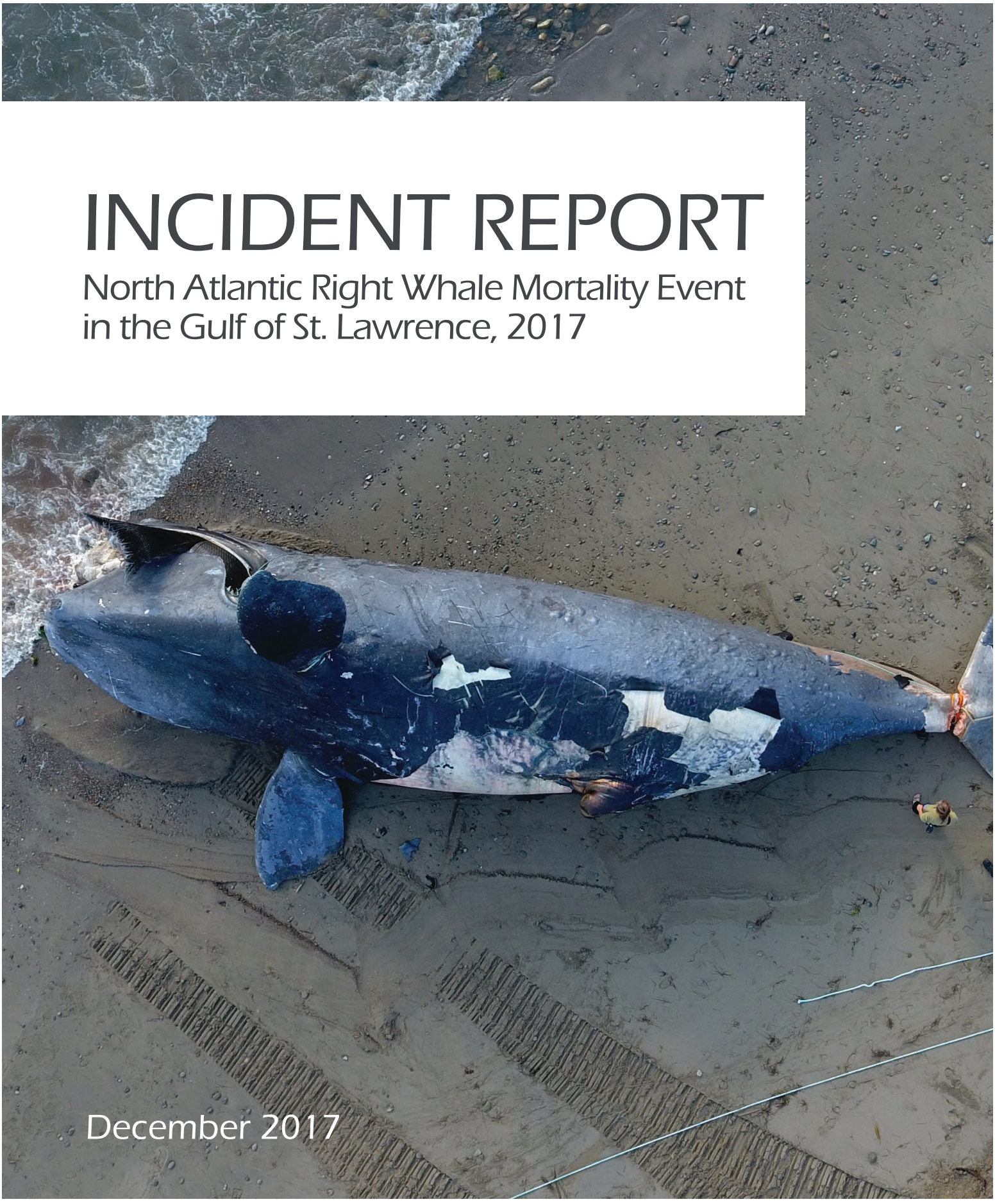
INCIDENT REPORT

North Atlantic Right Whale Mortality Event in the Gulf of St. Lawrence, 2017



December 2017

CANADIAN WILDLIFE HEALTH COOPERATIVE
RÉSEAU CANADIEN POUR LA SANTÉ DE LA FAUNE
MARINE ANIMAL RESPONSE SOCIETY MARS
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Incident Report

North Atlantic Right Whale Mortality Event

In the Gulf of St. Lawrence, 2017

December 29 2017 (modified from October 5 2017)

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PREFACE

The present incident report provides the details and conclusions of the investigation into the North Atlantic right whale mortality event experienced in 2017 in the Gulf of St. Lawrence.

The report focusses primarily on the necropsy findings which were prepared by lead veterinarians affiliated with the Canadian Wildlife Health Cooperative (CWHC). These findings were analysed collaboratively amongst the lead veterinarians (authors) and in consultation with other North American veterinarians and researchers.

The Marine Animal Response Society (MARS) and Fisheries and Oceans Canada (DFO) have provided analyses and contextual information relevant to the interpretation of the key findings presented by the lead veterinarians.

Given the desire for producing timely findings which are relevant in addressing the North Atlantic right whale mortality event in the Gulf of St. Lawrence, the scope of this report addresses only key relevant information on North Atlantic right whales and human activities which are considered to have played a role in this incident. As such, it is not intended to provide a complete portrait of the North Atlantic right whale population nor of the human activities occurring in the Gulf of St. Lawrence.

These findings are meant to provide a basis for the advancement of conservation actions, including decisions in response to this unprecedented mortality event.

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This report is dedicated to the memory of Joe Howlett

Executive Summary

The North Atlantic right whale (*Eubalaena glacialis*) is an endangered species which is protected under the *Species at Risk Act*. Sightings and identification of individual North Atlantic right whales (NARW) in the Gulf of St. Lawrence has increased over the last few years. Large numbers of NARWs were observed in the Gulf of St. Lawrence in 2017, due in part to extensive survey and surveillance efforts.

In 2017, an unprecedented NARW mortality event occurred in the Gulf of St. Lawrence. The present '*Incident Report - North Atlantic Right Whale Mortality Event In the Gulf of St. Lawrence, 2017'* is meant to describe the key findings in seven NARW necropsies as well as provide contextual information on the conditions and human activities occurring in the Gulf of St. Lawrence. Accordingly, the report is meant to provide information that will help to better understand the causes of death of these NARWs.

