	17	Floater, GoSL	Qc	Necropsy	Unknown COD	
2017	MARS2017-141	Eg-02	19-Jun-17	1402 (Glacier)	M	33	Floater, GoSL	Gulf	Necropsy	Vessel (blunt, suspect)	
2017	MARS2017-143	Eg-04	21-Jun-17	3603 (Starboard)	F	11	Floater, GoSL	Gulf	Necropsy	Entanglement (acute, confirmed)	
2017	MARS2017-155	EG-05 / F20170096	22-Jun-17	3512 (Contrail)	F	12	Floater, GoSL	Gulf	Examined or Sampled	Unknown COD	
2017	MARS2017-142	Eg-06	23-Jun-17	1207	M	37	Floater, GoSL	Gulf	Necropsy	Vessel (blunt, probable)	
2017	MARS2017-145	Eg-07	05-Jul-17		M	Unk	Floater, GoSL	Qc	Necropsy	Vessel (blunt, probable)	

2017	MARS2017-146	Eg-08	19-Jul-17	2140 (Peanut)	M	26	Floater, GoSL	Gulf	Necropsy	Vessel (blunt, suspect)	
2017	M20170095	Eg-10	21-Jul-17	2630	M	Unk	Trout River, NL	NL	Examined or Sampled	Unknown COD	
Year	**Incident #(s)**	**Field or Necropsy #(s)**	**Report Date**	**NEA # (Name)**	**Sex**	**Age**	**Initial Location Reported**	**DFO Region**	**Type of Examination^**	**Cause of Death (COD)**	**If not necropsied, signs of Human Interaction?***
2017	M20170094	Eg-12	27-Jul-17		M	Unk	Cape Ray, NL	NL	Examined or Sampled	Unknown COD	
2017	M20170093	Eg-13	30-Jul-17	1911	F	6	River of Ponds, NL	NL	Examined or Sampled	Unknown COD	
2017	MARS2017-312	Eg-09	15-Sep-17	4504	F	2	Floater, GoSL	Gulf	Necropsy	Entanglement (acute, confirmed)	
2019	MARS2019-130	EG2019-01	04-Jun-19	4023 (Wolverine)	M	9	Floater, GoSL	Gulf	Necropsy	Vessel (blunt, suspect)	
2019	MARS2019-146	EG2019-02	20-Jun-19	1281 (Punctuation)	F	38	Floater, GoSL	Gulf	Necropsy	Vessel (sharp, probable)	
2019	MARS2019-161	EG2019-03	25-Jun-19	1514 (Comet)	M	33	Floater, GoSL	Gulf	Necropsy	Vessel (blunt, probable)	
2019	QC2019064 / MARS2019-168	EG2019-04	25-Jun-19	3815	F	11	Floater, GoSL	Qc	Examined or Sampled	Unknown COD	
2019	QC2019070 / MARS2019-169	EG2019-05	26-Jun-19	3329	F	16	Anticosti Island, Qc	Qc	Examined or Sampled	Unknown COD	
2019	QC2019071 / MARS2019-170	EG2019-06	27-Jun-19	3450 (Clipper)	F	16	Floater, GoSL	QC	Necropsy	Vessel (blunt, probable)	
2019	Qc2019121 / MARS2019-223	EG2019-07	18-Jul-19	3421	M	15	Floater, GoSL	QC	Necropsy	Unknown COD	
2019	MARS2019-202	EG2019-08	24-Jun-19		Unk	Unk	Floater, Atlantic Ocean	Mar	Not examined	Unknown COD	
2019	MARS2019-232	EG2019-09	21-Jul-19		F	Unk	Floater, Atlantic Ocean	Mar	Not examined	Unknown COD	

^ **Necropsy or Partial Necropsy:** Cases where a complete or partial external and internal examination was conducted. **Examined or Sampled:** Cases where a necropsy was not performed due to inaccessibility of carcass, carcass too decomposed or other factors but where external documentation and/or minimal onshore or at sea sampling was completed. **Not examined:** Cases where the carcass was inaccessible, not recovered, lost or not examined beyond basic documentation and sampling.

Table 3. Reported entanglement or entrapments of North Atlantic right whales in eastern Canadian waters between 1999 to 2019. Additional information for entanglements available from the Atlantic Large Whale Disentanglement Network, Right Whale Consortium report cards, individual response organizations and, for 2017, in Daoust et al 2017.

Year	Date	NEA #	Location Initially Reported in Canada	Incident Type	Type of Response^	Additional information*
1999	05-Jun-19	2753	Bay of Fundy, NS	Entangled	Partially Disentangled	Confirmed gear free, 14-Apr-00 (GSC)
1999	18-Jun-19	WR 1999-07	Bay of Fundy, NS	Entangled	Lost	
1999	21-Jul-99	2710	Bay of Fundy, NS	Entangled	Disentangled/Released	Confirmed gear free, 20-Jul-00
2000	09-Jul-00	2746	Off Grand Manan, Bay of Fundy, NS	Entangled	Partially Disentangled	Confirmed gear free, 7-Sep-00
2000	18-Aug-00	2223	Bay of Fundy, NS	Entangled	Lost	Confirmed gear free, 8-Jun-01 (GSC)
2001	13-Sep-01	3040	Bay of Fundy, NS	Entangled	No Action	Confirmed gear free 26-Apr-07 (GSC)
2002	06-Jul-02	3107	Brier Island, Bay of Fundy, NS	Entangled	Disentangled/Released	Confirmed gear free, 30-Sep-02 (off CC) Died, 13-Oct-02 (Nantucket)
2002	04-Aug-02	2320	off Long Island, Bay of Fundy, NS	Entangled	Lost	Confirmed gear free, 14-Apr-06 (CCB) Died, 24-Jun-15 (GoSL)
2002	10-Aug-02	2040	Miramachi Bay, NB	Entangled	No Action	
2002	22-Aug-02	1815	Roseway Basin, NS	Entangled	No Action	
2002	30-Aug-02	3210	Bay of Fundy, NS	Entangled	Lost	
2003	09-Jul-03		Off Grand Manan, Bay of Fundy, NS	Entangled	Disentangled/Released	
2004	06-Sep-04	2301	Roseway Basin, NS	Entangled	Lost	Died, 3-Mar-05 (Virginia) COD: chronic entanglement

Year	Date	NEA #	Location Initially Reported in Canada	Incident Type	Type of Response^	Additional information*
2006	16-Aug-06	Unknown	Brier Island, NS	Entangled	Lost	
2006	17-Sep-06	1403	Bay of Fundy, NS	Entangled	Lost	Confirmed gear free, 12-Aug-07 (BOF)
2006	27-Sep-06	Unknown	Bay of Fundy, NS	Entangled	Lost	
2011	18-Sep-11	3123	Off Grand Manan, Bay of Fundy, NS	Entangled	No Action	Known to be entangled from US,29-Apr-11 (CCB)
2011	26-Sep-11	3302	Bay of Fundy, NS	Entangled	No Action	Known to be entangled from US, 22-Apr-11 (south Martha's Vineyard)
2011	27-Sep-11	3111	Grand Manan, NB	Entangled	Partially Disentangled	
2012	25-Aug-12	1708	Grand Manan, NB	Entrapped in Weir	Disentangled/Released	
2012	17-Oct-12	3790	Grand Manan, NB	Entrapped in Weir	Disentangled/Released	
2013	20-Sep-13	3946	Roseway Basin, NS	Entangled	Lost	Confirmed gear free, 25-Mar-14 (CCB)
2014	29-Jun-14	1131	Off Yarmouth, NS	Entangled	Lost	
2014	04-Sep-14	4001	Grand Manan, NB	Entangled	Lost	
2014	17-Sep-14	3279	Grand Manan, NB	Entangled	Lost	
2015	13-Jun-15	WR-2015-05	Brier Island, NS	Entangled	Lost	
2015	05-Jul-15	4140	Middle Head, Cape Breton, NS	Entrapped in Trap	Disentangled/Released	
2015	18-Jul-15	3160	Off Ingonish, Cape Breton, NS	Entangled	Disentangled/Released	

2015	13-Sep-15	1306	Roseway Basin, NS	Entangled	No Action	
2016	13-Aug-16	4057	off Grand Manan, Bay of Fundy, NS	Entangled	Partially Disentangled	
2016	16-Aug-16	1152	Off Cape Negro, NS	Entangled	Lost	
Year	**Date**	**NEA #**	**Location Initially Reported in Canada**	**Incident Type**	**Type of Response^**	**Additional information***
2016	28-Aug-16	2608	off Tiverton, Bay of Fundy, NS	Entangled	No Action	
2017	05-Jul-17	4510	off Miscou Island, NB	Entangled	Disentangled/Released	Confirmed gear free, 29-Jul-17 (GoSL)
2017	08-Jul-17	1317	off Miscou Island, NB	Entangled	Lost	Confirmed gear free, 25-Jul-17 (GoSL)
2017	09-Jul-17	4123	off Miscou Island, NB	Entangled	Disentangled/Released	Confirmed gear free, 29-Jul-17 (BOF)
2017	19-Jul-17	4094	off Miscou Island, NB	Entangled	No Action+	
2017	28-Aug-17	3245	off Percé, Gaspe Peninsula, Qc	Entangled	No Action+	Confirmed gear free, 16-Jan-18 (CCB)
2018	11-Jun-18	1142	Gulf of St. Lawrence	Entangled	No Action	known to be entangled from US, 01-April-14 (NJ)
2018	13-Jul-18	3312	Gulf of St. Lawrence	Entangled	Lost	
2018	30-Jul-18	3843	Bay of Fundy, NS	Entangled	Partially Disentangled	
2018	20-Aug-18	3960	Gulf of St. Lawrence	Entangled	Lost	Confirmed gear free, 31-Dec-18 (Nantucket)
2019	29-Jun-19	4440	Gulf of St. Lawrence	Entangled	Partially Disentangled	Confirmed gear free, 14-Aug-19 (GoSL)
2019	04-Jul-19	4423	Gulf of St. Lawrence	Entangled	Partially Disentangled	known to be entangled from US, 25-Apr-19 (GSC) Confirmed gear free 29-Oct-19 (GoSL)

2019	04-Jul-19	3125	Gulf of St. Lawrence	Entangled	Partially Disentangled	Additional disentanglement efforts by CCS, 3-Aug-19 (East of CC)
2019	06-Aug-19	1226	Gulf of St. Lawrence	Entangled	No Action	Died, 16-Sep-19 (off NY) COD: probable entanglement

^ Disentangled / Released: Cases where response was mounted, and the animal was completely disentangled or successfully released from structure
Partial Disentanglement: Cases where response was attempted, and gear was partially removed
Lost: Cases where the animal was searched for by response or survey teams but could not be relocated and the animal was subsequently lost
No Action: Cases where response was not legally permitted, teams were on standby but bad weather prohibited action or response was not possible due to lack of team

+ Note: disentanglement efforts were suspended by DFO from July 5, 2017– March 2018 following the death of Joe Howlett.

* GSC – Great South Channel; CC – Cape Cod; CCB – Cape Cod Bay; BOF – Bay of Fundy; GoSL – Gulf of St. Lawrence; NJ – New Jersey; NY – New York

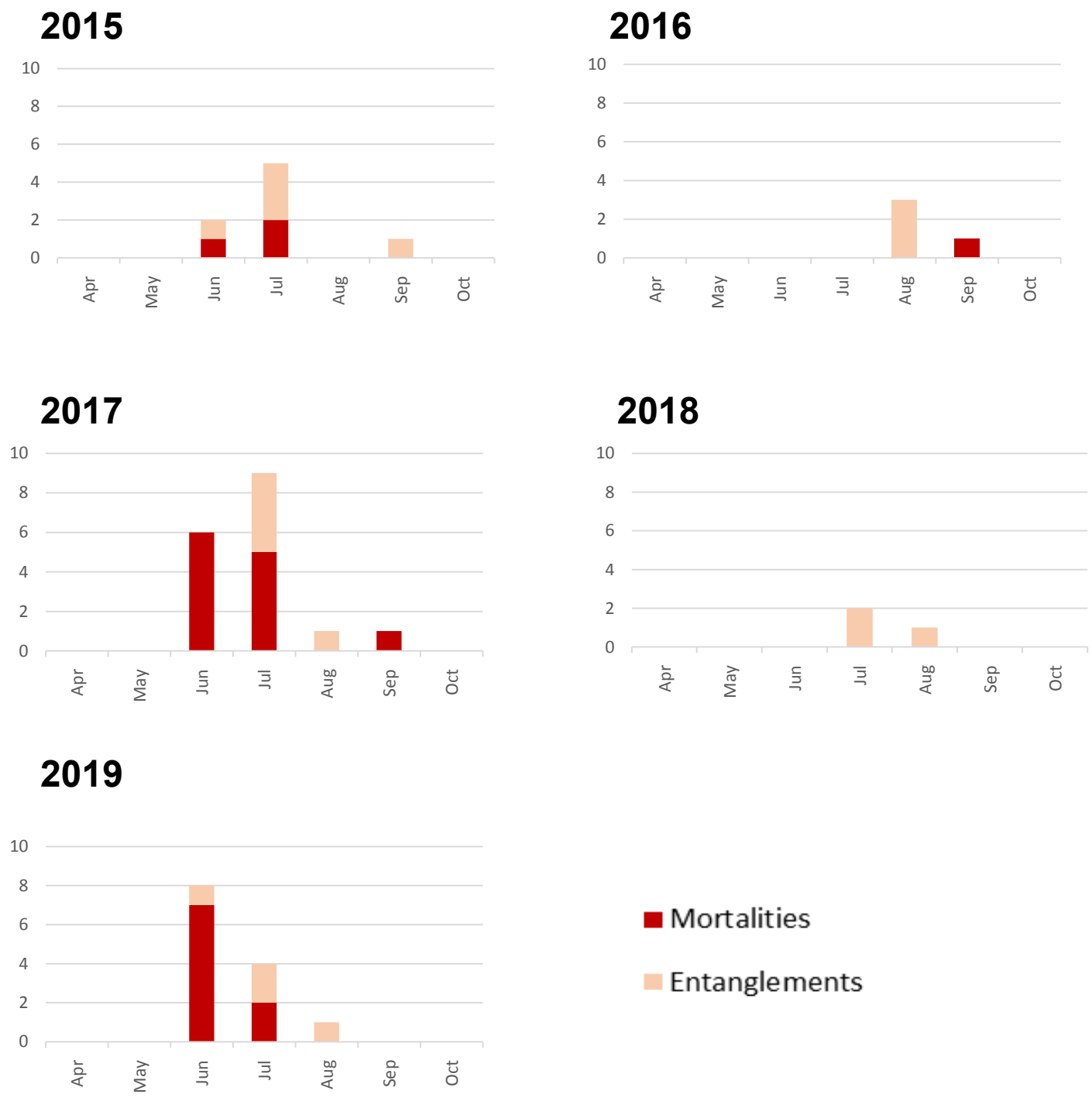


Figure 3. Monthly occurrence of mortalities (red) and entanglements/entrapments (pink) of North Atlantic right whales between 2015 – 2019

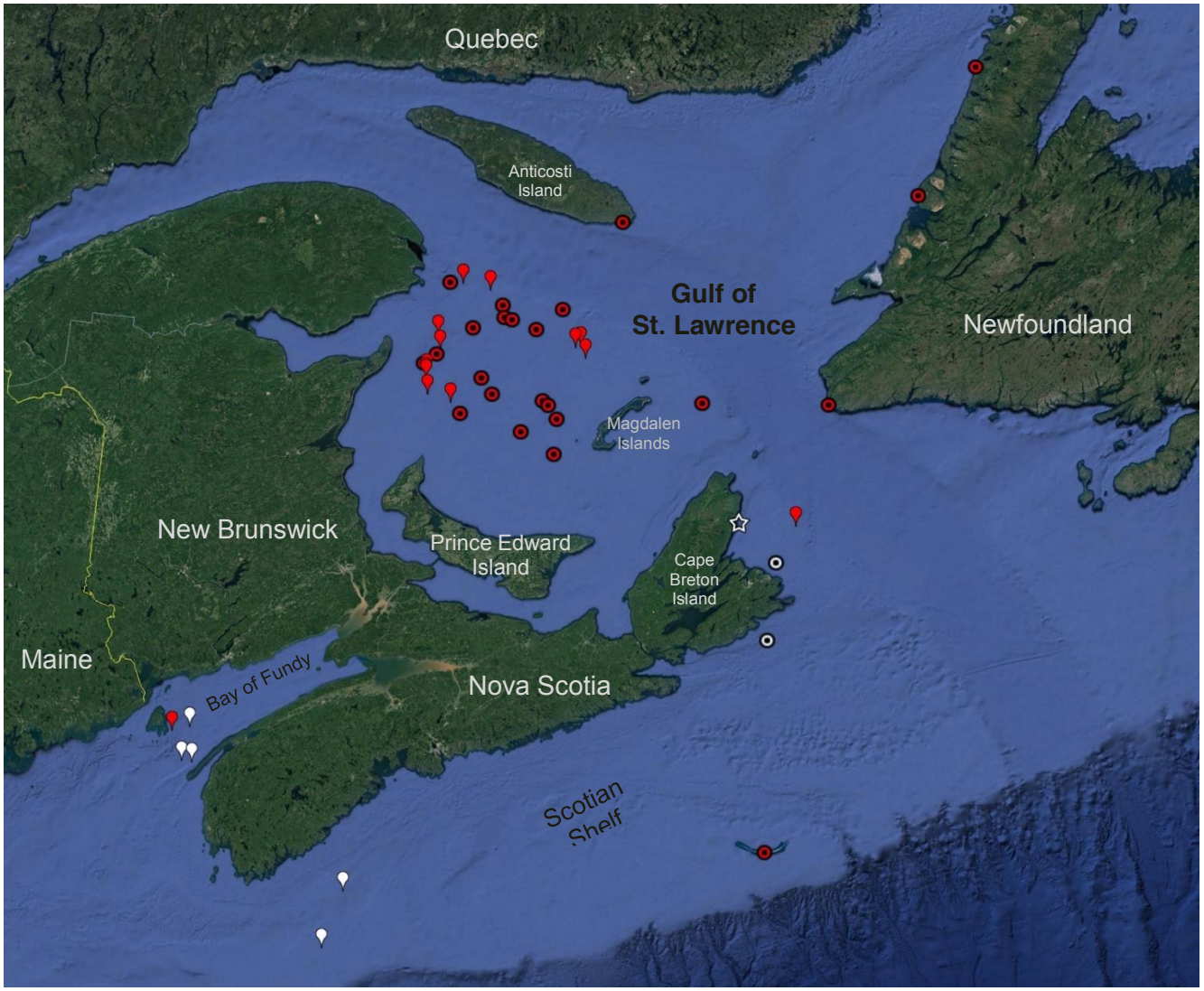


Figure 4. Locations of right whale mortalities (circles), entanglements (balloons) and entrapments (stars) in eastern Canada from 2015-2019. Markers coloured red are those which are known to have occurred in the Gulf of St. Lawrence or were traced back to activities there. White markers indicate that the cause of death or source of entanglement are not known.

Right whale sightings in eastern Canada, 1976 – 2019

In Canadian waters, right whales for many years were predominantly found in the Grand Manan Basin in the Bay of Fundy and Roseway Basin on the Scotian Shelf (Figure 5a). The regular seasonal use of these specific habitats resulted in their designation as Critical Habitat (DFO, 2014). Since 2010, however, there has been a reduction in the sightings and acoustic detections of right whales in these habitats (Davis et al. 2017; Figure 5b & c).

Prior to 2015, there were sporadic sightings of right whales in the GoSL, with fewer than a dozen individuals identified in most years (Figure 5a & b). However, during much of this time there was little dedicated survey effort in the GoSL with most reports being opportunistic sightings made by whale watch naturalists, researchers, and the public. The only long-term dedicated research has been conducted by the Mingan Island Cetacean Society (MICS) in an area north and west of Anticosti Island. As a result, there were significant knowledge gaps in the GoSL regarding the distribution and abundance of the species as well as understanding and mitigating threats to right whales.

Between 2015 - 2019, the surveys by MICS were augmented by researchers from several institutions with the New England Aquarium, Canadian Whale Institute, Dalhousie University, University of New Brunswick, NOAA's Northeast Fisheries Science Center and Fisheries and Oceans Canada. Results have shown that, during this time, right whales were increasing their use of this habitat (Figure 5c).

In 2019, data collected between June 2010 to November 2018 from a DFO passive acoustic monitoring network in the GoSL were analyzed and published which concurred with the results of visual surveys that there was an increase in the use of the Gulf of St. Lawrence during this period. Simard et al. (2019) found the mean daily occurrence of right whales in the feeding grounds off the Gaspé quadrupled after 2015 compared to 2011-2014.

Visual and acoustic surveys indicate that right whales are present in eastern Canada from June – January. The earliest detections in the Gulf of St. Lawrence have usually been at the end of April with a peak occurring from August to late October (data provided by researchers as reported in DFO 2019; Simard et al. 2019).

Preliminarily, New England Aquarium staff identified 137, 134 and 135 individual right whales in the Gulf of St. Lawrence in 2017, 2018 and 2019, respectively (*Note: the majority of individuals were catalogued, but several uncatalogued animals were also identified in each year.* New England Aquarium, pers. comm.). The sex ratio of observed whales has not been different than what was expected when compared to the catalogued population (New England Aquarium, pers. comm.). In some years, large numbers of adult females and their calves have been observed, with some suggesting the area may also be important for nursing as well as feeding. *For additional information on right whale sightings and acoustic detections in eastern Canada, see Annex 1 in Daoust et al 2017, Davis et al 2017, Simard et al 2019, DFO 2019 and references therein or reach out to individual right whale research teams.*

Aerial and vessel surveillance and surveys in eastern Canada, 2017 - 2019

Since the 2017 right whale mass mortality event in the Gulf of St. Lawrence, research effort as well as surveillance conducted by academic institutions and federal agencies increased substantially in eastern Canada.

For the purposes of this report, generalized categories of surveillance and surveys referred to here are:

- Aerial Surveillance: reporting of live, dead or distressed whales is included in the broad objectives of usual government surveillance activities to enforce regulations (e.g. DFO Conservation & Protection, Transport Canada)
- Dedicated Aerial Whale Surveys: aerial surveys dedicated to locating large whales, specifically right whales (e.g. DFO-Science, NOAA-NEFSC)
- Dedicated Whale Research Vessel Cruises: cruises with various research objectives related to studying whales (e.g. DFO-Science, MICS, NEA/CWI/DAL/UNB)
- Vessels of Opportunity with MMOs: Vessel cruises or opportunistic platforms with marine mammal observers (MMO) onboard (e.g. DFO fish surveys)

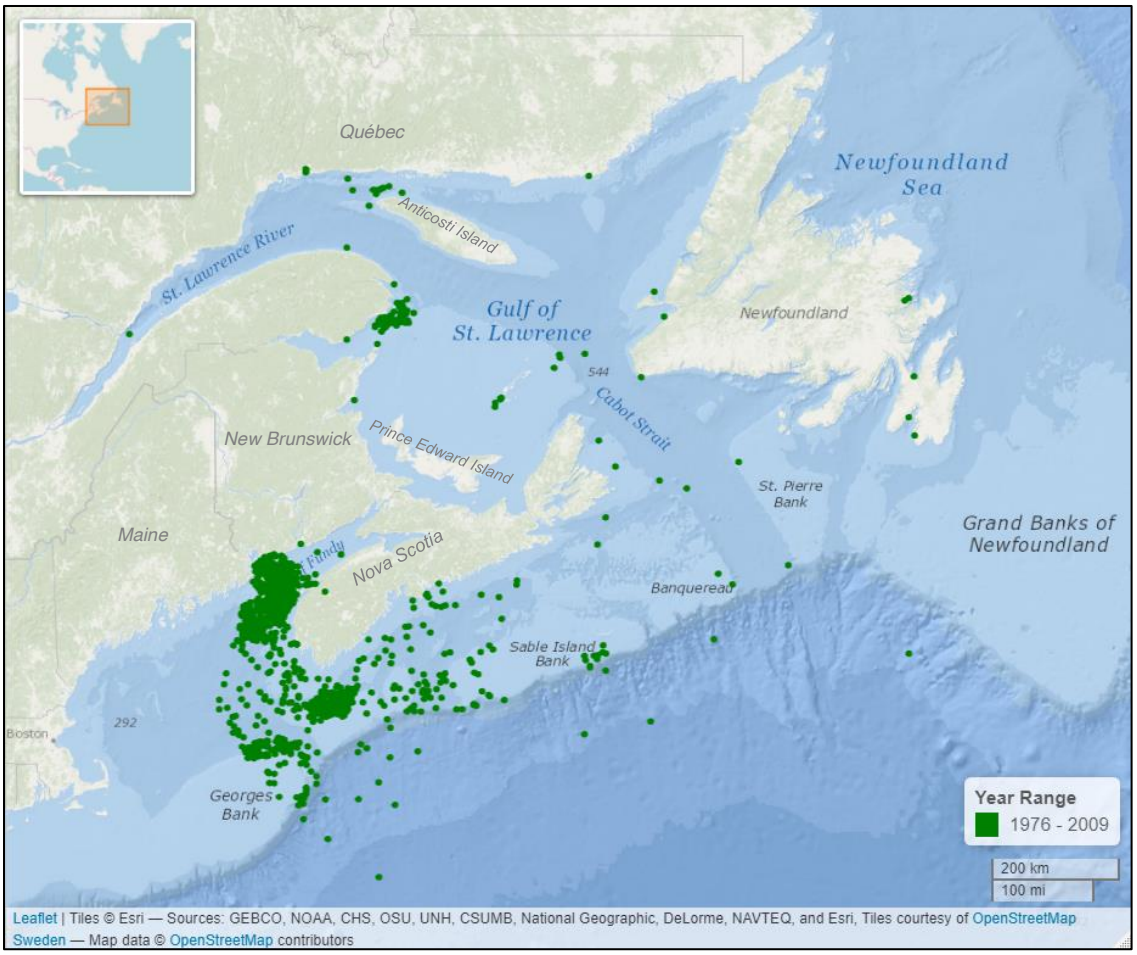
Note: The focus and objectives vary across these platforms. The presentation of information here is not meant to be a reflection of the effectiveness of the individual platforms or their personnel, but rather to give a general sense of the approximate effort in this region over this period and potential impacts on carcass or live-entangled whale detection. As well, the number of search hours or days have not necessarily been filtered by weather, visibility or sea state conditions. This will have an impact on the ability of personnel to detect animals. This information also does not include other platforms of opportunity which often report whale sightings or sightings of dead or distressed animals, including other government platforms and those from the public or industry.

Aerial and vessel-based surveillance and survey effort undertaken on Canadian and US government platforms in eastern Canada are summarized in Table 4. Aerial surveillance and survey effort increased significantly from 2017 to 2018, then with similar coverage continuing from 2018 to 2019. Government vessel-based survey (dedicated or opportunistic) effort has been very similar over the three years, ranging between approximately 600 – 820 hours (Table 4; Data provided by S. Ratelle, DFO- Gulf; V. Harvey, DFO-Quebec and A. Vanderlaan, H. Moors-Murphy and P. Emery, DFO-Maritimes).

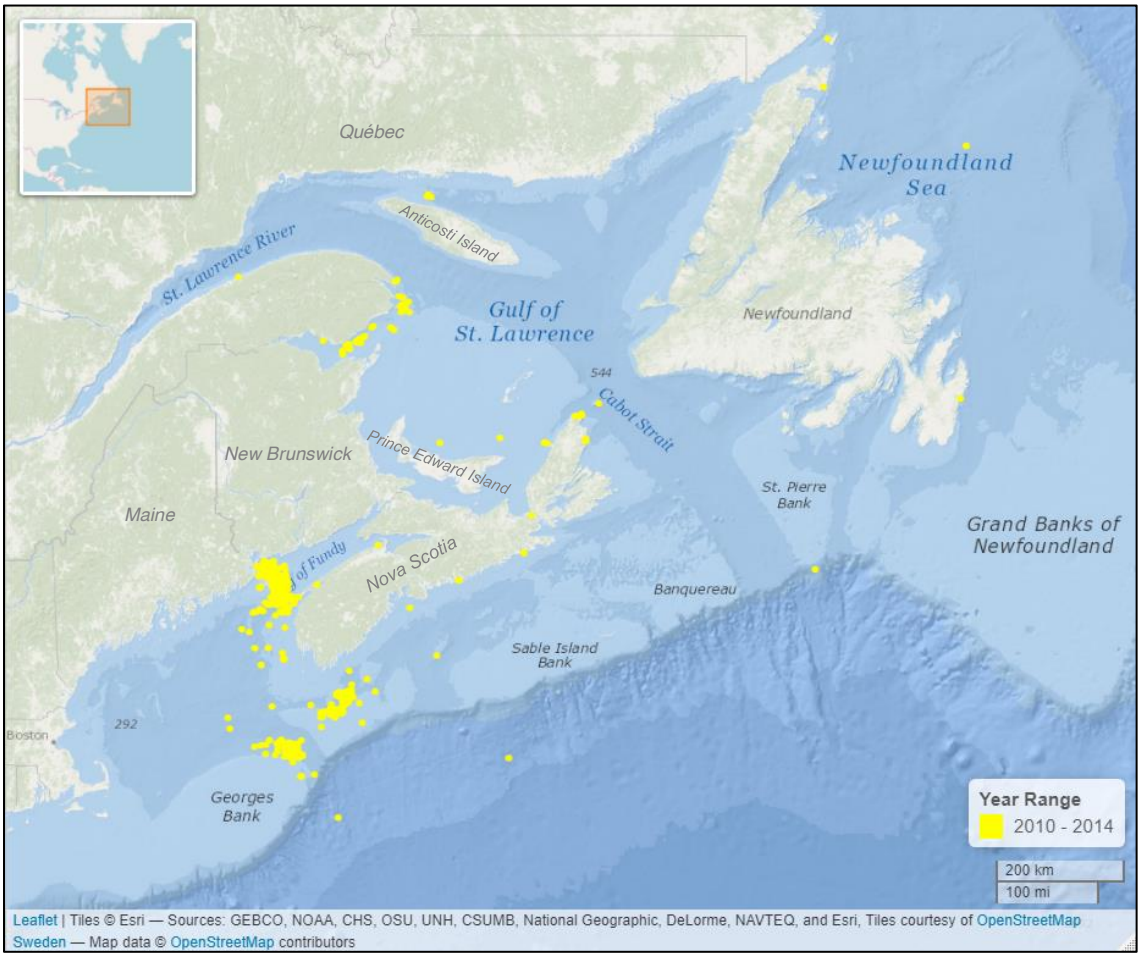
Vessel surveys conducted by Mingan Island Cetacean Society, New England Aquarium, Canadian Whale Institute, Dalhousie University, and the University of New Brunswick in the Gulf of St. Lawrence has increased slightly since 2017. Survey information is reported as days and this information is summarized in Table 5 (Data provided by New England Aquarium and from Johnson 2018. WhaleMap. Available at: https://whalemap.ocean.dal.ca/. Accessed 23-02-2020). *Note: non-government and academia vessel survey effort is reported as days, not as hours as with the government platforms. Also, some days were counted more than once as multiple platforms operated on the same day in different locations*.

Figure 6 illustrates the collective effort across government aerial and vessel platforms in eastern Canada (in hours; left axis) and by non-government or academic platforms in the Gulf of St. Lawrence (in days; right axis).

a)


Québec
Newfoundland Sea
Anticosti Island
St. Lawrence River
Gulf of St. Lawrence
Newfoundland
544
Cabot Strait
New Brunswick
Prince Edward Island
St. Pierre Bank
Maine
Nova Scotia
Grand Banks of Newfoundland
Banquereau
Sable Island Bank
292
Boston
Georges Bank
Year Range
1976 - 2009
200 km
100 mi
Leaflet | Tiles © Esri — Sources: GEBCO, NOAA, CHS, OSU, UNH, CSUMB, National Geographic, DeLorme, NAVTEQ, and Esri, Tiles courtesy of OpenStreetMap Sweden — Map data © OpenStreetMap contributors

b)


Québec
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Year Range
2010 - 2014
200 km
100 mi
Leaflet | Tiles © Esri — Sources: GEBCO, NOAA, CHS, OSU, UNH, CSUMB, National Geographic, DeLorme, NAVTEQ, and Esri, Tiles courtesy of OpenStreetMap Sweden — Map data © OpenStreetMap contributors

c)

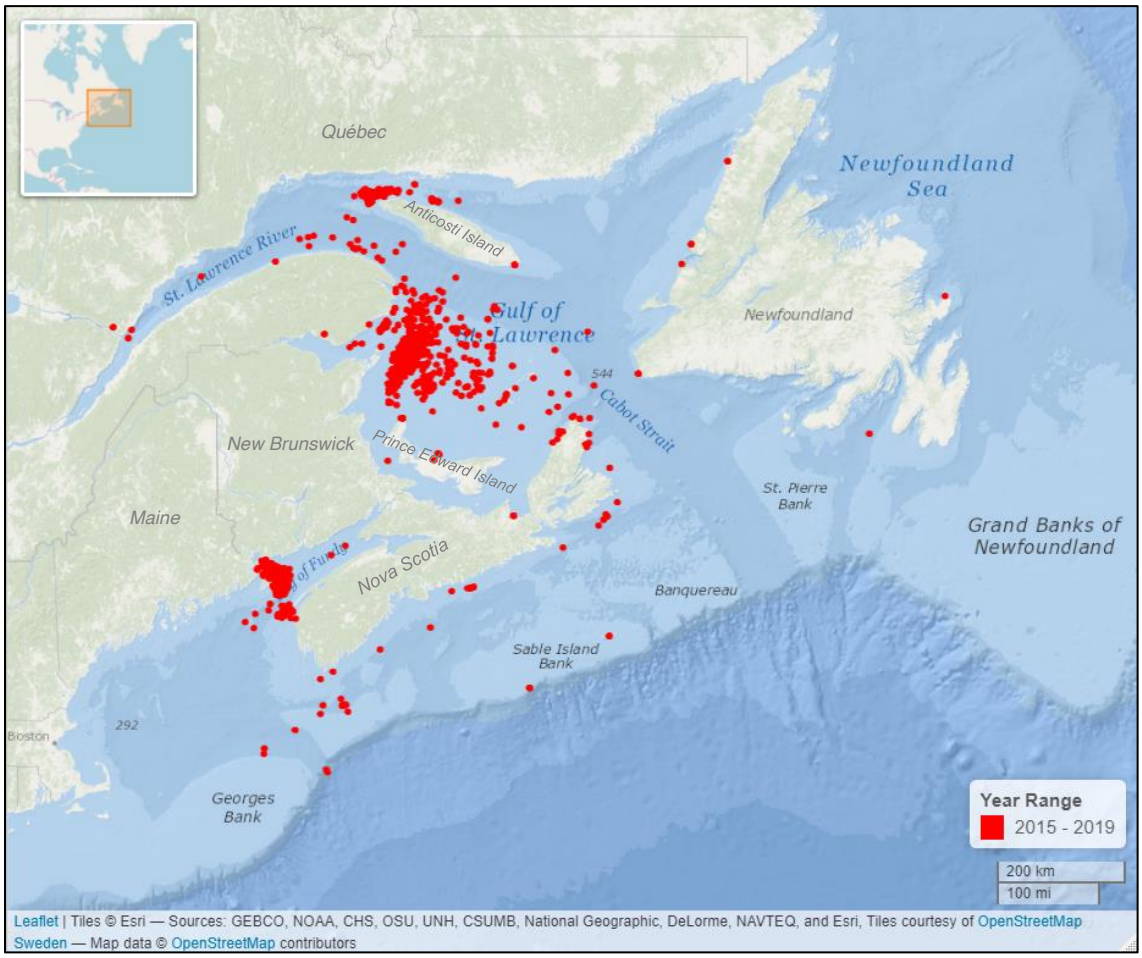


Figure 5. Sightings of North Atlantic right whales in the Gulf of St. Lawrence and Bay of Fundy from a) 1976 to 2009 (green dots), b) 2010 to 2014 (yellow dots), and c) 2010 to 2019 (red dots). Sightings provided by: Right Whale Consortium (2020). North Atlantic Right Whale Consortium Sightings Database 03/04/2020 (Anderson Cabot Center for Ocean Life at the New England Aquarium, Boston, MA, U.S.A.). *Disclaimer: This is a sightings map, not a distribution map. It is not known whether areas without sightings are because of whale absence or lack of surveillance. This map does not include right whale acoustic detections.*

Table 4. Number of surveillance, survey or opportunistic (with MMO present) aerial and vessel personnel ***hours*** conducted by Fisheries and Oceans Canada Science (DFO Science) and Conservation and Protection (C&P), Transport Canada (TC) and the National Oceanic and Atmospheric Administration (NOAA-NEFSC) in eastern Canada from 2017-2019.

	Government Platform	2017	2018	2019
Aerial surveillance and survey **hours**	DFO Science - twin otter	197.6	664.3	140
	DFO Science - Cessna	--	242.5	660
	DFO Science - Partenavia	--	94.5	--
	DFO C&P - Plane 1	--	800	1157
	DFO C&P - Plane 2	--	--	223
	TC Dash 7/8	251.2	367.1	586.7
	NOAA-NEFSC twin otter	152	152.5	150
	Total Aerial	**600.80**	**2320.90**	**2916.70**
Vessel survey **Hours**	CCGS Teleost	618.5	480	292
	CCGS Hudson	--	160	--
	CCGS Amundsen	--	--	14
	RV Coriolis	--	179	383.67
	Total Vessel	**618.50**	**819.00**	**689.67**

Table 5. Number of vessel survey ***days*** conducted by the Mingan Island Cetacean Study (MICS) and collaborative research by the New England Aquarium (NEA), Canadian Whale Institute (CWI), Dalhousie University (DAL) and the University of New Brunswick (UNB) in the Gulf of St. Lawrence from 2017-2019.

Platform	***2017***	***2018***	***2019***
*MICS**	60	68	79
NEA/CWI/DAL/UNB	13	23	29
TOTAL	**73**	**91**	**108**

** summarizes days across multiple platforms*

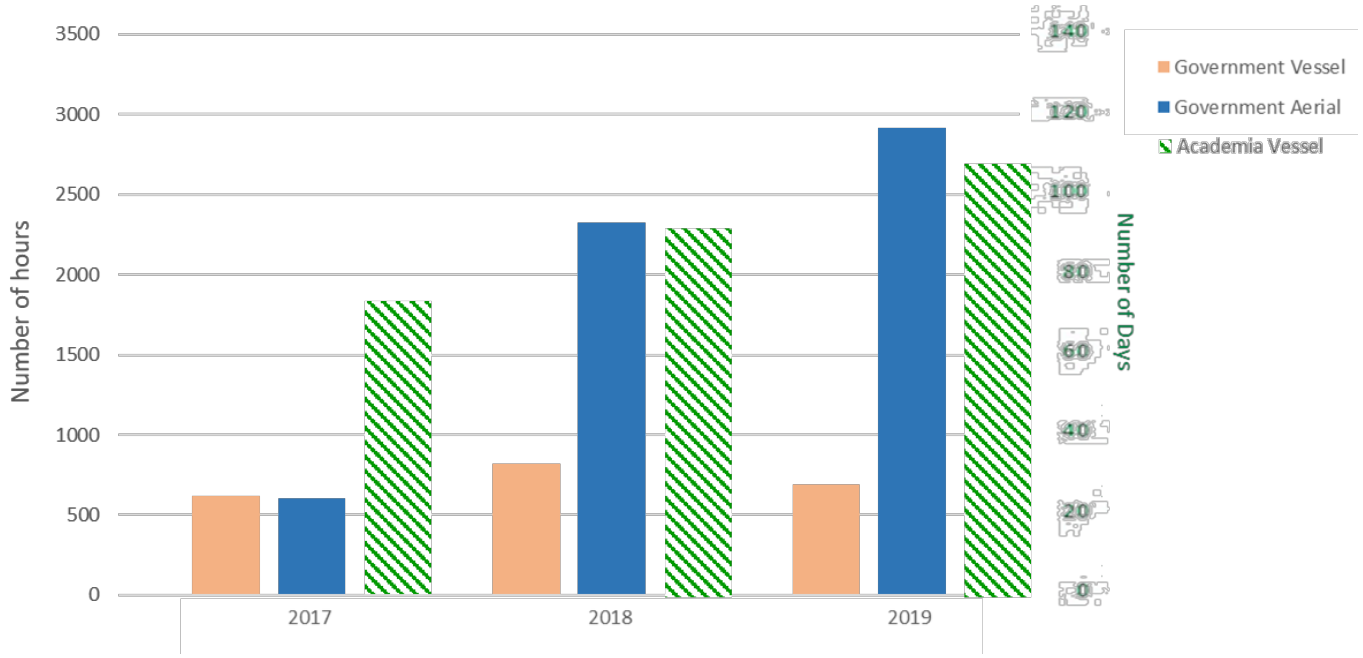


Figure 6. The collective number of surveillance and survey **hours** by government aerial (blue) and vessel (peach) platforms in eastern Canada (Fisheries and Oceans Canada-Science and Conservation & Protection, Transport Canada and the National Oceanic and Atmospheric Administration – Northeast Fisheries Science Center), aligned with the left axis. The number of collective survey **days** by non-government and academic (green hatched) platforms in the Gulf of St. Lawrence (Mingan Island Cetacean Society, New England Aquarium, Canadian Whale Institute, Dalhousie University, and the University of New Brunswick), aligned with the right axis.

The timing of surveillance, surveys and research efforts in eastern Canada has varied annually between 2017-2019. Non-government and academia vessel-based research efforts in the Gulf of St. Lawrence has ranged from June to October in most years, with most research being conducted in July and August (Figure 7). Much of the effort of MICS has centered in the region north and west of Anticosti Island and off the eastern tip of the Gaspe Peninsula while the collaborative efforts of the New England Aquarium, Canadian Whale Institute, Dalhousie University, and the University of New Brunswick has primarily been focused in the Shediac valley, Orpheline Trough east of Shippagan, New Brunswick and the Grand Manan Basin, Bay of Fundy (Figure 9 a and c).

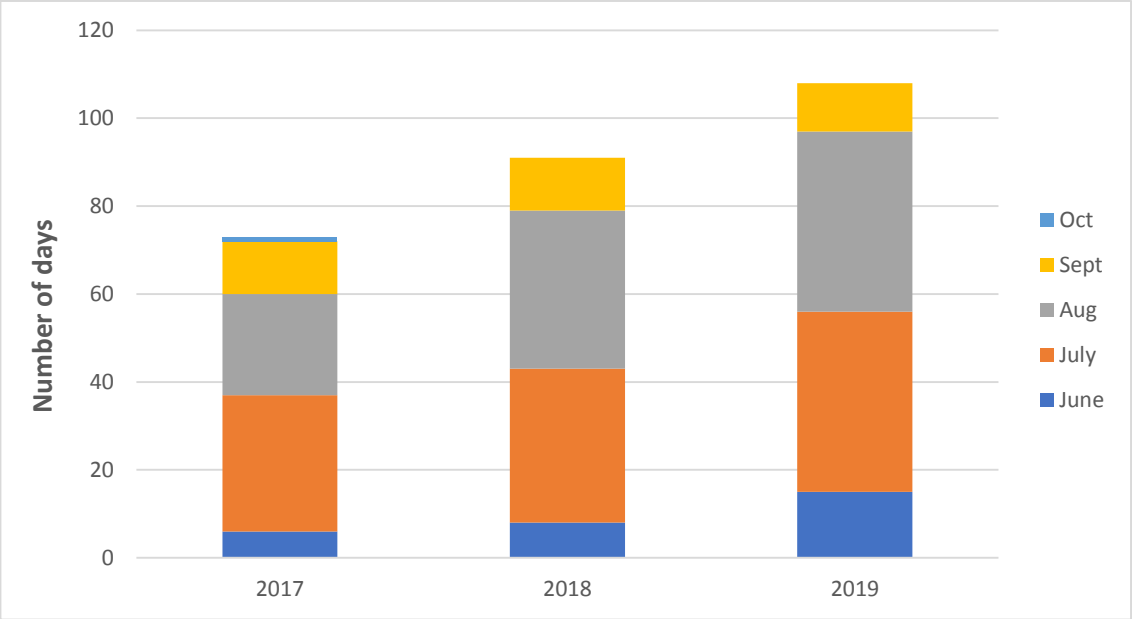


Figure 7. Number of **days** per month research has been conducted by the Mingan Island Cetacean Society, New England Aquarium, Canadian Whale Institute, Dalhousie University, and the University of New Brunswick in the Gulf of St. Lawrence collectively between 2017 – 2019. (Data provided by New England Aquarium and from Johnson 2018. WhaleMap. Available at: https://whalemap.ocean.dal.ca/. Accessed 23-02-2020. *Note: Some days were counted more than once as multiple platforms operated on the same day in different locations*).