Key Findings:

- Since early June, 12 NARWs have been found dead and five live-entanglements were also documented in the Gulf of St. Lawrence.
- Response to the mortality event included conducting complete examinations of the carcasses (i.e., necropsy) and additional diagnostic tests (e.g., histology, toxicology).
- Seven necropsies were performed on NARWs brought to shore in Norway PEI, Magdalen Islands QC, and Miscou NB.
- Two NARWs died from entanglement in fishing gear (probably acute, with subsequent drowning).
- For four NARWs, necropsy findings were compatible with acute death due to trauma.
- The cause of death of one NARW could not be determined because of advanced post-mortem decomposition, but some observations in this animal suggested blunt trauma.
- While the cause of death of an additional NARW sampled at-sea could not be determined without a necropsy, limited samples obtained from this carcass suggested acute death.
- No evidence was found to support the involvement of biotoxins, infectious diseases, or starvation as the primary causes of mortality in this investigation.
- Due to the very rapid rate of decomposition of these animals, it is imperative to ensure prompt identification, reporting, and response to such mortalities. However, valuable information can still be obtained from necropsies of animals in an advanced state of decomposition.
- The '*Incident Report - North Atlantic Right Whale Mortality Event In the Gulf of St. Lawrence, 2017'* includes detailed necropsy reports as well as other contextual information associated with the mortality event.
- Necropsy findings of trauma and entanglement coincide with high level of fisheries and maritime traffic in the Gulf of St. Lawrence.
- More research is needed to understand NARW habitat use in the Gulf of St. Lawrence as well as the human activities in these waters to prevent further NARW deaths.

Background

Gulf of St. Lawrence

'The Estuary and Gulf of St. Lawrence represent one of the largest and most productive estuarine/marine ecosystems in Canada and in the world. With a drainage basin that includes the Great Lakes, the St. Lawrence marine ecosystem receives more than half of the freshwater inputs from the Atlantic Coast of North America. The Estuary and Gulf of St. Lawrence (EGSL) ecosystem is also strongly influenced by ocean and climate variability in the North Atlantic, of both Arctic (Labrador Current) and tropical (Gulf Stream) origin. As a result, the EGSL exhibits large spatial and temporal variations in environmental conditions and oceanographic processes.

The Gulf of St. Lawrence (GSL) is a semi–enclosed sea, covering an area of about 240,000 km^2 and containing 3553 km^3 of water, that opens to the Atlantic Ocean through the Cabot Strait (104 km wide and 480 m in depth) and the Strait of Belle Isle (16 km wide and 60 m in depth).' (Figure 1) (Dufour and Ouellet 2007).

Figure 1. Map of the Gulf of St. Lawrence area outlined in orange.

North Atlantic Right Whale in Canada

North Atlantic right whales (*Eubalaena glacialis*) are one of the most endangered whales in the world. Once common in temperate waters of the North Atlantic, the species was seriously depleted by whaling. Since the cessation of whaling, NARWs have struggled to recover. A recent population analysis estimated the abundance to be 451 individuals (including only slightly more than 100 adult females), with the population trajectory declining since 2010 (Pace et al. 2017).

A migratory species, individuals regularly travel along the east coast of North America primarily from eastern Florida to the GSL 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; Brown et al. 2007). As well, the abundance and distribution of whales in these core habitats changes over time, with some areas being used more or less frequently than normally observed.

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 (Moore et al. 2005; Knowlton and Kraus 2001). As such, the species is listed and protected under Schedule 1, Part 2 of the *Species at Risk Act* (SARA) in Canada and the *Endangered Species Act* (ESA) in the US. Under the ESA and US *Marine Mammal Protection Act*, the National Marine Fisheries Service produces annual stock assessments, which include for each stock the allowable Potential Biological Removal (PBR) level. The current PBR for North Atlantic right whales is one whale per year (NOAA 2017). Observed annual mortalities are regularly above this “allowable” level.

The role of Canada in protecting NARWs and promoting their recovery is crucial because a high proportion of the extant population spends all or part of the summer and autumn months in Canadian waters. Both the SARA Recovery Strategy (DFO 2014) and proposed Action Plan (DFO 2016) for right whales address the need to identify and evaluate the effects of human activities, including supporting necropsies of dead animals in Canadian waters. As many indicators are not observable from an external examination alone (Moore *et al* 2005), a necropsy must be performed to determine the cause of death with any degree of certainty. As well, because some indicators of cause of death can disappear with decomposition, it is imperative that carcasses are examined as soon as possible, although even very decomposed carcasses can still yield valuable information and suggestions of cause of death.

North Atlantic Right Whale in the Gulf of St. Lawrence

Little is known about the distribution and habitat use of right whales in the GSL. Specific details on what is known about right whale distribution, including preliminary information for 2017, is provided in Annex 1.

Over the last four decades, there have been sporadic sightings of right whales in the GSL, with fewer than a dozen individuals identified in most years (Figure 2). However, during much of this

time there was little dedicated survey effort 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 consequence, there is a significant knowledge gap in the GSL regarding the distribution and abundance of the species resulting in little effort made to understand and mitigate threats to right whales.

Since 2015, researchers from several institutions have conducted dedicated surveys in the southern GSL to augment those ongoing by MICS in the northern Gulf. The area surveyed has varied from 14.349 km in 2015, 49.359 km in 2016, and 44.203 km in 2017 (additional details provided in Annex 1). Photographic analyses of individual whales indicate that in 2015 and 2016, more than 40 individual right whales were documented. To date, in 2017, preliminary analyses indicate over 100 individual whales have been identified (Figure 3).

Researchers continue to investigate why right whales appear to be increasing their use of the GSL. Initial observations suggest they are feeding in the region and research on their primary prey, *Calanus spp.*, suggests the GSL contains several potential feeding areas (Figure 3). The sex ratio of observed whales has not been different from what was expected when compared to the catalogued population. 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 (Annex 1)

There has also been an increase in the number of incidents reported since 2015 in the GSL or related to activities in that area. Four right whales were found dead, three in the Gulf proper (only one was obtained for necropsy) and one on Sable Island that was entangled in snow crab gear originally set off the Gaspé Peninsula. There were also two incidents of right whales entangled in snow crab gear set in the Gulf, one was disentangled off Sydney, NS while the other was disentangled in the Bay of Fundy (MARS, unpublished data).

Presently, it is difficult to say definitively whether there has been an increase in the use of the GSL by right whales. Observations of right whales have increased, especially in 2017, but so too has the dedicated survey and surveillance efforts. Education and outreach for identifying whale species as well as reporting sightings and incidents has also increased in recent years. Therefore, the observed higher presence of NARWs in the GSL could be due to the increased survey effort, or a change in the whale's distribution, or a combination of both. One thing is clear, to protect right whales throughout their range, dedicated research is critical to understand how and why the NARWs utilize the GSL and in order to develop and implement conservation measures specific to the area.

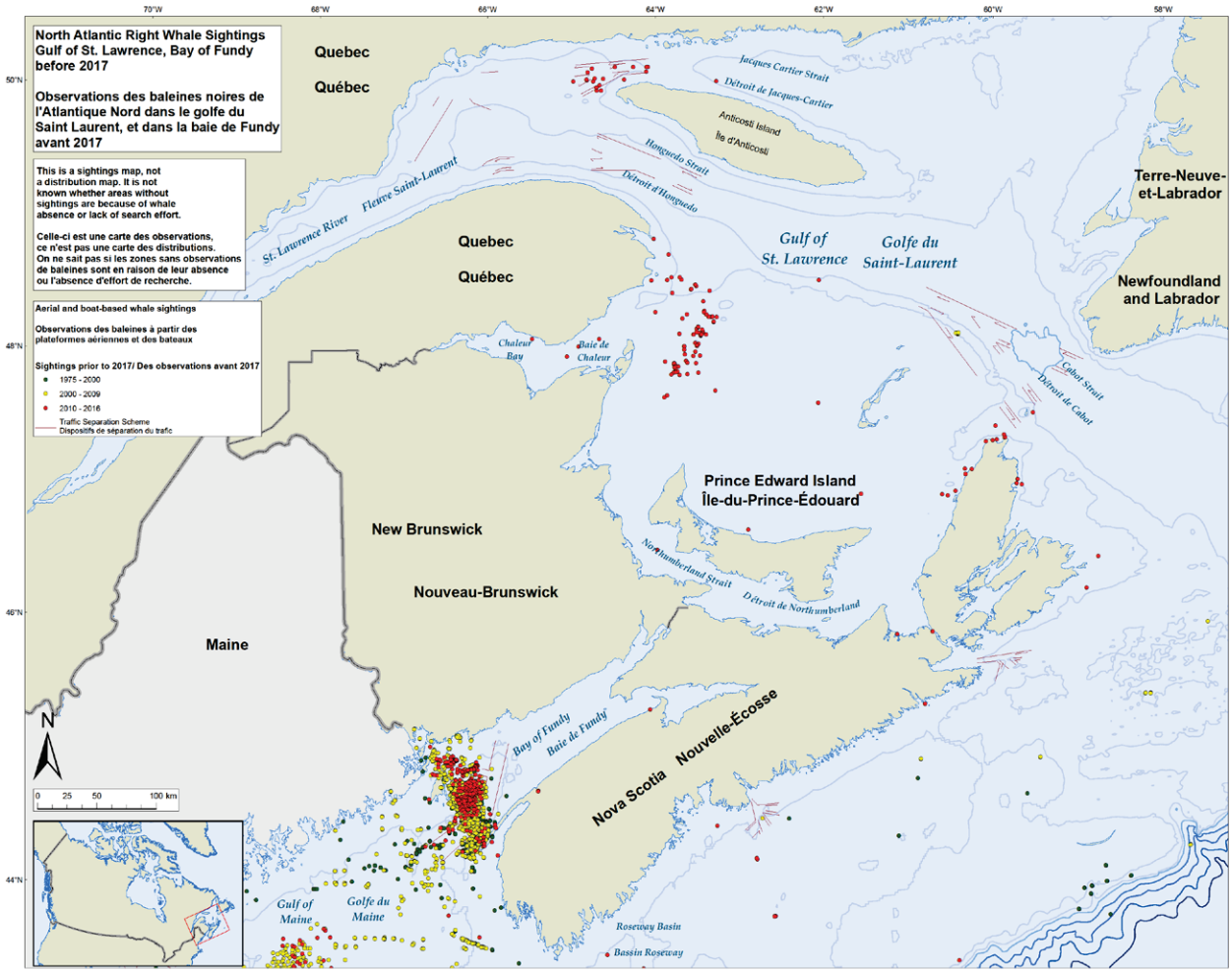

Figure 2: Sightings of North Atlantic right whales in the GSL and Bay of Fundy (BoF) from 1975 to 1999, 2000 to 2009, and 2010 to 2016. Map includes sightings information from multiple sources including: National Oceanographic and Atmospheric Agency (NOAA), Canadian Whale Institute (CWI), Mingan Island Cetacean Study (MICS), whale watching companies, for example. Complete historical sightings and details provided in Annex 1. 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 search effort. (DFO Science, unpublished data).