Information on government surveys and surveillance was not available monthly, but rather by date ranges per year (Figure 8). The date range of individual platforms varied significantly depending on the purpose of the effort. Surveillance and larger scale aerial research efforts tended to extend many months, while dedicated whale research cruises or MMOs on platforms of opportunities tended to be across very specific and shorter time frames. This also varied significantly across years, with the minimum effort in 2017 and increasing through 2018 and 2019. Areas covered by government surveillance and surveys are fairly broad (especially aerial coverage) and include the Gulf of St. Lawrence, Newfoundland, the Scotian Shelf and the Bay of Fundy (Figure 9 b and d). These areas are not covered equally temporally or spatially.

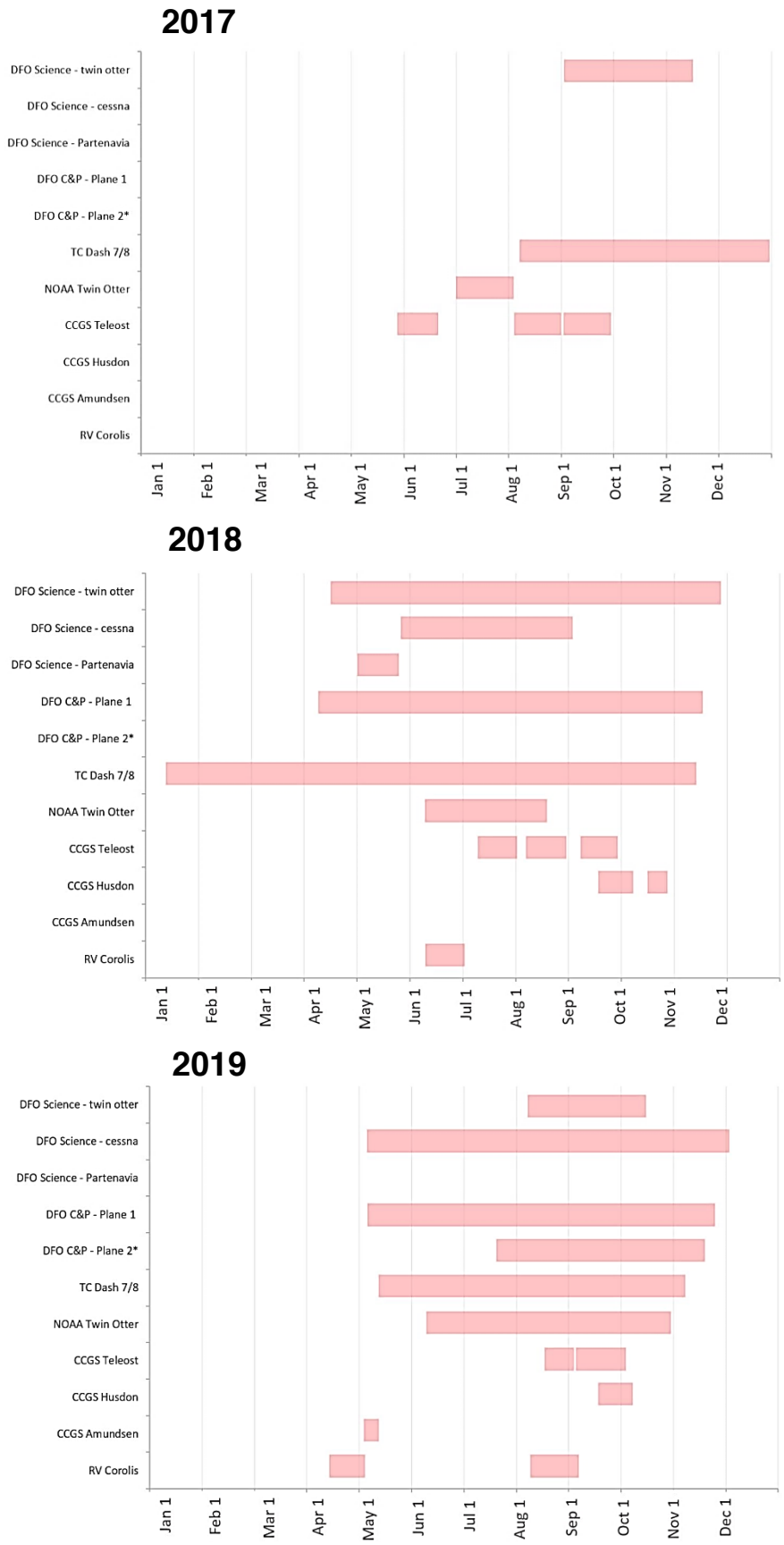


Figure 8. Date ranges of various government platforms conducting surveillance or surveys in eastern Canada, 2017-2019.

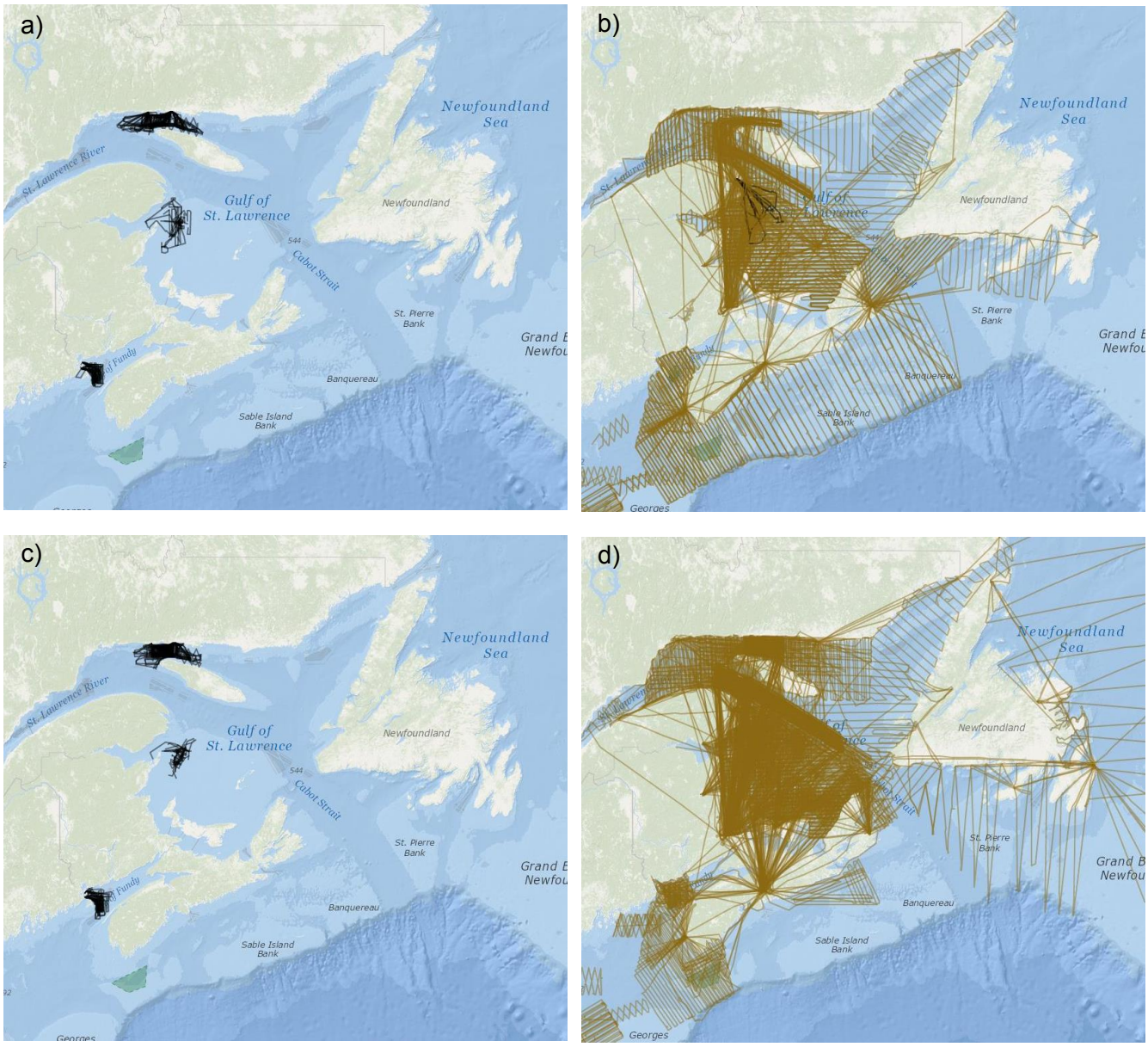
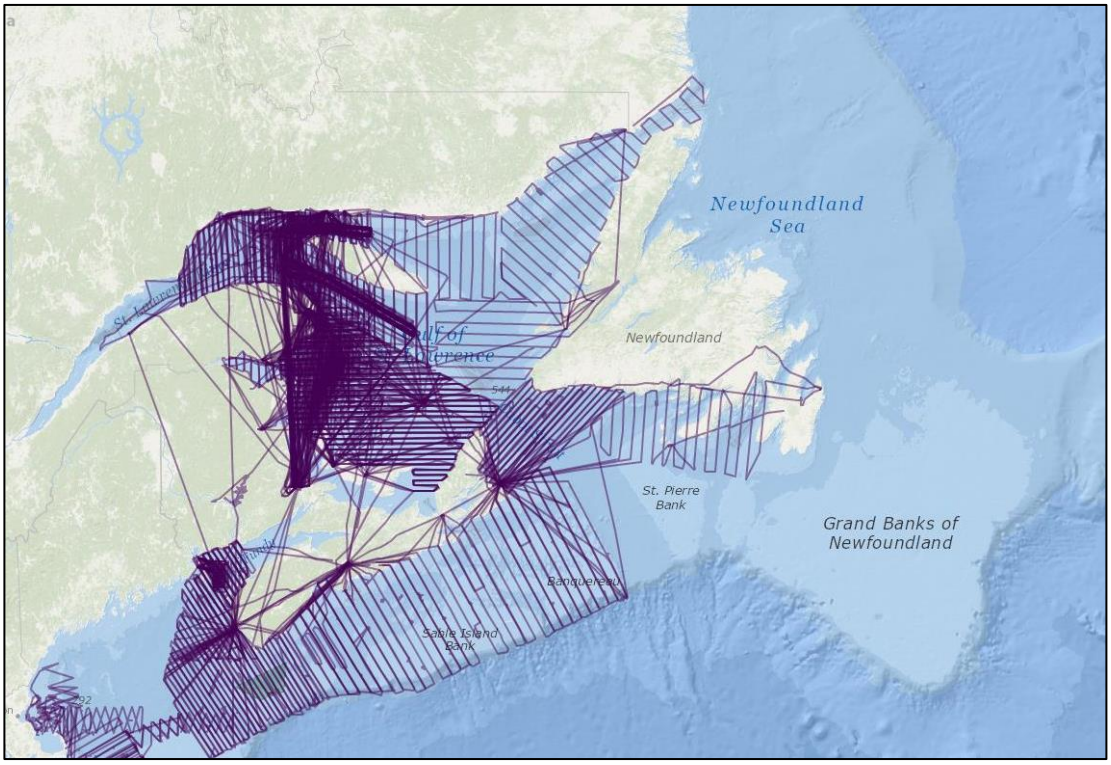


Figure 9. Surveys and surveillance by non-government (a) and government (b) platforms in 2018 and non-government (c) and government (d) platforms in 2019 (Source: Johnson 2018. WhaleMap. Available at: https://whalemap.ocean.dal.ca/. Accessed 02-04-2020).

When viewed in totality for an entire year, vessel and aerial surveillance and survey tracks from all platforms in 2018 and 2019 cover a significant proportion of the entire Gulf of St. Lawrence (Figure 10). When viewed in this manner, it appears that there is adequate vessel and aerial coverage of right whale incidents (i.e., entanglements and mortalities) in this region for the given time period.

a)



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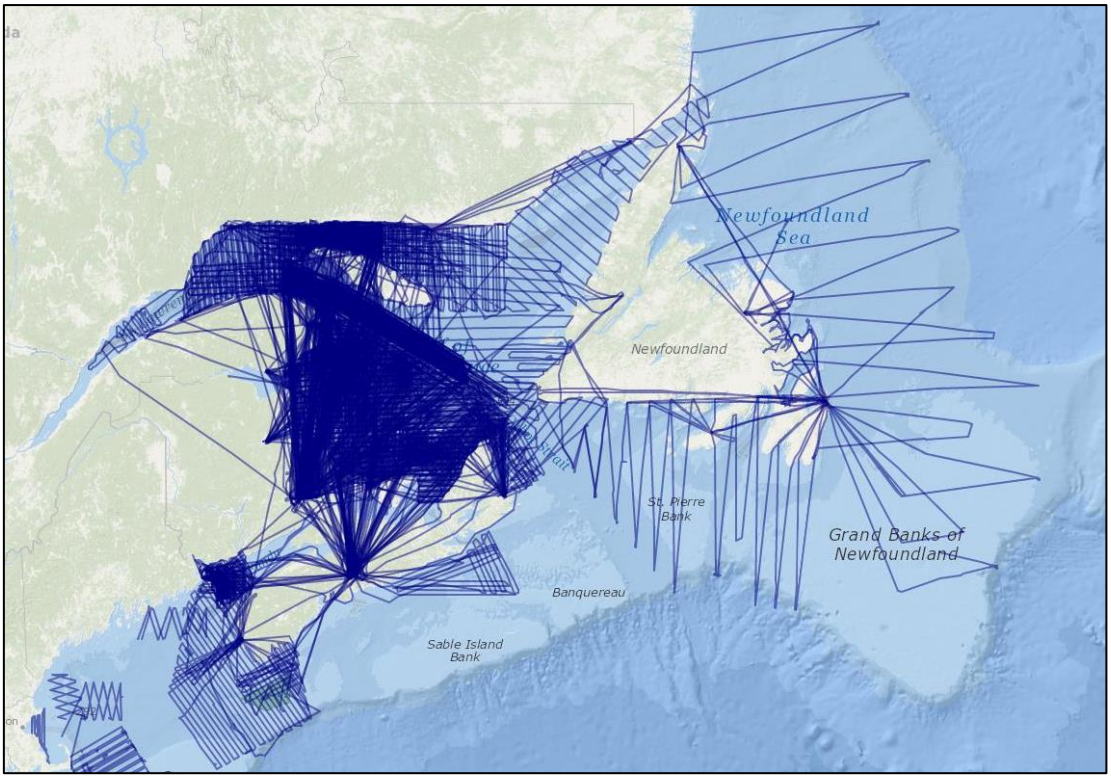


Figure 10. Vessel and aerial effort for all research and surveillance platforms in eastern Canada in a) 2018 and b) 2019 (Source: Johnson 2018. WhaleMap. Available at: https://whalemap.ocean.dal.ca/. Accessed 02-04-2020).

However, while the coverage of the region overall has increased significantly, at points in time, there are large gaps in surveillance coverage. Figure 11 provides an example of the coverage during the two period in June and July 2019 when most dead right whales were reported. During these periods, 6 dead right whales were all detected in June and 2 in July most of which evidenced moderate to advanced External Decomposition Levels (Levels 3 and 4, see annex I for level descriptions) at first sighting. Two of these animals were discovered off northern and eastern Cape Breton Island, which, as these examples show, there is very little aerial coverage. It is possible that not all track information is submitted to WhaleMap by Canadian Government platforms and so it is possible that for any given timeframe that the surveillance lines on WhaleMap may not be all inclusive. However between the 2017 to 2019 mortality events a significant percentage of carcasses are still in a more advanced state of decomposition at first sighting suggesting that, for the purpose of detecting dead whales, the current levels and platforms of surveillance are not effective at rapidly detecting floating carcasses.

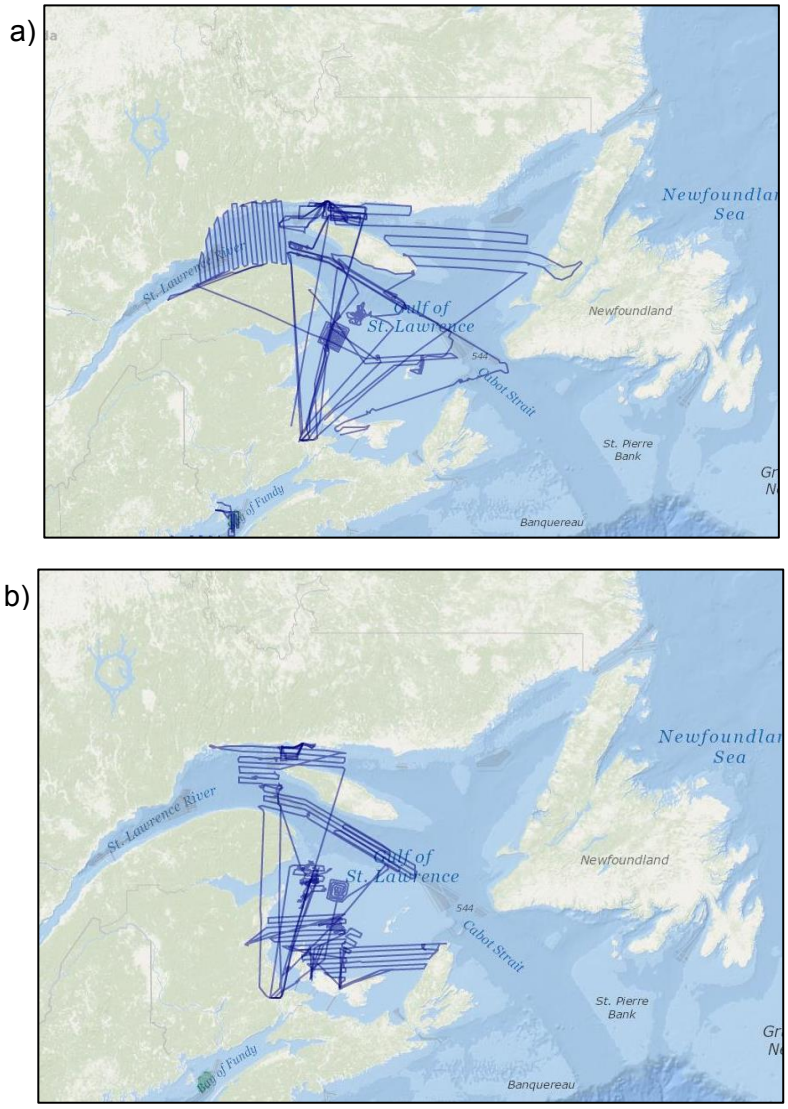


Figure 11. Vessel and aerial effort for all research and surveillance platforms in eastern Canada in 2019 for a) June 18-30 and b) July 20-23 (Source: Johnson 2018. WhaleMap. Available at: https://whalemap.ocean.dal.ca/. Accessed 02-04-2020).

Right whale mortalities and mitigation measures implemented to reduce entanglements and vessel strikes, 2017-2019

Throughout their range in both Canada and the US, right whales are subject to high levels of human-caused mortality, determined via necropsies to be primarily caused by vessel collisions and entanglement in fishing gear (Sharp et al 2019, Daoust et al 2017; Moore et al 2005; Knowlton and Kraus 2001).

In Canada, North Atlantic right whales have been assessed and considered to be an endangered species since 1980. Since this time, at least 42 mortalities and 45 entanglements / entrapments have been documented in Canadian waters, with the majority having occurred within the last 5 years (*Note: effort to detect and report incidents varies year-to-year and has improved greatly in the last 10-15 years*; see Table 1). In addition, there have been several individual right whales observed with serious injuries in Canadian waters (Henry et al., In Press) where serious injury is defined under the US Marine Mammal Protection Act as "any injury that is more likely than not to result in mortality" (NMFS, 2012). These animals are highly likely to perish sooner than their natural lifespan and while they continue to live, they are also unlikely to significantly contribute to the right whale population in terms of reproductive contributions (Kraus et al 2001).

With most incidents occurring within the last 5 years in Canada, Canada has a significant role to play in the existence and recovery of endangered North Atlantic right whales.

Both the *SARA* Recovery Strategy (DFO 2014) and proposed *SARA* Action Plan (DFO 2020) for right whales address the need to identify and evaluate the effects of human activities, including supporting necropsies of dead animals in Canadian waters. However, a 2018 audit by the Office of the Auditor General of Canada on Canada's progress to date for the protection of marine mammals concluded that, up to and including the 2017 fishing season, Fisheries and Oceans Canada, in collaboration with Parks Canada, Transport Canada, and Environment and Climate Change Canada, had not adequately protected marine mammals from threats posed by marine vessels and commercial fishing (Auditor General of Canada 2018). This conclusion is well supported by a timeline provided by Davies and Brillant (2019) which portrays the events related to the conservation of right whales in Canada from 1993 through the 2017 mass mortality crisis and the subsequent regulatory response in early 2018 (Figure 12). In general, prior to 2017, very few conservation efforts were implemented in Canada and most of the measures that were put in place prior to this time, were advocated for and undertaken primarily by individual scientists, non-government organizations and industry.

In their review of the federal government's actions to date, Davies and Brillant (2019) also concluded that prior to the 2017 mortality crisis, the Canadian government neglected to assess the risk to right whales [and other species] from an increase in snow crab fishing quotas and activity in the Gulf of St. Lawrence and neglected to implement a precautionary ecosystem-based fisheries management plan. This was despite knowledge that right whales were increasingly utilizing the Gulf of St. Lawrence since 2014-2015, a conclusion which was supported by the eventual analysis of acoustic recordings made from 2010 – 2018 by federal government scientists (Simard et al 2019).

During the 2017 mass mortality event, measures to reduce the risk of mortality and injury to right whales were implemented 50 and 68 days following the discovery of the first right whale carcass by DFO and Transport Canada, respectively (Figure 13). For fisheries, it wasn't until after 9 carcasses and 4 live entangled whales had been discovered that the fishery was closed (prior to this time, a static area was closed to fishing between July 14 – 24th, Figure 13b). The fishery was closed within 4 days of their usual closure date and was after the entirety of the snow crab quota had been caught. For shipping, a mandatory speed slow down to 10 knots was implemented for vessels 20 metres or longer travelling in the western Gulf of St. Lawrence on 11 August, after a further 2 carcasses had been discovered (Figure 13c). An additional carcass was discovered after these measures were put in place (Figure 13a).

In 2018, mitigation measures to reduce the risk of entanglements were strengthened with the implementation of a static fishery closure area and dynamic fisheries management in the fishing grids surrounding the static area (Figure

14b). This was in place from April 28 – June 30th (Figure 14a). Mitigation measures implemented to reduce the risk of vessel strikes were also modified slightly and were comprised of a combination of static and dynamic management areas (Figure 14b). Within the static zone, vessels greater than 20 metres or longer were required to slow down to 10 knots or less between April 28 – November 15th. In the dynamic zones (Areas A-D in Figure 14b), vessels were only required to slow down if a right whale had been sighted within the zones. If a whale were sighted, it would trigger a mandatory slow down to 10 knots or less for a period of 15 days which could be extended in the event of continued whale presence. The sighting of only one right whale would trigger fishing closures and vessel slow down in dynamically managed areas. In 2018, there were no reported mortalities of right whales in Canadian waters but there were four observed entanglements (two in the Gulf of St. Lawrence, one in the Bay of Fundy and one was an animal known to already be entangled since 2014; Figure 14a; Table 3).

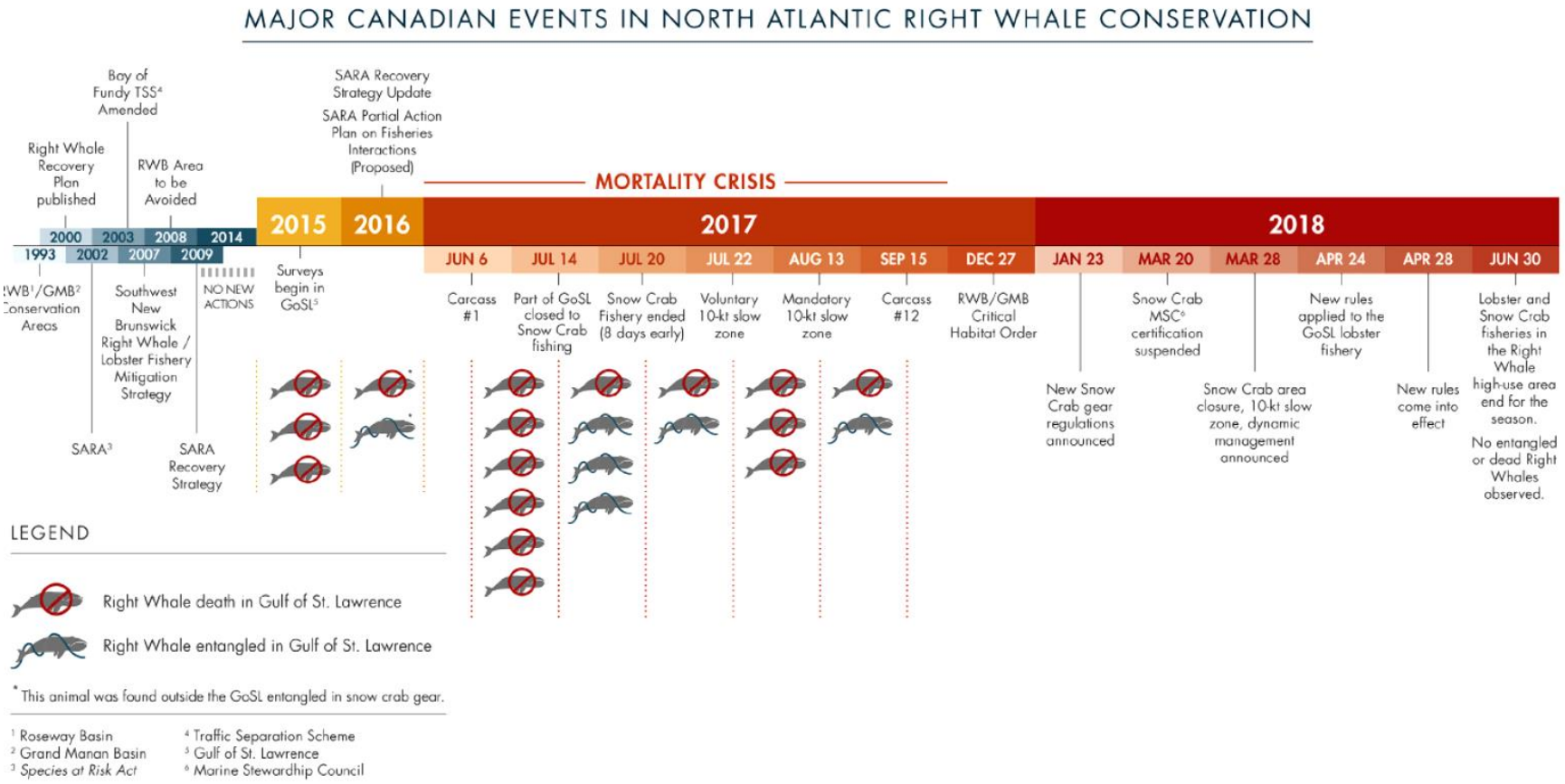


Figure 12. Timeline of efforts in Canada for the conservation of North Atlantic right whales since 1993, through the 2017 mass mortality crisis and the subsequent regulatory response in early 2018. Carcasses and entangled whales reported in Canadian waters prior to 2015 are not included in this figure nor are incidents which occurred in 2018 and 2019 (used with permission by authors; Davies and Brillant 2019).

Measures in 2019 were similar to those in 2018, however, the static closure fishing area was reduced to be approximately 60% smaller than it was in 2018 (Figure 15b). The area that was removed from the static fishing closure area was instead subject to dynamic fishing management measures. Measures to reduce the risk of vessel strikes were initially implemented as they were in 2018 with the added restriction that it applied to vessels 13 metres or longer. However, after 7 whales had died (four of which could be accessed and necropsied and all had indications that a vessel strike was the cause of death; Figure 15a; Table 2), additional measures were implemented by Transport Canada. Twelve days following the last of these incidents, an additional dynamic zone was added (Zone E), the static zone was divided into northern and southern zones to allow for more dynamic management, these static zones were extended to the area around the newly established Dynamic Zone E and the size of vessels required to comply with these measures was reduced to all vessels 13 metres or longer (Figure 15c).

In both years, there were also additional, non-risk reducing, voluntary or mandatory measures implemented such as mandatory gear marking, reporting of ghost gear and incident reporting to DFO. Though there was significant investment in research in the Gulf of St. Lawrence (and approaches) to acoustically detect right whales using a variety of methods including ocean gliders and deployed hydrophones, these detections were not used in 2018 or 2019 to aid in managing the closing or opening of fishing or vessel management areas. In total, 9 animals were found dead and a further 5 live animals were reported entangled in eastern Canada in 2019 (Table 1). On February 27th, the Ministers of Fisheries and Oceans Canada and Transport Canada announced the measures to be implemented in 2020 to reduce the risk of entanglements and vessel strikes to right whales. Many of these measures were like those in 2019 with some revisions or new measures added.

For fisheries, this includes:

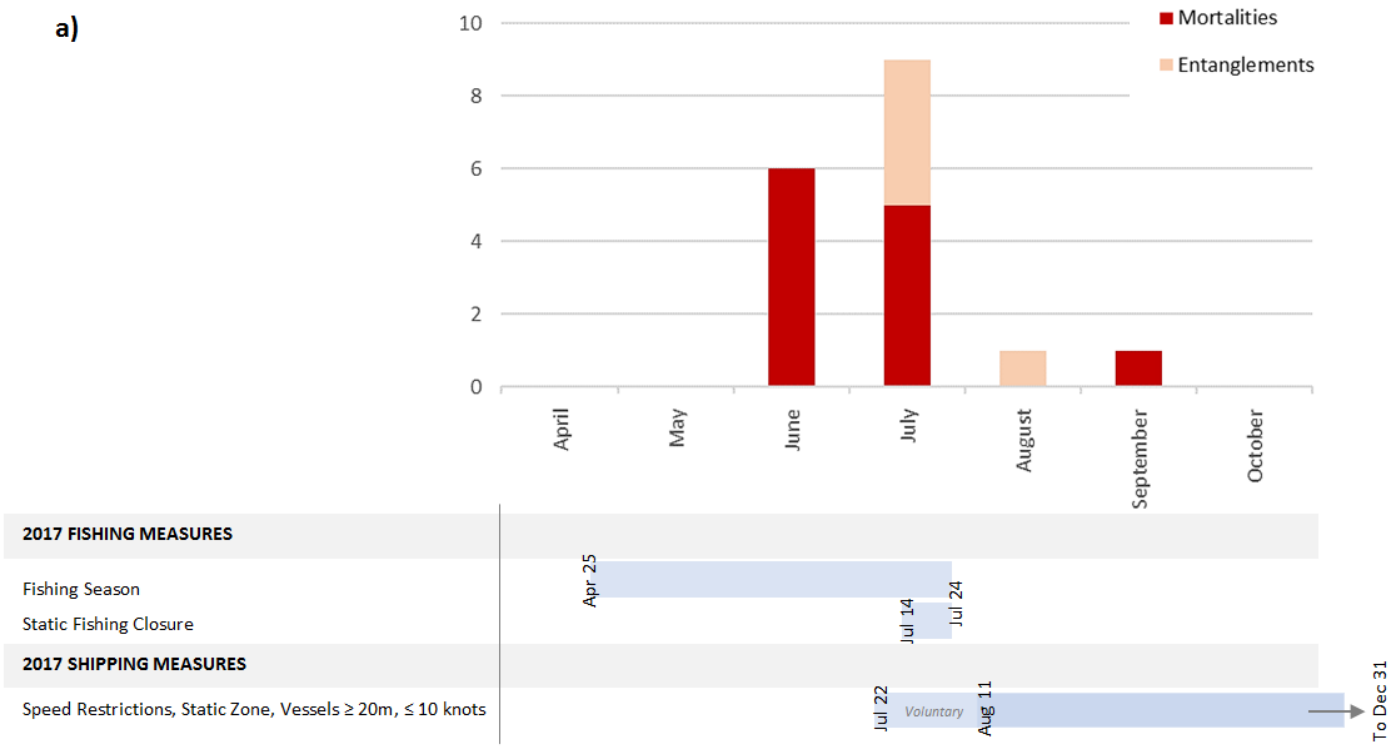
- both static and dynamic fisheries management
- a new season-long fishery closure protocol in areas where whales aggregate (to be determined during 2020 period)

For shipping, this includes:

- a reduced period of the 10-knot speed restrictions of 28 April to 15 September (still only for vessels 13m or longer)
- Zone E, introduced in late-2019 will be in place for the entire period in 2020
- a new seasonal vessel management area in the Shediac Valley where ships will be required to reduce their speed to 8 knots (timing and exact location to be determined during the 2020 period)
- a trial, voluntary speed restriction of 10 knots in the Cabot Strait in place the periods of 28 April to 15 June and 1 October to 15 November. *Note:* i*n both 2017 and 2019, several carcasses were reported between 20 June - 21 July, a timeframe during which this temporary speed reduction would not apply in this area*

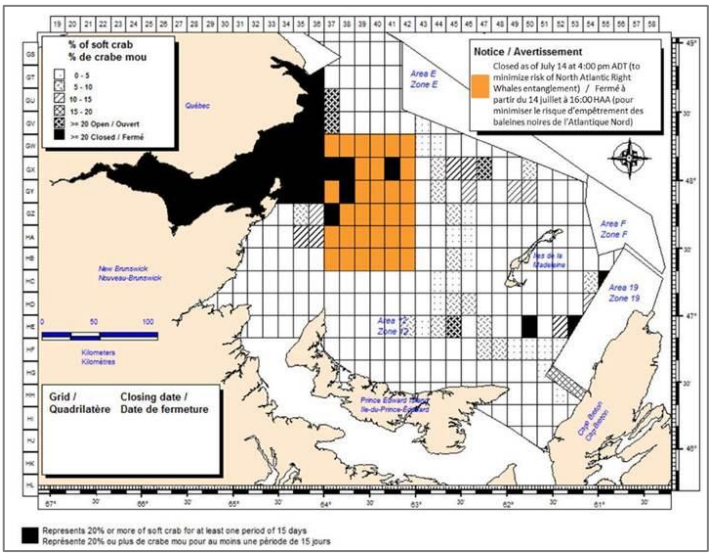
In addition, it has also been announced that both visual and acoustic detections would be used to trigger the closing of a fishing area or a vessel speed restriction. The use of acoustic detections will enable these measures to be implemented in periods where there is limited or no surveillance or weather conditions hinder visual observations. However, it will not aid in the detection of dead or live-entangled whales.

a)



b)

Static Fishing Closure (orange boxes):



c)

Shipping Speed Restrictions, Static Zone (grey box):

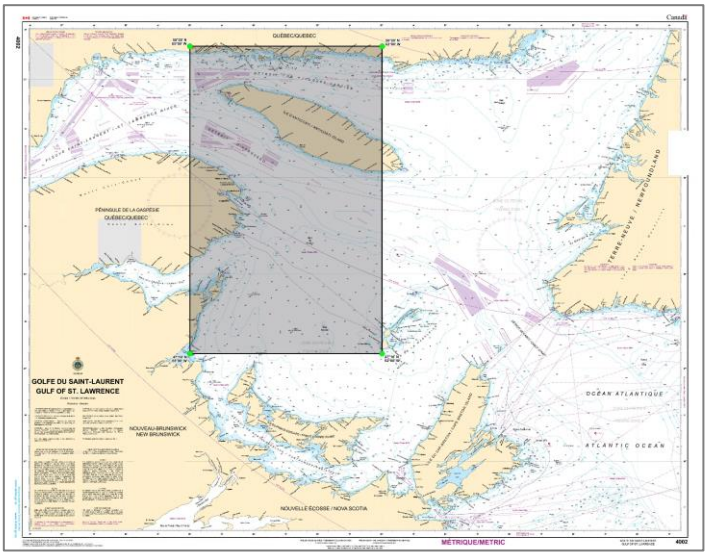
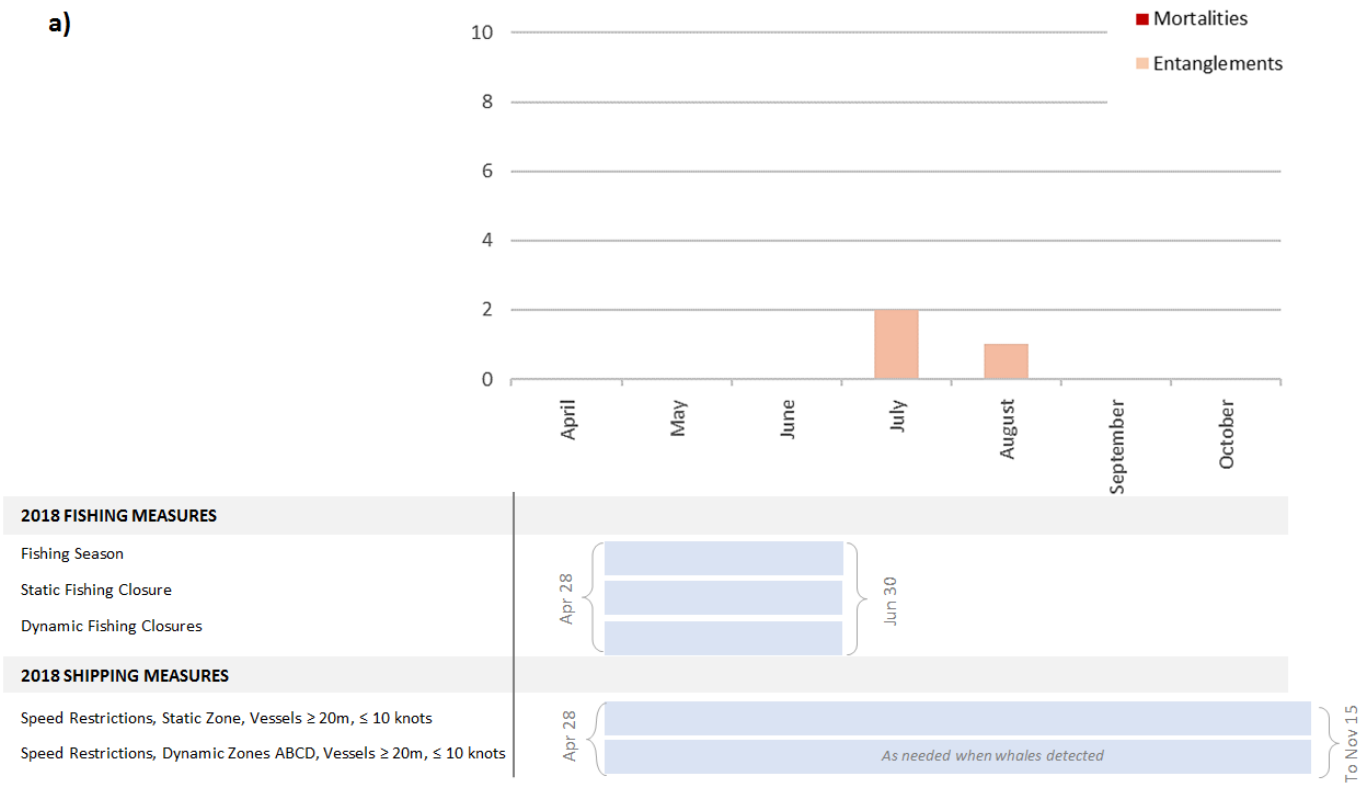


Figure 13. Graphic indicating the monthly mortalities and entanglements/entrapments of right whales and timing of the implemented fishing and shipping mitigation measures in eastern Canada in 2017 (a). Maps indicate the location of the implemented fishing mitigation measures as of July 14th (b) and shipping mitigation measures as of July 22nd (c). *Unless otherwise indicated, mitigation measures were mandatory.*

a)



b) Static and Dynamic Fishing and Shipping Measures:

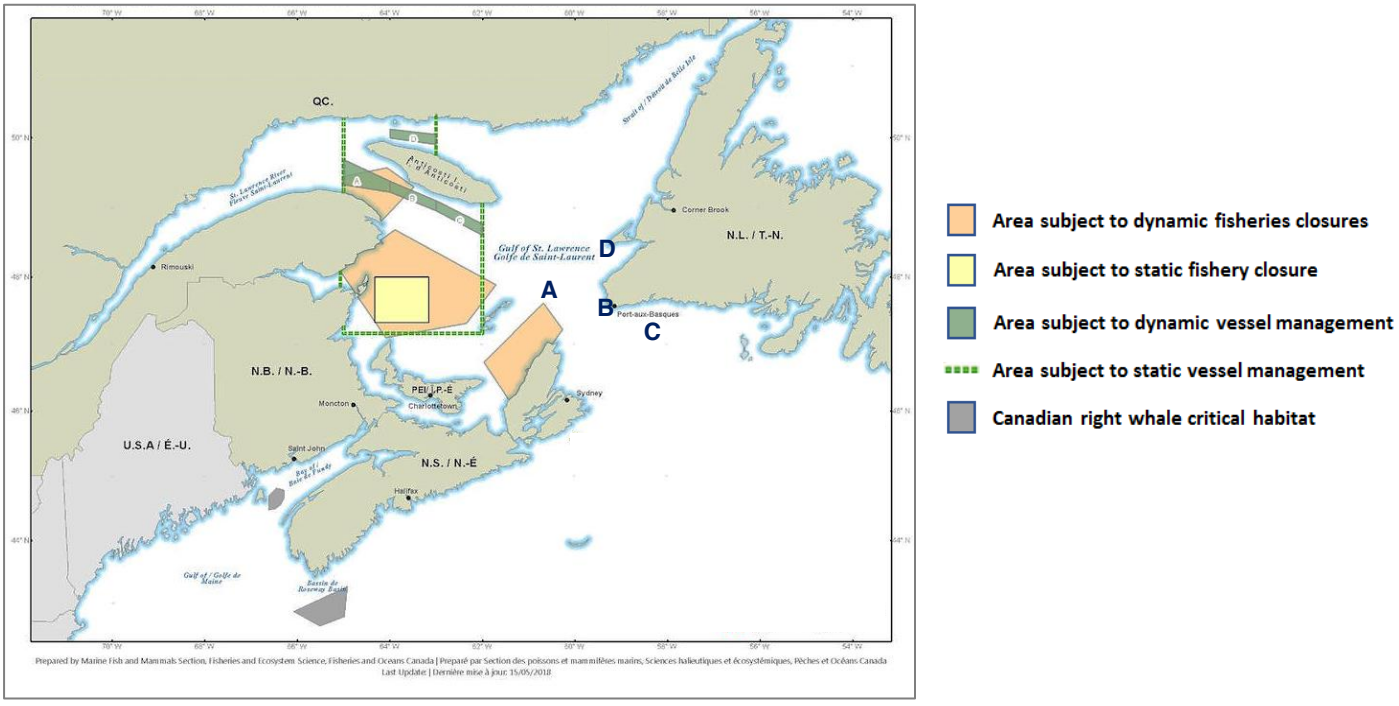
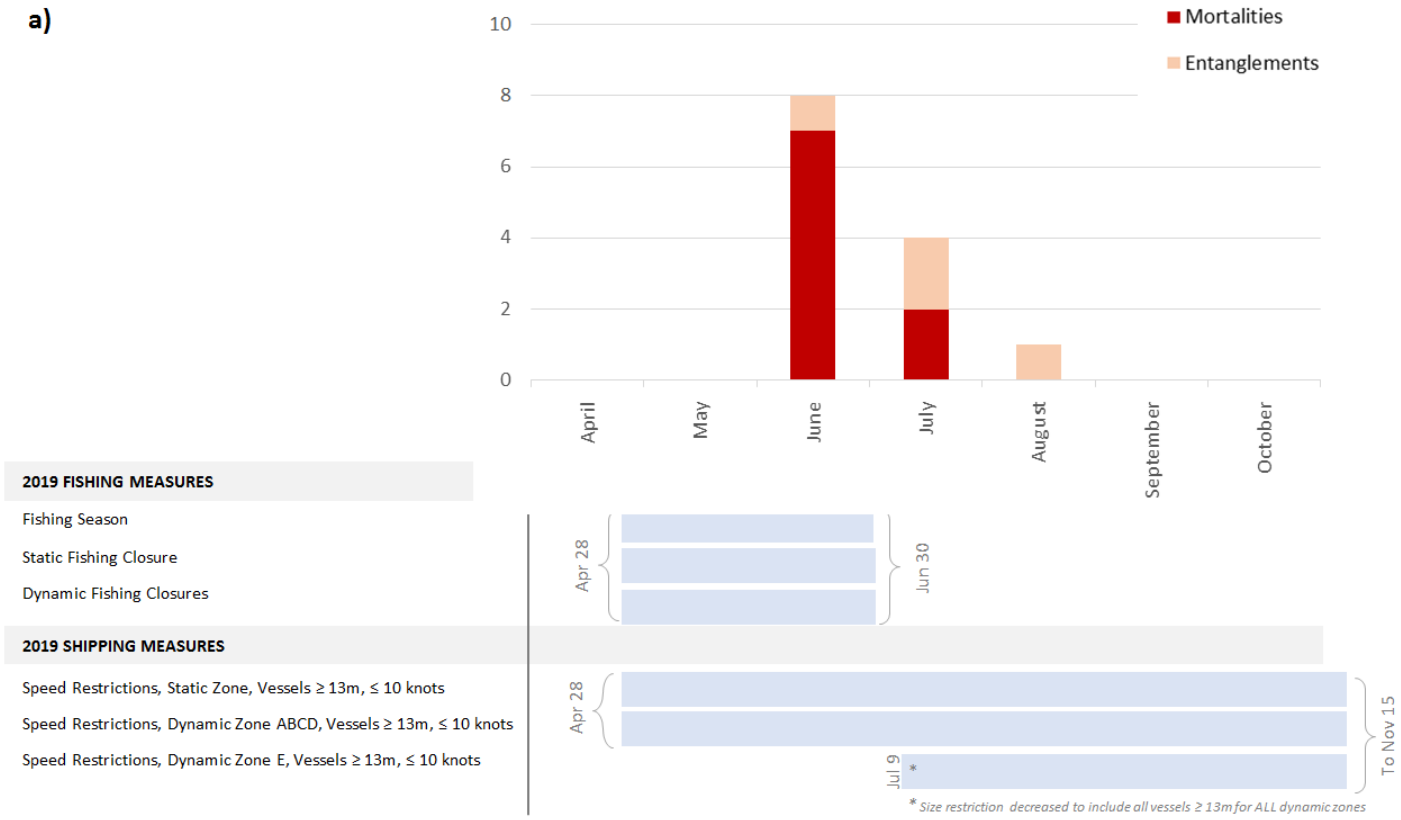
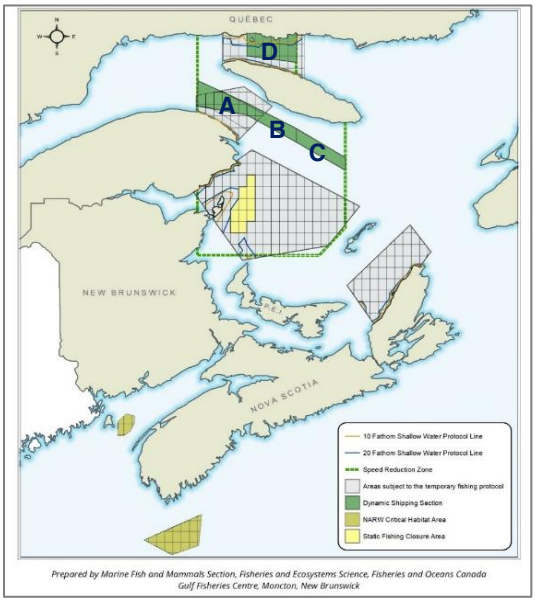


Figure 14. Graphic indicating the monthly mortalities and entanglements/entrapments of right whales and timing of the implemented fishing and shipping mitigation measures in eastern Canada in 2018 (a). Map (b) indicates the location of the implemented fishing and shipping mitigation measures as of April 28th. *Unless otherwise indicated, mitigation measures were mandatory.*

a)



b) **Static and Dynamic Fishing and Shipping Measures:**



c) **Additional Dynamic Shipping Measures implemented July 9:**

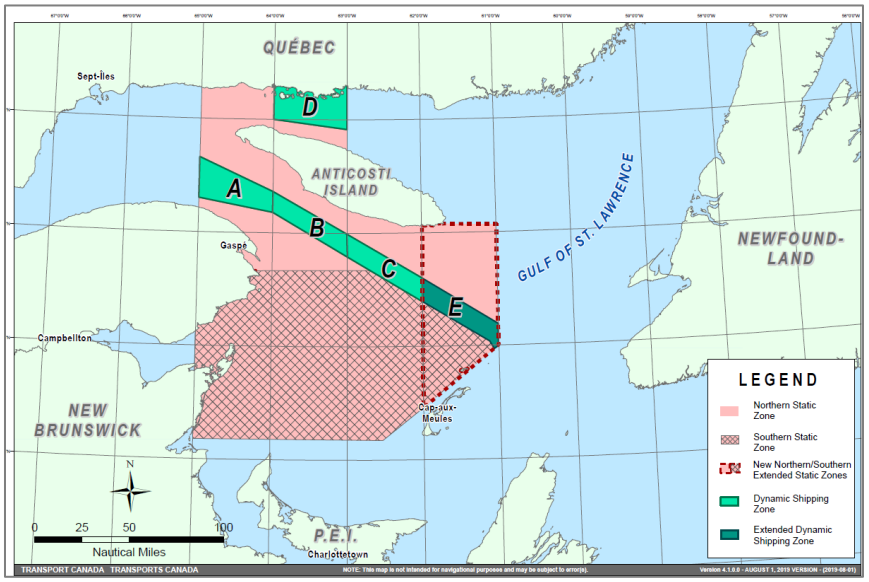


Figure 15. Graphic indicating the monthly mortalities and entanglements/entrapments of right whales and timing of the implemented fishing and shipping mitigation measures in eastern Canada in 2019 (a). Maps indicate the location of the implemented fishing and shipping mitigation measures as of April 28th (b) and additional shipping measures implemented as of July 9th (c). *Unless otherwise indicated, mitigation measures were mandatory.*

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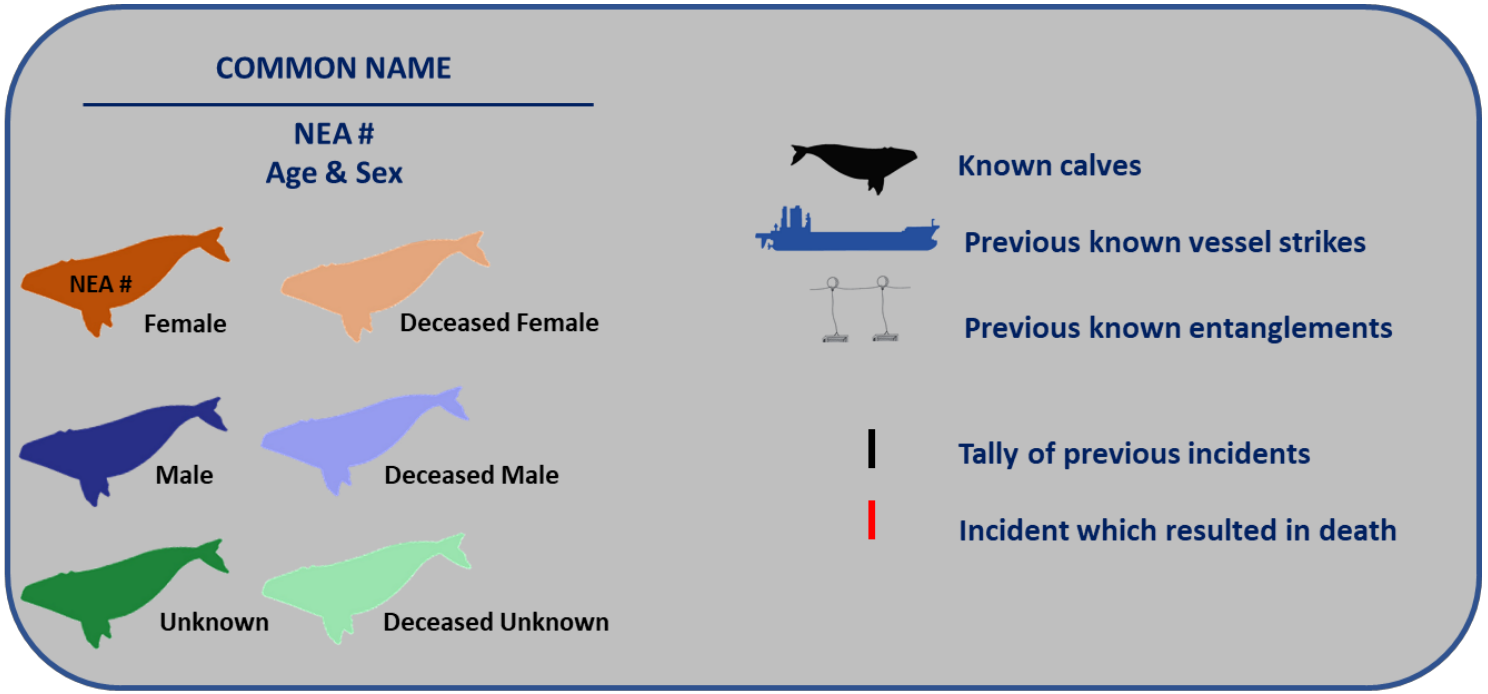
Annex B1: Sighting, Incident and Life History Information of Right Whales Involved in Mortality Incidents in Canadian Waters in 2019

Prepared by: Tonya Wimmer, Marine Animal Response Society

Information provided by: Phillip Hamilton, Marianna Hagbloom, Amy Knowlton, Monica Zani (Anderson Cabot Center for Ocean Life at the New England Aquarium; NEA), Isabelle Elliot, Corey Webster and Antoine Riviere (Fisheries and Oceans Canada; DFO), Allison Henry (NOAA) as well as various aerial and vessel based surveys: New England Aquarium (NEA)/Canadian Whale Institute (CWI)/University of New Brunswick (UNB)/Dalhousie University (Dal) surveys, Transport Canada National Aerial Surveillance Program, NOAA-Northeast Fisheries Science Centre (NEFSC) / DFO Survey, DFO Conservation & Protection (C&P) Surveys, Canadian Coast Guard and DFO-Quebec Seal Science Survey.

Legend for life history figures:



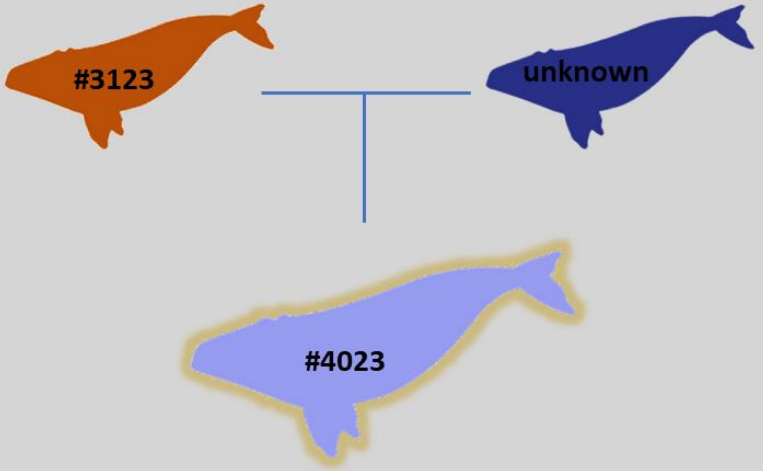
Note: Known calves are indicated. Particularly relevant for males, this doesn't mean there weren't others (or any if none are indicated). Just that the ones listed are the only ones which have been identified/genetically linked. The vessel and fishing gear clip art used here does not reflect those that caused any indicated injury or mortality.

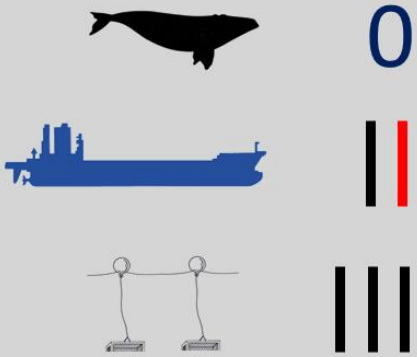
	Date	Latitude	Longitude	Area	Observer	Comments
Carcass #1 **Catalog #4023, Wolverine** **9 year old male**						
Last seen alive	August 21, 2018	48.0225	-63.7439	Gulf of St Lawrence	NEA / CWI / UNB / Dal	
Observed dead	June 4, 2019	48.2500	-63.1383	Gulf of St Lawrence	NEFSC / DFO aerial survey	
Subsequent carcass sightings	June 5, 2019	48.2300	-62.9150	Gulf of St Lawrence	NEFSC / DFO aerial survey	
	June 6, 2019	48.2095	-62.8628	Gulf of St Lawrence	Canadian Coast Guard / DFO C&P	Towed for necropsy
Necropsy	June 7, 2019	47.9878	-64.4820	Miscou Island, New Brunswick	CWHC / MARS / DFO	
Cause of death	**Blunt trauma, vessel strike (Suspect)**					
Field Code	MARS2019-130					
Other information	Previous sightings of #4023 have been in Florida, Cape Cod Bay, Massachusetts Bay, Jeffrey's Ledge, Southern New England, Great South Channel, Bay of Fundy and the Gulf of St. Lawrence					
Genetic results	Identity confirmed via genetics by North Atlantic Right Whale DNA Bank at Saint Mary's University					

WOLVERINE

NEA #4023

9 year-old male





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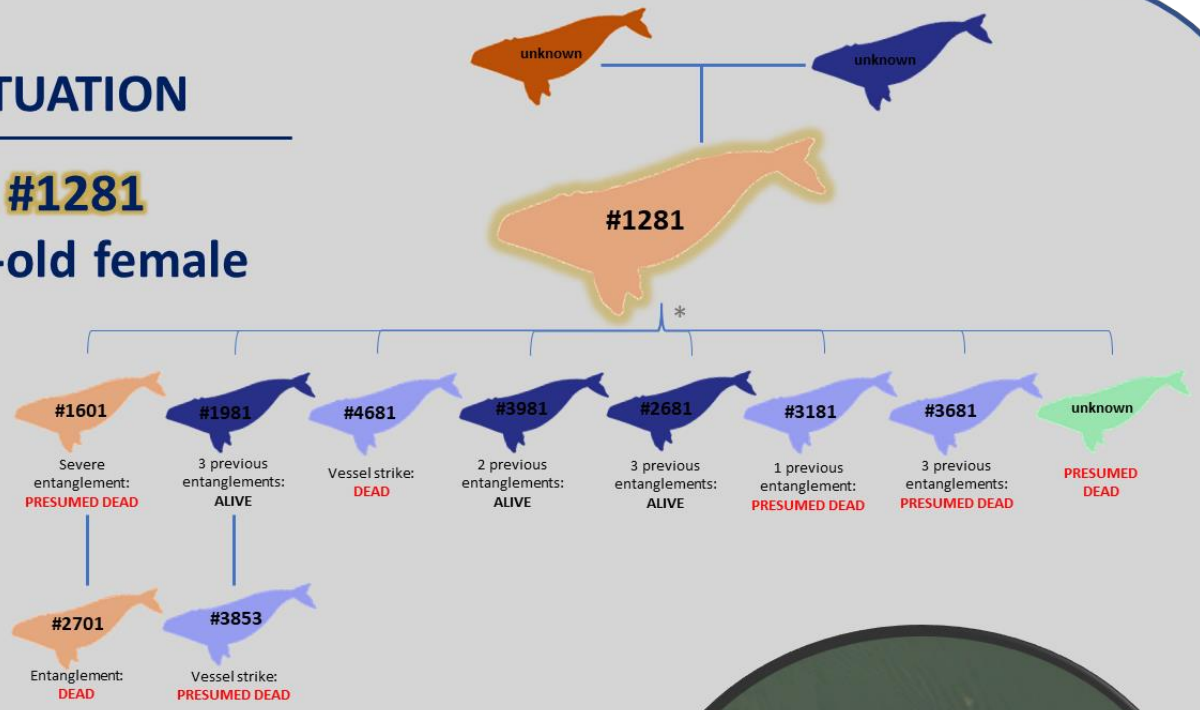
	Date	Latitude	Longitude	Area	Observer	Comments
Carcass #2 **Catalog #1281, Punctuation** **38 year old female**						
Last seen alive	June 7, 2019	48.1281	-62.6898	Gulf of St. Lawrence	NEFSC / DFO aerial survey	
Observed dead	June 20, 2019	47.6139	-60.7675	Gulf of St. Lawrence	Transport Canada	
Subsequent carcass sightings	June 24, 2019	47.3889	-61.0218	Gulf of St. Lawrence	Canadian Coast Guard / DFO C&P	Towed for necropsy
Necropsy	June 25, 2019	46.6589	-60.9800	Grand Etang, Nova Scotia	CWHC / MARS / DFO	
Cause of death	**Sharp trauma, vessel strike (Probable)**					
Field Code	MARS2019-146					
Other information	Previous sightings of #1281 have been in Florida, Georgia, North Carolina, Cape Cod Bay, Massachusetts Bay, Great South Channel, Gulf of Maine, Bay of Fundy, Roseway Basin and the Gulf of St. Lawrence					
Genetic results	Identity confirmed via genetics by North Atlantic Right Whale DNA Bank at Saint Mary's University					

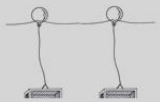
PUNCTUATION

NEA #1281

38+ year-old female



8 + 2 grandbabies



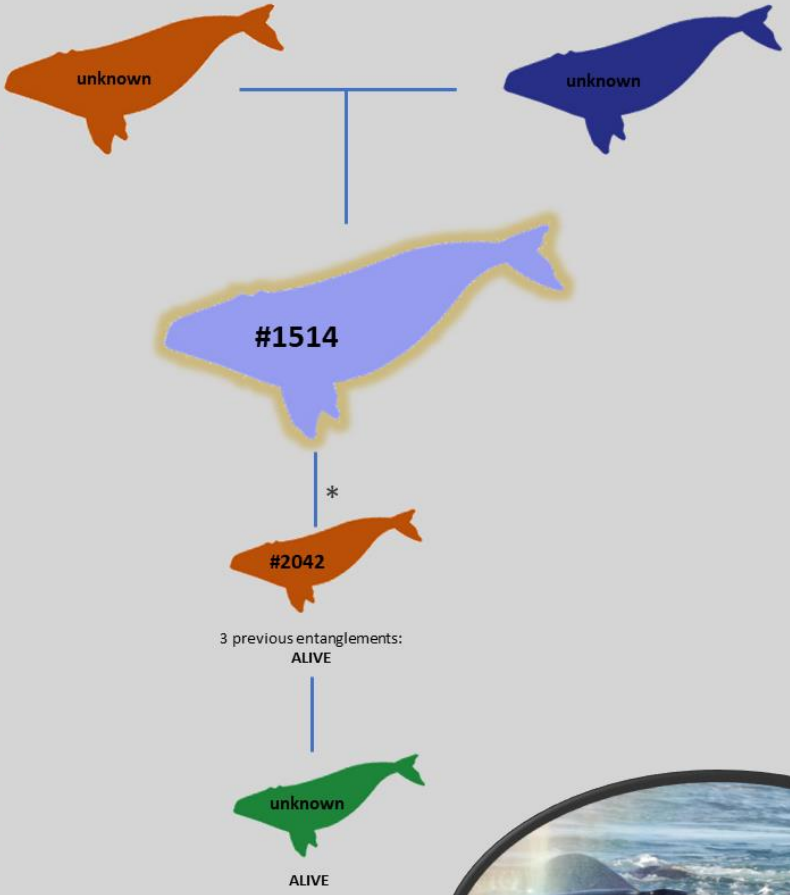
* Calves are not in order of birth

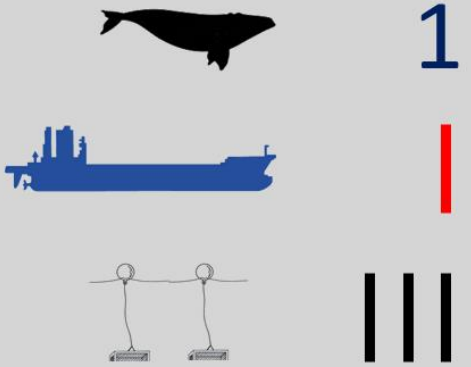
	Date	Latitude	Longitude	Area	Observer	Comments
Carcass #3 **Catalog #1514, Comet** **33 year old male**						
Last seen alive	June 7, 2019	48.2679	-62.5030	Gulf of St. Lawrence	NEFSC / DFO aerial survey	
Observed dead	June 25, 2019	47.8346	-64.0524	Gulf of St. Lawrence	Atlantic Canadian Fisherman	
Subsequent carcass sightings	June 27, 2019	47.7768	-63.7135	Gulf of St. Lawrence	Canadian Coast Guard / DFO C&P	Towed for necropsy
Necropsy	June 28, 2019	47.0116	-64.0431	Norway, PEI	CWHC / MARS / DFO	
Cause of death	**Blunt trauma, vessel strike (Probable)**					
Field Code	MARS2019-161					
Other information	Previous sightings of #1514 have been in Cape Cod Bay, Massachusetts Bay, Jeffrey's Ledge, Great South Channel, Gulf of Maine, George's Bank, Bay of Fundy, Roseway Basin and the Gulf of St. Lawrence					
Genetic results	Identity confirmed via genetics by North Atlantic Right Whale DNA Bank at Saint Mary's University					

COMET

NEA #1514

33+ year-old male





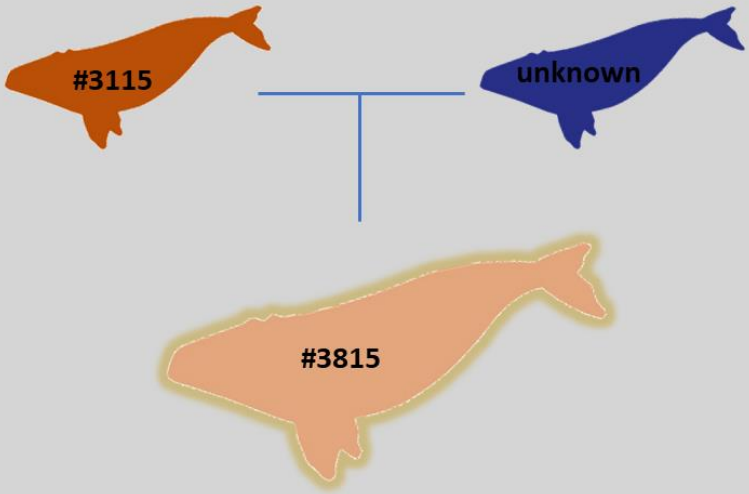
© NEA

* Known calves are shown. This may not be all of the calves Comet had fathered

	Date	Latitude	Longitude	Area	Observer	Comments
<u>Carcass #4</u> **Catalog #3815** **11 year old female**						
Last seen alive	June 7, 2019	48.2050	-62.5687	Gulf of St. Lawrence	NEFSC / DFO aerial survey	
Observed dead	June 25, 2019	47.5475	-62.56	Gulf of St. Lawrence	Transport Canada	
Subsequent carcass sightings	June 30, 2019	48.1383	-62.5195	Gulf of St. Lawrence	Transport Canada	
	July 5, 2019	47.6573	-63.3058	Gulf of St. Lawrence	DFO-C&P	
	July 6, 2019	47.6520	-63.223	Gulf of St. Lawrence	Transport Canada	
	July 7, 2019	47.5064	-63.0153	Gulf of St. Lawrence	Transport Canada	
	July 16, 2019	47.3163	-62.9881	Gulf of St. Lawrence	DFO Science Aerial Survey	
	July 18, 2019	47.3522	-62.9775	Gulf of St. Lawrence	Transport Canada	
Washed ashore	July 31, 2019	47.3070	-61.9720	Magdalen Islands, Qc	DFO C&P	Minimal sampling
Cause of death	**Unknown, No necropsy**					
Field Code	MARS2019-168					
Other information	Previous sightings of #3815 have been in Florida, Georgia, Cape Cod Bay, Massachusetts Bay, New Jersey, Jeffrey's Ledge, Great South Channel, Gulf of Maine, Bay of Fundy, Roseway Basin and the Gulf of St. Lawrence					
Genetic results	Sample to be provided to SMU					

NEA #3815

11 year-old female



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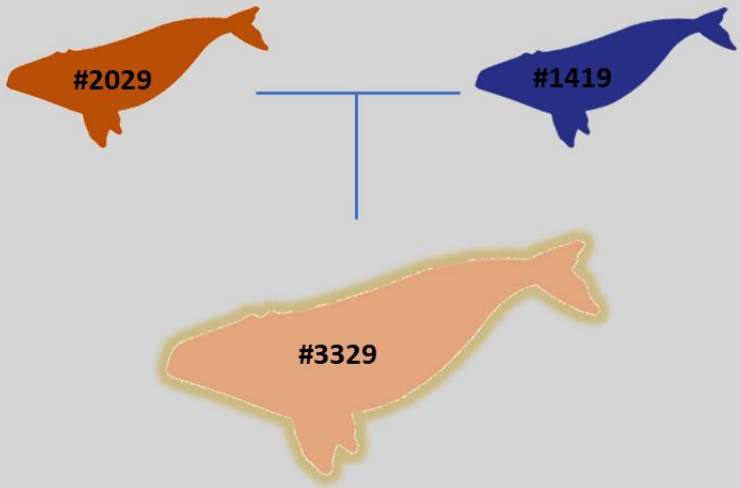
IIII

Cause of death of #3815 is unknown
(necropsy unable to be performed)

	Date	Latitude	Longitude	Area	Observer	Comments
Carcass #5 **Catalog #3329** **16 year old female**						
Last seen alive	April 25, 2019	41.7660	-70.38168	Cape Cod Bay, MA	Center for Coastal Studies	
Observed dead	June 25, 2019	49.0777	-61.7912	Anticosti Island, Qc	DFO- Quebec Seal Science Survey	
Subsequent carcass sightings	June 26, 2019	49.0777	-61.7912	Anticosti Island, Qc	DFO- Quebec Seal Science Survey	Minimal sampling, Left onsite
	January 29, 2020	49.0777	-61.7912	Anticosti Island, Qc		Animal still onsite
Cause of death	**Unknown, No necropsy**					
Field Code	MARS2019-169					
Other information	Previous sightings of #3329 have been in Florida, Georgia, South Carolina, Cape Cod Bay, Massachusetts Bay, Jeffrey's Ledge, Great South Channel, Gulf of Maine, Bay of Fundy and the Gulf of St. Lawrence					
Genetic results	Sample provided to North Atlantic Right Whale DNA Bank at Saint Mary's University, not yet processed					

NEA #3329

16 year-old female



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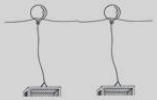


IIII

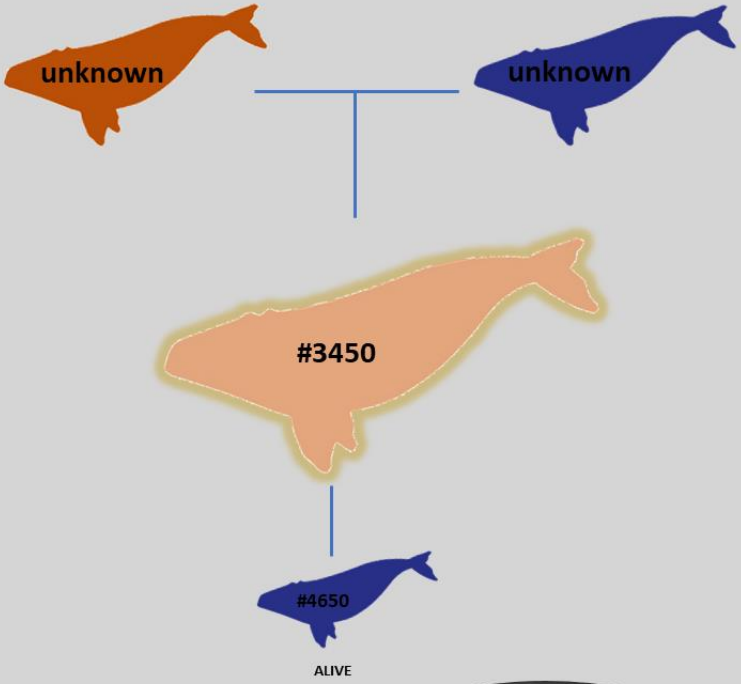
Cause of death of #3329 is unknown
(necropsy unable to be performed)

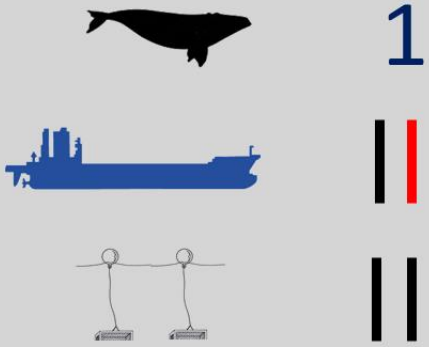
	Date	Latitude	Longitude	Area	Observer	Comments
Carcass #6 **Catalog #3450, Clipper** **15 year old female**						
Last seen alive	June 10, 2019	48.2828	-62.5269	Gulf of St. Lawrence	NEFSC / DFO aerial survey	
Observed dead	June 27, 2019	48.3493	-63.1655	Gulf of St. Lawrence	DFO-C&P	
Subsequent carcass sightings	June 29, 2019	48.3743	-62.8772	Gulf of St. Lawrence	Canadian Coast Guard / DFO C&P	Towed for necropsy
Necropsy	July 1, 2019	49.1386	-64.7445	Grand-Étang Bay, Qc	CWHC / RQUMM / DFO	
Cause of death	**Blunt trauma, vessel strike (Probable)**					
Field Code	MARS2019-170					
Other information	Previous sightings of #3450 have been in Florida, Georgia, South Carolina, Cape Cod Bay, Southern New England, Great South Channel, Gulf of Maine, Bay of Fundy and the Gulf of St. Lawrence					
Genetic results	Identity confirmed via genetics by North Atlantic Right Whale DNA Bank at Saint Mary's University					

CLIPPER

NEA #3450

15+ year-old female





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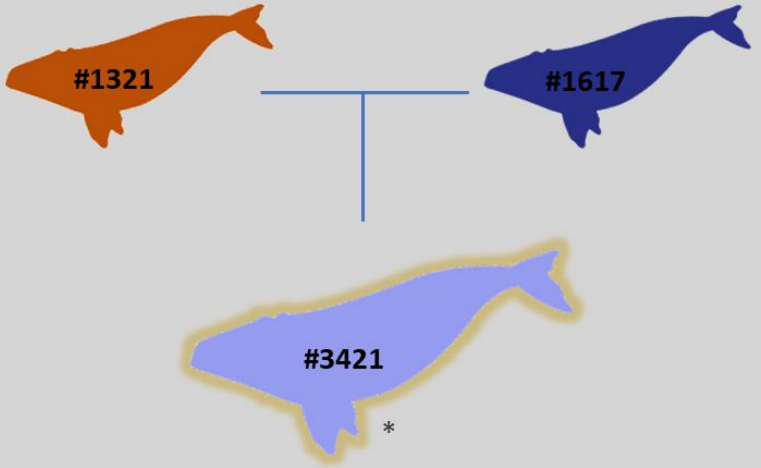
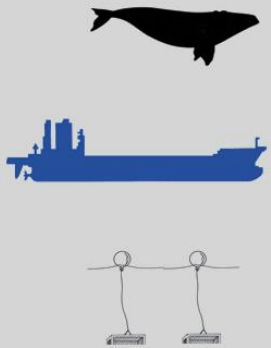
	Date	Latitude	Longitude	Area	Observer	Comments
Carcass #7 **Catalog #3421** **15 year old male**						
Last seen alive	June 10, 2019	48.2597	-62.5912	Gulf of St. Lawrence	NEFSC / DFO aerial survey	
Observed dead	July 18, 2019	48.1640	-62.7512	Gulf of St. Lawrence	DFO-C&P	
Subsequent carcass sightings	July 19, 2019	48.1640	-62.7512	Gulf of St. Lawrence	Canadian Coast Guard / DFO C&P	Towed for necropsy
Necropsy	July 21, 2019	49.1386	-64.7445	Grand-Étang Bay, Qc	CWHC / RQUMM / DFO	
Cause of death	**Necropsied, Could not be determined**					
Field Code	MARS2019-223					
Other information	Previous sightings of #3421 have been in Florida, Georgia, South Carolina, Massachusetts Bay, Jeffrey's Ledge, Southern New England, Great South Channel, Gulf of Maine, George's Bank, Bay of Fundy and the Gulf of St. Lawrence					
Genetic results	Identity confirmed via genetics by North Atlantic Right Whale DNA Bank at Saint Mary's University					

NEA #3421

15 year-old male





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1

Cause of death of #3329 is unknown (necropsy inconclusive)

* No known calves identified. This does not mean #3421 may not have fathered any calves

	Date	Latitude	Longitude	Area	Observer	Comments
Carcass #8 **Unidentified** **Unknown age and sex**						
Last seen alive	Unknown					
Observed dead	June 24, 2019	46.3250	-59.8750	Northern Cape Breton, NS	Atlantic Canadian Fisherman	
Subsequent carcass sightings	None					
Cause of death	**Unknown, Not examined, Carcass Lost**					
Field Code	MARS2019-202					
Other information	No other information available					
Genetic results	No sample obtained					

	Date	Latitude	Longitude	Area	Observer	Comments
Carcass #9 **Unidentified** **Female, Unknown age**						
Last seen alive	Unknown					
Observed dead	July 21, 2019	45.6881	-59.9561	Eastern Cape Breton, NS	Transport Canada	
Subsequent carcass sightings	July 22, 2019	45.5175	-60.0992	Eastern Cape Breton, NS	Transport Canada	
	July 22, 2019	45.5175	-60.0992	Eastern Cape Breton, NS	DFO C&P/Canadian Coast Guard	Collected blubber
	July 25, 2019	45.2090	-60.8166	Eastern Cape Breton, NS	Atlantic Canadian Fisherman	
Cause of death	**Unknown, Not examined, Carcass Lost**					
Field Code	MARS2019-232					
Other information	No other information available					
Genetic results	No sample obtained					

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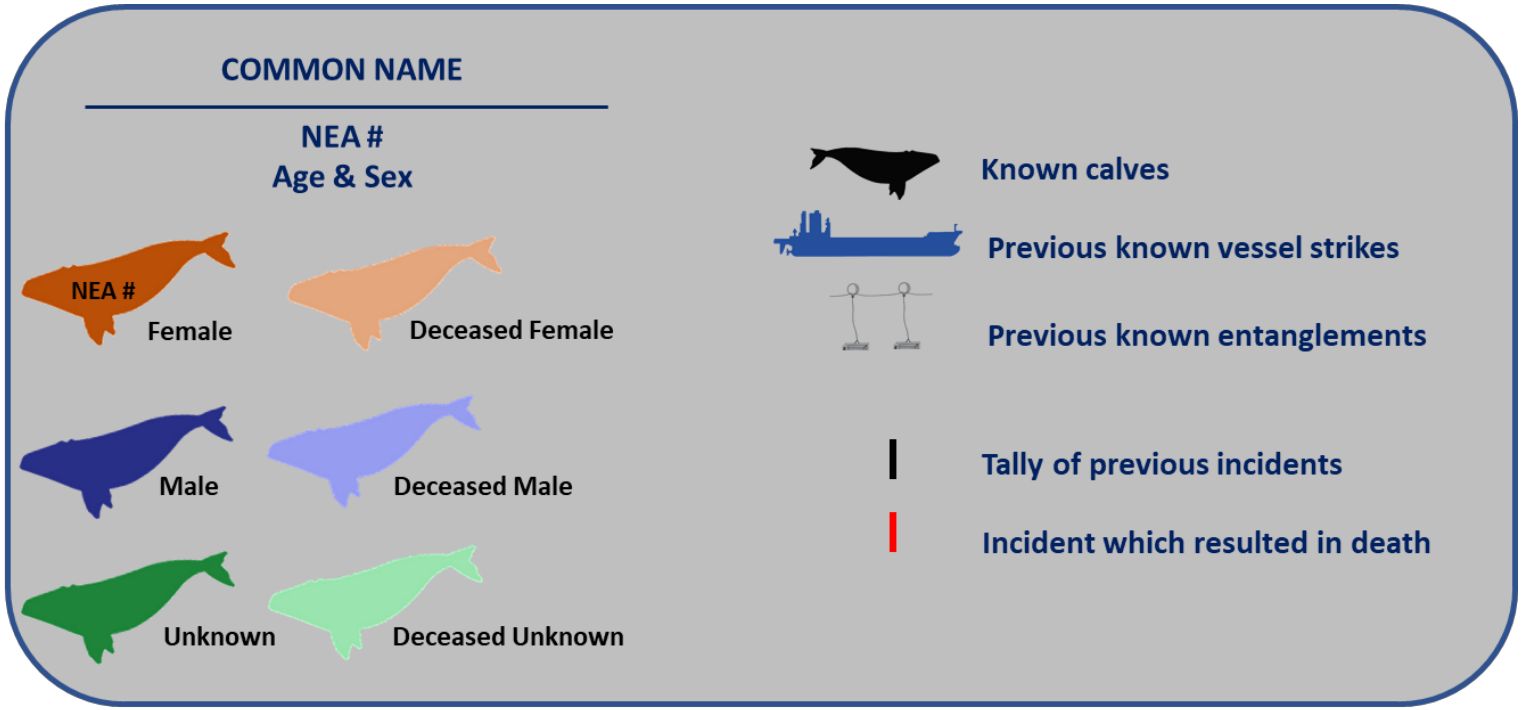
Annex B2: Sighting, Incident and Life History Information of Right Whales Involved in Entanglement Incidents in Canadian Waters in 2019

Prepared by: Tonya Wimmer, Marine Animal Response Society

Information provided by: Phillip Hamilton, Marianna Hagbloom, Amy Knowlton, Monica Zani (Anderson Cabot Center for Ocean Life at the New England Aquarium; NEA), Isabelle Elliot (Fisheries and Oceans Canada; DFO), Campobello Whale Rescue (CWRT), Tangly Whales, Center for Coastal Studies, Atlantic Large Whale Disentanglement Network, Allison Henry (NOAA) as well as various aerial and vessel based surveys: New England Aquarium (NEA)/Canadian Whale Institute (CWI)/University of New Brunswick (UNB)/Dalhousie University (Dal) surveys, Transport Canada National Aerial Surveillance Program, NOAA-Northeast Fisheries Science Centre (NEFSC) / DFO Survey, DFO Conservation & Protection (C&P) Surveys, Canadian Coast Guard.

Legend for life history figures:



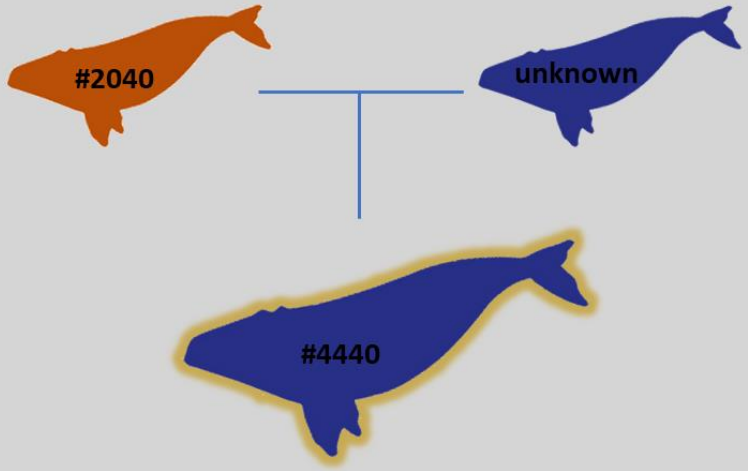
Note: Known calves are indicated. Particularly relevant for males, this doesn't mean there weren't others (or any if none are indicated). Just that the ones listed are the only ones which have been identified/genetically linked. The vessel and fishing gear clip art used here does not reflect those that caused any indicated injury or mortality.