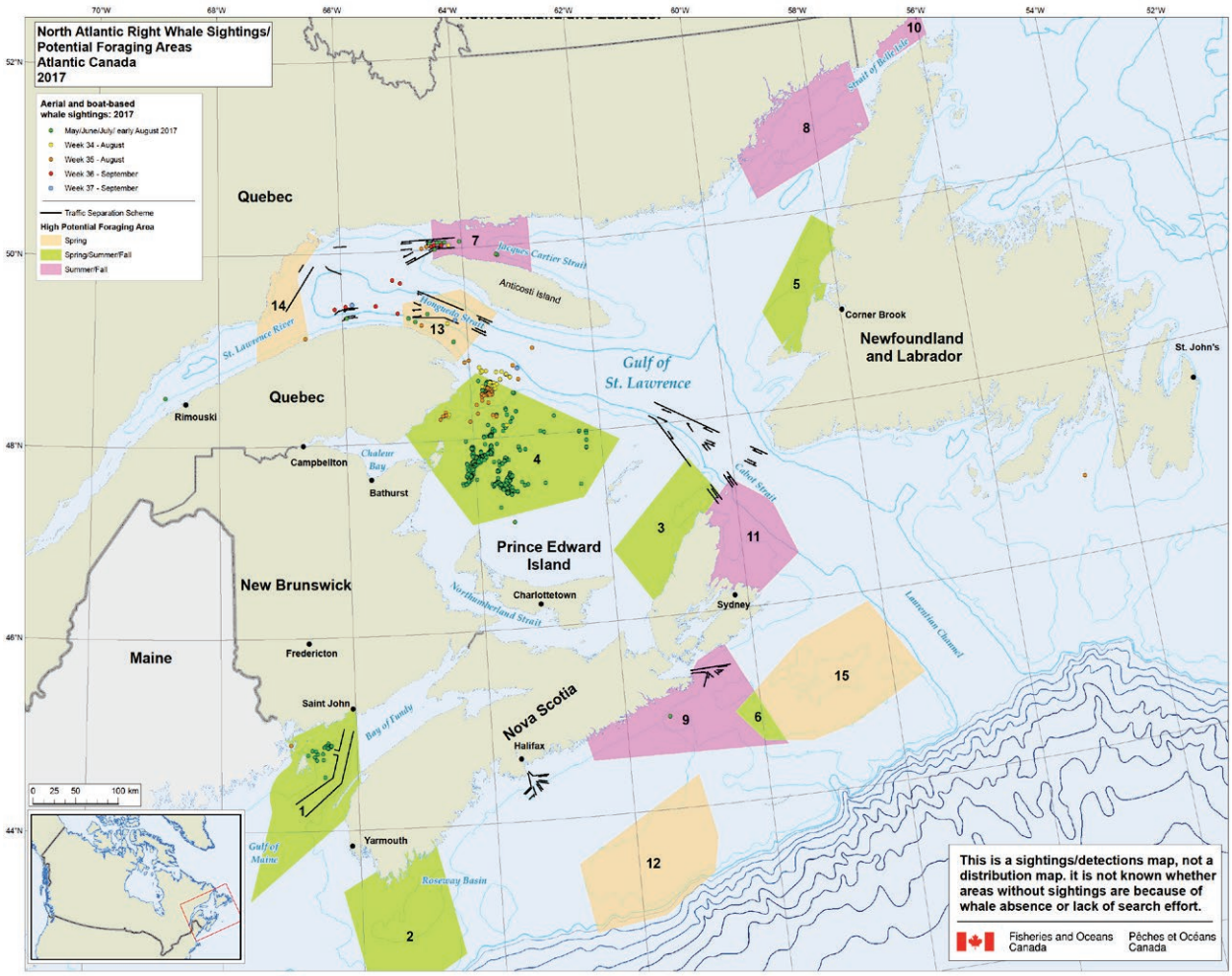

Figure 3: 2017 Sightings of North Atlantic right whales in the GSL and BoF overlying NARW foraging suitability areas. The latter were added to the map to identify other areas of interest for surveillance of NARW presence (produced by J.-F. Gosselin based on Dr. S. Plourde preliminary analysis, DFO Science). 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 search effort. (DFO Science, unpublished data).

Incident Timeline

Dead Whale Incidents

Between June 6th and September 15th, 2017, 13 incidents involving 12 dead NARWs were reported in the GSL (Table 1). Nine of these animals were observed floating in the southern GSL and an additional four came ashore in western Newfoundland (Figure 4). Reports were obtained from various sources: DFO Conservation and Protection (C&P) Surveillance, Canadian Coast Guard, National Oceanographic and Atmospheric Administration (NOAA) Aerial survey team, Marine Security Enforcement Team, members of the public and fishers. Colleagues with the New England Aquarium matched the individuals to the Right Whale Catalog and provided additional sighting and life history information (Annex 2a).

Carcasses ranged in their state of preservation codes from fresh to advanced decomposition. This made matching different carcasses, particularly those which came ashore in Newfoundland, difficult utilizing images alone (Annex 3). Genetic samples were obtained from all animals which were brought ashore for necropsy or sampled at sea (Whales #2-9) or were found beached ashore (Whales #10-13). At the time of this report, the sample for Whale #9 had not been analyzed, though its Catalog identification has been confirmed by the New England Aquarium (#4504). Thus, results regarding the genetic analyses presented here do not include this known individual. Finger bones and/or skin were collected from 12 carcasses (Whales #2-13). Whale #1 was never sampled while dead. In total, 12 genetic samples were submitted to the Natural Resources DNA Profiling and Forensic Centre (NRDPFC) at Trent University in Peterborough, ON and analyses conducted by Dr. Bradley White and colleagues.

Complete information is provided in Annex 4. The key findings for the samples analyzed to date are:

- For those carcasses identified by the New England Aquarium catalogue, the DNA profiles were consistent (Catalog# 1402, 1207, 3603, 3190, 2140, 3512).
- One of the Newfoundland carcasses (Whale #11, Cedar Cove whale) was one of the 8 known floaters (Whale #5 which had gone missing after July 4th, 2017). It was identified as Catalog #3512.
- None of the 3 other Newfoundland carcasses match Whale #1 (Catalog #3746).
- One of the Newfoundland carcasses (Whale #13, River of Ponds whale) was identified as right whale, Catalog# 4111.
- There were no matches for Whale #7 and thus, this is the only unidentified whale of the 9 floaters.

Based on these results, a total of **12** individual North Atlantic right whales were observed dead in the Gulf of St. Lawrence in 2017 at the time of report preparation.

Of the 12 dead individuals, there were eight males and four females. Nine of the dead animals were individually identified and included in the New England Aquarium Right Whale Catalog

(Annex 2a); ranging in age from 2 to at least 37 years old. Many 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 (additional details Annex 2a).

To examine where death could have occurred in the GSL, hindcast reverse trajectories were simulated for Whales #1-8, predicting their drift for 14 days prior to being reported dead (Annex 5). For many of the animals, most of the trajectories originate to the area on the western side of the southern Gulf of St. Lawrence.

A hindcast simulation of Whale #11 confirmed that it could have been one of the original floating eight whales as it originated from the southern GSL, corroborating the genetic analysis identifying this carcass as Whale #5. A forward-in-time simulation modeled for Whale #1 determined that it may have drifted through Cabot Straight, where the carcass was indeed resighted at a time corresponding to that of the model.