	Date	Latitude	Longitude	Area	Observer	Comments
Entanglement #1 Catalog #4440 5 year old male						
Last seen not entangled	August 17, 2018	47.9534	-63.7674	Gulf of St. Lawrence	NEA / CWI / UNB / Dal	
Observed entangled	June 29, 2019	47.9452	-63.8808	Gulf of St. Lawrence	CCGC A. Leblanc	
Subsequent sightings	July 5, 2019	48.0433	-63.8850	Gulf of St. Lawrence	NEA / CWI / UNB / Dal	
	July 9, 2019	47.5583	-64.1183	Gulf of St. Lawrence	NEFSC / DFO aerial survey	No dramatic configuration change CWRT attempt attach telemetry
	July 16, 2019	48.0088	-63.7220	Gulf of St. Lawrence	NEFSC / DFO aerial survey	CWRT partially disentangled
	July 19, 2019	47.5600	-64.1183	Gulf of St. Lawrence	NEFSC / DFO aerial survey	Line in mouth shed
	August 14, 2019	47.8410	-63.8600	Gulf of St. Lawrence	NEFSC / DFO aerial survey	Observed gear free
Outcome	**Partially disentangled (CWRT), Last observed gear free (confirmed)**					
Field Code	MARS2019-171					
Other information	Previous sightings of #4440 have been in Florida, Georgia, Cape Cod Bay, Massachusetts Bay, Jeffrey's Ledge, Great South Channel and the Gulf of St. Lawrence					

© NOAA- NEFSC

NEA #4440

5 year old male



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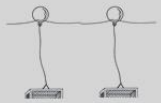

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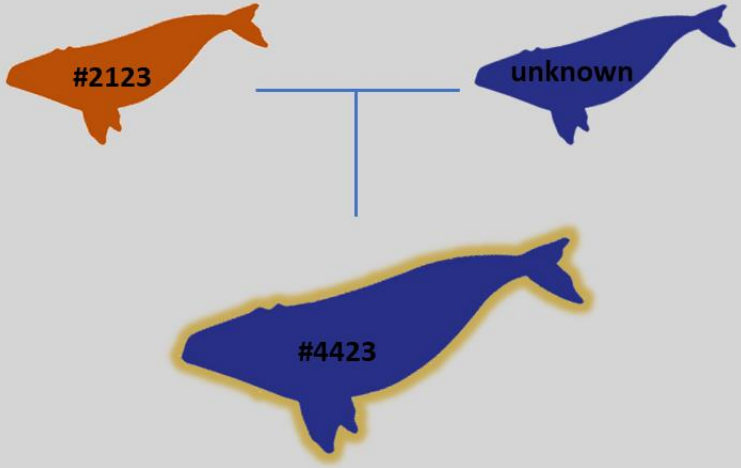
	Date	Latitude	Longitude	Area	Observer	Comments
Entanglement #2 Catalog #4423 5 year old male						
Last seen not entangled	August 20, 2018	47.9869	-63.7497	Gulf of St. Lawrence	NEA / CWI / UNB / Dal	
Observed entangled	April 25, 2019	41.7702	-69.3683	Great South Channel	AMAPPS aerial survey	Original entanglement
Subsequent sightings	July 4, 2019	48.0666	-63.9180	Gulf of St. Lawrence	N. Hawkins (Photo-journalist)	Remains entangled, No observed change in configuration
	July 9, 2019	46.7972	-63.8330	Gulf of St. Lawrence	NEFSC / DFO Aerial survey	
	July 11, 2019	47.9133	-63.7567	Gulf of St. Lawrence	NEFSC / DFO Aerial survey	CWRT partial disentanglement
	July 16, 2019	47.9767	-63.7833	Gulf of St. Lawrence	NEFSC / DFO Aerial survey	CWRT partial disentanglement
	July 19, 2019	48.0526	-63.9228	Gulf of St. Lawrence	NEA / CWI / UNB / Dal	
	August 8, 2019	47.7650	-64.0200	Gulf of St. Lawrence	NEA / CWI / UNB / Dal	No observed change in configuration, poor condition
	August 13, 2019	46.3500	-63.9950	Gulf of St. Lawrence	DFO Science Survey	No observed change in configuration, poor condition
	October 29, 2019	46.8839	-62.9500	Gulf of St. Lawrence	NEFSC / DFO Aerial survey	Observed gear free
Outcome	**Partially disentangled (CWRT), Last observed gear free (confirmed)**					
Field Code	MARS2019-188					
Other information	Previous sightings of #4423 have been in Florida, Georgia, Cape Cod Bay, Massachusetts Bay, Southern New England, Great South Channel, Bay of Fundy and the Gulf of St. Lawrence					

NEA #4423 *

5 year old male



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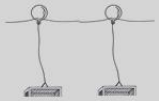

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* #4423 was already known to be entangled when first reported in Canadian waters in 2019. Source of that entangling gear is unknown

	Date	Latitude	Longitude	Area	Observer	Comments
Entanglement #3 **Catalog #: 3125** **18 year old male**						
Last seen not entangled	March 20, 2019	41.8548	-70.3181	Cape Cod Bay	Center for Coastal Studies	
Observed entangled	July 4, 2019	48.4583	-63.3350	Gulf of St. Lawrence	Transport Canada Aerial Surveillance	
Subsequent sightings	July 19, 2019	48.0483	-63.8217	Gulf of St. Lawrence	NEFSC / DFO Aerial survey	Telemetry buoy attached (NEA)
	July 23, 2019	46.1478	-59.6681	Eastern Scotian Shelf	Tangly Whales / DFO C&P/Canadian Coast Guard	Partial disentanglement (Tangly Whales)
	July 25, 2019	44.7925	-60.7051	Eastern Scotian Shelf	Tangly Whales / DFO C&P/Canadian Coast Guard	Partial disentanglement (Tangly Whales)
	August 2, 2019	41.8983	-69.1247	Great South Channel	Center for Coastal Studies / NEFSC Aerial Survey	Partial disentanglement (CCS), some gear remaining
Outcome	**Partially disentangled (Tangly Whales, CCS); line remaining and in poor condition**					
Field Code	MARS2019-184					
Other information	Previous sightings of #3125 have been in Florida, Georgia, Cape Cod Bay, Massachusetts Bay, Great South Channel, Gulf of Maine, George's Bank, Bay of Fundy, Roseway Basin, Gulf of St. Lawrence and Eastern Scotian Shelf					

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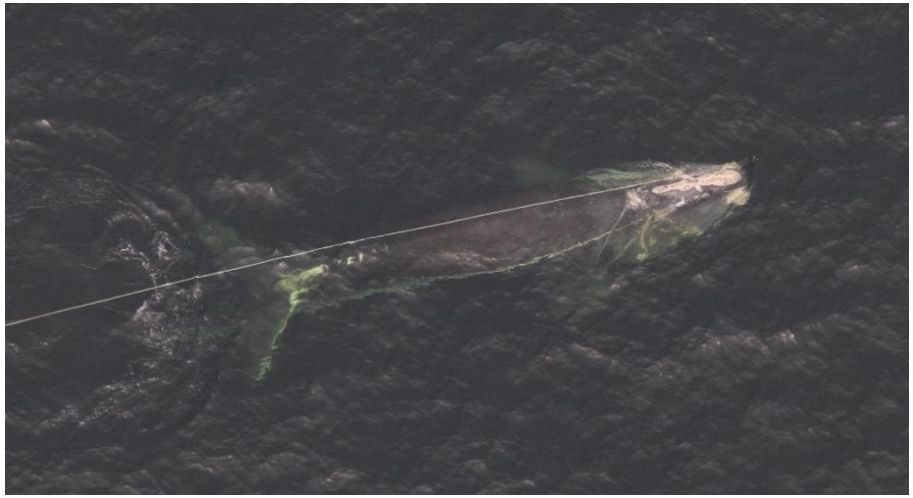

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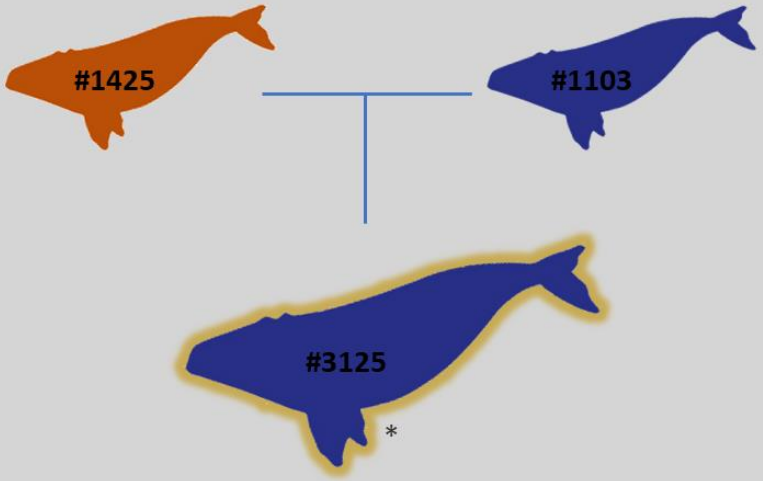
NEA #3125

18 year old male



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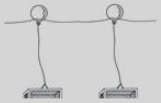

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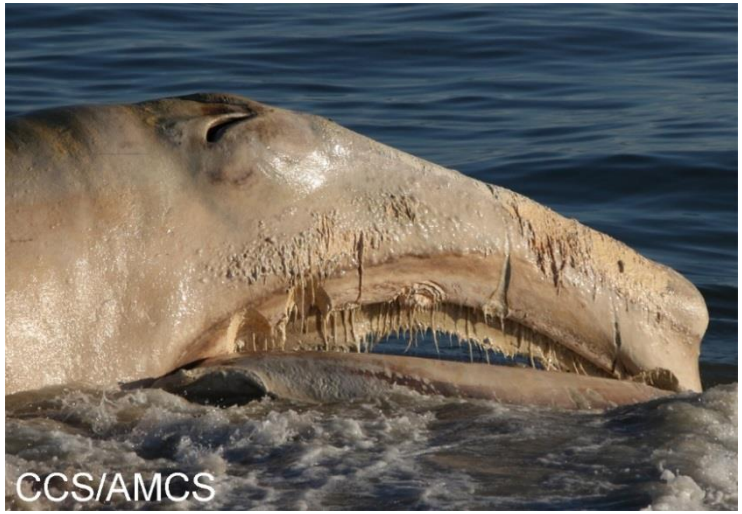
* No known calves identified. This does not mean #3125 may not have fathered any calves

	Date	Latitude	Longitude	Area	Observer	Comments
Entanglement #4 **Catalog #1226, Snake Eyes** **At least 40 year old male**						
Last seen not entangled	July 16, 2019	47.8047	-63.8815	Gulf of St. Lawrence	NEFSC / DFO Aerial Survey	
Observed entangled	August 6, 2019	48.0347	-62.2273	Gulf of St. Lawrence	DFO-C&P Aerial Surveillance Survey	Animal possibly anchored
Subsequent sightings	September 16, 2019	40.5834	-73.3110	Off Long Island, NY	New York Department of Environmental Conservation	Observed dead
	September 17, 2019	40.5095	-73.4476	Off Long Island, NY	AMCS / USCG / NY DNR	Towed ashore
Necropsy	September 18, 2019	40.5868	-73.5332	Jones Beach State Park, NY	AMCS / IFAW / CCS	
Outcome	**No disentanglement attempt in Canada (animal not relocated); Died and necropsied in New York, US**					
Cause of Death	**Entanglement**					
Field Code	MARS2019-258					
Other information	Previous sightings of #1226 have been in Massachusetts Bay, Jeffrey's Ledge, Great South Channel, Gulf of Maine, Bay of Fundy and the Gulf of St. Lawrence					

© DFO C&P



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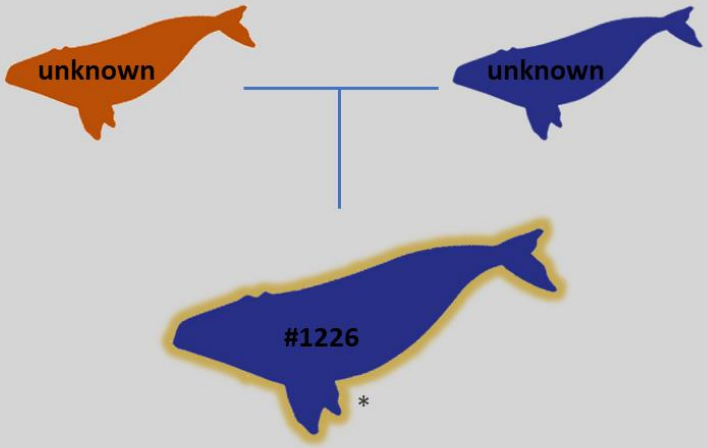
SNAKE EYES

NEA #1226

40+ year old male



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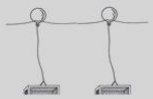


* No known calves identified. This does not mean #1226 may not have fathered any calves

Annex C

2019 Individual Necropsy Reports

WILDLIFE DIAGNOSTIC REPORT

CANADIAN WILDLIFE HEALTH COOPERATIVE

ATLANTIC REGION
Atlantic Veterinary College
550 University Avenue, Charlottetown, PE, C1A 4P3
Phone: 902.628.4314 Fax: 902.628.4314
Email: atlantic@cwhc-rcsf.ca

Date Report Generated: 2020-02-25 **Necropsy number: X11483-19**

Event Information

Event Code:	CWHC.204329	**Location:**	**Latitude:**	48.25
Cross Ref #:	EG2019-01, NEA #4021, "Wolverine"	Southern Gulf of St. Lawrence	**Longitude:**	-63.14
Species:	North Atlantic Right Whale (*Eubalaena glacialis*)			
Age:	Adult			
Sex:	Male			
Weight:	-			
Date Received:	2019-06-04			

Finder/Submitter Information

Submitter:
Isabelle Elliott
Fisheries & Oceans Canada - Moncton
P.O. Box 5030
Moncton, New Brunswick
Phone: (506) 851-6227
Email Address: Isabelle.Elliott@dfo-mpo.gc.ca

Information Provided For Event

On June 4, 2019, a male North Atlantic Right Whale (NEA #4021,"Wolverine") was found floating dead in the Gulf of St. Lawrence (48.25, -63.13833), only ~ 5nm off the Gaspe, Quebec. A complete necropsy was performed on Miscou Island (NB) on June 7 by a team including CWHC, MARS, OERS, and DFO.

Diagnosis and Interpretation

Final Diagnosis

Cause of death
1. Vessel strike (suspect), with focally extensive abrasion and contusion

Incidental
2. Caudal peduncle: Propeller scars, multiple, chronic
3. Oral cavity: Entanglement scars, multiple, chronic
4. Pectoral flipper, bilateral: Entanglement scars, multiple, chronic

Interpretation

This adult male North Atlantic Right Whale was in good body condition and had no evidence of elevated fecal glucocorticoids or biotoxins at his time of death. There were multiple lesions (superficial abrasion, blubber hemorrhage, and epaxial muscle contusion) which are consistent with an antemortem vessel strike (suspect), however how this strike may have resulted in or contributed to the death of this whale is unknown, as the lesions themselves are not severe enough to result in death. The location of this trauma (caudal to the blow hole) may indicate the possibility of head/neuro trauma in this case, however the pathogenesis of how this may occur in large whales is unknown and is likely not possible in the sense of how concussions occur in terrestrial species. There was no evidence of skeletal fractures, or extensive internal hemorrhaging which has been identified in vessel strikes as a cause of death in other causes of right whale mortalities. As internal organs and the brain were absent at necropsy (due to rapid decomposition and expulsion of organs out of the oral cavity), it is possible that critical lesions associated with cause of death may have been lost/obscured. There were numerous scars scattered throughout the body consistent with previous vessel strike sharp trauma (propeller) and chronic entanglement. This necropsy report will be included as an appendix in an larger Incident Report which will review and provide in depth discussion on all right whale incidents that occurred in the Gulf of St. Lawrence in 2019 and which will be made publicly available (on the CWHC and MARS websites). Please don't hesitate to contact me if you have questions concerning this report.

Laboratory Results

Necropsy

The body presented in approximately right lateral recumbency with the left pectoral flipper oriented upwards. The epaxial muscles are rounded and the body appears in good condition for the season/time of year. The skin is predominantly intact with multiple areas of fissures and post mortem sloughing. All baleen plates are present and firmly attached to the oral mucosa. There is no external evidence of recent entanglement. There is no fishing gear associated with the carcass. The decomposition code is considered an advanced code three based on significant post mortem autolysis of some internal organs.

Internal organs identified during necropsy: Larynx, lungs, some small intestines, colon, liver. All other internal organs were absent or liquefied.

The following is a description of significant observations made during the necropsy:

Observation 1, right flipper, (Photo: Y, Histology: N):
At the level of the caudal insertion of the right flipper is a 16 x 2.5 cm irregular white scar which partially wraps around the caudal aspect of the flipper.

Observation 2, right flipper, (Photo: Y, Histology: Y):
On the leading edge of the right flipper close to the cranial insertion are approximately six linear scars approximately 15 to 17 cm long and 2 cm wide. These scars partially wrap around the leading edge of the flipper.

Observation 3, cranial to cranial-insertion right flipper, (Photo: Y, Histology: N):
Just cranial to the cranial insertion of the right flipper on the lateral body wall are two narrow crisscrossing white lines that extend dorsally around the body (cannot see length as they extend into the recumbent side of the body).

Observation 4, left flipper, (Photo: Y, Histology: N):
On the leading edge of the left flipper are approximately 8 linear white lines varying between 1 and 4 cm wide, and 15 to 20 cm long. These lines wrap around the leading edge of the flipper.

Observation 5, left lateral body wall caudal to nuchal crest, (Photo: Y, Histology: N):
There is a narrow white line extending caudally from the level of the nuchal crest measuring approximately 1.5 m long and 0.5 cm wide.

Observation 6, left flipper, (Photo: Y, Histology: Y):
At the level of the cranial insertion of the left flipper is a 24 cm long, 2 cm wide, and 0.5 cm deep white scar which extends through the skin and into the underlying blubber.

Observation 7, lateral body wall cranial to cranial insertion of left flipper, (Photo: Y, Histology: Y):
There are 4 narrow white lines (similar to those described in observation 3) measuring approximately 0.5 cm wide and 1.5 mng that wrap around the body dorsoventrally.

Observation 8, mid lateral body wall, (Photo: Y, Histology: N):
Scattered over the left lateral body wall are numerous narrow white lines (similar to those in observation 3) of varying lengths (10 cm to several meters) which periodically crisscross each other and appear to partially wrap around the body dorsoventrally.

Observation 9, caudal peduncle, (Photo: Y, Histology: Y):
Along the dorsal midline at the level of the caudal peduncle is a deep scar measuring approximately 61 cm long, 10 cm wide, and 9 cm deep, that extends caudally onto the right lateral peduncle. Below this scar on the right lateral peduncle are two more similar parallel scars (chronic propeller lacerations) that extend caudally measuring 58 and 22 cm long respectively. The middle scar is indented to 10 cm in depth and the most ventral scar is only slightly indented. These scars are oriented at approximately 45° to the long axis of the whale. On cut surface the normal subcutaneous tissue of the dorsal most scar is obscured by dense stellate aggregates of white fibrous tissue.

Observation 10, caudal peduncle, (Photo: Y, Histology: N):
There are five linear white lines extending over the dorsal midline ridge of the caudal peduncle (caudal to observation 9). The lines range between 2 to 4 cm wide and 15 cm in length.

Observation 11, flukes, (Photo: Y, Histology: N):
There are numerous white lines (depigmentation) and patches scattered over the leading edges of both right and left flukes. Some lines appear to crisscross and measure between 10 to 25 cm long and 3 to 10 cm wide.

Observations 12, 13, 14, and 15, skin body wall, (Photo: Y, Histology: N):
Scattered over the dorsal, left lateral, and ventral body walls are a myriad of narrow white lines (scars) which are similar to those described in observation 3. These lines periodically crisscross and are approximately 1 cm wide and of varying length (10 to 100 cm).

Observation 16, baleen left, (Photo: Y, Histology: N):
On the left rake of baleen plates are three parallel linear indentations in the baleen plates extending from the most rostral to the most caudal plate. The indents are approximately 2 cm wide, and they are 33, 55, and 81 cm away from the maxillary gingiva, respectively. Each individual baleen plate is notched which aligns with notches on adjacent plates which together compose the ultimate effect of the linear indentations extending horizontally along the baleen.

Observation 17, ear bones, (Photo: Y, Histology: N):

Both ear bones are fractured from the base of the skull and are freely mobile. There is no evidence of hemorrhage associated with these fractures.

Observation 18, peritoneum, (Photo: Y, Histology: Y): Scattered over parietal and visceral peritoneal surfaces are several small accumulations of orange clear gelatinous material. Some of these accumulations were within blood vessels.

Observation 19, oral mucosa and tongue, (Photo: Y, Histology: Y): There are numerous, very irregular, coalescing areas that extend over approximately 80% of the lingual and sublingual surfaces where the mucosa is absent and exposing the submucosa which is bright red and roughened (suspect ulceration). The adjacent mucosal borders are irregular, firmly adhered to the submucosa, and outlined by either a dark brown or bright red 1 to 2 cm wide rim.

Observation 20, Submucosa rostral to blowhole, (Photo: Y, Histology: N): There is a small accumulation of red tinged gelatinous fluid between the blubber and the underlying muscle.

Observation 21, Oral cavity buccal mucosa, (Photo: Y, Histology: N): There is a 50 x 2 cm linear, white and slightly raised scar apparent on the surface of the right buccal mucosa.

Observation 22, Oral cavity buccal mucosa, (Photo: Y, Histology: N): There is a 0.5 m linear, white, slightly raised scar apparent on the buccal surface of the rostral lower right lip.

Observation 23, right lateral body wall, (Photo: Y, Histology: N): There is a focally extensive (approximately 0.5 x 3 m), well demarcated area that extends perpendicular to the long axis of the body from a level just caudal to the right eye to the dorsum just caudal to the blow hole where the skin is dark red and markedly roughened. There are a myriad of linear, parallel excoriations that extend deep into the affected skin, and that extend dorsoventrally (perpendicular to long axis of the body). The skin caudally or cranially to this area is intact, smooth, and unaffected by these changes.

Observation 24, Cranial blubber, (Photo: Y, Histology: N): There is a focally extensive, well demarcated, irregular area just caudal to the right eye where the blubber is diffusely bright red on cut surface. The ventral and dorsal margins of this area are irregular.

Observation 25, Epaxial muscle, (Photo: Y, Histology: N): There is a focally extensive area caudal to the blow hole and extending laterally on the right side, measuring approximately 2 meters in diameter where there is a large amount of dark red, gelatinous material expanding the subcutaneous tissue between the blubber and the underlying epaxial muscle. This dark red jelly like material extends caudally several meters beneath the dorsal aponeurosis of the epaxial muscles. This red gelatinous material can be firmly grasped in the hand and extends deeply into the adjacent epaxial muscle (probable contusion).

Toxicology

Lab:
Canadian Food Inspection Agency
(1981) DARTMOUTH LABORATORY -
CHEMISTRY 1992 AGENCY DRIVE
DARTMOUTH, NS B3B 1Y9

Sample: Feces

Tests:
Determination of Domoic Acid in Shellfish by LC-UV and LC-MS/MS
Determination of Lipophilic Shellfish Toxins in Shellfish by LC-MS/MS
Determination of Paralytic Shellfish Toxins in Shellfish by LC-FLD with Post-column Oxidation

Results:
Negative for all assessed biotoxins (see attached report for specific toxins tested)

Virology

Lab: Department of Fisheries and Oceans Canada, Winnipeg
Test: Virus isolation, cell culture
Sample: Tongue
Results: Cell cultures were negative for any viral growth or cell lysis over the course of several weeks.

Lab:Animal Health Center, Abbotsford, BC
Test: PCR (Parapox, herpesvirus consensus), Electron microscopy
Results: All PCR was negative, Electron microscopy was negative for viral particles.

Other lab results

Lab: Anderson Cabot Center for Ocean Life, at the New England Aquarium
Prepared by: Katherine Graham, MS, Rosalind Rolland, DVM, & Elizabeth Burgess, PhD
Sample: Feces
Test: Hormone analysis, Radioimmunoassay

Results (ng/g):
Progesterone: 265.2
Testosterone: 3505.9
Estrogens: 72.78
Glucocorticoids: 33.1
Thyroid: 30.9

Reproductive hormones are within expected normal limits for adult male North Atlantic Right Whales. Fecal glucocorticoids are low which incidate that he was not experiencing elevated physiologic stress prior to death and is supportive of an acute cause of death. Fecal thyroid levels were lower than the average recorded levels for right whales in the NEA database (50-60 ng/g~). This is consistent with newly observed population trends, indicating a decline in nutritional state and associated metabolic responses of North Atlantic right whales.

Histology
There is marked autolysis throughout these tissues.

Oral mucosa (buccal, lingual): There are multiple areas where the epidermis is markedly attenuated or missing entirely. There are rare aggregates of mononuclear cells expanding the dermal collagen adjacent to the epidermis, and there are occasional aggregates of keratinocytes throughout the stratum spinosum which contain eosinophilic intranuclear inclusions.

Observation #4 (skin): There is a focally extensive area where the epidermis is lacking in melanin in the stratrum basale, and there is extensive anastomosis of the affected rete ridges.

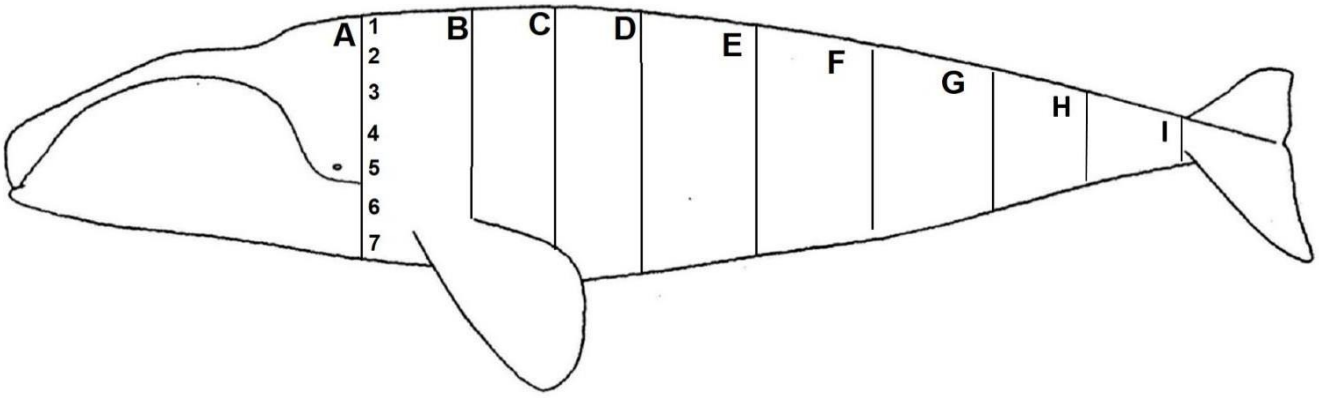
Observation #9 (skin): There is a focally extensive area where the epidermis is lacking in melanin in the stratrum basale, and there is extensive anastomosis of the affected rete ridges. There are multiple areas where the connective tissue of the dermal papillae between the epidermal rete ridges is expanded by large aggregates of mature neutrophils.

Tissues examined with no observable lesions: Adipose tissue, liver, unidentifiable soft tissues, observation #18 (collagen and adipose tissues), trachea, lungs.

Pathologists Laura Bourque

Blubber Thickness – EG2019-01

Necropsy #: X-11483-19 **Side examined: Right lateral**
Necropsy Date: June 7, 2019



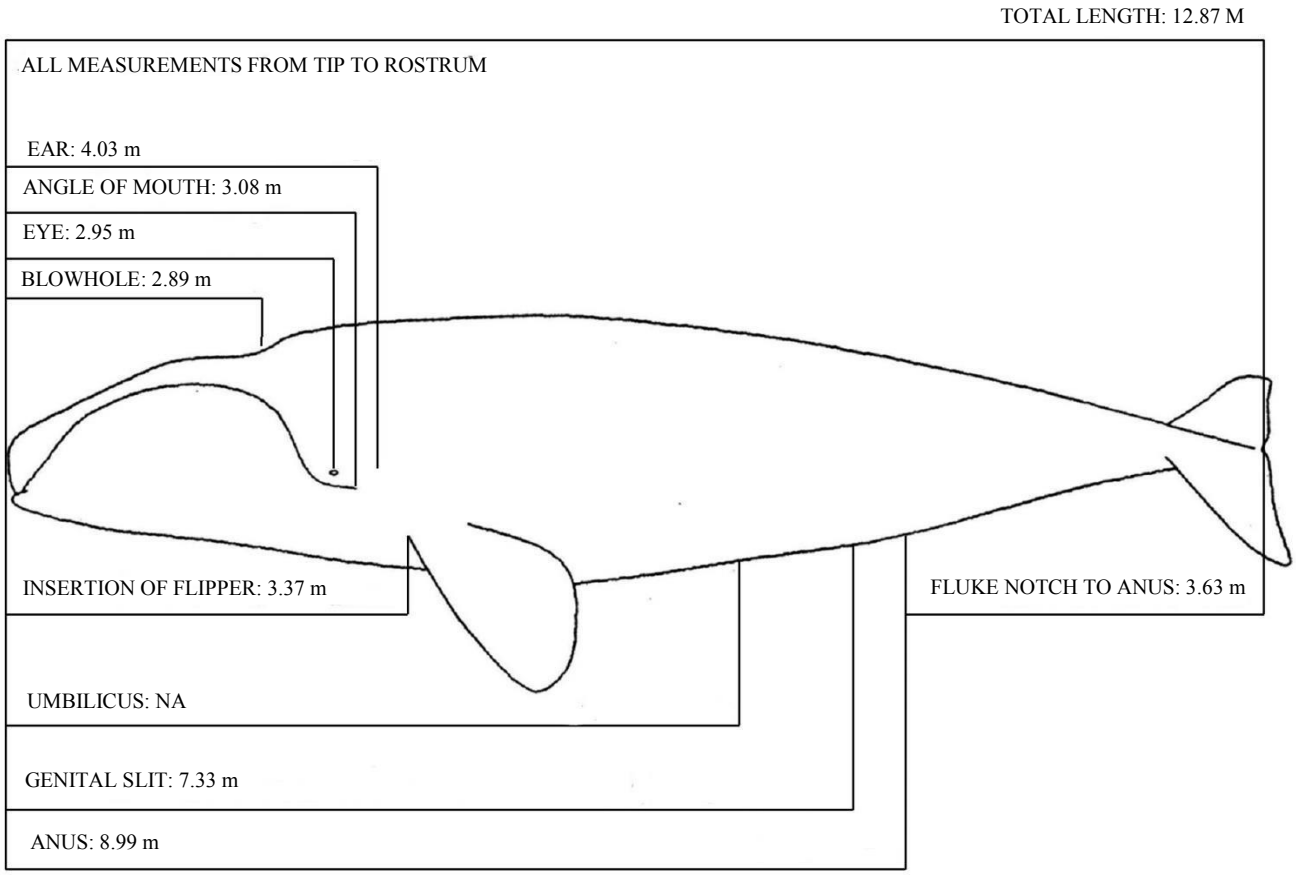
	A	B	C	D	E	F	G	H	I*
Dorsal	**Nuchal crest**	**Axilla**	**1/3 Axilla-umbilicus**	**2/3 Axilla-umbilicus**	**Umbilicus**	**1/2 umbilicus-anus**	**Anus**	**1/2 Anus-notch**	**Notch**
1	18.5	13	13	15	14	13.5	19.9	15	4
2	18.5	12.5	12.9	13.5	13.5	14	13.3	6	7
3	15	12.4	13.2	14.5	16.5	16.5	12.8	6.6	11
4	19.5	15	17.5	17	14.5	14.5	14	5.6	6.9
5	16.2	21	19	16.5	25	25	17	10.5	5.5
6	15.1	20	15.4	14.6	19	19	25	15.5	13.5
7	14.5	18	13.5	14.5	21.8	21.8	26	16	15.6
Ventral									
Mean	16.6	16.0	14.9	15.1	17.6	17.8	18.3	10.7	9.1

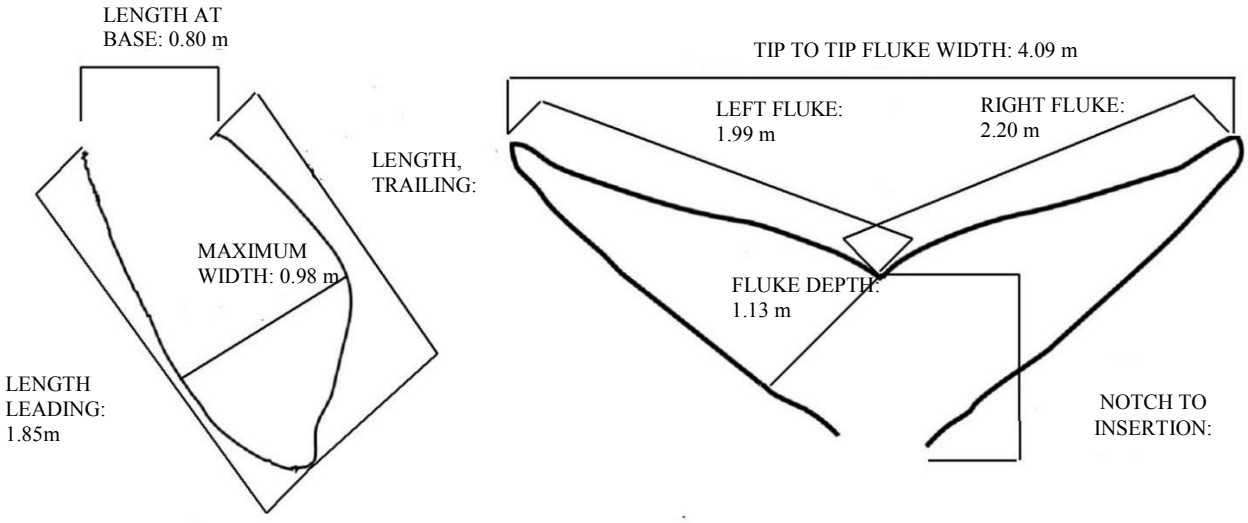
Circumference with blubber

	3.9	4.3	4.5	4.4	4.5	4.0	2.9	1.4	1.0

Notes:
Blubber thicknesses are in centimeters
Circumference measurements are in meters

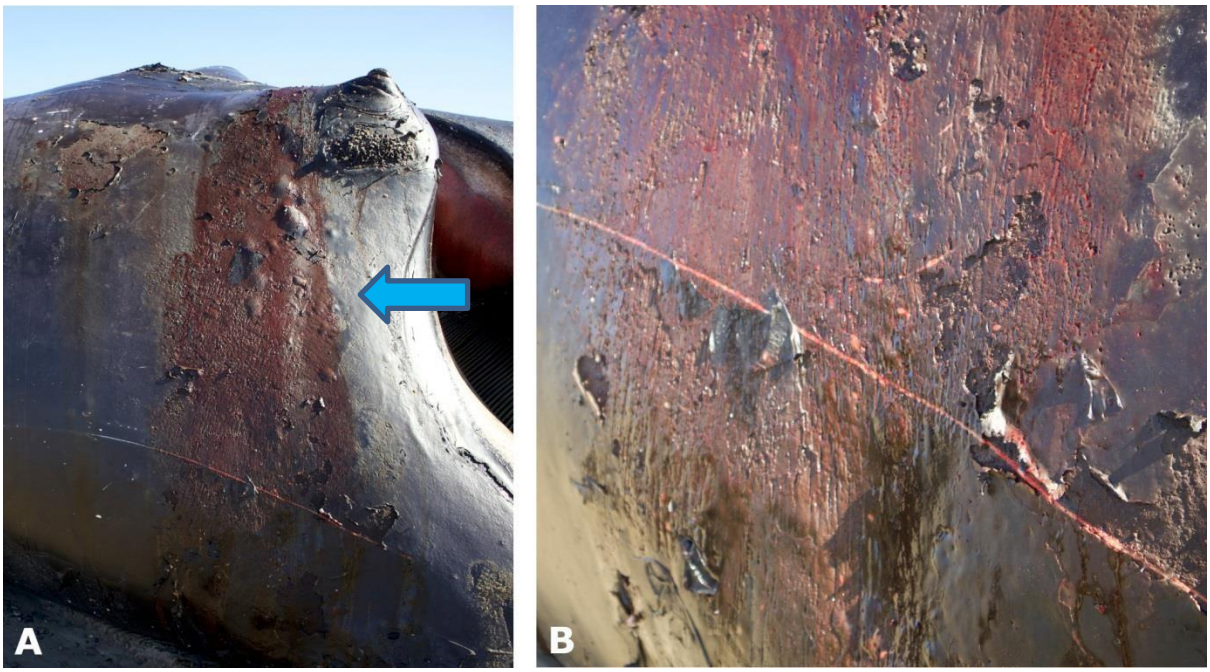
External morphometrics – EG2019-01





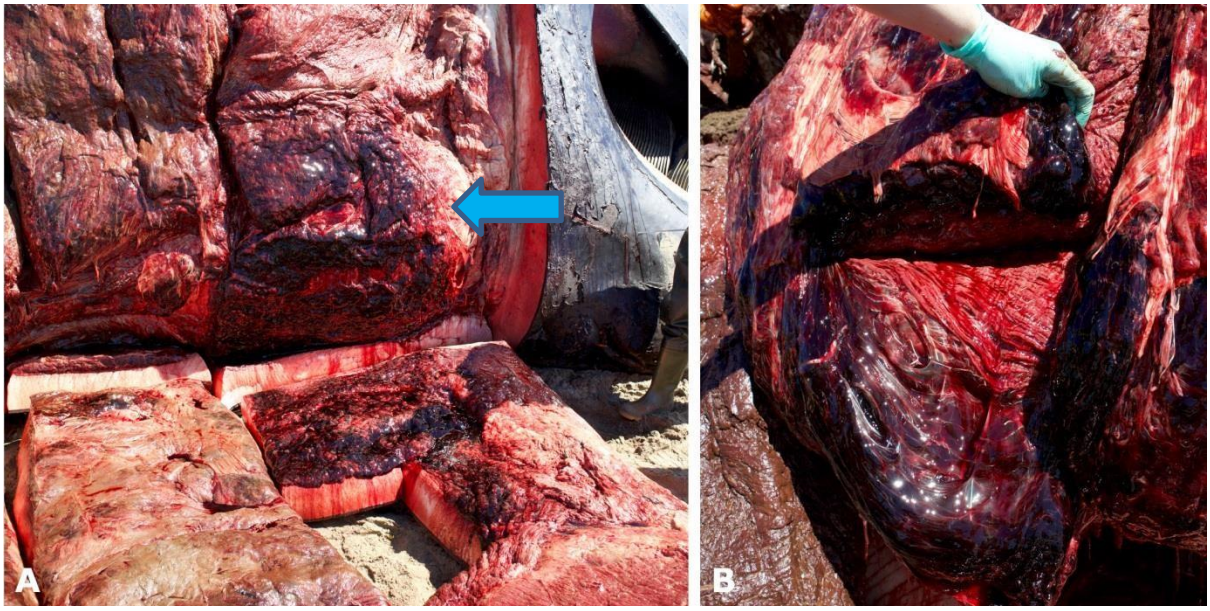
OBSERVATIONS - SELECTED IMAGES

Observation 23 : There is a focally extensive (approximately 0.5 x 3 m), well demarcated area that extends perpendicular to the long axis of the body from a level just caudal to the right eye to the dorsum just caudal to the blow hole where the skin is dark red and markedly roughened (A, blue arrow). The skin caudally or cranially to this area is intact, smooth, and unaffected by these changes. B) Close up of roughened area.

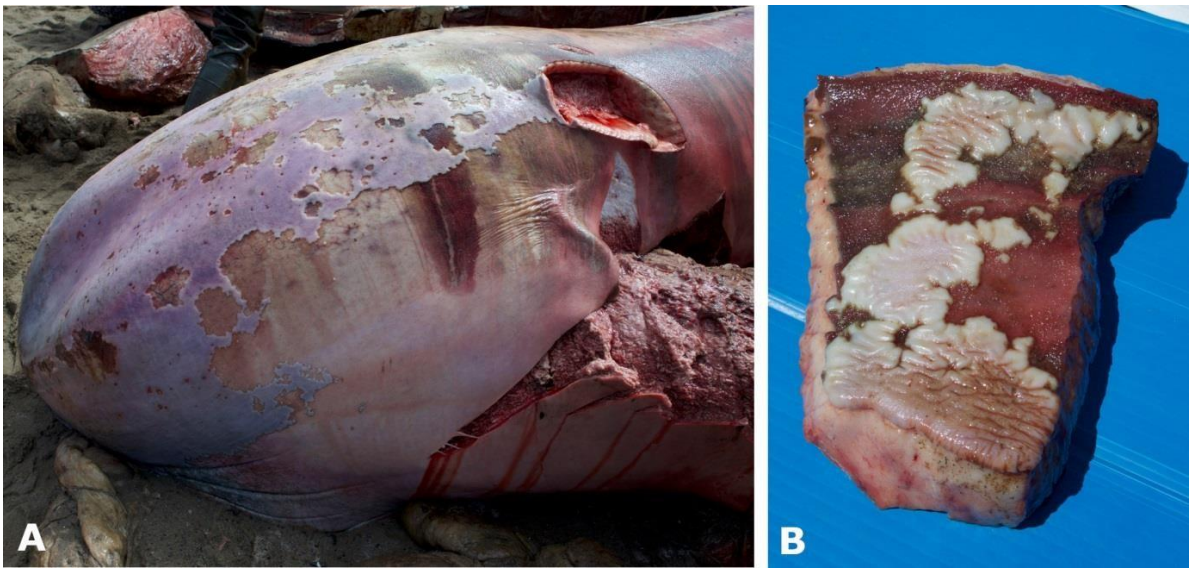


Observation 24 : There is a focally extensive, well demarcated, irregular area just caudal to the right eye where the blubber is diffusely bright red on cut surface (blue arrow). The ventral and dorsal margins of this area are irregular.

Observation 25 : Focally extensive area caudal to the blow hole and extending laterally on the right side, measuring approximately 2 meters in diameter where there is a large amount of dark red, gelatinous material expanding the subcutaneous tissue between the blubber and the underlying epaxial muscle (A, blue arrow). B) This dark red jelly like material extends caudally several meters beneath the dorsal aponeurosis of the epaxial muscles.

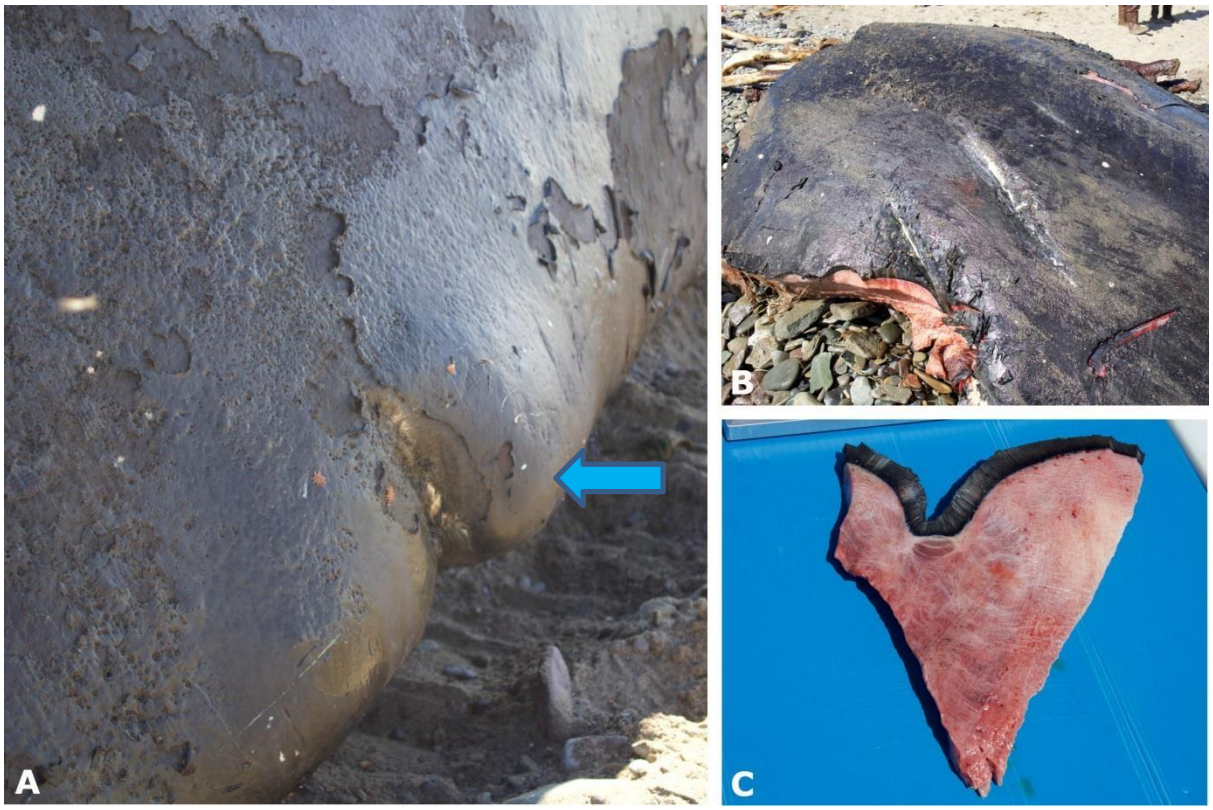


Observation 19 : A) There are numerous, very irregular, coalescing areas that extend over approximately 80% of the lingual and sublingual surfaces where the mucosa is absent and (B) exposing the submucosa which is bright red and roughened (suspect ulceration).



Observations 2, 6, 12-15, and 21 : Various white scars scattered over the body. A) Scars at insertion of right flipper. B) Scars at insertion of left flipper. C) Many fine white lines scattered over the body surface. D) Linear scar running over the buccal mucosa of the right side.

Observation 9 : Along the dorsal midline at the level of the caudal peduncle is a deep scar measuring approximately 61 cm long, 10 cm wide, and 9 cm deep, that extends caudally onto the right lateral peduncle (A, blue arrow)). Below this scar on the right lateral peduncle are two more similar parallel scars (chronic propeller lacerations) that extend caudally measuring 58 and 22 cm long respectively (B) On cut surface the normal subcutaneous tissue of the dorsal most scar is obscured by dense stellate aggregates of white fibrous tissue (C).



WILDLIFE DIAGNOSTIC REPORT

CANADIAN WILDLIFE HEALTH COOPERATIVE

ATLANTIC REGION
Atlantic Veterinary College
550 University Avenue, Charlottetown, PE, C1A 4P3
Phone: 902.628.4314 Fax: 902.628.4314
Email: atlantic@cwhc-rcsf.ca

Date Report Generated: 2020-02-25 **Necropsy number: X13662-19**

Event Information

Event Code:	CWHC.204511	**Location:**		**Latitude:**	47.61
Cross Ref #:	MARS2019-146, EG2019-02, NEA#1281, Southern Gulf of St. Lawrence "Punctuation"			**Longitude:**	-60.77
Species:	North Atlantic Right Whale (*Eubalaena glacialis*)				
Age:	Adult				
Sex:	Female				
Weight:	-				
Date Received:	2019-06-25				

Finder/Submitter Information

Submitter:
Isabelle Elliott
P.O. Box 5030
Moncton, New Brunswick
Phone: 506-851-2698(o), 378-0845(c)

Email Address: Isabelle.Elliott@dfo-mpo.gc.ca

Fisheries & Oceans Canada - Cheticamp
Cheticamp, Nova Scotia
Phone: (902) 224-2017

Information Provided For Event

This female North Atlantic Right Whale was found dead in the Gulf of Saint Lawrence on June 20th, 2019 to the north of Meat Cove, NS (47.36.50N, -60.46.03W DMS). This whale was towed to shore on Cape Breton Island (NS) and necropsy was performed on June 25, 2019.