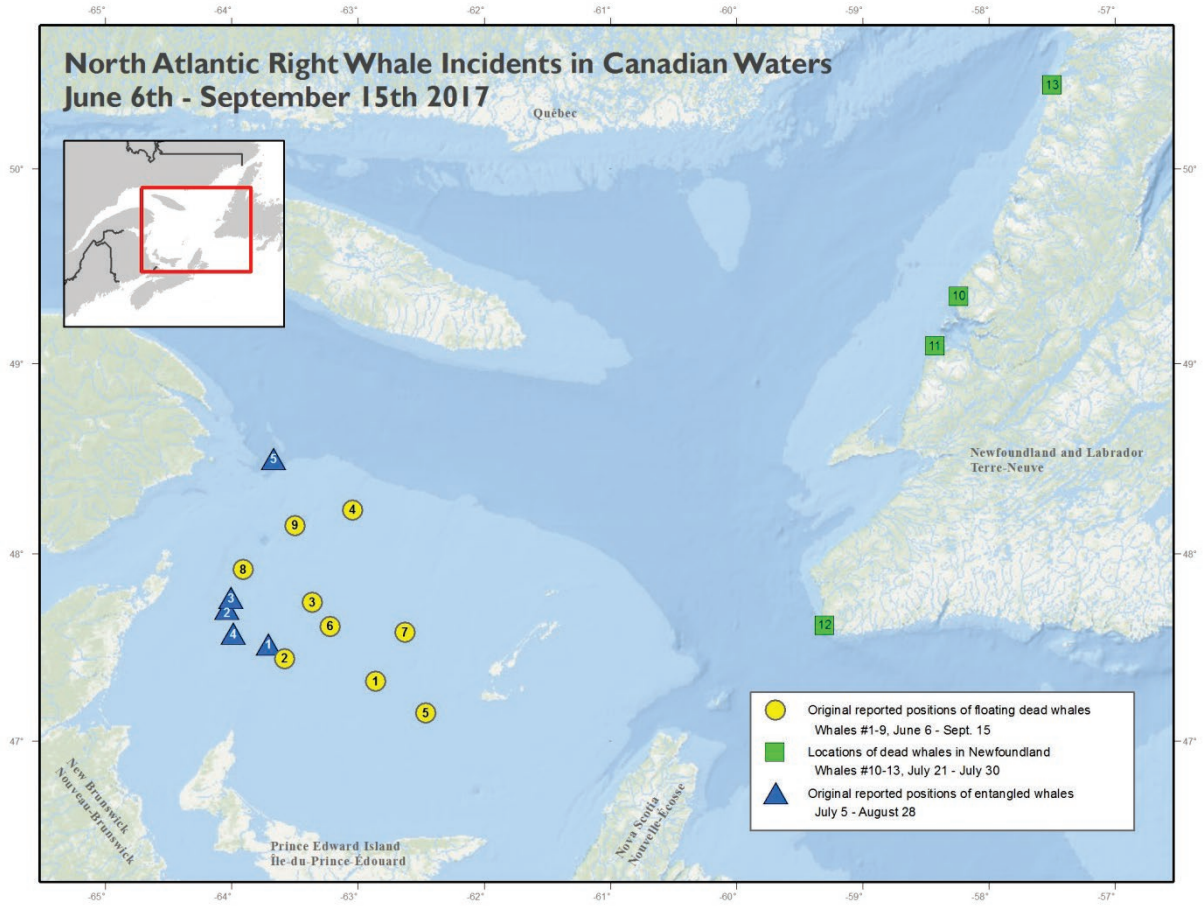

Figure 4. Locations of incidents involving dead and live, entangled North Atlantic right whales in the GSL between June 6th and Sept 15th, 2017. Whales labelled #1 – 13 are per Table 1.

Table 1. Dead North Atlantic right whales in Eastern Canada, June 6th to Sept 15th, 2017.

	Field #	Response Network Identification Code (if exist)	Date Observed/ Reported	NEAq Catalog ID	Carcass condition at first observation	Sex	Age	Location	Recovered?	Necropsied?	Necropsy Date	Last sighting alive prior to death (location)~
Floating Carcasses	1+	MARS2017-136	6/6/2017	#3746	Moderate	M	10 yrs	47.3204N -62.8597W GSL	No	No	NA	4/23/2017 (CCB)
	2	MARS2017-141	6/19/2017	#1402	Moderate	M	33 yrs	47.4423N -63.5820W GSL	Yes	Yes	7/29/2016	7/29/2016 (GSL)
	3	MARS2017-144	6/18/2017	#3190	Advanced	M	>17 yrs	47.7431N -63.3609W GSL	Yes	Yes	7/9/2017	4/14/2017 (CCB)
	4	MARS2017-143	6/21/2017	#3603	Fresh	F	11 yrs	48.2335N -63.04506W GSL	Yes	Yes	7/1/2017	4/23/2017 (SNE)
	5*	MARS2017-155	6/22/2017	#3512 (same as #11)	Moderate	F	12 yrs	47.1501N -62.4634W GSL	No	At-sea sampling	6/22/2017	4/24/2017 (CCB)
	6	MARS2017-142	6/23/2017	#1207	Moderate	M	>37 yrs	47.61545N -63.22338W GSL	Yes	Yes	6/30/2017	6/6/2014 (GSC)
	7	MARS2017-145	7/6/2017	Unknown	Moderate	M	Unknown	47.5832N -62.6267W GSL	Yes	Yes	7/10/2017	
	8	MARS2017-14-6	7/19/2017	#2140	Fresh	M	>26 yrs	47.91702N -63.90859W GSL	Yes	Yes	7/21/2017	6/27/2017 (GSL)
	9^	MARS2017-312	9/15/2017	#4504	Moderate	F	2 yrs	48.1503N -63.5009W GSL	Yes	Yes	9/19/2017	8/7/2015 (GSL)
Beached Carcasses	10+	M20170095	7/21/2017	Unknown	Advanced	M	Unknown	49.3485N -58.235W Church Point, Newfoundland	No	Limited shore sampling	7/29/2017	
	11*	F20170096	7/24/2017	#3512 (same as #5)	Advanced	F	As Above (#5)	49.0903N -58.425W Cedar Cove, Newfoundland	No	Limited shore sampling	7/29/2017	As Above (#5)
	12+	M20170094	7/27/2017	Unknown	Advanced	M	Unknown	47.6206N -59.298W Cape Ray, Newfoundland	No	Limited shore sampling	7/30/2017	
	13+	F20170093	7/30/2017	#4111 (based on genetics)	Advanced	F	6 yrs	50.4263N -57.499W River of Ponds, Newfoundland	No	Limited shore sampling	8/3/2017	9/16/2016 (BOF)

~ CCB = Cape Cod Bay, GSL = Gulf of St. Lawrence, GSC = Great South Channel, SNE = southern New England, BOF = Bay of Fundy

* Genetic analysis confirmed Whale #11 was Whale #5 (see Annex 4)

+ Genetic analyses confirmed that none of the remaining NL carcasses were Whale #1 (see Annex 4)

^ At this time, the genetic results are pending

Live Whale Incidents

Between July 5th and August 28th, five entangled right whales were observed (Table 2). Two of these animals were disentangled by a team lead by Joe Howlett with the Campobello Whale Rescue Team aboard a DFO Shippagan Fast Response Craft (FRC) while a third shed the gear on its own. A response was not mounted for the remaining two animals and their fates are currently unknown. It has been confirmed that the dead, entangled whale reported on September 15th (Whale #9) is not one of these two animals. Additional sighting and life history information as well as images are provided in Annex 2b.