Diagnosis and Interpretation

Final Diagnosis

Cause of death
1. Vessel strike (probable), with severe focally extensive body wall laceration and abdominal penetration

Incidental
2. Verminous nephritis, multifocal, chronic, mild (Crassicauda sp.)
3. Caudal lateral body wall, left side: Propeller scars, multiple, chronic
4. Caudal lateral body wall, right side: Scar, focally extensive, chronic
5. Caudal peduncle: Entanglement scar, multiple, chronic
6. Lateral lip, left: Scar, multiple, chronic

Interpretation

This adult female North Atlantic Right Whale was in excellent body condition and was not reproductively active at her time of death (see fecal hormonal analysis). The cause of death is considered to be sharp trauma due to vessel strike as indicated by the severe laceration in the dorsal lateral body wall that penetrated deeply into the abdominal cavity. This type of laceration would be caused by a very large category 4 vessel (cruise ships, tug boats, large shipping vessels, and mega yachts) and could be either caused by a fixed protruding structure (keel, skeg, rudder) or a massive propeller with a large pitch. The lack of elevated fecal glucocorticoids is supportive of an acute cause of death, and fecal analysis for biotoxins was negative. There were numerous old scars scattered around the body, some of which were consistent with previous sharp trauma from vessel strike, and some that were associated with past chronic entanglement. There were multiple granulomas scattered throughout the kidneys that were consistent with parasitism caused by the genus of nematode *Crassicauda* which is commonly found in the kidneys of large whale species (incidental findings). This necropsy report will be included as an

appendix in an larger Incident Report which will review and provide in depth discussion on all right whale incidents that occurred in the Gulf of St. Lawrence in 2019 and which will be made publicly available (on the CWHC and MARS websites). Please don't hesitate to contact me if you have questions concerning this report.

Laboratory Results

Necropsy

The body presented in approximately right lateral recumbency with the left pectoral flipper oriented upwards. The epaxial muscles are rounded and the body appears in excellent condition for the season/time of year. The skin is predominantly intact with occasional areas of fissures and post mortem sloughing. All baleen plates are present and firmly attached to the oral mucosa. The decomposition code is code three based on moderate autolysis of internal organs and moderate sloughing of the skin. There is no fishing gear associated with the carcass. An ear plug was identified and sampled from the left external ear canal. The following are the internal organs that were identified during necropsy: Lungs, trachea, bronchi, heart, kidney, liver, spleen, intestines, colon, stomach, vagina, cervix, and body of uterus.

The following is a description of significant observations made during the necropsy:

Observation 1, left dorsolateral body wall, (Photo: Y, Histology: Y):
There is a severe laceration measuring approximately 5 m long and 3 m at its greatest width that gradually curves from the caudal dorsal midline towards the left lateral body wall just caudal to the costal arches. The margins of the laceration are relatively uniform, with the exception of an 25 x 10 cm irregular deviation in the left lateral margin that corresponds to an at sea sampling site. The laceration extends through skin, blubber, and epaxial muscles and the exposed soft tissues are white to tan and partially decomposed. It was apparent from photographs taken at sea that numerous loops of intestine and colon were eviscerated through this laceration at one time. These intestinal loops were not apparent during necropsy, and the exposed soft tissues filling the gaping laceration consisted largely of epaxial muscle, fascia, body wall musculature, peritoneum, and the eviscerated body of the uterus and cervix. The epaxial muscles and soft tissues are torn cranial to the cutaneous laceration forming a cavity beneath the blubber and skin that extends approximately 2.5 m cranial to the primary laceration.

Observation 2, left dorsolateral body wall, (Photo: Y, Histology: Y):
There is a raised, mottled white linear scar measuring 1.02 m long and 11 cm wide that extends caudo-ventrally along the left lateral body wall running parallel to the left lateral margin of "observation 1". On section there is full thickness depigmentation of the epidermis and the adjacent blubber/dermis is effaced by abundant interlacing bundles of collagen (scar tissue) measuring approximately 10 cm deep.

Observation 3, Left lower lip, (Photo: Y, Histology: N):
Extending caudally over the lateral lip surface from the rostral tip are two linear indented mottled white scars running parallel to each other and separated by approximately 60 cm. These scars measure between 65 and 62 cm in length and approximately 5 cm wide. On section there is full thickness depigmentation of the epidermis.

Observation 4, Left dorsolateral body wall, (Photo: Y, Histology: Y):
Protruding out of the laceration described in "observation 1", is the wall of a tubular organ (suspect uterine wall) which has multiple coalescing extensive areas where the wall is dark red and edematous. This tubular organ contained abundant opaque red fluid with numerous tan white concretions floating throughout it.

Observation 5, Ventral mandibular symphysis, (Photo: Y, Histology: Y):
Extending caudally on the ventral surface of the intermandibular symphysis are numerous (>15) flat white lines varying between 5 and 35 cm in length and several cm wide. On section their epidermis is thinner compared to adjacent unaffected epidermis, and there is full thickness depigmentation.

Observation 6, Ventral abdomen, (Photo: Y, Histology: N):
There are numerous (approximately 10) thin white lines that extend craniocaudally over the ventral surface of the abdominal wall. These lines range from several cm to 85 cm long and they are flat and approximately 0.5 cm wide.

Observation 7, Ventral caudal peduncle, (Photo: Y, Histology: N):
On the ventral aspect of the caudal peduncle there is a slightly indented white linear scar measuring 40 cm long and 8.5 cm wide that warps circumferentially to the dorsal surface. Three other white scars run parallel to the main and larger scar on the dorsal peduncle, which measure between 13 to 20 cm long, and between 2 and 7 cm wide. On section all scars have full thickness depigmentation of the epidermis.

Observation 8, Kidney, (Photo: Y, Histology: Y):
Scattered throughout the reniculi of the kidney are numerous firm encapsulated nodules which contain thick, off-white, gritty caseous exudate (granulomas). Several of these nodules are tubular in shape.

Observation 9, Kidney, (Photo: Y, Histology: Y):
One adrenal gland is located. There are numerous petechiae scattered over the capsular surface and throughout the cortex and medulla.

Observation 10 and 13, Laceration left lateral body wall (observation 1), (Photo: Y, Histology: Y):
There are multiple areas of varying size (10 to 50 cm in diameter) where the soft tissues at the cranial margin of the laceration of observation 1 are dark red and gelatinous (suspect hemorrhage).

Observation 11, Left lateral body wall, (Photo: N, Histology: Y):
There is a roughly circular white slightly indented scar approximately 3 cm in diameter located on the left lateral body wall half way between the genital slit and the umbilicus. The adjacent dermis is effaced by abundant collagen fibers.

Observation 12, Leading edge of light and right flippers, (Photo: Y, Histology: N):
There are 2 to 3 white lines rounding the proximal leading edges of both flippers, the largest measuring 5 x 20 cm.

Observation 14, Epaxial muscles exposed in observation 1 laceration, (Photo: Y, Histology: Y):
The epaxial muscles on the left lateral margin of the laceration of observation 1 have numerous pale tan to dark brownstreaks extending throughout the exposed muscle and extend deep into the underlying muscle. The muscle affected by these streaks is tattered and friable.

Observation 15, Caudal skull left side, (Photo: Y, Histology: N):
Adjacent to the left lateral occipital condyle are multiple small bony nodules that project perpendicularly from the periosteal surface measuring between 2 and 5 cm in diameter.

Observation 16, Caudal left lateral body wall, (Photo: Y, Histology: Y):
There are five slightly indented parallel scars running caudo-cranially at an angle over the caudal right lateral body wall. Proceeding caudocranially, each scar measures 89, 113, 100, 91, and 74 cm in length (respectively) and approximately 2.5 cm wide. The distances between the scars are 26, 28, 28, and 28.7 cm, respectively (old propeller scars).

Toxicology
Lab:
Canadian Food Inspection Agency
(1981) DARTMOUTH LABORATORY - CHEMISTRY
1992 AGENCY DRIVE
DARTMOUTH, NS B3B 1Y9

Sample: Feces

Tests:
Determination of Domoic Acid in Shellfish by LC-UV and LC-MS/MS
Determination of Lipophilic Shellfish Toxins in Shellfish by LC-MS/MS
Determination of Paralytic Shellfish Toxins in Shellfish by LC-FLD with Post-column Oxidation

Results:
Negative for all assessed biotoxins (see attached report for specific toxins tested)

Other lab results
Lab: Anderson Cabot Center for Ocean Life, at the New England Aquarium
Prepared by: Katherine Graham, MS, Rosalind Rolland, DVM, & Elizabeth Burgess, PhD
Sample: Feces
Test: Hormone analysis, Radioimmunoassay

Results (ng/g):
Progesterone: 362.1
Testosterone: 137.3
Estrogens: 19.50
Glucocorticoids: 26.2
Thyroid: 9.5

Reproductive hormones are within expected normal limits (295 ± 145 ng/g) for adult non-pregenant female North Atlantic Right Whales and indicate that she was not pregnant at her death. Fecal glucocorticoids are low which incidate that this whale was not experiencing elevated physiologic stress prior to death and is supportive of an acute cause of death. Fecal thyroid levels were lower than the average recorded levels for right whales in the NEA database (50-60 ng/g~). This is consistent with newly observed population trends, indicating a decline in nutritional state and associated metabolic responses of North Atlantic right whales.

Histology
There is moderate to marked autolysis throughout these tissues.

Observation #4, skin: There is a focally extensive area where the epidermis is lacking in melanin in the stratrum basale, and there is extensive anastomosis of the affected rete ridges.

Kidney, caseous nodules: These nodules are surrounded by a dense fibrous capsule which surrounds large concretions of mineral and amorphous eosinophilic necrotic cellular debris. Embedded within this exudate are numerous aggregates of fragmented, amphophilic hyaline structures which are round to oval and range between 10 and 25 microns in diameter (autolyzed helminth eggs). Intact eggs sometimes contain an amorphous eosinophilic embryo.

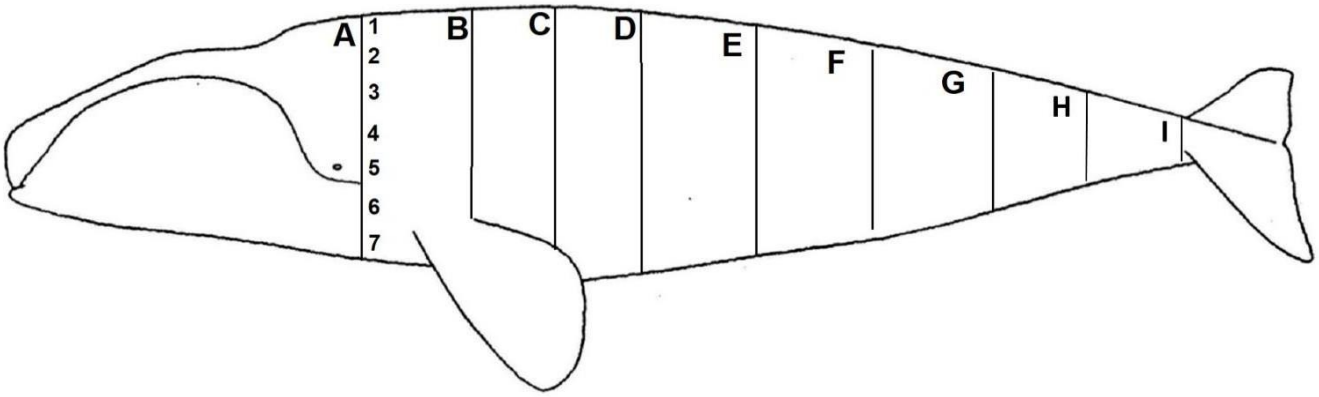
The following tissues had no abnormal microscopic findings: Observation #1 (skin, blubber, skeletal muscle), observation #14 (skeletal muscle), lung, bronchus, skeletal muscle, heart, trachea,

Pathologists Laura Bourque

Morphological measurements

Blubber Thickness – EG2019-02

Necropsy #: X-13662-19 **Side examined: Right lateral recumbency**
Necropsy Date: June 25. 2019



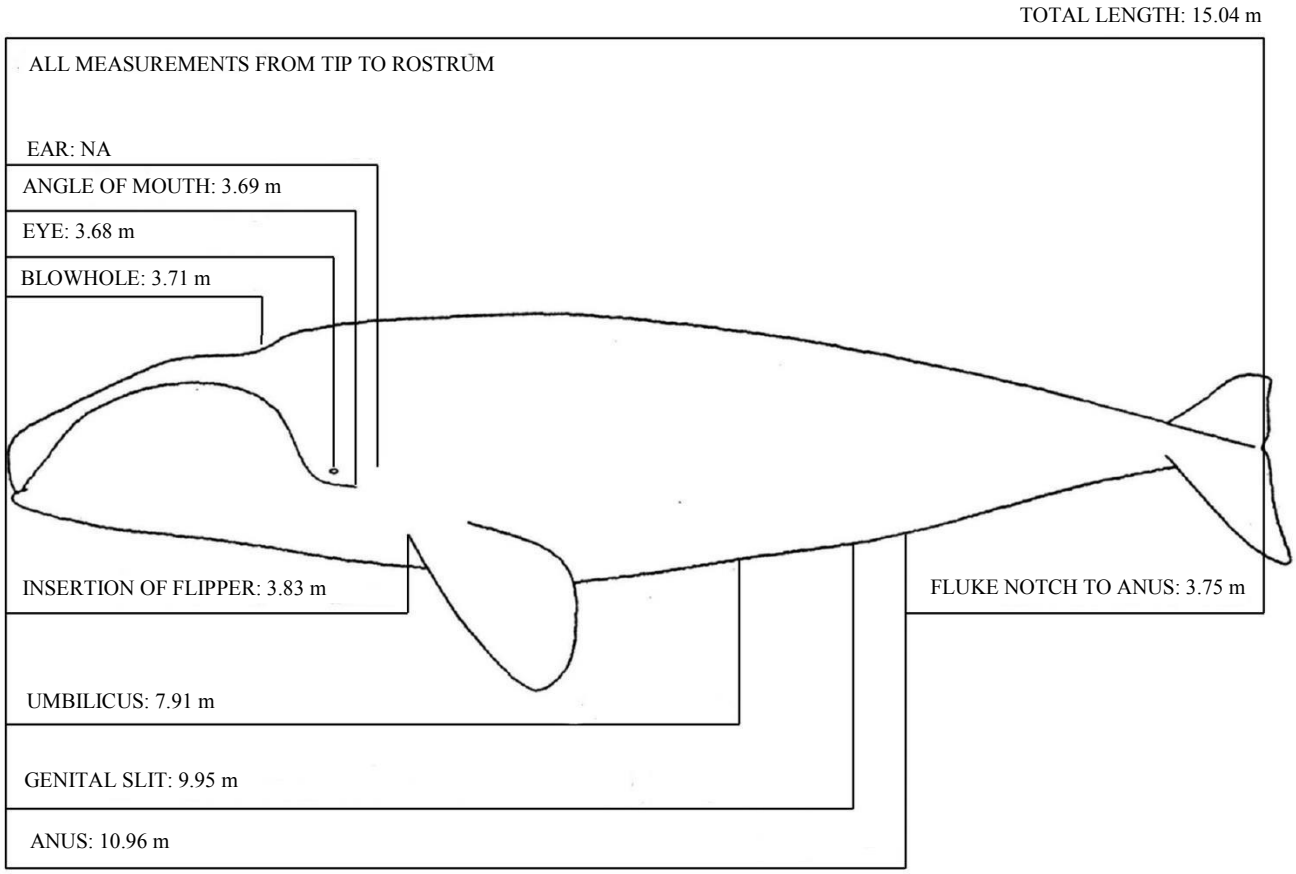
	A	B	C	D	E	F	G	H	I*
Dorsal	**Nuchal crest**	**Axilla**	**1/3 Axilla-umbilicus**	**2/3 Axilla-umbilicus**	**Umbilicus**	**1/2 umbilicus-anus**	**Anus**	**1/2 Anus-notch**	**Notch**
1	22	16	13	15	15	15.1	23	18	NA
2	17	14	17	18	19.5	14.5	17.5	12	NA
3	19	19.5	20	20	24.5	19	17.5	12.5	NA
4	12	27.5	29.5	24.5	21	22	21	12.5	NA
5	NA	26.5	26.5	24	22.5	21	21	13	NA
6	19	22	23.5	21.5	23.2	27	23	19	NA
7	25	21.5	21.4	22	25	29	30	23	NA
Ventral									
Mean	19	21	21.6	20.7	21.5	21.1	21.9	15.7	NA

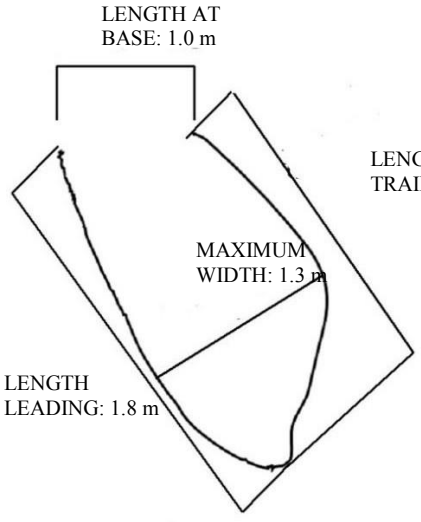
Circumference with blubber

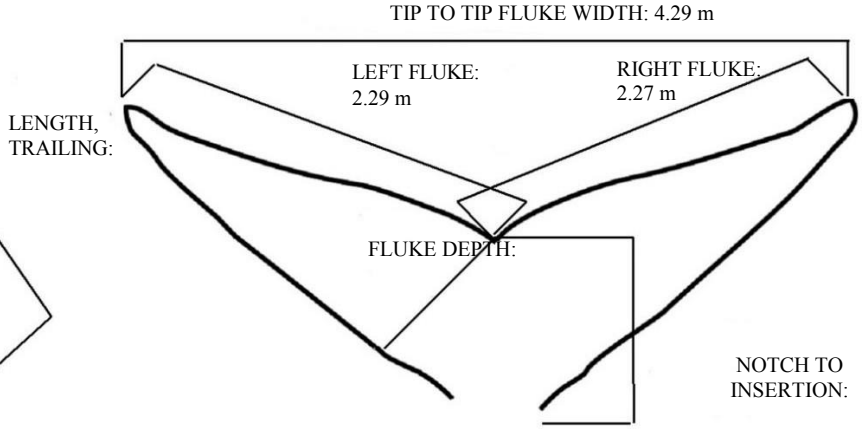
	4.9	6	5.6	5.2	5.9	NA	NA	2.4	NA

Notes:
Blubber thicknesses are in centimeters
Circumference measurements are in meters

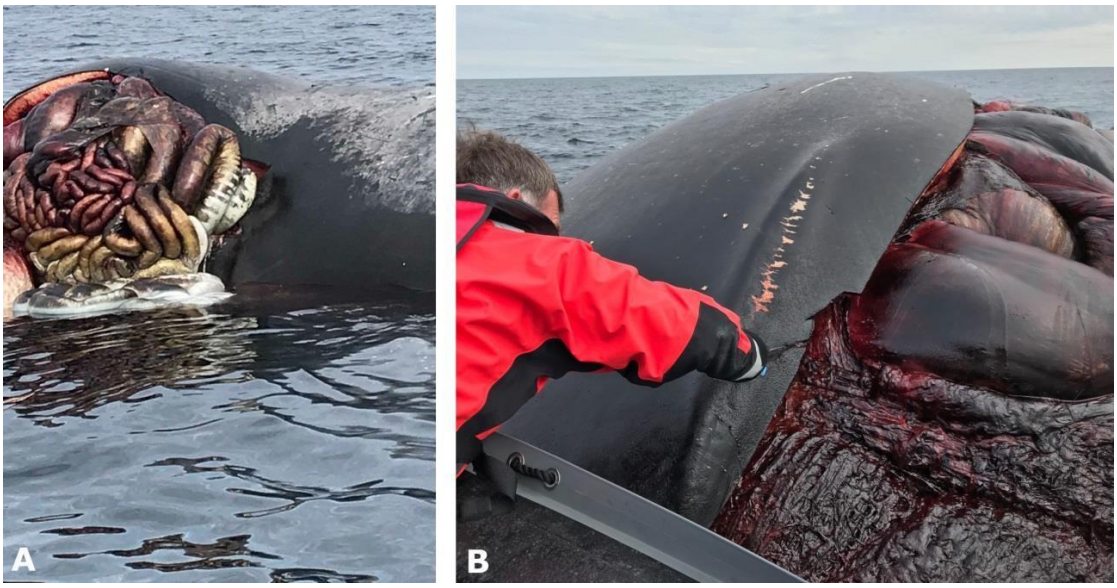
External morphometrics – EG2019





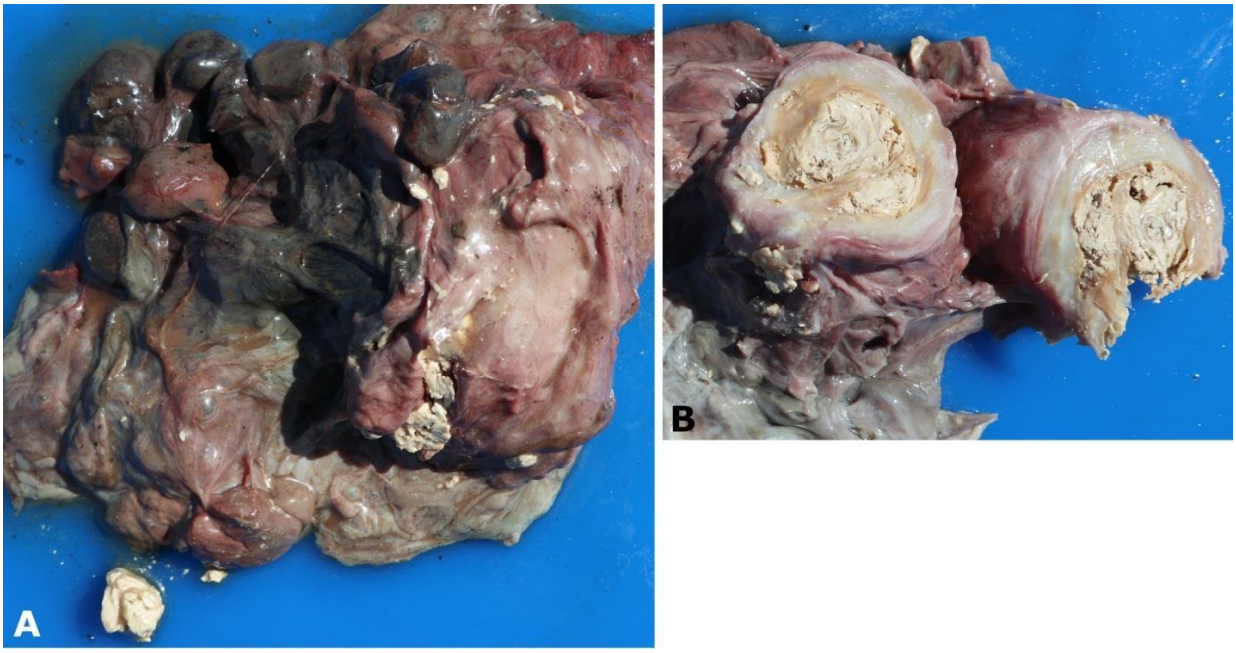


At sea observation: A) A large laceration is present in the dosal lateral flank of the whale from which abundant loops of intestines are protruding. B) Close up of the laceration. The skin in this image is intact and shows no evidence of blistering or sloughing indicating that this was a recently deceased whale (photo credits : Department of Fisheries and Oceans).



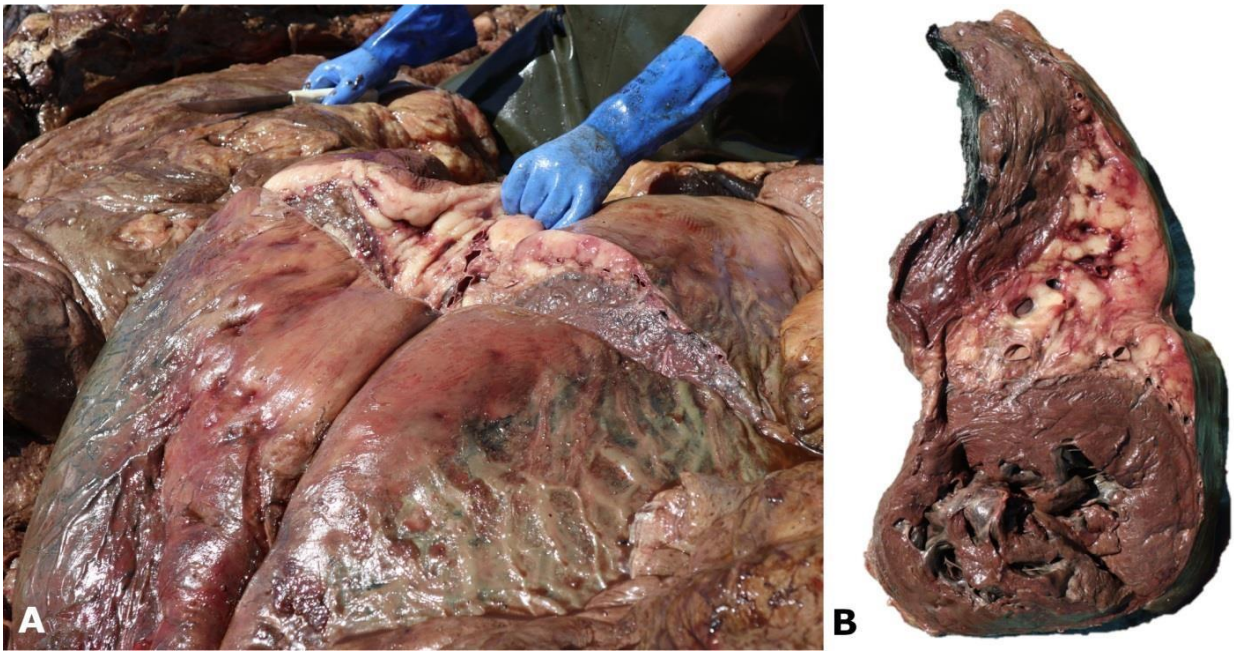
Observation 1: A) There is a severe laceration measuring approximately 5 m long and 3 m at its greatest width that gradually curves from the caudal dorsal midline towards the left lateral body wall just caudal to the costal arches. The laceration extends through skin, blubber, epaxial muscles, and penetrates the abdominal cavity. The abundant loops of intestine noted in this laceration while at sea are no longer present. B) Cranial margin of the laceration. C) At sea smapling site. D) Skeletal muscle exposed at the margin of the laceration. E) Renal reniculi that are exposed and protruding through the laceration. F) Portion of cervix and uterine body (opened) extruding through the laceration (blue arrow).

Observation 8, kidney: Scattered throughout the kidney are numerous firm encapsulated nodules which contain thick, off-white, gritty caseous exudate (granulomas). Several of these nodules are tubular in shape.

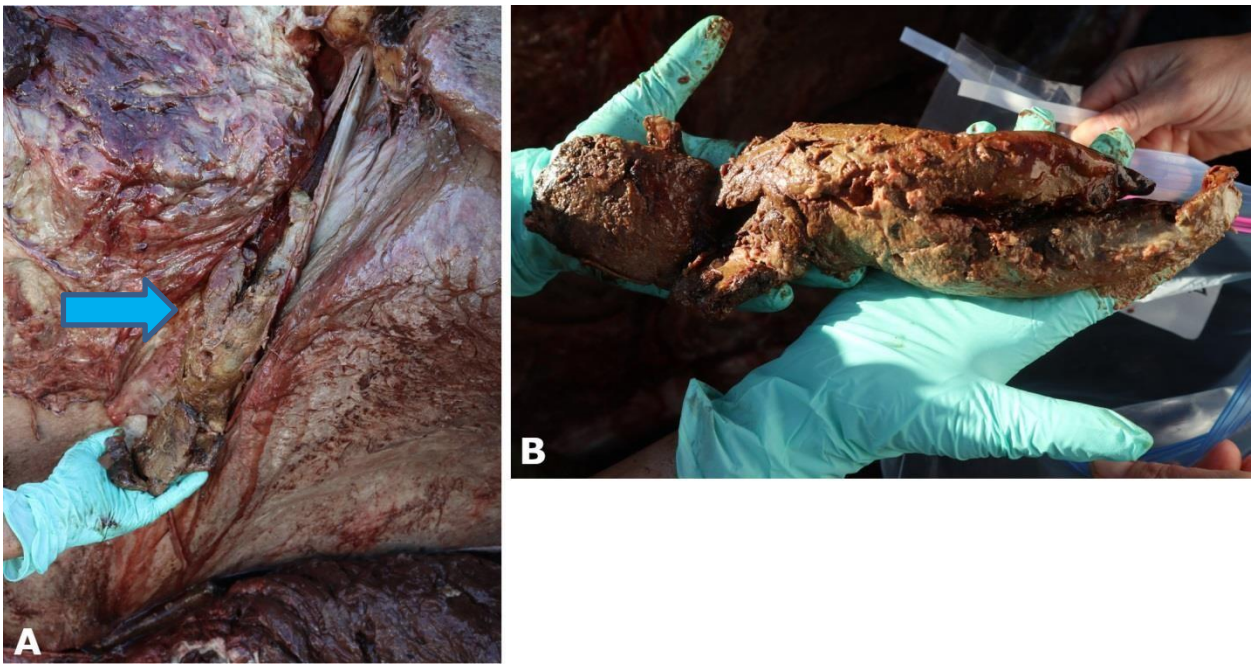


Observations 2, 3, 7, and 16: A) Observation 2, a raised, mottled white linear scar running along the left lateral body wall parallel to the left lateral margin of "observation 1". On section there is full thickness depigmentation of the epidermis and the adjacent blubber/dermis is effaced by abundant interlacing bundles of collagen (scar tissue) 10 cm deep (B). C) Observation 3, extending caudally over the lateral surface of the lip are two linear indented white scars running parallel to each other. D) Observation 16, five indented parallel scars on the right caudo-lateral body wall (old propeller scars). E) Observation 7, ventral peduncle with wrapping scars that extend onto the dorsal peduncle (F).

Observation, heart: The heart was identified intact in the thoracic cavity and surrounded by abundent epicardial fat (A). B) Cross section through the ventricular walls and demonstrates the abundant epicardial fat between the ventricules.



Observation, ear plug: An ear plug was identified and sampled from the left external ear canal (blue arrow).



WILDLIFE DIAGNOSTIC REPORT

CANADIAN WILDLIFE HEALTH COOPERATIVE

ATLANTIC REGION
Atlantic Veterinary College
550 University Avenue, Charlottetown, PE, C1A 4P3
Phone: 902.628.4314 Fax: 902.628.4314
Email: atlantic@cwhc-rcsf.ca

Date Report Generated: 2020-02-25 **Necropsy number: X13339-19**

Event Information

Event Code: CWHC.204513
Cross Ref #: EG2019-03, NEA #1514, "Comet"
Species: North Atlantic Right Whale (*Eubalaena glacialis*)
Age: Adult
Sex: Male
Weight: -
Date Received: 2019-06-28

Location: Southern Gulf of St. Lawrence
Latitude: 47.83
Longitude: -64.05

Finder/Submitter Information

Submitter:
Isabelle Elliott
Fisheries & Oceans Canada - Moncton
P.O. Box 5030
Moncton, New Brunswick
Phone: (506) 851-6227
Email Address: Isabelle.Elliott@dfo-mpo.gc.ca

Information Provided For Event

A male North Atlantic Right Whale was found dead in the Gulf of Saint Lawrence on June 25th, 2019 just to the south of New Richmond, Quebec. This whale was towed to Norway PEI June 28 and necropsy was performed on the same day.

Diagnosis and Interpretation

Final Diagnosis

Cause of death
Vessel strike (probable), with focally extensive contusions, unilateral tympanoperiotic fracture, hemothorax, and intra-calvarial hemorrhage.

Incidental
Flukes, skin (bilateral): Chafing ulcer (entanglement), multifocal, severe, chronic
Pectoral flipper skin, left: Ulceration with dermatitis (entanglement), focally extensive, moderate, chronic
Peduncle, skin: Entanglement scars, multiple, chronic
Body wall skin, ventral: Entanglement scars, multiple, chronic
Oral cavity mucosa: Entanglement scars, multiple, chronic

Interpretation

This adult male North Atlantic Right Whale was in good body condition as indicated by adequate thickness of blubber (Miller et al. 2011), and it did not have elevated fecal biotoxins which may have indicated antemortem toxicity. The cause of death in this case is considered to be probable vessel strike as supported by numerous lesions compatible with trauma including contusions, fractures, and internal hemorrhage. This whale demonstrated moderately elevated fecal glucocorticoids (273 ng/g) as compared to normal levels taken from free ranging apparently healthy right whales, or which died from an acute death (65 ± 7 ng/g). Elevated fecal glucocorticoids implies that this whale was experiencing increased physiologic stress at least 1 to 2 days prior to death. A possible cause of chronic stress in this whale could be related to pain caused by open wounds (entanglement related) present on the leading edges of each flukes (chafing from trailing rope) and the left front flipper. Image analysis from the New England Aquarium North Atlantic right whale catalogue indicate that this whales most recent entanglement was in 2005 which is when the fluke ulcers were first observed (Amy Knowlton, personal communication). Aside from the healing wounds, there were numerous old/well healed scars scattered over the body that are compatible with previous entanglements. The reason why some wounds healed on this whale while others did not is unknown. The majority of internal organs were absent and so it is not possible to rule out underlying infectious diseases. This necropsy report will be included as an appendix in an larger Incident Report which will review and provide in depth discussion on all right whale incidents that occurred in the Gulf of St. Lawrence in 2019 and which will be made publicly available (on the CWHC and MARS websites). Please don't hesitate to contact me if you have questions concerning this report.

Miller CA, Reeb D, Best PB, Knowlton AR, Brown MW, Moore MJ. 2011. Blubber thickness in right whales Eubalaena glacialis and Eubalaena australis related with reproduction , life history status and prey abundance. 438:267–283.

Laboratory Results

Necropsy

The body presented in left lateral recumbency with the left pectoral flipper oriented upwards. The epaxial muscles are rounded and the body appears in excellent condition for the season/time of year. The skin is predominantly intact with multiple areas of fissures and post mortem sloughing. All baleen plates are present and firmly attached to the oral mucosa. The decomposition code is advanced code three based on significant autolysis of internal organs and sloughing of the skin. There is no fishing gear associated with the carcass. The only internal organs identified were segments of the colon, intestines, stomach, and liver. A large ear plug was identified in the external ear canal of one ear.

The following is a description of significant observations made during the necropsy:

Observation 1, right lateral body wall, (Photo: Y, Histology: N):
At approximately the level of the genital slit there is a localized area of chalky white, superficial discoloration of the skin with poorly defined margins measuring 2.20 x 0.40 m.

Observation 2, right dorso-lateral body wall, (Photo: Y, Histology: Y):
On the right dorso-lateral body wall just caudal to the insertion of the flipper is an approximately triangular area of patchy white discoloration of the skin measuring 1.43 m long, and 20 cm at its widest point and less than 5 cm at its tip. On section the adjacent superficial dermis is obscured by a thin layer of fibrous connective tissue.

Observation 3, Right commissure of the oral cavity, (Photo: Y, Histology: Y):
There is an area of white depigmentation of the mucocutaneous junction of the right lateral oral commissure that curves inward and extends along the corresponding buccal mucosa measuring approximately 97 cm long and 20 cm wide. There is no apparent fibrosis of the adjacent subcutaneous tissue.

Observation 4, Right caudal maxilla at lip edge, (Photo: Y, Histology: N):
There are three linear slightly raised pale scars measuring approximately 25 cm long and 2 cm wide.

Observation 5, Sublingual mucosa, rostral oral cavity, (Photo: Y, Histology: N):
There is a linear pale grey slightly raised scar measuring 23 cm long and 1 cm wide beneath the tongue.

Observation 6, Left cranial buccal mucosa, (Photo: Y, Histology: N):
On the inner surface of the lower left lip is an area of grey depigmentation measuring 40 x 6 cm.

Observation 7, Leading edge of left flipper, (Photo: Y, Histology: N):
There are approximately 12 areas of white discoloration wrapping around the leading edge of the left flipper. The white area adjacent to the flipper insertion is centrally ulcerated with roughened margins measuring 26 cm long and 2.5 cm wide.

Observation 8, Ventral abdomen, (Photo: Y, Histology: Y):
On the ventral abdomen caudal to the anus are two raised mottled white parallel scars running cranio-caudally measuring 78 cm and 60 cm long respectively, and approximately 4 cm wide.

Observation 9, ventral caudal peduncle, (Photo: Y, Histology: Y):
There are three linear crisscrossing areas of white discoloration wrapping around the peduncle measuring between 20 and 30 cm long and between 2 and 3 cm wide. There is a small amount of dermal fibrous connective tissue elevating the depigmented epidermis on section.

Observation 10 and 11, Fluke leading edges, (Photo: Y, Histology: Y):
On the leading edge of both flukes are ellipsoidal areas of cutaneous ulceration measuring approximately 30 cm long and 10 cm wide. The skin of the ulcerated margin is uneven and white and the exposed subcutaneous tissue is dark red and edematous.

Observation 12, Leading edge of right fluke, (Photo: Y, Histology: N):
There are several white crisscrossing lines on the leading edge of the right fluke which often coalesce and are difficult to distinguish from each other at times.

Observations 13 and 14, Cranial right lateral body wall, (Photo: Y, Histology: Y):
There is a 60 cm in diameter indented area in the right lateral body wall where the muscles are dark red and gelatinous and the caudal most rib is displaced upwards and laterally. This rib is readily mobile (suspect towing artifact).

Observation 15, Left ventrolateral body wall caudal to axilla, (Photo: Y, Histology: N):
There is a focal red discoloration of the blubber in this area that extends beneath the recumbent surface of the whale. What is available for measurement is 60 cm long and full blubber thickness.

Observation 16, Right commissure of the oral cavity, (Photo: Y, Histology: N):

The blubber of the right lateral commissure of the oral cavity is diffusely red on section.

Observations 17 and 23, left mandible and sublingual tissue, (Photo: Y, Histology: Y):
The subcutaneous tissue surrounding the left mandible is diffusely expanded by dark red gelatinous material (edema, hemorrhage – Observation 17). The hemorrhage and edema extend into the underlying skeletal muscle and also medially into the adjacent sublingual soft tissues which are markedly expanded by it (observation 23). In comparison, the right mandible and sublingual soft tissues are normal and not affected by similar changes.

Observations 18, Thoracic cavity, (Photo: Y, Histology: Y):

The pleural surfaces of the left costal arches are coated by a 3 to 4 cm thick layer of dark red to black putty-like material (clotted blood). There are numerous large aggregates of clotted blood (between 10 and 20 cm in diameter) free floating throughout the thoracic viscera.

Observations 19, right lateral vertebral column, (Photo: Y, Histology: Y):
Diffusely underlying the periosteum of the vertebral bodies and transverse processes is a 2 to 3 cm thick layer of waxy brown material.

Observations 20, Right mandible, (Photo: Y, Histology: N):
The subcutaneous tissues surrounding the caudal right mandible and temporo-mandibular joint are dark red and mildly gelatinous.

Observations 21, Right ear, (Photo: Y, Histology: N):
The right ear bone is fractured at its base from the caudal skull. There is no evidence of blood.

Observations 22, Brain cavity, (Photo: Y, Histology: N):
Approximately one third of the volume of the cranium is occupied by abundant dark red to black putty-like material.

Observations 24, Left ear bone, (Photo: Y, Histology: N):
The left ear bone is fractured from the skull at its base which is surrounded by abundant dark black putty-like material which is admixed with several irregularly shaped shards of bone.

Observations 25, Thoracic vertebrae, (Photo: Y, Histology: Y):
At approximately the level of T11 to T12, there is a vertebral body with its ventral periosteum expanded by a myriad of coalescing small boney nodules (osteophytes).

Toxicology
Lab:
Canadian Food Inspection Agency
(1981) DARTMOUTH LABORATORY -
CHEMISTRY 1992 AGENCY DRIVE
DARTMOUTH, NS B3B 1Y9

Sample: Feces

Tests:
Determination of Domoic Acid in Shellfish by LC-UV and LC-MS/MS
Determination of Lipophilic Shellfish Toxins in Shellfish by LC-MS/MS
Determination of Paralytic Shellfish Toxins in Shellfish by LC-FLD with Post-column Oxidation

Results:
Negative for all assessed biotoxins (see attached report for specific toxins tested)

Other lab results
Lab: Anderson Cabot Center for Ocean Life, at the New England Aquarium
Prepared by: Katherine Graham, MS, Rosalind Rolland, DVM, & Elizabeth Burgess, PhD
Sample: Feces
Test: Hormone analysis, Radioimmunoassay

Results (ng/g):
Progesterone: 370.3
Testosterone: 175.5
Estrogens: 33.92
Glucocorticoids: 272.6
Thyroid: 23.6

The fecal glucocorticoids of this whale were moderately elevated beyond what is normally observed in adult male, free ranging Right Whales (65 ± 7 ng/g) suggesting that this whale potentially suffered a more prolonged decline in health. Comet also had a reduced level of fecal testosterone compared to normal males (10,203 ± 1641 ng/g) suggesting that he had reduced testicular function. Fecal thyroid levels were lower than the average recorded levels for right whales in the NEA database (50-60 ng/g~). This is consistent with newly observed population trends, indicating a decline in nutritional state and associated metabolic responses of North Atlantic right whales.

Histology
There is moderate to marked post mortem autolysis throughout these tissues.

Observation #10 and 11 (skin): There is full thickness ulceration of the epidermis which exposes the underlying dermal collagen. There are a large number of degenerate neutrophils and fibrin expanding the superficial dermal collagen fibers. In observation #10, there is generalized moderate hyperplasia of the stratum basale of the adjacent epidermis. There are multiple areas where the adjacent epidermis is elevated from the underlying basement membrane by large aggregates of inflammatory cells and pyknotic debris.

Observation #7 (skin): There are large numbers of degenerate neutrophils, lymphocytes, and fewer macrophages that expand the dermo-epidermal junction.

Observation #9 (skin): There is full depigmentation of the epidermis.