Of the five entanglements, three of the individuals were male, one female and one unknown. Of the known and catalogued individuals (n=4), they ranged in age from 6 to 33 years old. Again, as with the dead animals, most of the individuals had been previously sighted in many of the other core habitats in the US and Canada, including the GSL. Additional information, including the last known sighting prior to entanglement, if known, is provided in Table 2 (additional details and images are provided in Annex 2b).

Images of the entangled whales and the gear examined from the disentangled animals showed the involvement of snow crab fishing gear in at least four of the whales. Gear that was removed from the first entangled animal was partially retained (i.e., some rope and buoys). Gear from the second animal was lost during the disentanglement.

Table 2. Live entanglements of North Atlantic right whales in the Gulf of St. Lawrence in 2017.

Field #	Response Network Identification Code (if exist)	Date observed entangled	NEAq Catalog ID	Sex	Age	Location	Last sighting prior to entanglement+	Documented ?	Fishing Gear Identity (if known)	Disentangled? (date)	Subsequent sighting date and status
1	MARS2017-175	7/5/2017	Unknown (BK01BOF2015*)	Unk.	Unk.	47.5167N --63.7117W	7/7/2015 (BOF)	Yes	Snow crab gear	Yes	7/29/2017 Gear Free
2	MARS2017-179	7/8/2017	1317	M	33 yrs	47.7133N -64.0283W	4/23/2017 (CCB)	NA	Snow crab gear	No – could not relocate animal	7/25/2017 Gear Shed
3	MARS2017-185	7/9/2017	4123	M	6 yrs	47.7447N -64.0187W	7/8/2017 (GSL)	Yes	Snow crab gear	Yes (7/10/2017)	7/29/2017 Gear Free
4	MARS2017-195	7/19/2017	4094	F	7 yrs	47.5733N -63.9900W	4/23/2017 (SNE)	Yes	Snow crab gear	No - response not permitted	Not resighted
5	MARS2017-264	8/28/2017	3245	M	15 yrs	48.5000N -63.6667W	8/25/2017 (GSL)	Yes	Unknown	No - response not permitted	10/29/2017 Status unknown

+ CCB = Cape Cod Bay, GSL = Gulf of St. Lawrence, SNE = southern New England, BOF = Bay of Fundy

* This individual has not been added to the Catalog at this time so only has a field ID number

Analysis - Synopsis of Necropsy Reports

Mortality of North Atlantic Right Whales (*Eubalaena glacialis*)
Southern Gulf of St. Lawrence, June-September 2017

Leads: Pierre-Yves Daoust[1] and Émilie L. Couture[2,3]

Other collaborators: Laura Bourque[1], Stéphane Lair[2], Benjamin Lamglait[2], Rozenn le Net[2], Stephen Raverty[4], and William McLellan[5].

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[3] Zoo de Granby, Granby, Québec
[4] Canadian Wildlife Health Cooperative / Réseau canadien pour la santé de la faune, British Columbia, Animal Health Centre, Animal Health Branch, British Columbia Ministry of Agriculture
[5] Biology and Marine Biology, University of North Carolina Wilmington

This section summarizes the necropsy reports completed on carcasses of seven North Atlantic right whales found dead in the southern Gulf of St. Lawrence in June, July and September 2017. Individual necropsy reports as well as results of sample analysis from EG#5 are provided in Annex 9.

Whale	Sex	Age (years)	Necropsy
EG#2	male	33	June 29, Norway, northwestern Prince Edward Island
EG#3	male	>17	July 9, l'Étang-du-Nord, Magdalen Islands, Québec
EG#4	female	11	July 1, Norway, northwestern Prince Edward Island
EG#6	male	>37	June 30, Norway, northwestern Prince Edward Island
EG#7	male	not identified	July 10, l'Étang-du-Nord, Magdalen Islands, Québec
EG#8	male	26	July 22, Miscou Island, New Brunswick
EG#9	Female	2	September 19, Miscou Island, New Brunswick

Note: The whale numbers above correspond to the numbers in Table 1 (e.g., EG#2 = Whale #2)

A minimal number of samples (skin, blubber, muscle, feces) were also collected at-sea on June 21st from the carcass of an eighth whale, EG#5 (female), which was subsequently lost and later found ashore in Cedar Cove, Newfoundland.

As is often the case with large whales, interpretation of observations made on the seven animals necropsied was impaired by advanced post-mortem decomposition and therefore

needed to be made with caution. With this consideration, the following final primary diagnoses were reached:

EG#2: Acute internal hemorrhage compatible with blunt trauma (suspected[1])
EG#3: Cause of death undetermined (very advanced post-mortem decomposition)
EG#4: Acute entanglement in fishing gear and subsequent drowning (probable)
EG#6: Acute internal hemorrhage compatible with blunt trauma (probable)
EG#7: Skull (maxilla, premaxilla) fracture due to blunt trauma (probable)
EG#8: Acute internal hemorrhage compatible with blunt trauma (suspected)
EG#9: Acute entanglement in fishing gear and subsequent drowning (probable)

[1] *In this document, the terms 'confirmed', 'probable' and 'suspected' were adapted from Moore et al. (2013).*

In contrast to domestic animals, investigation of causes of mortality in wild animals is also made more difficult by the complete lack of history surrounding the time of death. Such investigations are therefore best approached by a process of elimination whereby each of the more common causes of mortality normally recognized in individual species is systematically considered and either ruled out or retained, e.g., emaciation / starvation, toxicity, infectious disease, and physical injury.

Emaciation / starvation

Evaluation of body condition was based on blubber thickness in mid-dorsal and/or mid-ventral regions (W.A. McLellan, University of North Carolina at Wilmington, pers. comm.; Miller et al. 2011):

Whale	Blubber, mid-dorsal region (cm)	Blubber, mid-ventral region (cm)
EG#2		23
EG#3	12	15.5
EG#4	7.5	
EG#6		20.5
EG#7	17	12
EG#8	20	20.5
EG#9	9.2	11.3

Based on these measurements and on the time of year when the whales were examined, it was concluded that three animals had seasonally robust blubber thickness (EG#2, EG#6, and

EG#8), three had relatively thin blubber thickness (EG#3, EG#9 [both in a particularly severe state of decomposition] and EG#7)), and one had thin blubber thickness (EG#4).

EG#4 was considered in poor body condition, but based on the history available, its entanglement in fishing gear when found did not seem long enough to account for this. Therefore, the cause of its poor body condition could not be clearly explained. However, some lesions identified in the carcass suggested that this animal may have previously suffered from a more chronic entanglement. Three other whales had relatively thin blubber but were not emaciated, and the remaining three whales were in good body condition. Therefore, overall, emaciation / starvation does not appear to have been involved as a primary cause of death in this mortality event.

Poisoning by algal biotoxin

At the onset of this mortality event, suggestions were made about the possible involvement of an algal biotoxin to account for so many dead right whales in a relatively short period of time. However, this hypothesis can now be dismissed as a primary cause of death on the following grounds:

- Whereas algal biotoxins typically affect several animal groups, including mammals, birds and fish, as happened in the GSL in 2008 when paralytic shellfish toxins (PST) were involved (Starr et al. 2017), no unusual deaths besides those of right whales were observed in the Gulf prior to or during the mortality event.
- Samples of phytoplankton and zooplankton were collected in the southern GSL in early to mid-June, the timeframe of the first sighting of floating right whale carcasses. Phytoplankton was analyzed to determine the presence of potentially harmful species capable of producing PST or domoic acid. Zooplankton was analyzed for the presence of PST. Results did not support the involvement of biotoxins in this mortality event (Annex 6).
- A total of 11 samples (stomach contents, intestinal contents, feces, liver, kidney) from six whales (including feces from EG#5) were tested for PST, domoic acid, and lipophilic shellfish toxins. None of these toxins were detected. (Natalie Berrigan, for Wade Rourke, Unit Supervisor - Toxins, Dartmouth Chemistry Laboratory, Canadian Food Inspection Agency, pers. comm.; results included in Individual Necropsy Reports)
- Scarratt (Annex 6) pointed out that exposure to sub-lethal levels of biotoxins may contribute to mortality of marine mammals by affecting their behaviour or mobility, thus increasing their susceptibility to negative human interactions such as collision with ships. In the present case, right whales may have been exposed to sub-lethal levels of biotoxins during their migration along the east coast of the US, where large blooms of some potentially harmful phytoplankton species were reported in late 2016 and during spring and summer 2017 (Annex 6). However, it would be surprising that several whales suffering the same fate in a relatively short period of time be all chronically affected by biotoxins and, again, no toxins were detected in the samples collected at necropsy.

Infectious disease

The possibility of an infectious disease being involved in the death of five of the seven whales, either directly by causing death or indirectly by weakening them and making them more susceptible to other pathological processes such as trauma, cannot be ruled out but is unlikely. The main organs that are often affected by an infectious disease, e.g., lungs, liver, kidneys, had either been expelled from the thoracic and abdominal cavities by internal pressure build-up generated by post-mortem decomposition or were so decomposed that no ancillary test such as histology or microbiology could be used to detect any trace of infection. (Only EG#2 had some changes on surface of its tongue and inner surface of its lips that could raise the prospect of an underlying viral infection of undetermined clinical significance. However, because of post-mortem decomposition, none of these changes could be confirmed as pathological on histology.)

Nonetheless, involvement of an infectious disease in this mortality event is unlikely, based on what is known of the characteristic behaviour of a pathogen in a host population. The population of North Atlantic right whales being at a very low density, animals are generally broadly dispersed, thus providing very limited opportunities for a pathogen of heightened virulence, originating either from within this population or from other marine mammals in the region, to affect a relatively large number of animals in a relatively short period of time. Moreover, no lesion suggestive of an infectious / inflammatory process, such as unusual discolouration, unusual masses, or presence of suppuration, was seen in organs still present and recognizable in some of these whales at necropsy.

Entanglement in fishing gear

Entanglement in fishing gear has been identified as one of the leading causes of mortality in North Atlantic right whales (Knowlton et al. 2012). The carcasses of two of the seven whales necropsied (EG#4 and EG#9) were entangled in fishing gear when retrieved. The history available on EG#4 suggested that it had not been entangled for more than 8 days. However, this animal was considered thin, and it bore scars around the insertions of both flippers that were compatible with a previous chronic entanglement in fishing gear. Recent analyses on the effects of snow crab gear entanglement in North Atlantic right whales demonstrate that the extreme weight of snow crab gear inflicts debilitating drag forces upon even healthy individuals. It is therefore possible that EG#4 was unable to carry the final set of gear it encountered (identified at the time of necropsy) and subsequently drowned, a conclusion reinforced by its previously emaciated and thus weakened state. Details on likely timeline and gear involved are provided in the section on “Analysis - Gear Entanglements EG#4 and EG#9” and in Annex 7a&b.

EG#9, also entangled in snow crab fishing gear when retrieved, was only 2 years old and the smallest of the seven whales examined. The gear was attached to a large snow crab pot and, considering the heavy weight of the gear in relation to the relatively small size of this animal, it is therefore conceivable that it also drowned following entanglement. Details on gear involved provided in the section on “Analysis- Gear Entanglements EG#4 and EG#9” and in Annex 7c.

In addition, another five, alive, whales were found entangled in fishing gear in the southern GSL in summer 2017, thus indicating that this type of negative human interaction represents a substantial threat to this species in that region.

Interestingly, careful external examination of the five other carcasses presented in this synopsis revealed the presence of superficial linear scars, some in the head region, others along the peduncle, at least some of which suggested previous entanglement in ropes. This was not unexpected since, according to Knowlton et al. (2012), 82.9% of North Atlantic right whales have been entangled at least once in their life and, on average, 25.9% of adequately photographed animals acquired new wounds or scars each year.

Trauma

Trauma caused by human interaction, particularly vessel collision, has been a major cause of mortality in the population of NARWs (Laist et al. 2001; Moore et al. 2004). Campbell-Malone et al. (2008) identified two types of trauma from vessel collision: sharp, such as caused by propellers and rudders, usually leaving obvious external evidence of injury, and blunt, when the animal is struck by the hull of a vessel, often with little external evidence of injury due to the thick blubber which absorbs some of the impact.

No external evidence of injury was seen in EG#2, EG#3, EG#6, and EG#8. However, some lacerations were noted in the mandible and rostrum of EG#7. This whale's rostrum was severely damaged and had lost most of its bony structures. In contrast, rostral bones were still present in EG#3 and EG#9, the two most decomposed of all seven carcasses. In EG#3, these bones were fractured at their caudal attachment to the skull, but the carcass had beached on its own and may have been moved around by the surf for a few days. The rostrum of EG#9, towed to shore for necropsy, was completely intact. These observations led us to believe that the rostrum of EG#7 could have sustained a severe injury, thus lacerating the intraoral rete, an elaborate network of blood vessels thought to have a thermoregulatory function (Ford and Kraus 1992), and causing fatal blood loss (washed out by the sea) and also resulting in eventual exteriorization of the rostral bones. The fragile nature of the rostrum would have resulted in external evidence of injury in this animal despite the likely blunt nature of the trauma. A similar cause of death was described in one of the four right whales reported by Campbell-Malone et al. (2008) and in the Blunt Force Trauma section of Moore et al. (2013).