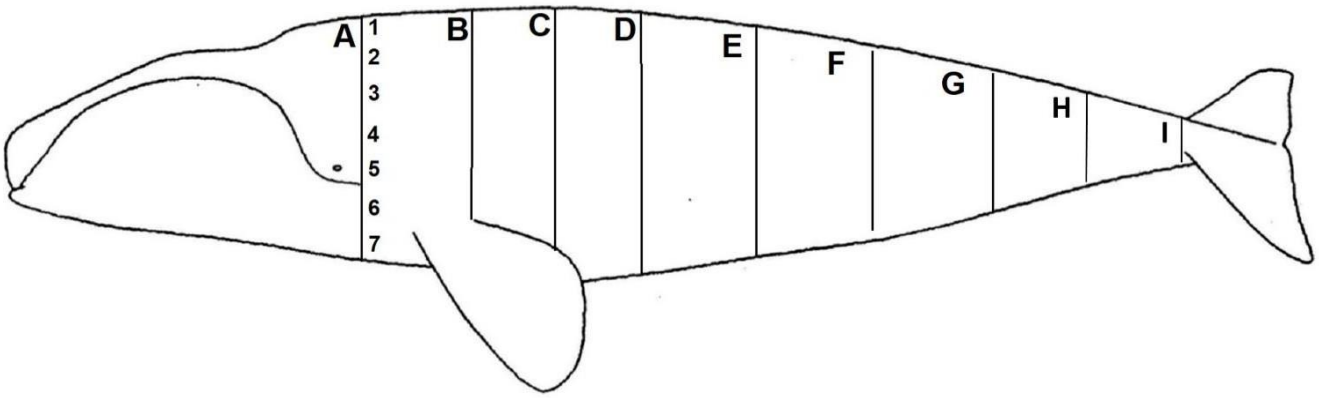
The following tissues had no microscopic abnormalities: Bronchus, stomach, observation #17 (skeletal muscle), heart, observation #13 (skeletal muscle), colon, skeletal muscle, observation #14 (skeletal muscle), tongue, liver

Pathologists Laura Bourque

Morphological measurements

Blubber Thickness – EG2019-03

Necropsy #: X-13339-19 **Side examined: Left lateral recumbency**
Necropsy Date: June 28, 2019



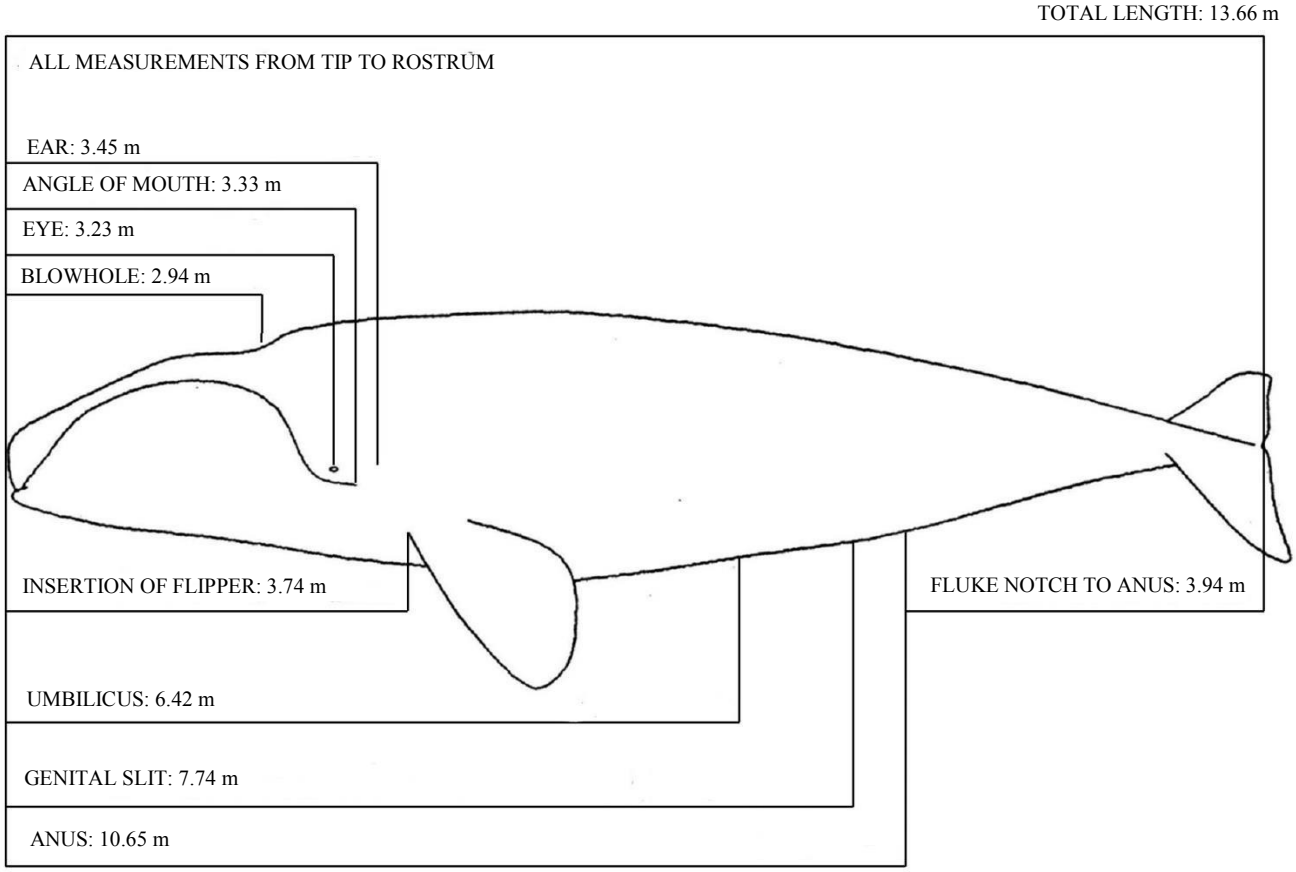
	A	B	C	D	E	F	G	H	I*
Dorsal	**Nuchal crest**	**Axilla**	**1/3 Axilla-umbilicus**	**2/3 Axilla-umbilicus**	**Umbilicus**	**1/2 umbilicus-anus**	**Anus**	**1/2 Anus-notch**	**Notch**
1	16.0	15.0	14.0	13.8	17.0	16.0	20.0	14.0	NA
2	15.5	13.5	14.5	17.0	18.4	16.0	15.5	7.5	NA
3	18.0	18.0	18.5	19.5	22.0	17.5	15.8	6.0	NA
4	24.5	18.0	22.0	24.0	22.5	20.0	18.0	8.0	NA
5	20.0	19.5	24.0	26.0	21.0	25.0	26.0	5.2	NA
6	21.5	20.0	21.0	20.0	21.0	26.0	27.0	6.8	NA
7	23.5	20.5	19.5	18.5	17.0	18.5	26.0	13.5	NA
Ventral									
Mean	19.9	17.8	19.1	19.8	19.8	19.9	21.2	8.7	NA

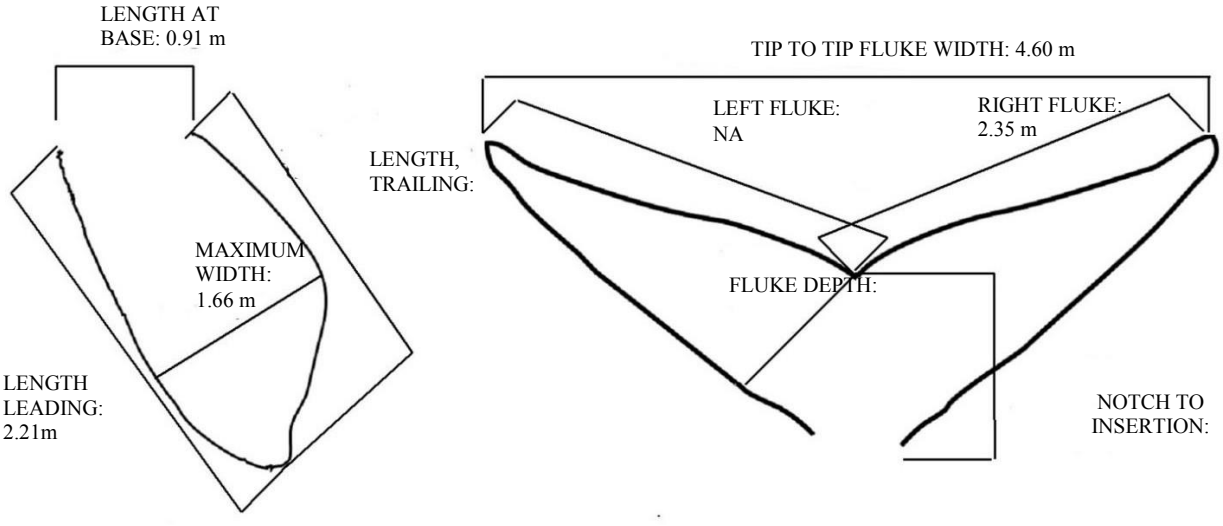
Circumference with blubber

	4.25	4.65	4.70	4.75	4.70	4.50	3.10	1.46	1.05

Notes:
Blubber thicknesses are measured in centimeters
Circumference measurements are in meters

External morphometrics – EG2019-03



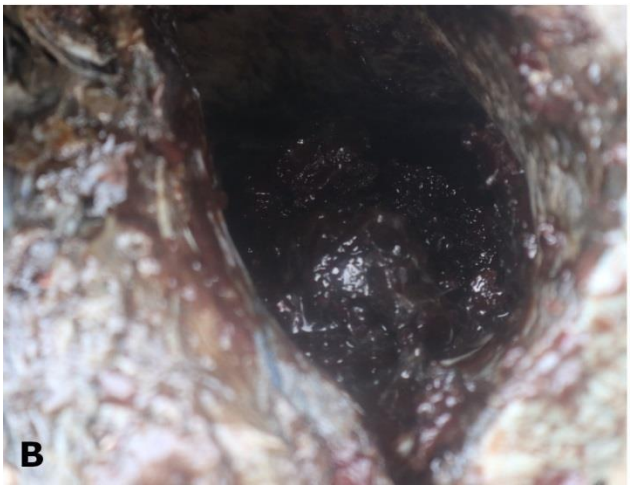


Observation 17 and 23: A) The subcutaneous tissue surrounding the left mandible is diffusely expanded by dark red gelatinous material (edema). B) There is a large amount of red fluid that elevates the blubber (blue arrow). C) Red fluid extends into the underlying skeletal muscle. D) Red fluid extends medially into the adjacent sublingual soft tissues. The blue arrow points to the blubber and affected soft tissues which have been reflected back from the mandibles of the right to lie on the ground opposite (on the left).

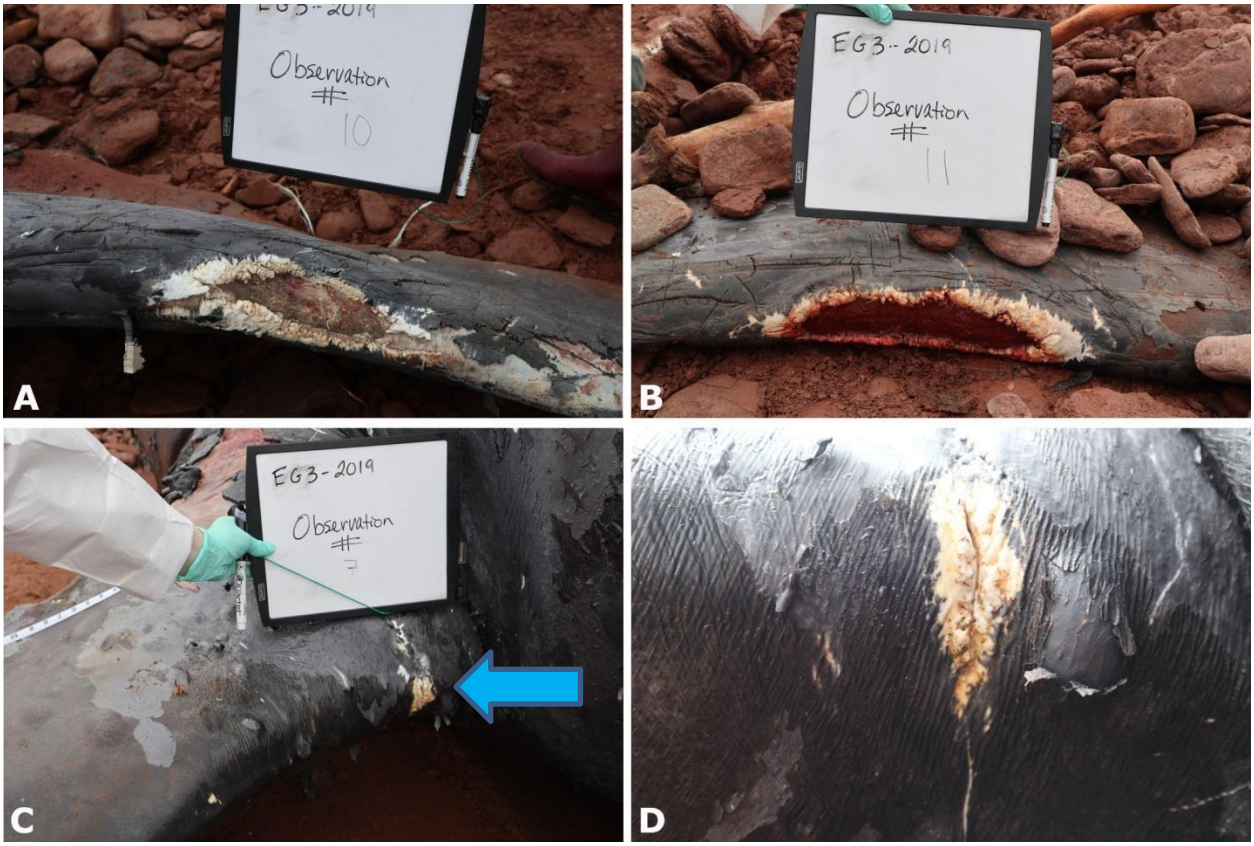
Observation 18: A) The pleural surfaces of the left costal arches are coated by a 3 to 4 cm thick layer of dark red to black putty-like material (clotted blood). There are numerous large aggregates of clotted blood (between 10 and 20 cm in diameter) free floating throughout the thoracic viscera. B) An example of a large clump of putty within the thoracic cavity.

Observation 24, left tympano-periotic bone: A) The left ear bone is fractured from the skull at its base which is surrounded by abundant dark black putty-like material which is admixed with several irregularly shaped shards of bone (blue arrow). B) close up of the affected ear bone *in situ* demonstrated in (A). C) The fractured left tympanoperiotic bone is removed from the skull (middle). An example of the fractured skull bone surrounding the fractured ear is on the left. An example of the black putty surrounding the fractured ear bone is on the right.

Observation 22, calvarium: A) Approximately one third of the volume of the cranium is occupied by abundant dark red to black putty-like material (blue arrow). B) Close up of the black putty described in (A).



Observations 7, 10, 11 : These images represent multiple open healing wounds that were located around EG2019-03's body. A) Observation 10 is a 34 x 10 cm oval area of cutaneous ulceration on the leading edge of the right fluke. B) Observation 11 is a 34 x 11 cm oval area of cutaneous ulceration on the leading edge of the left fluke. C) Observation 7 is a 26 x 2.5 cm area on the leading edge of the left flipper at the insertion where the skin is depigmented and roughened surrounding a central linear, depressed area (blue arrow). D) Close up of observation 7.



Observations 2, 4, 8, 9: These images represent various incidental (old) scars that were located over the body of this whale. A) Depicts the white comet tail scar for which this whale recieved its given name. B) Concentric scars located on the caudal peduncle that are consistent with previous entanglement. C) Old scars on the ventrum caudal to the anus, entanglement related. D) Entanglement scars in the oral cavity.

Observation, external ear canal: A large plug was observed and sampled from one of the external ear canals.

WILDLIFE DIAGNOSTIC REPORT

CENTRE RÉGIONAL DU QUÉBEC
Faculté de médecine vétérinaire
Université de Montréal
3200, rue Sicotte, Saint-Hyacinthe, QC, J2S 2M2
Téléphone: 450-773-8521 Poste 8346
Télécopieur: 450-778-8116
Courriel: quebec@cwhc-rcsf.ca

Date Report Generated: 2020-02-04 **Necropsy number: P2386-19**

Event Information

Event Code: CWHC.206067
Cross Ref #: EG2019-06 / Catalogue #3450, « Clipper »
Species: North Atlantic Right Whale (*Eubalaena glacialis*)
Age: Adult
Sex: Female
Weight:
Date Received: 2019-07-01

Location: Off shore Percé Québec
Latitude: 48.52
Longitude: -64.21

Finder/Submitter Information

Submitter:
Stephanie Ratelle
Species at Risk / Marine Mammals, DFO-MPO Gulf Region, Science
Science, 343 University Avenue
Moncton, New Brunswick, E1C 9B6
Phone: (506) 851-4335
Email Address: Stephanie.ratelle@dfo-mpo.gc.ca

Information Provided For Event

Identification:

Species: North Atlantic Right Whale (*Eubalaena glacialis*)
Identification: Catalogue #3421
Mortality event identification: EG2019-07
Sex: Male
Length: 13.30 m
Age: 15 years old

History:

This right whale was last seen alive on June 10, 2019 in the Gulf of St. Lawrence by a NOAA aerial surveillance team. The whale was found dead floating off the Gaspé Peninsula on July 18, 2019 (48°09.841N and 62°45.072W). The carcass was towed by fishery officers on July 20, 2019 to the *Grand étang* rest area (Gaspesia) where the post-mortem examination was performed.

Diagnosis and Interpretation

Final Diagnosis

Cause of death:

1. Hemothorax, severe, acute, probable vessel strike

Other diagnoses:

2. Partial amputation of the fluke (inactive, low significance)
3. Superficial remodeled cutaneous scars (inactive, non-significant)

Interpretation

The carcass was ascribed a decomposition condition code of 4. Therefore, the interpretation of the observations made should be done with caution. This animal was considered in good body condition for the season, based on its blubber thickness (Miller et al, 2011).

The different macroscopic observations made are highly suggestive of a blunt trauma, most likely following a vessel strike. Indeed, the dark red putty-like material within the thoracic cavity and along the vertebral canal is suggestive of clotted blood (cooked by internal heat and pressure generated by post-mortem decomposition). Therefore, it is believed that the death of this animal was caused by an extensive hemothorax (hemorrhages in the thoracic cavity). These hemorrhages were probably associated with a damaged *rete mirabile* (complex network of blood vessels within intercostal muscles in the dorsal region of the thoracic cavity of whales). A blunt trauma caused by a ship strike is the most likely cause of these hemorrhages. This suspicion of a blunt trauma is also supported by the presence of subpannicular contusion-like areas on the left side of the whale.

The fecal glucocorticoid concentration in this individual is within normal baseline levels, which suggests that the death of this whale was caused by an acute event rather than a consequence of a chronic condition. Levels of fecal glucocorticoid of similar magnitude have been reported in other right whales that died rapidly following vessel strikes (Rolland et al., 2017).

Other findings observed on this whale included an old partial amputation of the tail fluke (lesion known) and superficial lineal depigmentations interpreted as old scars. The good body condition of this whale suggests that these lesions did not affect its foraging capacity. The tail fluke amputation was probably caused by a propeller strike. The breaks observed in the oral mucosa are believed to be post mortem sloughing, and therefore non-significant. The "herniation" of the genital tract from the abdominal cavity is also believed to be an artefact associated with decomposition.

In conclusion, this post-mortem investigation revealed evidences that support that a vessel strike was the most likely cause of death of this whale.

References:

Miller, CA., et al. Blubber thickness in right whales *Eubalaena glacialis* and *Eubalaena australis* related with reproduction, life history status and prey abundance. Marine Ecology Progress Series 438 (2011): 267-283.

Rolland RM, McLellan WA, Moore MJ, Harms CA, Burgess EA and Hunt KE (2017) Fecal glucocorticoids and anthropogenic injury and mortality in North Atlantic right whales (*Eubalaena glacialis*). Endangered Species Research 34: 417-429.

Laboratory Results

MACROSCOPIC EXAMINATION

Necropsy was performed at *Grand Étang*, Gaspésie, on July 1, 2019.
Carcass conservation code: 4

This carcass is in poor preservation state. Externally, the carcass is intact, not collapsed and the skin is still present on the vast majority of the body surface. However, the internal organs are markedly decomposed and very difficult to identify. Actually, most of the thoracic and abdominal viscera could not be properly identified during the macroscopic examination (probably expelled orally following the increase in internal pressure occurring during decomposition).

Complete morphological measurements may be found in **Appendix I.** Photographs and general distribution of the different observations (O) noted thorough this description are found in **Appendix II**.

Morphological Measurements

Blubber thicknesses were measured at seven locations from mid-dorsal to mid-ventral and at eight levels from cranial to caudal. Blubber thickness was considered adequate, with 13 cm on the mid-length of the body (2/3 axilla-umbilicus) on the dorsal line, which is in the average of the values measured in this species in summer (12.2 cm ± 2.16 cm) by Miller et al. (2011).

External Examination

The majority of the carcass is still covered by intact skin. Several linear areas of epidermal depigmentation (white), believed to be scars, are observed:

- Multiple linear depigmentations, 10 to 30 cm in length, on the ventral aspect of the head (O10).
- A 51 cm long linear mark (O6) and a 50 cm long linear mark, parallel to the longitudinal axis of the body and slightly depressed (O3), in the cranial third and the caudal third of the left side of the body respectively.
- Two slightly depressed 25 and 35 cm in length, 5 cm apart from each other linear marks on the right side. Each of these is centred on a small raised circular area (O21).
- A 50 cm long linear mark at the base of the right pectoral flipper.

Other cutaneous changes are noted:

- An unpigmented 25 cm long depression, on the ventral edge of the right mandible, running up to the baleen (O8).
- A *Morse code* depigmentation on the mid-third of the left side, 15 cm in length (O5).
- An unpigmented, 3 cm in diameter slightly raised nummular lesion on the cranial aspect of the left side (O7).

- An 5 X 3.5 cm firm depression on the ventral aspect of the carcass, centred on a forked slightly curved white line (O11).
- A 120 cm longX 8 cm wide linear swelling on the ventral aspect of the carcass, caudally to the anus, oblique to the longitudinal axis of the whale (O1).
- Two white, ovoid, contiguous 3 cm in length depressions on the cranial edge of the left side of the tail (O4).

The right distal two thirds of the caudal fluke is missing (old, completely healed, amputation) (O2).

Musculoskeletal system

Two hemorrhagic areas of 13 X 30 cm and 4 X 30 cm are observed in the subcutaneous space on the left side of the body (O12) and on the right side of the peduncle (O13) respectively. Several vertebrae at the thoraco-lumbar junction region are darkly coloured. This dark coloration is also present on the internal face of the adjacent epaxial muscles (O15). The left epaxial muscles are red and liquefied over an area of 80 X 30 cm just caudally to this (O16). The entire vertebral canal is filled with a coagulated dark red *putty-like* materiel. This material seemed to be partially contained in a tubular structure, within the vertebral canal, possibly a blood vessel (O19).

Abdominal and thoracic cavities

The uterus seems to be herniated thought the abdominal wall (O14). The liver, some segments of the digestive tract and the uterus were identified and sampled. The oral mucosa of the right mandible presents several irregularly shaped ulcer-like lesions with well-defined margins (O18). The dorsal aspect of the thoracic cavity contains a large quantity of dark red putty-like materiel (probably coagulated blood) (O17 and O20). This material contains some tangled fibres (interpreted as remaining *mirabile rete*).

HISTOLOGY

Skin lesions
Observation 3 (E): There is a focal and slight decrease of the pigmentation, especially at the base of the epidermal papilla.
Observation 4 (F): The surface of the epidermis is irregular and showing some areas of thinning. There is a focal decrease of the pigmentation of the epidermis, especially at the base of the epidermal papilla. These papillae seem shorter and slightly disorganized. No cellular infiltration seen.
Observation 5 (G): Focally, the pigmentation of the epidermis is moderately decreased, especially at the base of the epidermal papilla.
Observation 6 (H, I): On slide H, a focally extensive epidermal depigmentation is noted with a mild disorganization of the base of the epidermal papilla. The s*tratum spinosum* contains two small invaginations of partially necrotic *stratum corneum*.
Observation 11 (L): There is a focal and slight decrease of the pigmentation with a mild disorganization of the base of the epidermal papilla associated with a moderate infiltration of the adjacent dermis by inflammatory cells.
Observation 21 (P, Q): The epidermis is separated from the dermis (probably artefactual). On slide P, there is a focally extensive epidermal depigmentation. On slide Q, small infiltrations of inflammatory cells and some foci of pigmentary incontinence are present in the superficial dermis.

Other samples

Observation 19 (tubular structure in the vertebral canal) (M): Two of the sections correspond to markedly decomposed connective stroma on unknown origin. One of the sections could correspond to a blood vessel (central lumen lined by two symmetrical walls that are composed of two distinct layers of connective tissue). The third section is composed of muscle fibers.

Observation 17 (*rete mirabile*?) (O): This sample is formed by markedly decomposed connective structures that are suggestive of blood vessels.

Observation 18 (oral mucosa) (R, S): On two sections, there is a loss of the mucosa with well-defined margins. No inflammatory or proliferative change present (post-mortem artefact).

Mammary gland (Z): Inactive mammary gland. Normal tissue.

Observation 12 (suspected subcutaneous hemorrhage, left side) (AF): Marked post mortem changes; origin of this tissue uncertain.

No histological change detected in the following samples: skin – observations 1 (A), 2 (B, C, D), 7 (J, K), skin of the rostrum (T), thoracic muscle (N, Y), left epaxial muscle (AD), cervical muscle (AE), liver (V, W, X), rostral vibrissae (U) and urinary bladder (AG). The post mortem artefacts are marked.

FECAL GLUCOCORTICOID ASSAY

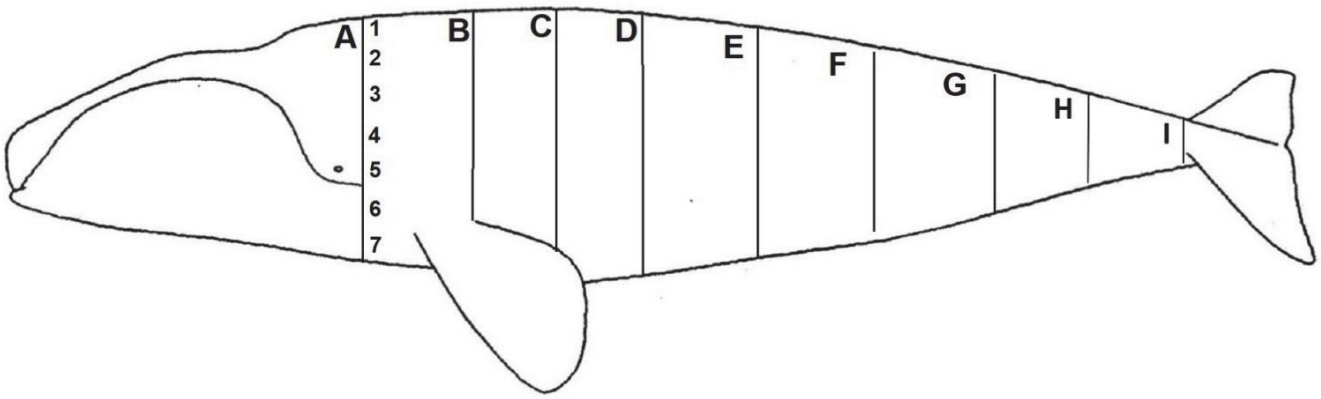
12.53 ng/g (New England Aquarium).

Pathologists Marion Jalenques DMV, Resident
Stéphane Lair DMV, Diplomate ACZM

Appendix I – Morphological measurements

Blubber thickness – EG2019-06

Field#: CQSAS EG2019-06 **Side examined**: Left **Observer**: Anthony François
Date: July 1, 2019



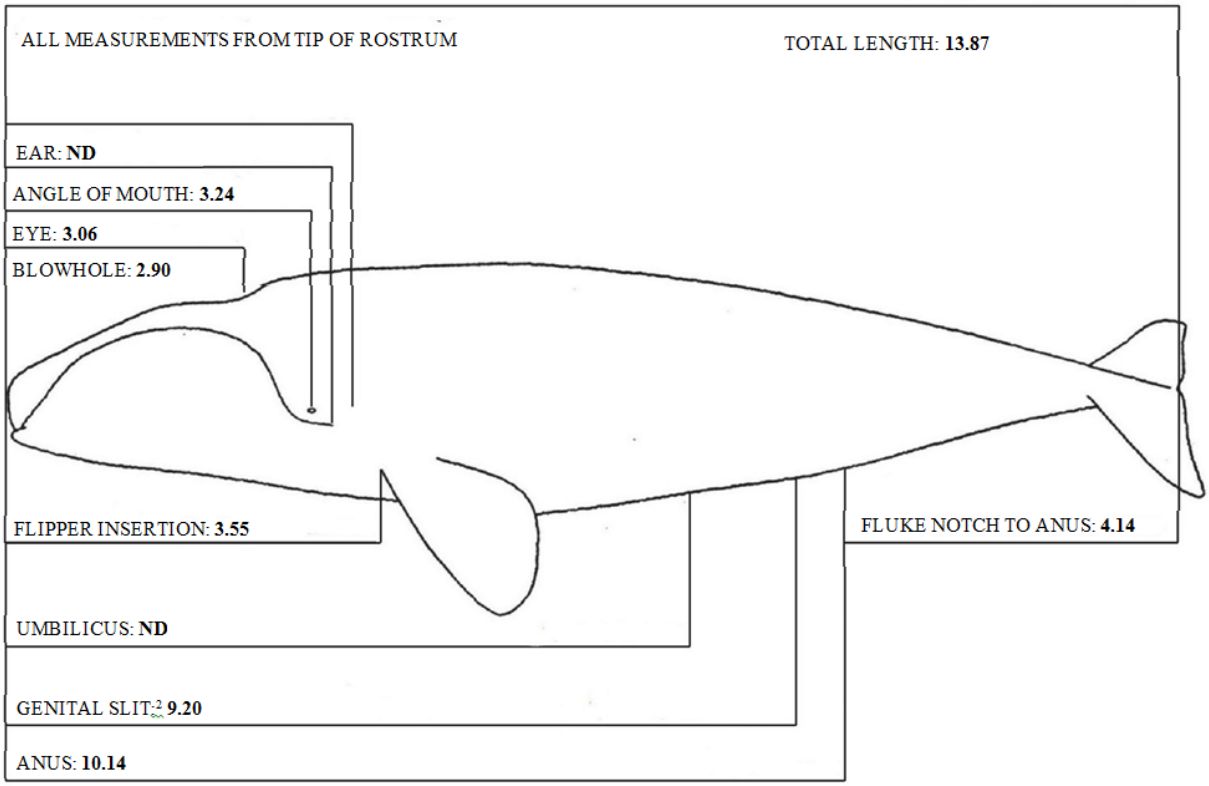
	A	B	C	D	E	F	G	H	I*
Dorsal	**Nuchal crest**	**Axilla**	**1/3 Axilla-Umbilicus**	**2/3 Axilla-Umbilicus**	**Umbilicus**	**1/2 Umbilicus-Anus**	**Anus**	**1/2 Anus-Tail insertion**	**Tail insertion**
1	18	14	11.8	13	16	23	20	14	ND
2	14.5	11	12.4	12.5	13.5	14.5	16.5	8	ND
3	17	15.5	17.5	15	16	16.5	16.5	7.5	ND
4	14	16	19.5	18	17	18	16	10	ND
5	14	23	21	20	21	18	23	11.5	ND
6	17	19	20.5	19	19	23	23	14.8	ND
7	22	22	19	18	21	26	22	15	ND
Ventral									
Mean	16.6	17.2	17.4	16.5	17.6	19.9	19.6	11.5	ND

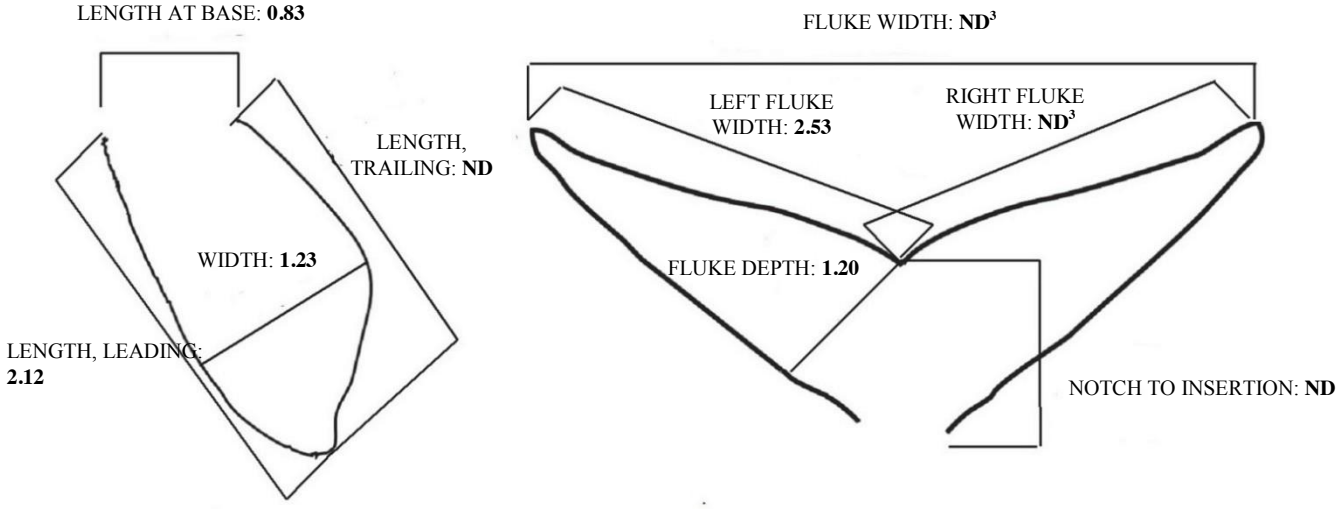
Circumference with blubber

	414	395	439	443	427	367	303	169	ND

Note: all measures are in cm.
* Not measured because of rope.

External morphometrics[1] – EG2019-06





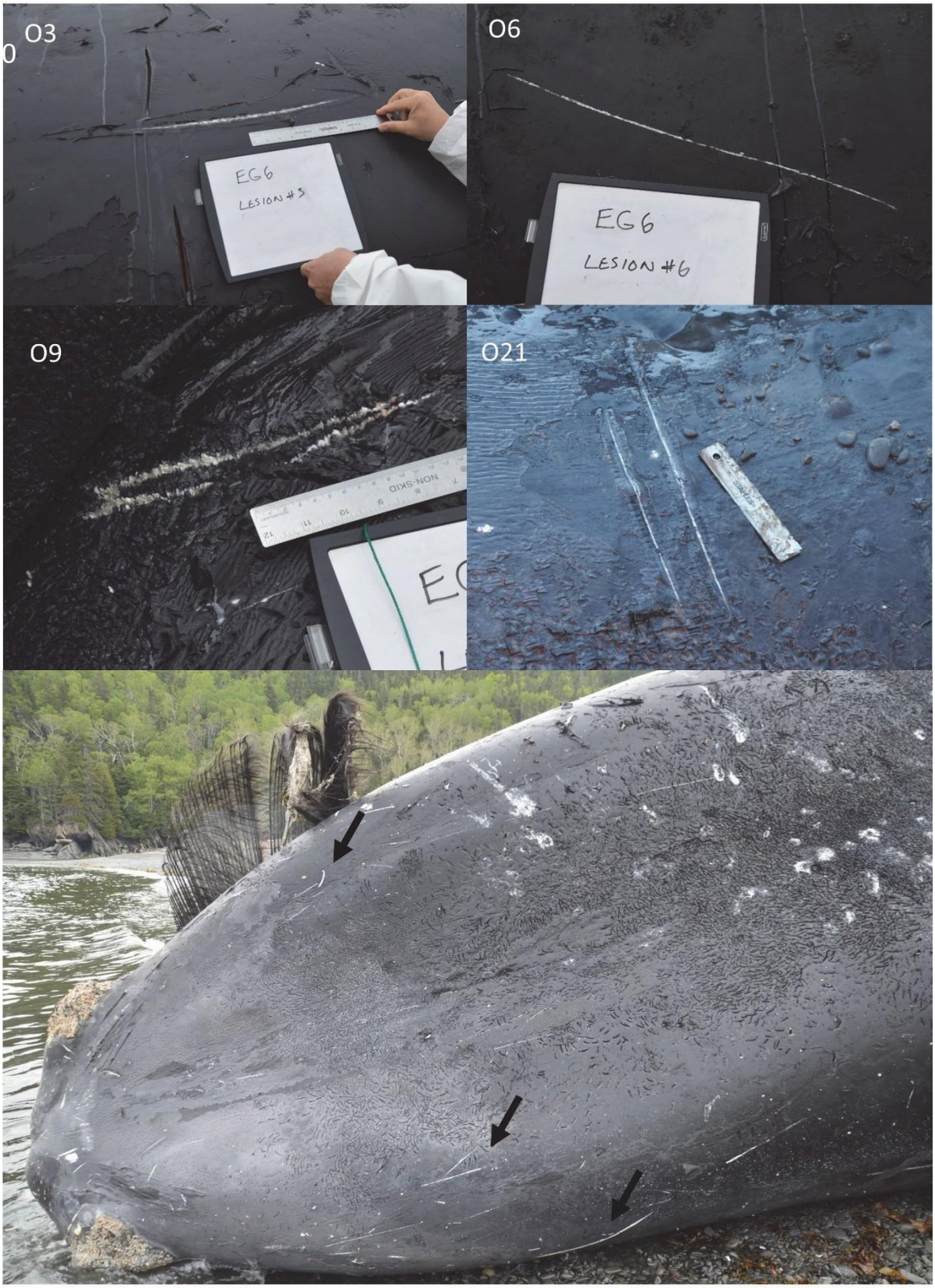
[1] Measures in cm
[2] Rostrum to cranial border of the genital slit
[3] Right side amputated

Appendix II – Observations

Observation 1: Linear swelling, 120 cm long by > 8 cm wide, on the ventral aspect of the carcass, caudally to the anus, oblique to the longitudinal axis of the whale; some irregular white areas are visible along this lesion.

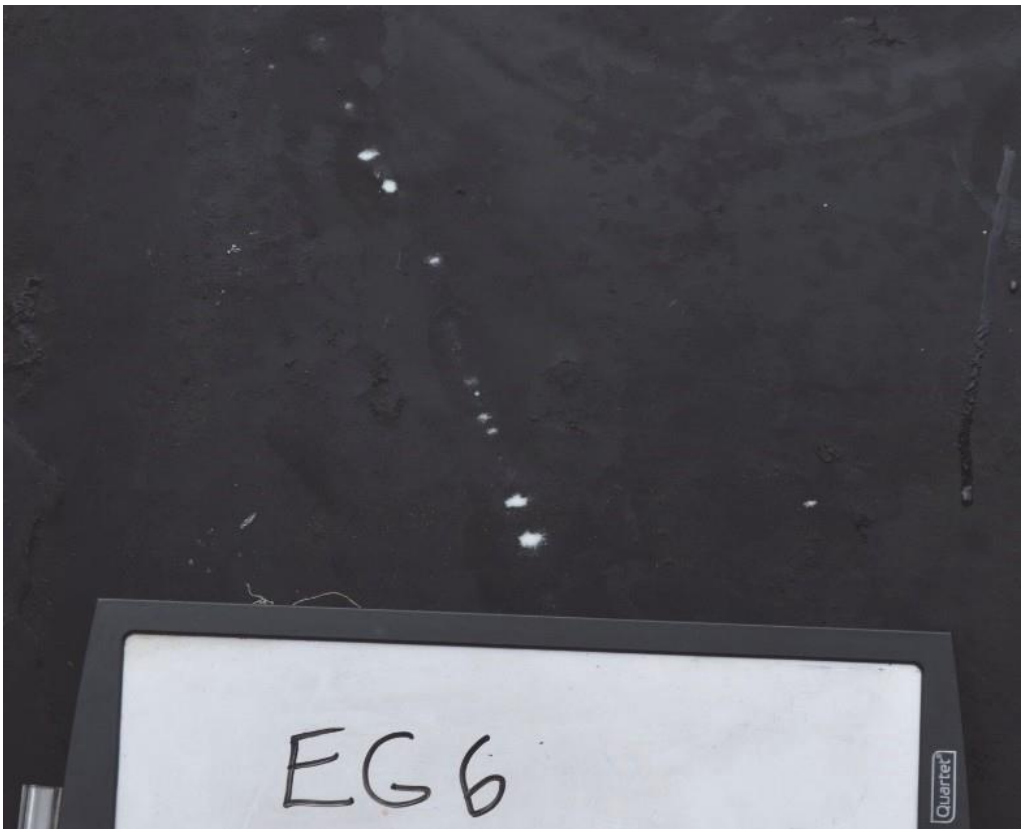
Observation 2: The right distal two thirds of the fluke is amputated (old lesion previously documented in this animal).

Observations 3, 6, 9, 10 and 21. Linear epidermal depigmentations are noted. Considered to be scars/superficial abrasions.



Observation 4: Two white, ovoid, contiguous depressions, on the cranial edge of the left side of the tail, 3 cm in length.

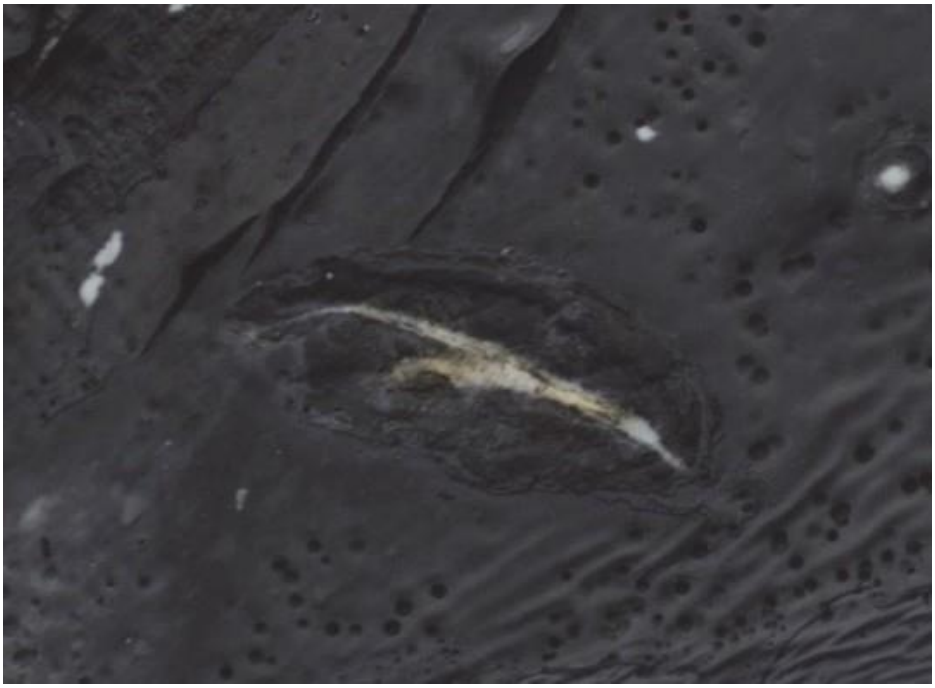
Observation 5: *Morse code* depigmentation on the mid-third of the left side, 15 cm in length.



Observation 7: Depigmented nummular lesion, slightly raised, in the cranial aspect of the left side, 3 cm in diameter.

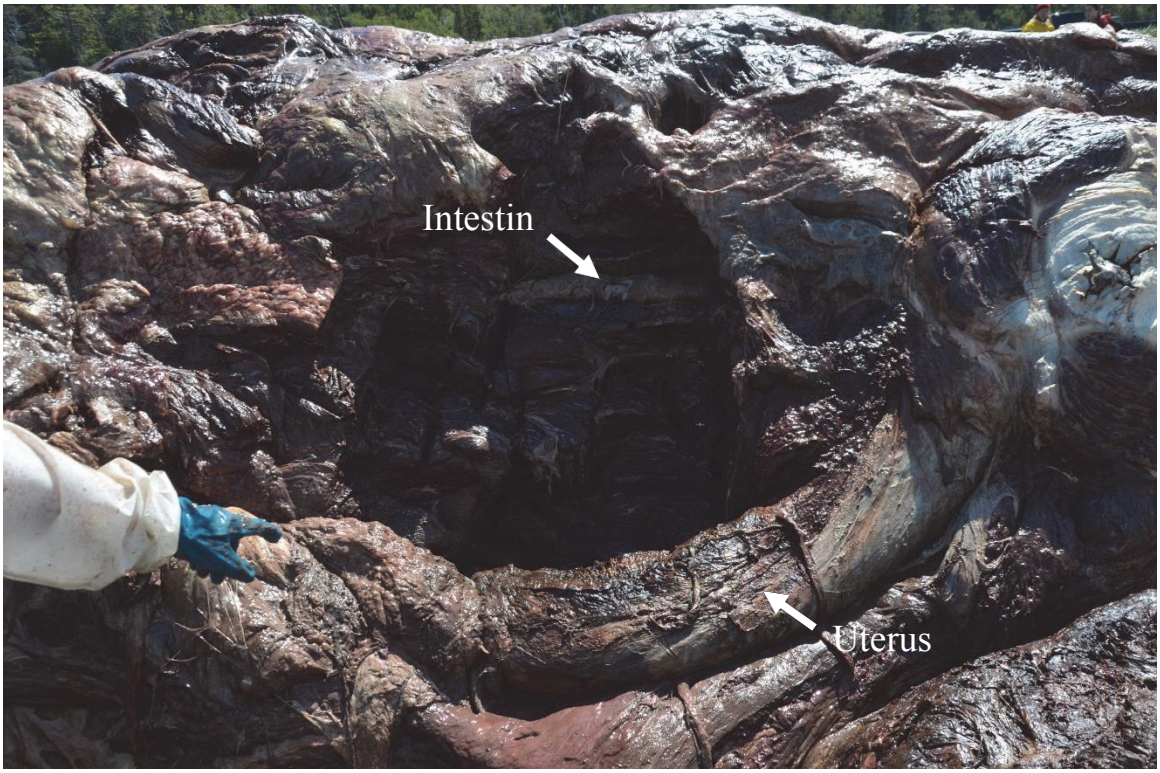
Observation 8: Depigmented depression, on the ventral edge of the right mandible, running up to the baleen, 25 cm in length (white arrows). Right picture: higher magnification of the observation.

Observation 11: A 8.5 X 3.5 cm firm depression on the ventral aspect of the carcass, and centred on a forked white line slightly curved; considered to be a scar.

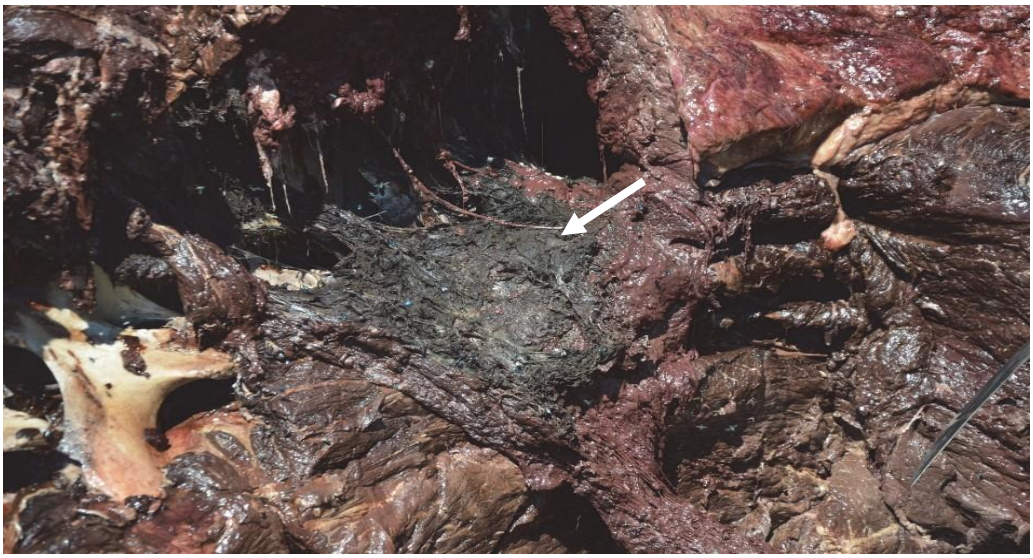


Observations 12 and 13: Two areas of subcutaneous hemorrhages (13 X 30 cm and 4 X 30 cm) are observed in the left side (left picture) and on the right side of the peduncle (right picture) respectively.

Observation 14: Herniation of the genital tract thought the abdominal wall (which was sectioned). Believed to be post mortem.



Observation 15: Dark coloration on the internal face of the epaxial muscles (arrow) at the thoraco-lumbar junction region.



Observation 16: Caudally of the observation 15. The left epaxial muscles have a dark red colour and are liquefied over an area of 80 X 30 cm.

Observations O17 and O20: A large quantity of dark putty-like materiel (probably coagulated blood) is observed in the dorsal region of the thoracic cavity. This material contains some tangled fibres interpreted as fragmented *mirabile rete*.

Observation O18: The oral mucosa of the right mandible presents several breaks, with irregular shape and well-defined edges. Believe to be post mortem mucosal sloughing.

WILDLIFE DIAGNOSTIC REPORT

CENTRE RÉGIONAL DU QUÉBEC
Faculté de médecine vétérinaire
Université de Montréal
3200, rue Sicotte, Saint-Hyacinthe, QC, J2S 2M2
Téléphone: 450-773-8521 Poste 8346
Télécopieur: 450-778-8116
Courriel: quebec@cwhc-rcsf.ca

Date ReportGenerated: 2020-02-04 **Necropsy number: P3944-19**

Event Information

Event Code:	CWHC.206068	**Location:**	Off shore Gaspesia Québec
Cross Ref #:	EG-2019-07		
Species:	North Atlantic Right Whale (*Eubalaena glacialis*)	**Latitude:**	48.69
Age:	Adult	**Longitude:**	-62.61
Sex:	Male		
Weight:			
Date Received:	2019-07-21		

Finder/Submitter Information

Submitter:
Stephanie Ratelle
Species at Risk / Marine Mammals, DFO-MPO Gulf Region, Science
Science, 343 University Avenue
Moncton, New Brunswick, E1C 9B6
Phone: (506) 851-4335
Email Address: Stephanie.ratelle@dfo-mpo.gc.ca

Information Provided For Event

Identification:

Species: North Atlantic Right Whale (*Eubalaena glacialis*)
Identification: Catalogue #3421
Mortality event identification: EG2019-07
Sex: Male
Length: 13.30 m
Age: 15 years old

History:

This right whale was last seen alive on June 10, 2019 in the Gulf of St. Lawrence by a NOAA aerial surveillance team. The whale was found dead floating off the Gaspé Peninsula on July 18, 2019 (48°09.841N and 62°45.072W). The carcass was towed by fishery officers on July 20, 2019 to the *Grand étang* rest area (Gaspesia) where the post-mortem examination was performed.

Diagnosis and Interpretation

Final Diagnosis

Cause of death:

1. No cause of death identified

Other diagnoses:

2. Focally extensive vertebral (L12 and L13) osteophytosis (incidental)

Interpretation

The cause of death of this whale remains undetermined. The carcass was in a very poor preservation state; with the exception of the testis, the internal viscera could not be recognized. This animal was considered in good body condition for the season, based on its blubber thickness (Miller et al, 2011). This good nutritional status is suggestive of a relatively acute (sudden) death (as opposed to a chronic condition that could have affected the foraging capacity of the whale and would therefore be associated with loss of body condition).

This individual was observed alive in the Gulf without any specific anomaly a month and a half prior to the finding of the carcass. No evidence of recent entanglement present. Even if the *putty-like* material observed in the epaxial muscles could be interpreted as muscular hemorrhages, the level of uncertainty is too high to conclude that this change was assuredly *ante-mortem*. Even if this presentation had been associated with actual *ante-mortem* hemorrhages, these hemorrhages would have been to localize to account for the death of this animal. In addition, no other sign of recent trauma was detected. Nevertheless, any evidence of internal hemorrhages may have been washed away with the sea, with the rest of the internal organs due to the internal pressure induced by decomposition.

This whale had abnormal bone growths, called osteophytes or exostoses, on two lumbar vertebrae. Vertebral anomalies of different natures have been reported in the literature in several cetacean species, both in captivity and in the wild: (1) ankylosing spondylosis or discarthrosis (geriatric process), (2) spondylo-osteomyelitis or infectious spondylitis, and (3) spondyloarthritis (inflammation of the joint, from various causes including genetic or infectious) (Kompanje 1999; Félix 2007). In this case, the relatively young age of the whale and the fact that the lesions are focal suggest either a localized infectious process (spondylo-osteomyelitis) (Sweeney et al. 2005) or an old trauma (Craig et al., 2016). When extensive, vertebral anomalies can be implicated in the stranding and death of cetaceans (Sweeney et al. 2005; Félix et al. 2007). Although this lesion was associated with a complete fusion of two lumbar vertebrae, the good body condition of the whale indicates that this lesion did not affect its foraging capacity and should be therefore seen as an incidental finding unrelated to the death of the animal.

In conclusion, the advanced state of decomposition of this carcass and the absence of internal organs markedly hampered the interpretation of the observations made during the post-mortem examination. Even if the good body condition is somewhat suggestive of an acute event such as a boat strike, this suspicion could not be confirmed with a high level of certainty. It should be noted that since fecal material was not available, levels of fecal glucocorticoid could not be determined.

References:

Craig, L. E., Dittmer, K. E., & Thompson, K. G. (2016). Chapter 2. Bones and joints. In: Jubb, Kennedy & Palmer's pathology of domestic animals: vol. 1. 6th ed. (Ed. G Maxie) pp. 16–163.

Félix, F., Haase, B., & Aguirre, W. E. (2007). Spondylitis in a humpback whale (*Megaptera novaeangliae*) from the southeast Pacific. Diseases of aquatic organisms, 75(3), 259-264.

Kompanje, E. J. O. (1999). Considerations on the comparative pathology of the vertebrae in Mysticeti and Odontoceti; evidence for the occurrence of discarthrosis, zygarthrosis, infectious spondylitis and spondyloarthritis. Zoologische Mededeelingen, 73, 99-130.

Miller, Carolyn A., et al. (2011). Blubber thickness in right whales *Eubalaena glacialis* and *Eubalaena australis* related with reproduction, life history status and prey abundance. Marine Ecology Progress Series 438: 267-283.

Sweeny, M. M., Price, J. M., Jones, G. S., French, T. W., Early, G. A., & Moore, M. J. (2005). Spondylitic changes in long-finned pilot whales (*Globicephala melas*) stranded on Cape Cod, Massachusetts, USA, between 1982 and 2000. Journal of Wildlife Diseases, 41(4), 717-727.

Laboratory Results

Necropsy was performed at *Grand Étang,* Gaspesia, on July 21, 2019.
Carcass conservation code: 4.

MACROSCOPIC EXAMINATION

This carcass is in poor preservation state. Externally, the carcass is intact and not collapsed. However, very little epidermis remains on the carcass and, apart from the testis, no internal organs could be recognized. The tongue is absent. The viscera were probably expelled orally due to the increase in internal pressure occurring during decomposition.

Complete morphological measurements may be found in **Appendix I**. Photographs and general distribution of the different observations (O) noted thorough this description are found in **Appendix II**.

Morphological measurements

Blubber thicknesses were measured at seven locations from mid-dorsal to mid-ventral and at eight levels from cranial to caudal. Blubber thickness was considered adequate, with 14 cm on the mid-length of the body (2/3 axilla-umbilicus) on the dorsal line, which is in the average of the values measured in this species in summer (12.2 cm ± 2.16 cm) by Miller et al. (2011).

External examination

Very little epidermis remains on the carcass. The surface of the exposed dermis is creamy to pink in colour. Rare linear areas of epidermal depigmentation (white) are noted on the remaining epidermis, with no associated change in underlying dermis.

- Multiple linear depigmentations, 10 to 30 cm in length, on the ventral aspect of the head (O10).
- An 87 cm long linear lesions between the two flippers (O1).
- A 16 cm long X ≥ 2 cm wide linear lesions on the ventral surface of the right flipper (O2).
- Multiple discrete superficial linear lesions (scratches) from few centimeters to a meter long (O3)
- A 30 cm long X 2 cm wide curvilinear lesion in the middle of the ventral surface of the fluke (O4).

A 20 cm wide irregular ulcer-like lesion with well-defined margins is observed on the oral mucosa, on each side of the tongue (O7).

Musculoskeletal system

The left thoracic epaxial muscle appear partially liquefied and partially replaced by a dark red putty-like material over approximately 1.25 m (O5). The bodies of the 12th and 13th lumbar vertebrae are completely joined by well formed osseous bridges creating a complete ankylose of the intervertebral articulation. These two vertebrae were boiled in water to remove muscular and connective tissue in order to facilitate the description of the osseous structures. These bony structures are composed of a complex network of highly disorganized rudimentary osseous spicules (exostoses) covering almost completely the left side and the ventral aspect of both vertebral bodies (O6). These osseous spicules, are friable, are entangled with connective tissue and create a complete fusion of the two adjacent vertebrae. Minimal exostoses are also present on the surface of the right side of the vertebral bodies. These proliferative osseous lesions do not seem to invade the vertebral bodies (the periosteum seem to be intact). The diameter of the intravertebral canal and the width of the intervertebral space do not seem to be affected by these changes.

Abdominal and thoracic cavities

The only viscera that can be identified are the testes, which are found in the thoracic cavity (O6). None of the other abdominal or thoracic organs could be located.

HISTOLOGY

Observation 6 (organs in the thoracic cavity) (D, E): These organs contain poorly preserved tubular structures organized in an architecture suggestive of seminiferous tubules. These organs are therefore believed to be the testes. Due to the very poor preservation state, it is not possible to evaluate the presence (or absence) of spermatogenesis.

Observation 9 (oral mucosa) (F): There is a loss of the mucosa with well-defined margins. No inflammatory or proliferative change present (post-mortem artefact).

Exostoses (G): These exostoses are formed by a network of irregularly shaped trabeculae of compact osseous tissue forming numerous cavities. These cavities are filled with an acidophilic material in which putrefied muscle fibers are occasionally seen. No evidence of active inflammation or pathogen in the sections examined.

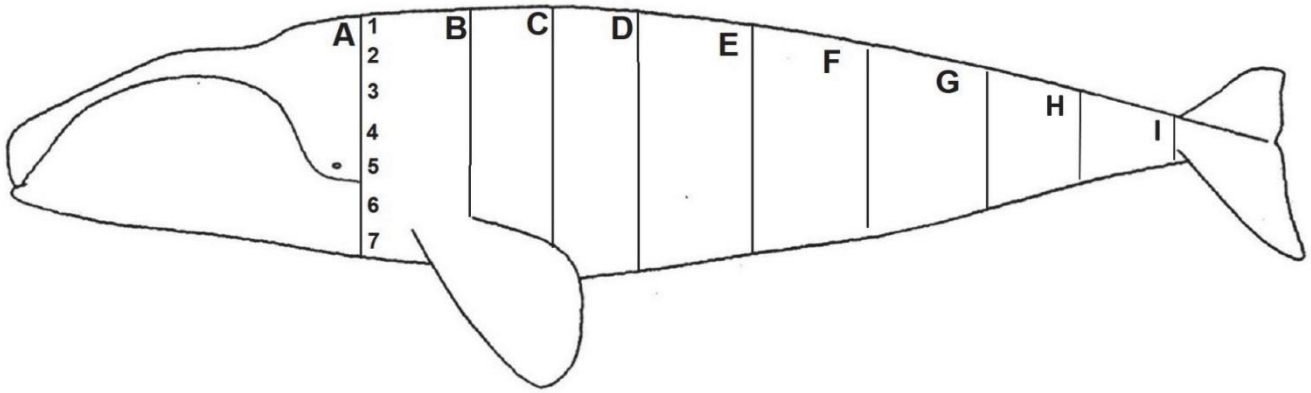
No histological change detected in the following samples: skin (A), blubber (B), muscle (B), muscle – observation 5 (C). The post-mortem artefacts are marked.

Pathologists Marion Jalenques, DMV, Residente
Stéphane Lair DMV, Diplomate ACZM

Appendix I – Morphological measurements

Blubber thickness – EG2019-07

Field#: CQSAS EG2019-07 **Side examined**: left
Observer: Isabeau Pratte **Date**: 21 July 2019



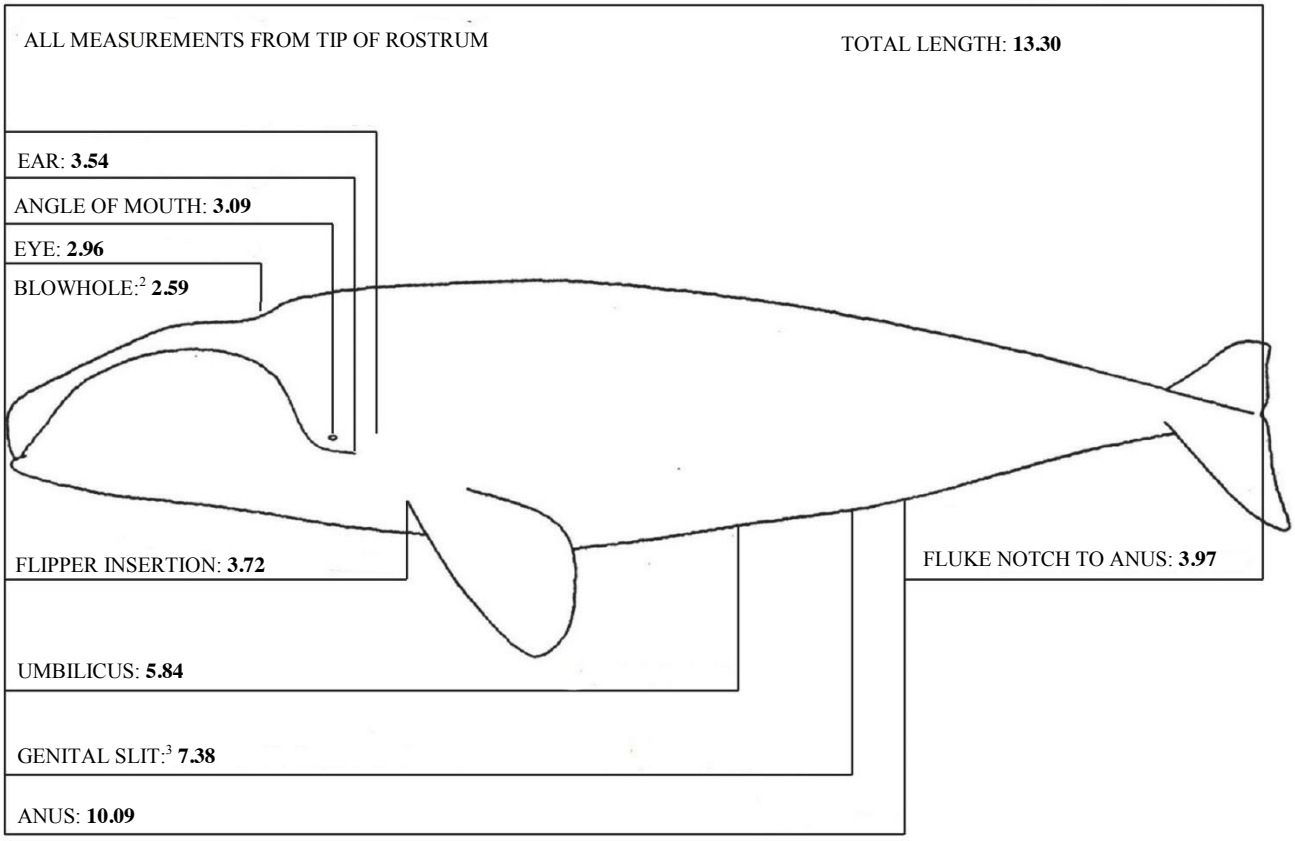
Dorsal	Nuchal crest	Axilla	1/3 Axilla-Umbilicus	2/3 Axilla-Umbilicus	Umbilicus	1/2 Umbilicus-Anus	Anus	1/2 Anus-Tail insertion	Tail insertion
1	11	14.5	13.5	14	13.4	16	14	20.2	ND
2	13.2	12	13	14.5	15.5	16.5	14	19	ND
3	20.5	14.5	15	16.5	19	20.5	15	15	ND
4	16.8	22	20.5	22	21	18	19	8	ND
5	19.5	15	25	25	22	28.4	28.4	6.5	ND
6	20	18	23	20.1	19	24.3	24.9	5.8	ND
7	22.6	18.3	19.5	18.5	24	20.9	28.2	6.5	ND
Ventral									
Mean	17.7	16.3	18.5	18.7	19.1	20.7	20.5	11.6	ND

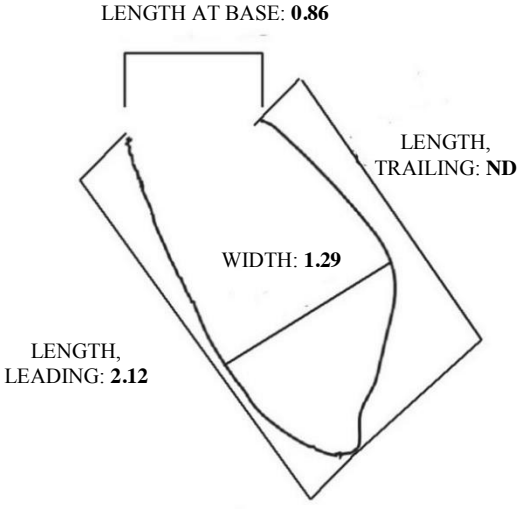
Circumference with blubber

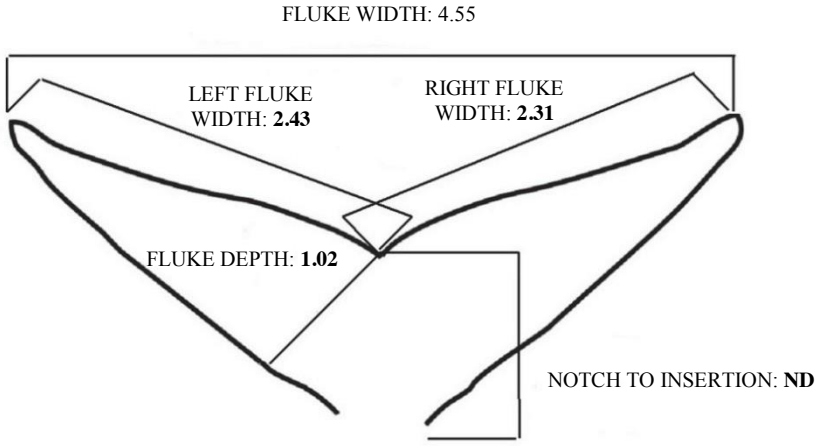
	412	487	479	452	469	470	300	146	ND

Notes:
- all measures are in cm
- no skin between B and G
* Not measured because of rope.

External morphometrics[1] – EG2019-07





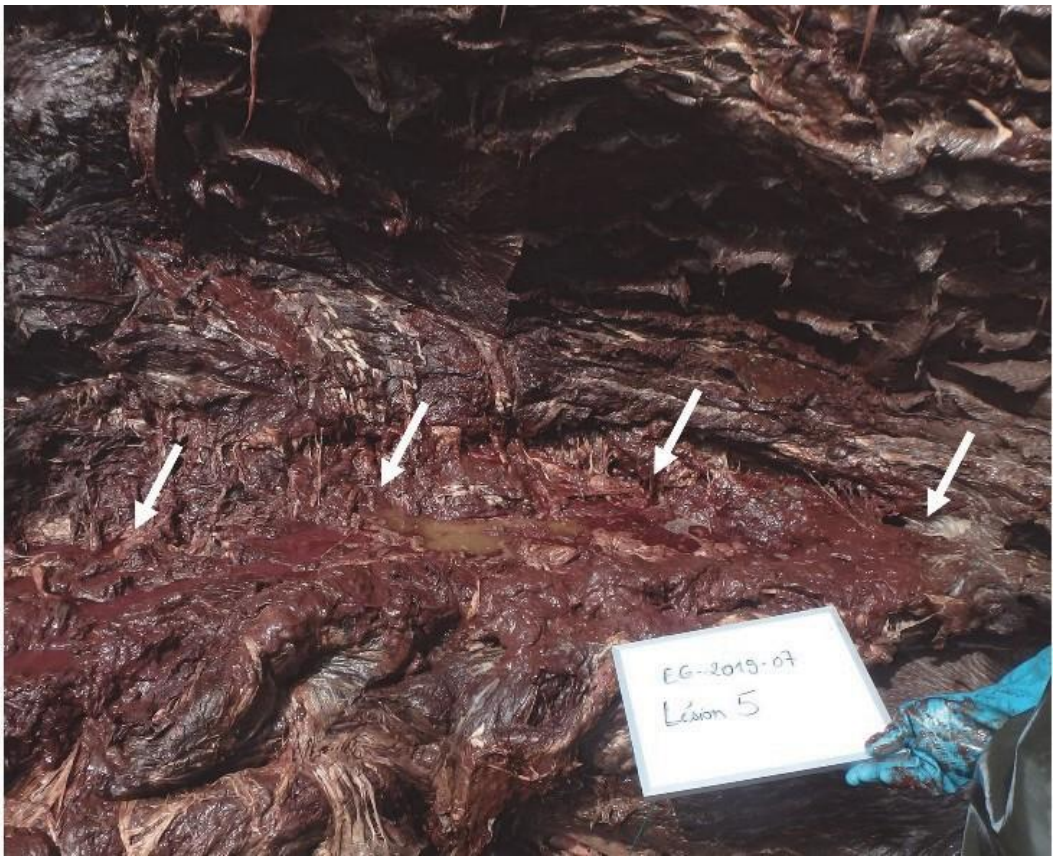


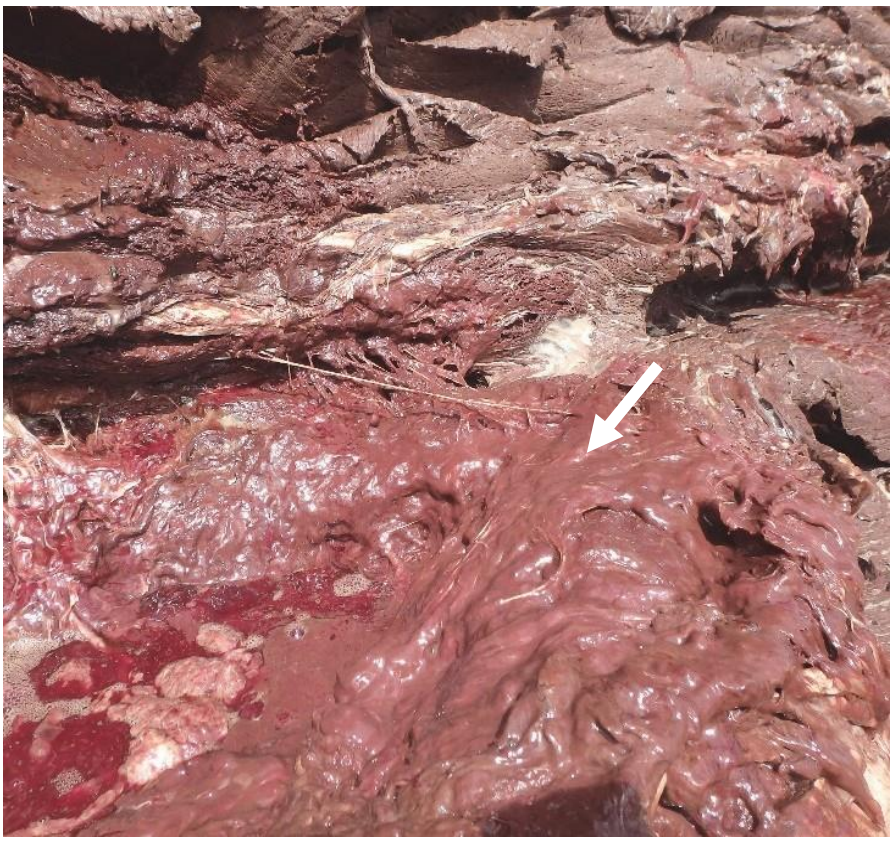
[1] Measures in cm.
[2] Rostrum to rostral border of the blowhole.
[3] Rostrum to cranial border of the genital slit.

Appendix II – Observations

Observations 1, 2, 3 (not shown) and 4. Rare linear epidermal depigmentation (white) are observed on the sections of the epidermis still attached to the dermis. No change observed in the underlying dermis. Interpreted as superficial scars.

Observation 5. Top picture: The left thoracic epaxial muscle appear partially liquefied and partially replaced by a dark red putty-like material (arrows) over approximately 1.25 m. Bottom picture: Close up of this material (arrow).





Observation 6. Prepared 12th and 13th lumbar vertebrae completely joined by well-formed osseous bridges composed of a complex network of highly disorganized rudimentary osseous spicules (exostoses). These osseous proliferations are associated with a complete fusion of the adjacent vertebra.

Observation 7. Irregular ulcer-like lesions with well-defined margins are observed on the oral mucosa, on each side of the tongue. This change is believed to be a post-mortem artefact.

Annex D: Comparison of right whale carcasses EG2019-08 and EG2019-09

Prepared by: Tonya Wimmer, Marine Animal Response Society

Collaborators: Laura Bourque, Pierre-Yves Daoust, Megan Jones, Allison Henry, Laurie Murison, Michael Moore, Moira Brown, Bill McLellan, Marianna Hagbloom and Amy Knowlton

Marine animal incident reporting protocols: The basics

There are several basic principles related to how response networks confirm species identification and whether individuals are the same that are relevant to the examination of right whale carcasses EG2019-08 and EG2019-09.

Identifying species

Various characteristics are used to distinguish different species: size, colour patterns, presence and length of ventral grooves, number of blowholes, length and colour of baleen as well as body, head and flipper shape. Unless the observer is considered an expert or there are images provided with the initial report, the species is not considered confirmed until additional information such as images, video or genetic samples are collected (and analyzed in the case of genetic samples).

Precautionary Approach: If the species cannot be confirmed, the animal is recorded as unidentified.

Distinguishing individuals

Occasionally, incidents involving the same species occur in proximity to one another, on beaches and at sea. Variables such as decomposition can affect the quality of the carcass and ability to see individual characteristics or features. The quality of visual materials collected during observations of carcasses as well as whether all relevant parts of the animal were captured can also affect the ability to see individual characteristics or features.

To accurately track incidents, it is important to determine if the animals are the same or different. In order to do this, animals are examined for individually identifying marks such as colour patterns, callosities or other identifying patterns, scars, wounds or markers. Individuals have also been matched utilizing the pattern of ventral grooves or decomposition. If not being towed or buried immediately (or not at all in the case of many non-right whales species observed floating), carcasses can also be tagged or marked in a way to provide a unique tracker or mechanism to track. In many cases, other experts are consulted in order to gain consensus. In general, one needs visual and/or genetic confirmation or reasonable lack of doubt by response experts as to the identity of individual animals in question to conclude two animals are the same.

Precautionary Approach: If there is insufficient evidence or there is doubt as to whether two animals are the same, then a precautionary approach must be followed whereby the individuals in question are considered separate individuals (Sharp *et al. 2019;* Lair *et al.* 2016*)*

Right whale carcasses EG2019-08 and EG2019-09

On June 24th, the carcass of a dead, large whale was reported floating 8.7 nm north of Glace Bay, Nova Scotia by a fisherman (MARS2019-202, EG2019-08; Figure 1).

Carcass EG2019-08 was relatively fresh (Level 1, see annex I for External Decomposition Level definitions) state of decomposition, however, no images were available from the individual reporting the animal though they suggested it could be a male right whale. Unfortunately, due to other ongoing incidents involving EG2019-02, 03 and 04 at that time, human resources were being utilized and not available to follow up with the fisherman. A request was made of DFO at that time to have a plane try to relocate the

whale in order to confirm the species. Due to limited resources, follow-up with DFO wasn't possible until mid-July. Responders were informed that a plane hadn't been deployed to locate the whale, though a C&P team tried to relocate the carcass by vessel but was unsuccessful.

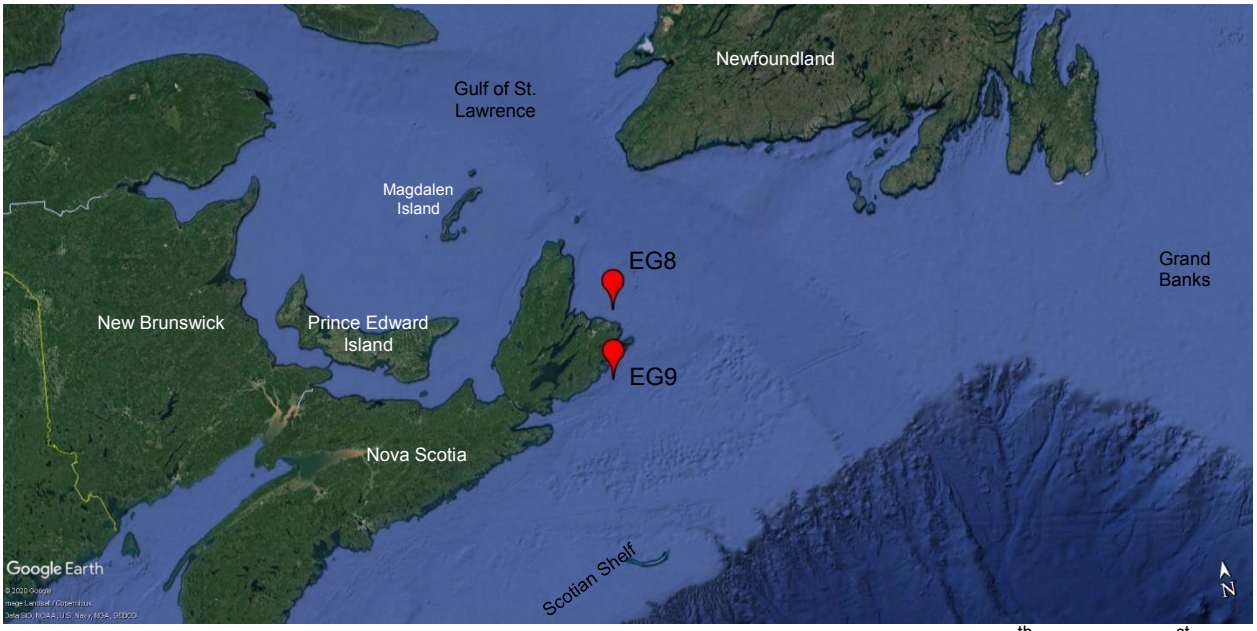


Figure 1. Initial reported locations of right whales EG2019-08 and EG2019-09, June 24th and July 21st 2019, respectively, off Cape Breton Island, Nova Scotia.

In mid-July, responders were informed that C&P had been unable to relocate the carcass. MARS then followed up with the reporting fisherman, who on June 24th had said there were no visual materials, but upon discussions in July, confirmed he did have visual materials and provided several images and a video.

While the images were not high quality and the carcass appeared to be twisted (MARS and expert colleagues that were consulted (L. Murison/Grand Manan Whale and Seabird Research Station, A. Henry/NOAA-NEFSC and M. Zani/New England Aquarium) were able to determine that the carcass from June 24th was a North Atlantic right whale. Unfortunately, given the time that had passed, the carcass had been lost, and no further reports of this individual were received.

Figure 2. Image of right whale reported on June 24th, 2019 (EG2019-08). Right whale mandibular callosities are indicated by the red circle.

On July 21st, a dead, floating female right whale (EG2019-09) was reported by a Transport Canada National Aerial Surveillance survey off eastern Cape Breton Island (MARS2019-232; Figure 1; Figure 3a). This individual was in an advanced state of decomposition (Level 4). The carcass was subsequently observed on July 22nd by another Transport Canada survey (Figure 3b). DFO/Canadian Coast Guard relocated the animal via vessel the same day and attempted to collect a genetic sample. However, despite their best efforts, experts were not consulted prior nor during deployment and the DFO team was not trained to obtain appropriate genetic bone samples. Consequently, only blubber was collected which is not suitable sample for genetic analysis. The last sighting of this individual was on July 25th by a local fisherman off Canso, Nova Scotia (Figure 3c).

<u>One or two carcasses?</u>

Questions arose as to whether whale EG2019-09, reported July 21 2019, could be the same animal as EG2019-08, which was reported on June 24th.

Genetic information was not available for either animal. Based on the available visual materials (which was limited for each whale, particularly EG2019-08) and despite extensive efforts by the New England Aquarium staff, neither EG2019-08 nor EG2019-09 could be photographically matched to known individuals in the right whale catalogue.

A drift analysis of EG2019-08 was completed by DFO as well as a hindcast of EG2019-09. These predictive analyses were done assuming the tracked object was a particle, rather than the standard method utilized for conducting drift and hindcasts of floating whale carcasses which model a 40' partially submerged shipping container (M. Moore, Pers. Comm.).

The drift analysis of EG2019-08 indicated that while the "particle carcass" would have drifted along the eastern coast of Cape Breton Island towards the reported position of EG2019-09 (Figure 4), it would have encountered Scatarie Island around June 26th (Figure 4b) and then moved along the eastern coast from the 26th – early July towards Chedabucto Bay (Figure 4 c-d). By July 21st, when EG9 was first sighted near the shores of eastern Cape Breton, Figure 1), whale EG2019-08 was predicted to have drifted far offshore (Figure 4e), if it hadn't remained ashore earlier that month as indicated by Figure c-d.

A hindcast analysis of whale EG2019-09 indicated that the "particle carcass", originating on July 21 off Gabarus, NS (Figure 5a), would have been very near Scatarie Island on July 19, 2019 (Figure 5b) and then along northern Cape Breton between Glace Bay to Ingonish around July 11th (Figure 5c). *This is well after the initial sighting of EG2019-08 on June 24, 2019.*

An expert team from New England Aquarium (A. Knowlton, M. Hagbloom, P. Hamilton), Woods Hole Oceanographic Institute (M. Moore), University of North Carolina Wilmington (W. McLellan) and the Canadian Whale Institute (M. Brown), in consultation with the report authors, examined all available information and concluded that they are ***not able to conclusively determine that these two whales are the same individual***.

Thus, *following a precautionary approach utilized by global response and research communities*, these two animals should be considered <u>separate</u> individuals.

a)

b)

c)

Figure 3. Image of right whale (EG2019-09) reported on a) July 21st, 2019 by Transport Canada, b) July 22nd by DFO C&P and c) July 25th by a local fisherman.

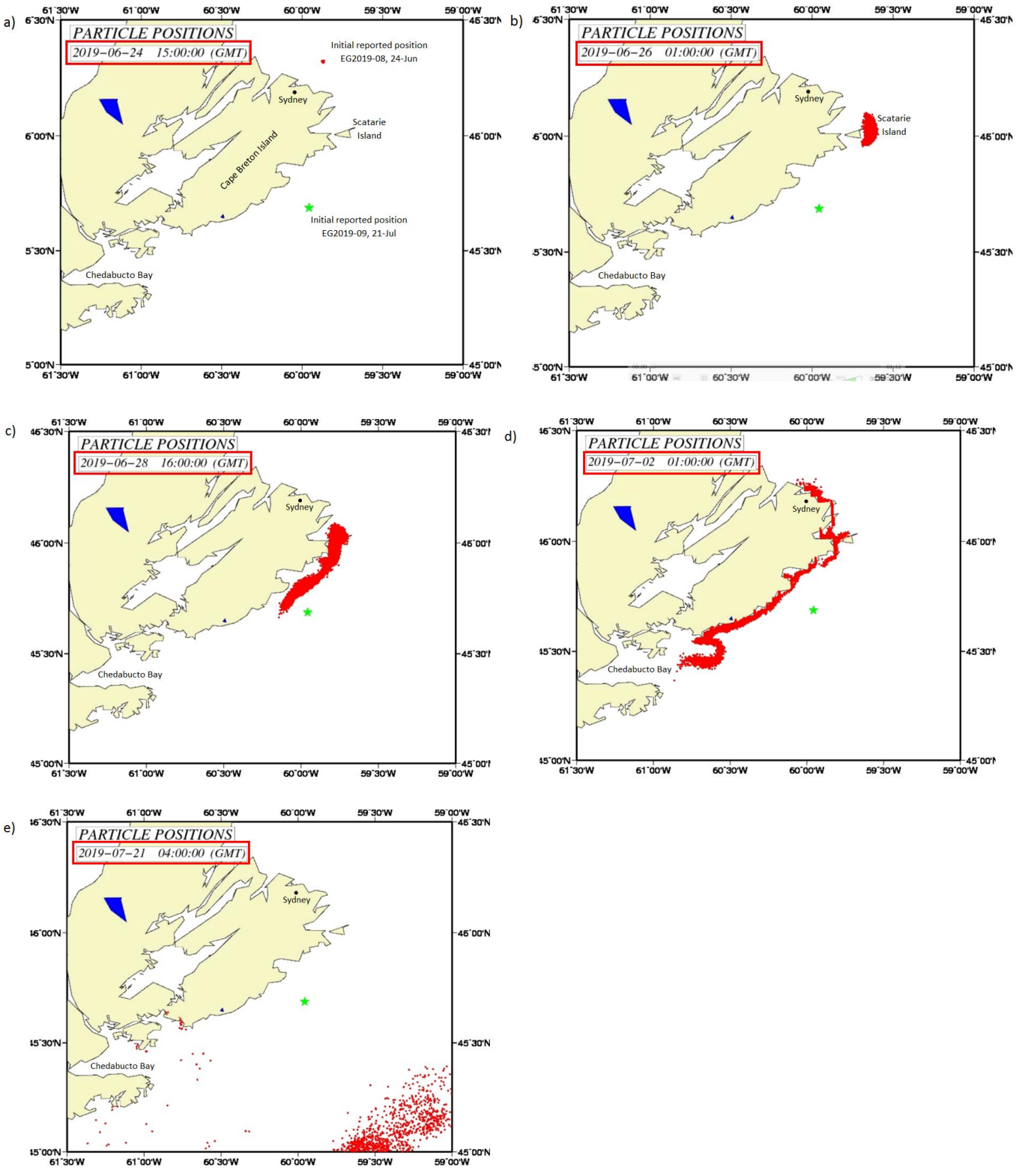


Figure 4. Predicted position of whale EG2019-08 (red dots) when a) first observed on 24 June 2019, b) 2 days later near Scatarie Island, c) and d) along eastern Cape Breton 4- and 6-days later, respectively, and e) on 21 July 2019 when whale EG2019-09 was discovered at the position indicated by the green star. Images are screen grabs from drift analysis conducted by DFO, utilized with permission from DFO-Maritimes.

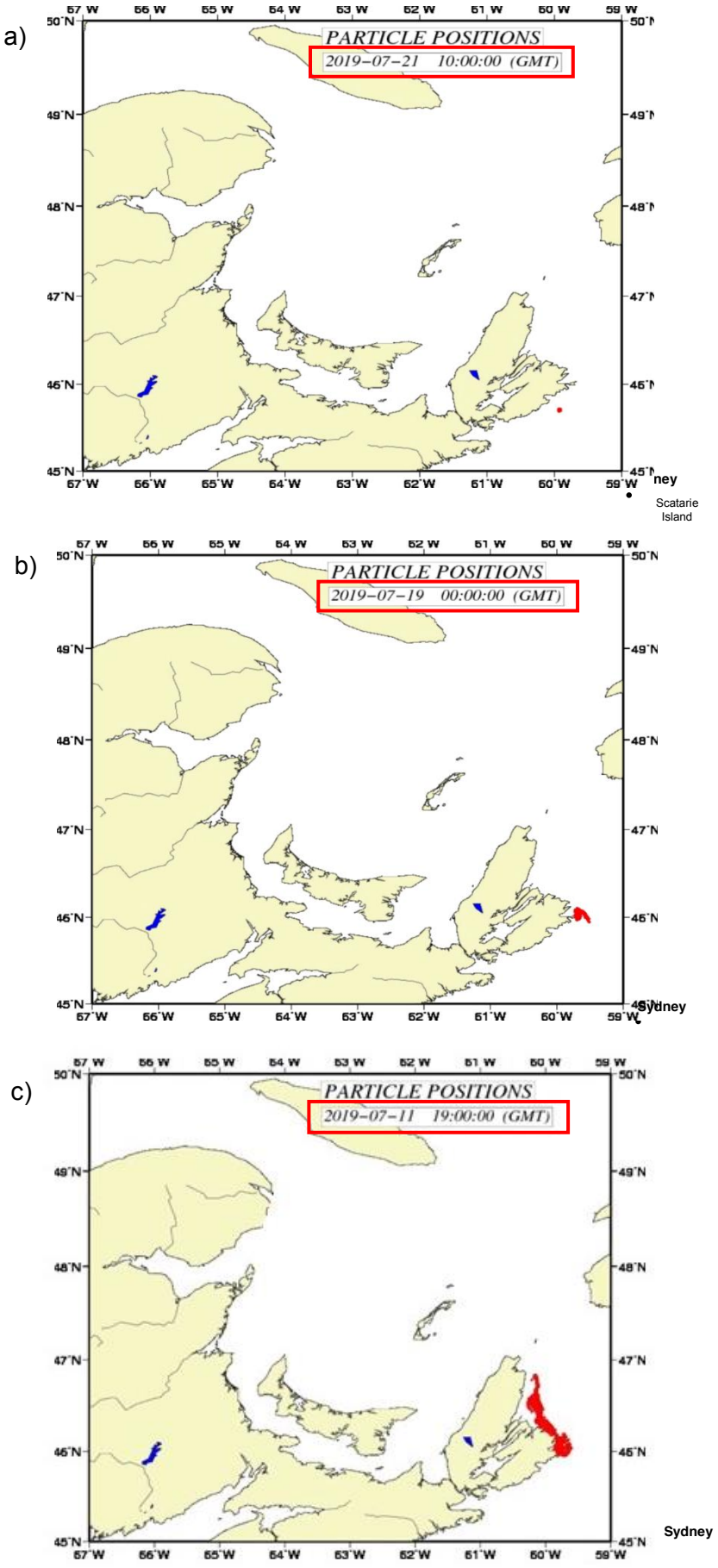


Figure 5. Predicted hindcast positions of whale EG2019-09 (red dots) when (a) first observed on 21 July 2019, (b) 2 days prior near Scatarie Island on 19 July and (c) along northern Cape Breton 8 days prior on 11 July 2019. Images are screen grabs from hindcast analysis conducted by DFO, utilized with permission from DFO-Maritimes.

Annex E: DNA Profiling and Identification of 2020 Dead North Atlantic Right Whales

Authors: Dr. Brenna A. Frasier and Dr. Timothy R. Frasier

DNA profiling conducted by: Dr. Brenna Frasier and Sonya Radvan at Saint Mary's University, Halifax, Nova Scotia

February 14, 2020

As part of ongoing genetic assessment of the North Atlantic right whale, biopsy and tissue samples collected from both live and dead individuals are genetically profiled on an annual basis. This analysis has been ongoing since the late 1980's and has resulted in an extensive North Atlantic right whale tissue and DNA data bank containing profiles of about 80% of the individuals remaining of the species. This has been a collaborative effort on behalf of Saint Mary's University, New England Aquarium (NEAq), Trent University, Woods Hole Oceanographic Institution (WHOI), National Marine Fisheries Service (NMFS), several US State Agencies, the Canadian Department of Fisheries and Oceans (DFO) and a variety of other NGOs.

Obtaining genetic profiles from dead individuals is particularly important as it allows us to confirm identity for those that are identified in the field using the photo-identification catalog (http://rwcatalog.neaq.org/Terms.aspx), or to determine identity for those that are too decomposed for visual identification. As part of this work, a genetic profile is considered to include an individual's sex, mitochondrial DNA control region haplotype, and genotype at 28 microsatellite loci. While the mitochondrial haplotype provides information on which of 6 matrilines an individual belongs, the microsatellite genotype provides individual-level resolution for identification, as well as information on parentage.

Because DNA from dead whales is both degraded (thus low quality) and of low quantity, complete genotypes are rarely possible and instead we profile (or attempt to profile) samples at a smaller number of loci (usually 5 – 9 loci) that work well in the laboratory and are highly variable.

In late 2019 our laboratory received five samples of bone tissue from five dead whales found in the summer of 2020 (EG#1, 2, 3, 6, and 7) (Table 1). The DNA obtained from these samples was in excellent condition and so we were able to obtain almost complete profiles from these specimens. We are currently re-profiling four of the loci from which we do not have data. These five animals were previously identified by the New England Aquarium (EG#1 = NEA4023, EG#2 = NEA1281, EG#3 = NEA1514, EG#6 = NEA3450, EG#7 = NEA3421) and our genetic profiles are consistent with these identifications, with no mismatching sexes, haplotypes, or microsatellite loci.

In early 2020, we received samples from EG#5. Since this sample has just been received, it has not yet been processed, but results are forthcoming.

Table 1: DNA results for the genetic profiling of five 2020 dead whales (EG#1, 2, 3, 6, 7). Shown here is the results for the comparison of the dead whale profiles to the profiles previously collected from these individuals when they were alive.

	Field ID	NEA	Lab ID(s)	Sex	mtDNA	Microsatellite Data
Dead EG #1						
Previous profile from individual		4023	179171	M	H	
Dead whale profile	MARS 2019-130		221596	M	H	Profiles match at 13/13 comparable loci
Conclusion: These data are consistent with the in-field identification of the individual NEA4023 "Wolverine"						
Dead EG #2						
Previous profile from individual		1281	20, 265, 816	F	A	
Dead whale profile	MARS 2019-146		221594	F	A	Profiles match at 20/20 comparable loci
Conclusion: These data are consistent with the in-field identification of the individual NEA1281 "Punctuation"						
Dead EG #3						
Previous profile from individual		1514	314, 790	M	C	
Dead whale profile	MARS 2019-161		221595	M	C	Profiles match at 19/19 comparable loci
Conclusion: These data are consistent with the in-field identification of the individual NEA1514 "Comet"						
Dead EG #5						
	MARS 2019-169					
Sample at lab but not yet analysed.						
Dead EG #6						
Previous profile from individual		3450	842	F	D	
Dead whale profile	MARS 2019-170		221593	F	D	Profiles match at 17/17 comparable loci
Conclusion: These data are consistent with the in-field identification of the individual NEA3450 "Clipper"						
Dead EG #7						
Previous profile from individual		3421	637	M	B	
Dead whale profile	MARS 2019-223		221597	M	B	Profiles match at 18/18 comparable loci
Conclusion: These data are consistent with the in-field identification of the individual NEA3421						
Dead EG #4, 8, 9, 10 - No sample to lab						

Annex F

Fecal Biotoxin Analysis Results

EG2019-01, EG2019-02, EG2019-03, EG2019-06

Canadian Food Inspection Agency / Agence canadienne d'inspection des aliments

CANADIAN FOOD INSPECTION AGENCY
REPORT OF ANALYSIS

FISH PRODUCTS SAMPLING SUBMISSION
Version: 7.0.0
Serial: 000007354282

System ID: 2019FFI-0000080010-4 **Receptions by all Labs:** 1
Reference No.: 2019FFIS-0000083868-4 **Number of Jobs Authorized:** 1

Laboratory No.: DAR-FD-2019-CH-06177 **Date Received:** 2019-12-09 **Job Status:** Authorized

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Program: FISH **Function:** DOMESTIC
Sampling Plan: 2019_FS400D - Domestic: Chemistry & Chemical contaminants complaints-including investigations
Product vs. Environmental: Product

Country of Origin: CANADA
Sampled At: DAOUST, PIERRE-YVES DR.
ATLANTIC VETERINARY COLLEGE, UPEI
DEPARTMENT OF PATHOLOGY & MICROBIOLOGY
550 UNIVERSITY AVENUE
CHARLOTTETOWN, PE C1A4P3

Sample Priority: Regular
Number of Units per Sample: 2
Submitter Comments: NORTH ATLANTIC RIGHT WHALE " WOLVERINE" JUNE 7, 2019 X-11483-19 (EG1-19) FECES LB

Date Received: 2019-12-09
Risk Category: Bivalve Molluscan

Lab Sample No.: DAR-FD-2019-CH-06177-0001
Inspection Sample No.:

Primary Process: FREEZING
Sample Type: Feces
Identification Code: EG # 1-19
Species: NORTH ATLANTIC RIGHT WHALE - EUBALAENA GLACIALIS

Sample Assessed: No Decision

Method: TOX-DA-LC / 1 : Determination of Domoic Acid in Shellfish by LC-UV and LC-MS/MS

Domoic Acid	Not detected at the reporting limit.

Test Assessed: No Decision

Method: TOX-DSP-LC / 1 : Determination of Lipophilic Shellfish Toxins in Shellfish by LC-MS/MS

Gymnodimine	Not detected at the reporting limit.
Pectenotoxin 1	Not detected at the reporting limit.
Pectenotoxin 2	Not detected at the reporting limit.
Pectenotoxin 3	Not detected at the reporting limit.
Pectenotoxin 4	Not detected at the reporting limit.
Pectenotoxin 6	Not detected at the reporting limit.
Pectenotoxin 11	Not detected at the reporting limit.
Okadaic Acid	Not detected at the reporting limit.
Dinophysis Toxin 1	Not detected at the reporting limit.
Dinophysis Toxin 2	Not detected at the reporting limit.
Okadaic Acid Esters	Not detected at the reporting limit.
Dinophysis Toxin 1 Esters	Not detected at the reporting limit.
Dinophysis Toxin 2 Esters	Not detected at the reporting limit.
Yessotoxin	Not detected at the reporting limit.
1A-Homo yessotoxin	Not detected at the reporting limit.
45 OH Yessotoxin	Not detected at the reporting limit.
45 hydroxy 1A-homo yessotoxin	Not detected at the reporting limit.
Total Pectenotoxin	Not detected at the reporting limit.
Total Okadaic Group Toxins	Not detected at the reporting limit.
Total Yessotoxin	Not detected at the reporting limit.

Test Assessed: No Decision

Execution Time: 2020-02-04 04:00:31 PM

Canada

System ID:	2019FFI-0000080010-4	***Receptions by all Labs:***	1
Reference No.:	2019FFIS-0000083868-4	***Number of Jobs Authorized:***	1

Method: TOX-PCOX / 1 : Determination of Paralytic Shellfish Toxins in Shellfish by LC-FLD with Post-column Oxidation (PCOX)

Gonyautoxin-4	Not detected at the reporting limit.
Gonyautoxin-1	Not detected at the reporting limit.
Decarbamoylgonyautoxin-3	Not detected at the reporting limit.
Decarbamoylgonyautoxin-2	Not detected at the reporting limit.
Gonyautoxin-5	Not detected at the reporting limit.
Gonyautoxin-3	Not detected at the reporting limit.
Gonyautoxin-2	Not detected at the reporting limit.
Neosaxitoxin	Not detected at the reporting limit.
Decarbamoylsaxitoxin	Not detected at the reporting limit.
Saxitoxin	Not detected at the reporting limit.
N-sulfocarbamoylgonyautoxin-2	Not detected at the reporting limit.
N-sulfocarbamoylgonyautoxin-3	Not detected at the reporting limit.
PSP - Total	Not detected at the reporting limit.

Test Assessed: No Decision

Job Authorized:	2020-02-04	***Authorized By:***	Wade Rourke		***Authorized***
Job Assessed:		No Decision		***Date Assessed:***	2020-02-04

These results relate only to the sample as received and tested by this laboratory.

*** END OF REPORT ***

Canadian Food Inspection Agency / Agence canadienne d'inspection des aliments

CANADIAN FOOD INSPECTION AGENCY
REPORT OF ANALYSIS

FISH PRODUCTS SAMPLING SUBMISSION
Version: 7.0.0
Serial: 000007354313

System ID: 2019FFI-0000080008-4 **Receptions by all Labs:** 1
Reference No.: 2019FFIS-0000083866-4 **Number of Jobs Authorized:** 1

Laboratory No.: DAR-FD-2019-CH-06179 **Date Received:** 2019-12-09 **Job Status:** Authorized

Laboratory: (1981) DARTMOUTH LABORATORY - CHEMISTRY
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Fax: (902) 536-1122
Cell:
Email: ALEXIS.JOHNSON@CANADA.CA

Program: FISH **Function:** DOMESTIC
Sampling Plan: 2019_FS400D - Domestic: Chemistry & Chemical contaminants complaints-including investigations
Product vs. Environmental: Product

Country of Origin: CANADA
Sampled At: DAOUST, PIERRE-YVES DR.
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DEPARTMENT OF PATHOLOGY & MICROBIOLOGY
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CHARLOTTETOWN, PE C1A4P3

Sample Priority: Regular
Number of Units per Sample: 1
Submitter Comments: MARS 2019-146 EG#2 FECAL SAMPLE COLL'D JUNE 25,2019

Date Received: 2019-12-09
Risk Category: Bivalve Molluscan

Lab Sample No.: DAR-FD-2019-CH-06179-0001
Inspection Sample No.:

Primary Process: FREEZING
Sample Type: Feces
Identification Code: EG # 2
Species: NORTH ATLANTIC RIGHT WHALE - EUBALAENA GLACIALIS

Sample Assessed: No Decision

Method: TOX-DA-LC / 1 : Determination of Domoic Acid in Shellfish by LC-UV and LC-MS/MS

Domoic Acid	Not detected at the reporting limit.

Test Assessed: No Decision

Method: TOX-DSP-LC / 1 : Determination of Lipophilic Shellfish Toxins in Shellfish by LC-MS/MS

Gymnodimine	Not detected at the reporting limit.
Pectenotoxin 1	Not detected at the reporting limit.
Pectenotoxin 2	Not detected at the reporting limit.
Pectenotoxin 3	Not detected at the reporting limit.
Pectenotoxin 4	Not detected at the reporting limit.
Pectenotoxin 6	Not detected at the reporting limit.
Pectenotoxin 11	Not detected at the reporting limit.
Okadaic Acid	Not detected at the reporting limit.
Dinophysis Toxin 1	Not detected at the reporting limit.
Dinophysis Toxin 2	Not detected at the reporting limit.
Okadaic Acid Esters	Not detected at the reporting limit.
Dinophysis Toxin 1 Esters	Not detected at the reporting limit.
Dinophysis Toxin 2 Esters	Not detected at the reporting limit.
Yessotoxin	Not detected at the reporting limit.
1A-Homo yessotoxin	Not detected at the reporting limit.
45 OH Yessotoxin	Not detected at the reporting limit.
45 hydroxy 1A-homo yessotoxin	Not detected at the reporting limit.
Total Pectenotoxin	Not detected at the reporting limit.
Total Okadaic Group Toxins	Not detected at the reporting limit.
Total Yessotoxin	Not detected at the reporting limit.

Test Assessed: No Decision

Execution Time: 2020-02-04 04:03:29 PM

Canada

System ID:	2019FFI-0000080008-4	***Receptions by all Labs:***	1
Reference No.:	2019FFIS-0000083866-4	***Number of Jobs Authorized:***	1

Method: TOX-PCOX / 1 : Determination of Paralytic Shellfish Toxins in Shellfish by LC-FLD with Post-column Oxidation (PCOX)

Gonyautoxin-4	Not detected at the reporting limit.
Gonyautoxin-1	Not detected at the reporting limit.
Decarbamoylgonyautoxin-3	Not detected at the reporting limit.
Decarbamoylgonyautoxin-2	Not detected at the reporting limit.
Gonyautoxin-5	Not detected at the reporting limit.
Gonyautoxin-3	Not detected at the reporting limit.
Gonyautoxin-2	Not detected at the reporting limit.
Neosaxitoxin	Not detected at the reporting limit.
Decarbamoylsaxitoxin	Not detected at the reporting limit.
Saxitoxin	Not detected at the reporting limit.
N-sulfocarbamoylgonyautoxin-2	Not detected at the reporting limit.
N-sulfocarbamoylgonyautoxin-3	Not detected at the reporting limit.
PSP - Total	Not detected at the reporting limit.

Test Assessed: No Decision

Job Authorized:	2020-02-04	***Authorized By:***	Wade Rourke		***Authorized***
Job Assessed:		No Decision		***Date Assessed:***	2020-02-04

These results relate only to the sample as received and tested by this laboratory.

***** END OF REPORT *****

Canadian Food Inspection Agency / Agence canadienne d'inspection des aliments

CANADIAN FOOD INSPECTION AGENCY
REPORT OF ANALYSIS

FISH PRODUCTS SAMPLING SUBMISSION
Version: 7.0.0
Serial: 000007354297

System ID: 2019FFI-0000080009-4 **Receptions by all Labs:** 1
Reference No.: 2019FFIS-0000083867-4 **Number of Jobs Authorized:** 1

Laboratory No.: DAR-FD-2019-CH-06178 **Date Received:** 2019-12-09 **Job Status:** Authorized

Laboratory: (1981) DARTMOUTH LABORATORY - CHEMISTRY
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Fax: (902) 536-1122
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Email: ALEXIS.JOHNSON@CANADA.CA

Program: FISH **Function:** DOMESTIC
Sampling Plan: 2019_FS400D - Domestic: Chemistry & Chemical contaminants complaints-including investigations
Product vs. Environmental: Product

Country of Origin: CANADA
Sampled At: DAOUST, PIERRE-YVES DR.
ATLANTIC VETERINARY COLLEGE, UPEI
DEPARTMENT OF PATHOLOGY & MICROBIOLOGY
550 UNIVERSITY AVENUE
CHARLOTTETOWN, PE C1A4P3

Sample Priority: Regular
Number of Units per Sample: 2
Submitter Comments: COMET FECES JUNE 28,19

Date Received: 2019-12-09
Risk Category: Bivalve Molluscan

Lab Sample No.: DAR-FD-2019-CH-06178-0001
Inspection Sample No.:

Primary Process: FREEZING
Sample Type: Feces
Identification Code: EG3-19
Species: NORTH ATLANTIC RIGHT WHALE - EUBALAENA GLACIALIS

Sample Assessed: No Decision

Method: TOX-DA-LC / 1 : Determination of Domoic Acid in Shellfish by LC-UV and LC-MS/MS

Domoic Acid	Not detected at the reporting limit.

Test Assessed: No Decision

Method: TOX-DSP-LC / 1 : Determination of Lipophilic Shellfish Toxins in Shellfish by LC-MS/MS

Gymnodimine	Not detected at the reporting limit.
Pectenotoxin 1	Not detected at the reporting limit.
Pectenotoxin 2	Not detected at the reporting limit.
Pectenotoxin 3	Not detected at the reporting limit.
Pectenotoxin 4	Not detected at the reporting limit.
Pectenotoxin 6	Not detected at the reporting limit.
Pectenotoxin 11	Not detected at the reporting limit.
Okadaic Acid	Not detected at the reporting limit.
Dinophysis Toxin 1	Not detected at the reporting limit.
Dinophysis Toxin 2	Not detected at the reporting limit.
Okadaic Acid Esters	Not detected at the reporting limit.
Dinophysis Toxin 1 Esters	Not detected at the reporting limit.
Dinophysis Toxin 2 Esters	Not detected at the reporting limit.
Yessotoxin	Not detected at the reporting limit.
1A-Homo yessotoxin	Not detected at the reporting limit.
45 OH Yessotoxin	Not detected at the reporting limit.
45 hydroxy 1A-homo yessotoxin	Not detected at the reporting limit.
Total Pectenotoxin	Not detected at the reporting limit.
Total Okadaic Group Toxins	Not detected at the reporting limit.
Total Yessotoxin	Not detected at the reporting limit.

Test Assessed: No Decision

System ID:	2019FFI-0000080009-4	***Receptions by all Labs:***	1
Reference No.:	2019FFIS-0000083867-4	***Number of Jobs Authorized:***	1

Method: TOX-PCOX / 1 : Determination of Paralytic Shellfish Toxins in Shellfish by LC-FLD with Post-column Oxidation (PCOX)

Gonyautoxin-4	Not detected at the reporting limit.
Gonyautoxin-1	Not detected at the reporting limit.
Decarbamoylgonyautoxin-3	Not detected at the reporting limit.
Decarbamoylgonyautoxin-2	Not detected at the reporting limit.
Gonyautoxin-5	Not detected at the reporting limit.
Gonyautoxin-3	Not detected at the reporting limit.
Gonyautoxin-2	Not detected at the reporting limit.
Neosaxitoxin	Not detected at the reporting limit.
Decarbamoylsaxitoxin	Not detected at the reporting limit.
Saxitoxin	Not detected at the reporting limit.
N-sulfocarbamoylgonyautoxin-2	Not detected at the reporting limit.
N-sulfocarbamoylgonyautoxin-3	Not detected at the reporting limit.
PSP - Total	Not detected at the reporting limit.

Test Assessed: No Decision

Job Authorized:	2020-02-04	***Authorized By:***	Wade Rourke		***Authorized***
Job Assessed:		No Decision		***Date Assessed:***	2020-02-04

These results relate only to the sample as received and tested by this laboratory.

***** END OF REPORT *****

Canadian Food Inspection Agency / Agence canadienne d'inspection des aliments

CANADIAN FOOD INSPECTION AGENCY
REPORT OF ANALYSIS

FISH PRODUCTS SAMPLING SUBMISSION
Version: 7.0.0
Serial: 000007354329

System ID: 2019FFI-0000080007-4 **Receptions by all Labs:** 1
Reference No.: 2019FFIS-0000083865-4 **Number of Jobs Authorized:** 1

Laboratory No.: DAR-FD-2019-CH-06180 **Date Received:** 2019-12-09 **Job Status:** Authorized

Laboratory: (1981) DARTMOUTH LABORATORY - CHEMISTRY
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Fax: (902) 536-1122
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Program: FISH **Function:** DOMESTIC
Sampling Plan: 2019_FS400D - Domestic: Chemistry & Chemical contaminants complaints-including investigations
Product vs. Environmental: Product

Country of Origin: CANADA
Sampled At: DAOUST, PIERRE-YVES DR.
ATLANTIC VETERINARY COLLEGE, UPEI
DEPARTMENT OF PATHOLOGY & MICROBIOLOGY
550 UNIVERSITY AVENUE
CHARLOTTETOWN, PE C1A4P3

Sample Priority: Regular
Number of Units per Sample: 1
Submitter Comments: EG-6-2019 CWITC IPE FECES

Date Received: 2019-12-09
Risk Category: Bivalve Molluscan

Lab Sample No.: DAR-FD-2019-CH-06180-0001
Inspection Sample No.:

Primary Process: FREEZING
Sample Type: Feces
Identification Code: EG # 6
Species: NORTH ATLANTIC RIGHT WHALE - EUBALAENA GLACIALIS

Sample Assessed: No Decision

Method: TOX-DA-LC / 1 : Determination of Domoic Acid in Shellfish by LC-UV and LC-MS/MS

Domoic Acid	Not detected at the reporting limit.

Test Assessed: No Decision

Method: TOX-DSP-LC / 1 : Determination of Lipophilic Shellfish Toxins in Shellfish by LC-MS/MS

Gymnodimine	Not detected at the reporting limit.
Pectenotoxin 1	Not detected at the reporting limit.
Pectenotoxin 2	Not detected at the reporting limit.
Pectenotoxin 3	Not detected at the reporting limit.
Pectenotoxin 4	Not detected at the reporting limit.
Pectenotoxin 6	Not detected at the reporting limit.
Pectenotoxin 11	Not detected at the reporting limit.
Okadaic Acid	Not detected at the reporting limit.
Dinophysis Toxin 1	Not detected at the reporting limit.
Dinophysis Toxin 2	Not detected at the reporting limit.
Okadaic Acid Esters	Not detected at the reporting limit.
Dinophysis Toxin 1 Esters	Not detected at the reporting limit.
Dinophysis Toxin 2 Esters	Not detected at the reporting limit.
Yessotoxin	Not detected at the reporting limit.
1A-Homo yessotoxin	Not detected at the reporting limit.
45 OH Yessotoxin	Not detected at the reporting limit.
45 hydroxy 1A-homo yessotoxin	Not detected at the reporting limit.
Total Pectenotoxin	Not detected at the reporting limit.
Total Okadaic Group Toxins	Not detected at the reporting limit.
Total Yessotoxin	Not detected at the reporting limit.

Test Assessed: No Decision

System ID:	2019FFI-0000080007-4	***Receptions by all Labs:***	1
Reference No.:	2019FFIS-0000083865-4	***Number of Jobs Authorized:***	1

Method:	TOX-PCOX / 1 : Determination of Paralytic Shellfish Toxins in Shellfish by LC-FLD with Post-column Oxidation (PCOX)	
	Gonyautoxin-4	Not detected at the reporting limit.
	Gonyautoxin-1	Not detected at the reporting limit.
	Decarbamoylgonyautoxin-3	Not detected at the reporting limit.
	Decarbamoylgonyautoxin-2	Not detected at the reporting limit.
	Gonyautoxin-5	Not detected at the reporting limit.
	Gonyautoxin-3	Not detected at the reporting limit.
	Gonyautoxin-2	Not detected at the reporting limit.
	Neosaxitoxin	0.09 mg STXdiHCl eq/kg
	Decarbamoylsaxitoxin	Not detected at the reporting limit.
	Saxitoxin	Not detected at the reporting limit.
	N-sulfocarbamoylgonyautoxin-2	Not detected at the reporting limit.
	N-sulfocarbamoylgonyautoxin-3	Not detected at the reporting limit.
	PSP - Total	9 ug STXdiHCl eq/100g
Test Assessed:		No Decision

Job Authorized:	2020-02-04	***Authorized By:***	Wade Rourke		***Authorized***
Job Assessed:		No Decision		***Date Assessed:***	2020-02-04

These results relate only to the sample as received and tested by this laboratory.

***** END OF REPORT *****

Annex G

Fecal Hormone Analysis Results

EG2019-01, EG2019-02, EG2019-03, EG2019-06

Stress and reproductive hormone results for fecal samples collected from North Atlantic right whales during the 2019 mortality event in the Gulf of St. Lawrence

Prepared by Katherine Graham, MS, Rosalind Rolland, DVM, & Elizabeth Burgess, PhD
Anderson Cabot Center for Ocean Life at the New England Aquarium

A Report to the Marine Animal Response Society
with funding from DFO-Maritimes, Species at Risk

Correspondence to eburgess@neaq.org
February 2020

BACKGROUND:

Fecal samples were collected during necropsy of four North Atlantic right whales (NARW) in the Gulf of St. Lawrence, Canada, in 2019. Samples were shipped by Tonya Wimmer (Marine Animal Response Society) to the Anderson Cabot Center for Ocean Life at the New England Aquarium (NEAq) for hormone analysis. All fecal samples were analyzed for hormones associated with stress and metabolic responses (glucocorticoids and thyroid hormone), along with informative reproductive hormones (progesterone, testosterone and estrogens). The use of fecal samples can be particularly valuable for investigation of necropsy cases. Firstly, rapid postmortem decomposition renders blood sampling unreliable for analysis; whereas, our work has shown that meaningful patterns in hormone metabolites persist in feces despite potential carcass degradation (Rolland *et al.*, 2017). Moreover, hormones accumulate in feces over several days of digestive transit (i.e., ~1-2 days prior), such that fecal hormone data can provide insights into vital physiological responses that occurred prior to whale death.

METHODS:

Hormone metabolites were extracted from feces and quantified using standard processing protocol for NARW samples and previously validated immunoassay techniques (see Rolland *et al.*, 2005, 2017; Hunt *et al.*, 2006). In brief, fecal samples were freeze-dried (~1 week) and 0.2 g of dried feces was extracted with 2.0 mL of 90% methanol. Fecal extracts were measured for hormone metabolites using radioimmunoassay for glucocorticoids (corticosterone assay, MP Biomedicals #07-120103; see Hunt *et al.*, 2006; Rolland *et al.*, 2017), progesterone, testosterone (both in-house ^{3}H assays; see Rolland *et al.*, 2005) and estrogens (total estrogens assay, MP Biomedicals #140202; see Rolland *et al.*, 2005), and an enzyme-immunoassay for thyroid hormone (triiodothyronine assay, Arbor Assays #K056; Rolland, in prep.). Fecal

hormone results are reported in nanograms of immunoreactive hormone metabolite per gram of dry feces (ng/g). Hormone results for individual whales were interpreted based on our extensive and long-term physiological database on NARWs (Rolland, NEAq), which are referenced here as means ± SE.

RESULTS:

Fecal hormone concentrations for each whale are presented in **Table 1**, along with sample collection date and preliminary necropsy findings.

Table 1. Hormone concentrations in fecal samples collected postmortem from four North Atlantic right whales in the Gulf of St. Lawrence in 2019.

Whale ID	Sex	Sample Date	Progesterone (ng/g)	Testosterone (ng/g)	Estrogens (ng/g)	GCs (ng/g)	Thyroid (ng/g)	Notes
Wolverine Eg4023 (Carcass #1)	Male	7 Jun 2019	265.2	3505.9	72.78	33.1	30.9	COD: pending/unknown
Punctuation Eg1281 (Carcass #2)	Female	25 Jun 2019	362.1	137.3	19.50	26.2	9.5	COD: Compatible with sharp force trauma (vessel strike).
Comet Eg1514 (Carcass #3)	Male	28 Jun 2019	370.3	175.5	33.92	272.6	23.6	COD: Highly compatible with blunt force trauma (vessel strike).
Clipper Eg3450 (Carcass #6)	Female	1 Jul 2019	266.2	56.2	61.00	12.5	8.8	COD: Compatible with blunt force trauma (vessel strike).

Reproductive hormones

For all whales, reproductive hormone concentrations (progesterone, testosterone, and estrogens) were within expected ranges for male and female NARWs (see Rolland *et al.*, 2005). Interestingly, the older male, *Comet* (>34 y.o.) showed a low level of fecal testosterone (176 ng/g) for an adult male (10,203 ± 1641 ng/g; Rolland *et al.*, 2005), suggesting possible reduced testicular function at the time of his death. The younger nine-year-old male, *Wolverine*, had more elevated fecal testosterone levels (3,506 ng/g), although his level was still below the normal range reported for reproductively active males (5,253–15,761 ng/g; Rolland *et al.,* 2005). However, *Wolverine's* testosterone result is likely to be influenced by seasonality, since his level was recorded in early June (cf. most adult males measured over July–September; Rolland *et al.,* 2005). Other sex hormone data for progesterone (265 ng/g) and estrogen levels (72 ng/g) provide additional information to show that *Wolverine* had levels similar to adult males (333 ± 43 ng/g and 95 ± 21 ng/g, respectively), indicating he was likely sexually mature.

Punctation was a well-known reproductive female (>38 y.o.) who had been a prolific breed during her life (giving birth to eight calves) with her last calf born in 2016.

There was concern that *Punctuation* may have been pregnant at the time of her death. Fecal progesterone concentration for *Punctuation* was 362 ng/g, which is within the range of non-pregnant females (295 ± 145 ng/g) and substantially below levels reported for confirmed pregnant females (201,240 ± 27,025 ng/g; Rolland *et al.*, 2005). Across all hormones measured both reproductive and stress-related, fecal sample results for *Punctuation* suggest a low likelihood of pregnancy at the time of her death. The other female, *Clipper* (> 15 y.o.) showed a hormone profile consistent with a resting adult female (i.e., not pregnant and not lactating), such that her progesterone (266 ng/g cf. 295 ± 145 ng/g) and estrogen concentrations (61 ng/g cf. 57 ± 11 ng/g) were similar to levels expected for this female reproductive state (Rolland *et al.*, 2005).

Stress and metabolic hormones

For comparison, the fecal glucocorticoid concentrations for all four NARW that died in 2019 have been depicted alongside reference values for apparently healthy whales, whales that died from an acute impact (e.g., vessel strike), and dead whales that suffered chronic impacts (e.g., whales severely injured by entanglement or live-stranded), as reported in Rolland *et al.* (2017) (see **Figure 1**). Fecal glucocorticoid concentrations in three individuals, *Wolverine* (33 ng/g), *Punctuation* (26 ng/g), and *Clipper* (12.5 ng/g), were within normal baseline levels and consistent with other right whales that died rapidly from vessel strikes (46 ± 19 ng/g, range = 13–112 ng/g, n = 5; Rolland *et al.*, 2017). Our previous studies have shown that fecal glucocorticoid levels in whales that die from acute vessel strikes are often not different from apparently healthy whales (Rolland *et al.*, 2017). These results are expected because hormones accumulate in feces over several days of digestive transit and a whale impacted by blunt force trauma often does not survive long enough for a stress response to be detectable in feces. In contrast to these individuals, *Comet* (273 ng/g) had highly elevated fecal glucocorticoid concentrations (three-fold higher) compared to apparently healthy adult males (65 ± 7 ng/g, n = 22; Rolland *et al.*, 2017), suggesting that this moribund whale potentially suffered a more prolonged decline in health. Of note during sample processing, this fecal sample from *Comet* had a moderate oily consistency, even after completing the extraction process. This is an atypical texture for right whale feces, and significant changes in fat content of fecal samples may influence steroid hormone measurement (Kalliokoski *et al.*, 2012).

Fecal thyroid hormone concentrations for all four whales ranged between 9 and 31 ng/g. These concentrations were slightly below levels recorded averages for all males and females (~50-60 ng/g) in our database since 1999. The relatively lower thyroid hormone levels measured in these whales is consistent with newly observed population trends, indicating a decline in nutritional state and associated metabolic responses of North Atlantic right whales (Rolland, in prep.).

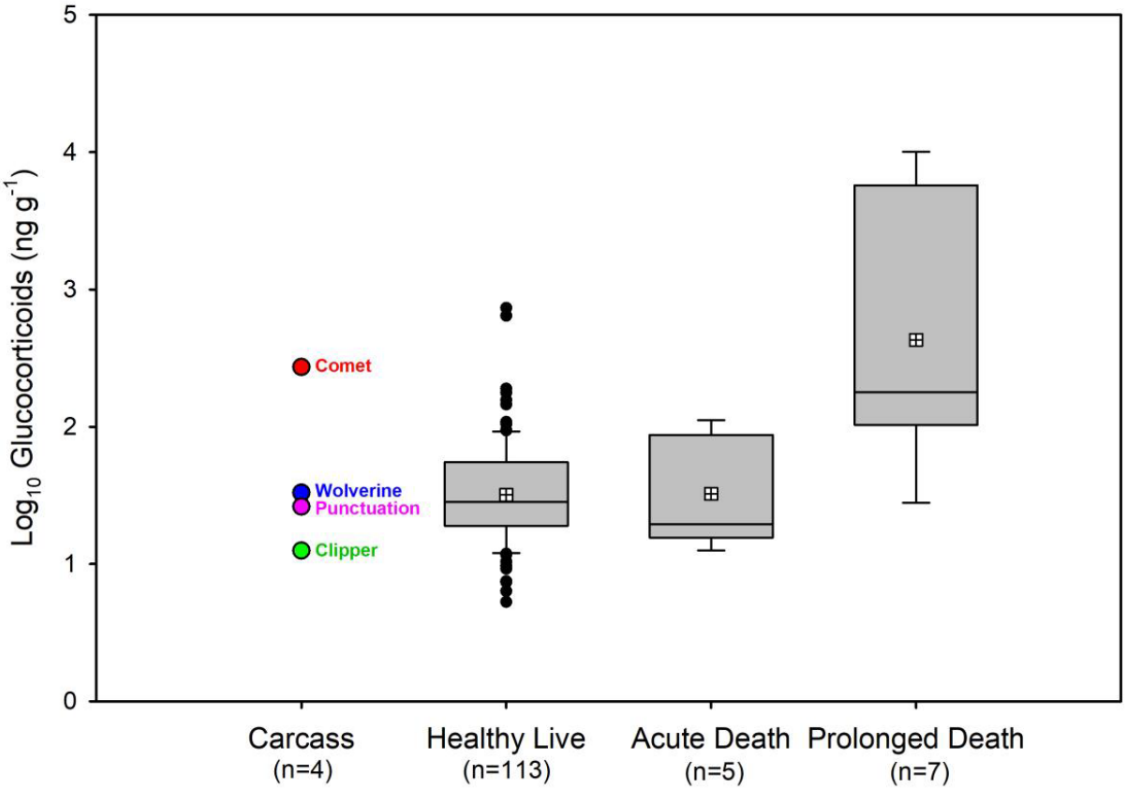

Figure 1. Fecal glucocorticoid concentrations (ng/g) in four deceased North Atlantic right whales from the 2019 mortality event in the Gulf of St. Lawrence, as compared to apparently healthy whales, whales that died an acute death (i.e., whales struck by a vessel), and whales that suffered a prolonged time course to death (i.e., whales severely injured by entanglement or live-stranded). Values are plotted on a logarithmic scale for clearer delineation between groups. For boxplots, the horizontal line within the box indicates the median value, the hatched square indicates the mean, the height of the box encompasses the distance between the 25th and 75th quartile, and the whiskers delineate extreme observations. Outliers are marked with a closed circle (> 1.5 x interquartile range). Samples sizes (n) are indicated in parentheses. Figure modified from Rolland *et al.* (2017).

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* Data can be considered final and may be included in animal reports. Please credit the Anderson Cabot Center for Ocean Life at the New England Aquarium accordingly. These data will be published as part of a long-term dataset on North Atlantic right whale hormone values (Rolland, NEAq).

Annex H - Observations of leading edge fluke injuries of right whale #1514 at death and when living

Prepared by: Amy Knowlton, information provided by the New England Aquarium

Entanglement that lead to these injuries occurred between June 28, 2003 and May 3, 2005. #1514 experienced two entanglements prior to this 2005 event, one between March 31, 1995 and August 18, 1997 which resulted in minor scars and another one between September 16, 1997 and July 7, 2000 also resulting in minor scars.

There were no clear observations of the flipper insertions prior to necropsy but based on the nature of that wound, it is assumed it was from this same 2005 event.

No subsequent entanglement events were documented for #1514.

June 28, 2019, Norway PEI, Canada – Canadian Wildlife Health Cooperative, necropsy image (right fluke leading edge)

Aug 13, 2018 – right leading edge (New England Aquarium under DFO permit)

Aug 13, 2018 - right and left leading edge (New England Aquarium under DFO permit)

Mar 28, 2017 - left leading edge (Woods Hole Oceanographic Institution: Taken under NMFS/NOAA permit under the authority of the Marine Mammal Protection Act and the U.S. Endangered Species Act).

Aug 28, 2009 - right leading edge (New England Aquarium under DFO permit).

Nov 11, 2006 - right leading edge (Whale Center of New England: Taken under NMFS/NOAA permit under the authority of the Marine Mammal Protection Act and the U.S. Endangered Species Act).

Apr 27, 2006 - left leading edge (Center for Coastal Studies: Taken under NMFS/NOAA permit under the authority of the Marine Mammal Protection Act and the U.S. Endangered Species Act).

Annex I – Assessment of external decomposition level of floating right whale carcasses

Prepared by: Laura Bourque, Wildlife pathologist, Canadian Wildlife Health Cooperative

Floating right whale carcasses may be discovered in a variety of states of decomposition ranging from freshly dead to advanced decomposition. Systematic and objective description of the level of decomposition of a floating carcass is important as, in some cases, it can approximate the length of time a carcass has been dead (Post mortem interval) and also serves as a rough indicator of overall effectiveness of year to year carcass detection. Establishing a post mortem interval is problematic in right whales due to the compounding factors of internal pressure and heat buildup, and at sea environmental conditions which generate considerable variation in the rate of decomposition between carcasses. However, there are still broad states of decomposition that are observable in floating carcasses that can be used to indicate which carcasses have been floating for longer periods compared to others

To our knowledge, there is no standard system for objectively describing the level of external decomposition of floating right whale carcasses. The current system that is widely used for all marine mammals is that described in “Marine Mammals Ashore, Geraci and Lounsbury, 1993” which details a series of codes which can be used to described the condition of individual animals that are stranded or beached on shore as follows:

Code 1: Live animal

Code 2: Carcass in good condition (fresh/edible)

Code 3: Carcass in fair condition but with decomposition present (organs are intact)

Code 4: Carcass in poor condition with advanced decomposition (liquefaction of organs)

Code 5: Mummified or skeletal remains

Applying the above code system to dead floating right whale carcasses is problematic for a number of reasons. The code system is meant for marine mammals that are found on shore, not those that are in their natural environment. Consequently, there is no benefit to “code 1” in this context as a freely swimming right whale is presumed normal. In the case of dead right whales, the criteria separating a code 2 from a code 3 carcass are based largely on the ability to examine the internal body cavity for the purpose of assessing the degree of soft tissue decomposition. Not only is this practically impossible for whale carcasses that are floating hundreds of kilometers off shore, but often times the organs will are rapidly expelled out of the mouth (due to buildup of internal heat and pressure) so they are not present for evaluation. Therefore, trying to apply a code system to organs that you cannot see and that probably are not even there is ineffective. The same issue can apply when trying to differentiate between carcasses with moderate decomposition (code 3) and advanced decomposition (code 4). Floating right whale carcasses that may outwardly appear to have only mild/moderate decomposition will in reality have advanced internal decomposition with liquefaction of whatever internal soft tissues are remaining. The final outcome measured in code 5 (skeletal remains) also does not readily apply to floating right whale carcasses which lose most of their skeletal elements after prolonged decomposition and typically end as a floating or beached “shell” of blubber. Although in some ways it is possible to apply the code system to floating right whale carcasses, it seems that there are significant inconsistencies in its use due its reliance on internal criteria that are not easily observable, and the fact that at sea right whale carcasses do not follow the same pattern of decomposition that carcasses on land do.

Having a standard set of criteria for describing the level of external decomposition of dead floating right whales would provide consistency in at sea carcass descriptions as well as a means of estimating the year to year ratios of fresh vs decomposed carcasses at initial observation. We therefore propose the following set of external decomposition “levels” which are specific to dead floating right whale carcasses. We have used the term “level” to differentiate this system from the code system which can still be used effectively during onshore necropsy. The ability to classify carcasses using these levels will necessarily be entirely dependent on the quality and quantity of images that are available from the initial sightings of carcasses at sea.

Level 1

A level 1 carcass can be considered a “fresh” carcass where the mortality occurred recently. Depending on the time of year and environmental conditions, this time frame could vary from hours to several days. Organ expulsion out of the mouth and anogenital slit may or may not have occurred at this point. Level 1 carcasses should display all of the criteria below. Any deviation from these criteria would warrant a classification as level 2.

Descriptive criteria for a level 1 carcass:

- Relatively minimal carcass bloating
- Evidence of fresh (light pink or red) tissues or blood in the water surrounding the carcass
- The skin is smooth and intact with no or only minimal evidence of skin blistering, cracking, or sloughing
- No or only minimal evidence of bird droppings and scavenging

See below for case examples from the 2017 and 2019 Gulf of St. Lawrence (GoSL) right whale mortality events that fit the above criteria based on aerial and vessel based images of first observations.

EG2017-06

EG2019-01

EG2019-02

EG2019-08

Level 2

A level 2 carcass has been floating for an indeterminate period of time (days) and displays clear evidence of significant decomposition. Organ expulsion through the oral cavity and anogenital slit has almost certainly occurred at this point to a greater or lesser degree. Carcasses demonstrating a significant portion of exposed blubber following skin sloughing warrant a classification of level 3.

Descriptive criteria for a level 2 carcass:

- Significant blistering, cracking, and superficial sloughing of the skin over the greater portion of the exposed surface of the carcass
- No or only minimal evidence of exposed blubber
- Organs and soft tissues present at the opening of the oral cavity and anogenital slit demonstrate significant decomposition and livor mortis
- Birds and bird droppings are present over the greater portion of the exposed surface of the carcass

See below for case examples from the 2017 and 2019 GoSL right whale mortality events that fit the above criteria based on aerial and vessel based images of first observations.

EG2017-08

EG2017-03

EG2019-06

EG2019-03

EG2017-04

Level 3

A level 3 carcass has been floating for a prolonged period of time (days to weeks) and displays evidence of advanced decomposition. All or the majority of internal organs have been expelled out of the oral cavity and anogenital slit and are no longer present at either of these orifices. Carcasses which have lost all adherent skin and demonstrate significant flattening warrant a classification of level 4.

Descriptive criteria for a level 3 carcass:

- Significant sloughing of skin has occurred over the majority of the carcass and the exposed blubber is yellow to brown.
- The carcass is still “round” in profile
- Any exposed soft tissues or genital tissues are significantly decomposed with advanced livor mortis
- Islands of adherent skin are still apparent scattered over the exposed carcass

See below for case examples from the 2017 and 2019 GoSL right whale mortality events that fit the above criteria based on aerial and vessel based images of first observations.

EG2017-05

EG2017-01

EG2017-02

EG2017-07

EG2017-09

EG2019-07

EG2019-05

Level 4

A level 4 carcass has been floating for a prolonged period of time (weeks) and is in a terminal state of decomposition. All internal organs and a large part of the skeleton have been expelled out of the oral cavity.

Descriptive criteria for a level 4 carcass:

- The carcass is visibly flat in profile
- There is no adherent skin
- The blubber is diffusely yellow to brown

See below for case examples from the 2017 and 2019 GoSL right whale mortality events that fit the above criteria based on aerial and vessel based images of first observations.

EG2017-10

EG2017-11

EG2017-12

EG2019-04

EG2019-09

The CWHC is a cross-Canada network of partners and collaborators dedicated to wildlife health and includes internationally renowned wildlife disease diagnosticians and researchers.

The Marine Animal Response Society (MARS) is a Nova Scotia-based charitable organization dedicated to marine animal conservation through response, research and engagement. Our goal is to build relationships that result in the conservation, recovery and stewardship of all marine animals and ocean ecosystems.
www.marineanimals.ca

The Quebec Marine Mammal Emergency Response Network is an umbrella group of organizations and institutions responsible for organizing, coordinating and implementing measures aimed at reducing accidental mortality of marine mammals, rescuing marine mammals in difficulty, and facilitating data acquisition from beached or drifting carcasses in the waters of the St. Lawrence in Quebec. The Network relies on the support of more than 200 volunteers.

www.rqumm.org