Observations were made in EG#2, EG#6, and EG#8 which were compatible with severe internal lesions resulting from blunt trauma. These observations consisted of: 1) presence of an abundant amount of dark brown to black putty-like material interpreted as clotted blood (cooked by internal heat and pressure generated by post-mortem decomposition) in the thoracic region (external to the thoracic cavity in EG#2 and within it in EG#6 and EG#8); 2) presence of similar material filling the occipital foramen (aperture of the skull through which the spinal cord extends into the vertebral canal) in EG#2 and EG#6; and 3) fracture of one or both middle/inner ear complexes (tympano-periotic bones) in EG#6 and EG#8, associated with the presence of black putty-like material in EG#6. Similar putty-like material was also found in some areas of the epaxial and hypaxial musculature in EG#7, and both middle/inner ear complexes of this whale were fractured at their base. These changes in the four whales were accompanied by an

accumulation of red-tinged fluid between blubber and underlying muscle mass and patchy areas of red discoloration of the blubber, of varied distribution among the whales. The latter changes could be construed as further suggestion of pre-mortem blunt trauma, although the possibility that at least some of them were post-mortem should not be ruled out. Importantly, the observations described above were not made in EG#4 and EG#9, the two entangled whales.

Assuming that the putty-like material did correspond to clotted blood, its presence free in body cavities could have resulted from tearing forces on internal organs and tissues (e.g., lungs, major blood vessels) caused by a blunt trauma. Importantly, it could also have resulted from tears in a very extensive network of blood vessels called “rete mirabile” (“wonderful net”). This network derives from the aorta and branches extensively within intercostal muscles in the dorsal region of the thoracic cavity of whales. From there, it extends into the spinal canal where it surrounds the spinal cord and continues to the brain, forming its main blood supply (Marshall 2002). Damage to the rete mirabile at the junction between skull and vertebral column would thus explain the abundant amount of clotted blood filling the foramen magnum. Interestingly, few of the descriptions of right whales that had presumably died from vessel collision mention the presence of putty-like material in internal cavities (Campbell-Malone et al. 2008; Moore et al. 2004).

No bone fractures clearly attributable to blunt trauma were seen in EG#2, EG#6 and EG#8, except possibly some involving the middle-inner ear complex on one or both sides in EG#6 and EG#8. Fractures of these parts of the skull were reported in some of the whales described by Moore et al. (2004) that had died from collision with a ship, but these were accompanied by obvious fractures in adjacent regions of the skull. It is also possible that these middle-inner ear complexes were dislodged or broken after death as the carcasses were pulled onshore, due to strong tension at the junction of the head and vertebral column. Regardless, death from internal hemorrhage caused by blunt trauma remains plausible even without the presence of bone fractures, considering the cushioning effect of the very thick blubber and the intrinsic flexibility of the ribs in a diving mammal.

EG#3, a very decomposed carcass, had multiple fractures of the skull, involving both middle-inner ear complexes and maxillary, premaxillary and occipital bones. This carcass had beached, in contrast to the six other carcasses which had been found at sea and towed to shore. Surf action on the beach may therefore have accounted for these multiple skull fractures. However, dark brown putty-like material suggestive of clotted blood completely filled the foramen magnum and brain case, raising the possibility that this whale had also suffered from blunt trauma.

Collision with a vessel would be the most plausible explanation for death from blunt trauma in a large whale at sea. Beyond this, however, there does not appear to be enough information in the scientific literature to help us determine the types of vessels that may have been involved in the death of some of these whales. Several factors, including the speed of the vessel, the configuration of its bow, and perhaps even the shape of the whales (e.g., the rotund shape of a right whale as compared to the relatively slender and streamlined shape of a rorqual such as a

blue whale or a fin whale) could influence the types of traumatic lesions, including presence or absence of bone fractures, in the injured animals.

Analysis of fecal glucocorticoids

The adrenal glands respond to stress by increasing production of glucocorticoids which are eventually excreted via bile into the intestine. Thus, levels of fecal glucocorticoids can be used as potential indicator of chronic stress (more than 2 days in NARWs, based on intestinal transit time in this species). These levels were found to match normal baseline values in all five whales from which fecal samples were available (EG#4, EG#5, EG#7, EG#8, EG#9), thus suggesting that these whales had died before an elevated response to stress could be reflected in a rise in fecal glucocorticoids (Annex 8). This result would be compatible with an acute death from blunt trauma, as suggested for EG#7 and EG#8, and from drowning following acute entanglement in fishing gear, as suggested for EG#9. However, it is at odds with some of the observations made in EG#4. This animal was thought to have also died from acute entanglement in fishing gear with subsequent drowning, but the entanglement could have lasted for up to 8 days. More importantly, this whale was in poor body condition and had scars around the insertions of both flippers that were compatible with a previous chronic entanglement in fishing gear. The possibility that the samples collected from EG#4, EG#7 and EG#8 were not good representatives of fecal material cannot be ruled out. However, material from EG#5 was collected at sea directly from its anus, with no potential for contamination by other components of the carcass, and was considered a reliable fecal sample, thus suggesting an acute death in this animal. Of all the putative fecal samples collected, that from EG#9 was the most reminiscent of actual fecal pellets, and results of analysis of fecal glucocorticoids in this animal should also be reliable.

Time after death

A reliable estimate of the interval between death and necropsy would be a very important addition to a necropsy report. Unfortunately, the many variables influencing the rate of decomposition of an animal greatly complicate this task, especially in a large whale. The large mass of right whales and their very thick blubber have a major impact on heat dissipation of the carcass following death (McLellan et al. 2004), while ambient water temperatures may also have a significant influence. Compared with smaller cetaceans, internal temperature increases rapidly after death in these large whales, and deeper body tissues may therefore become unrecognizable in a short period of time (McLellan et al. 2004). Organs may also be expelled through the mouth as a result of internal pressure buildup associated with internal decomposition. All these variables render precise determination of the time of death impossible and also complicate the use of codes of post-mortem decomposition established for smaller cetaceans (Geraci and Lounsbury 2005).

Among the seven whales necropsied, the interval before first sighting of the carcass at sea and necropsy varied between 2 and 21 days. EG#8 had the shortest interval (2 days). It was still covered with skin when sighted at sea and still had its baleen plates when brought ashore, but large sheets of the skin had started to peel off, some internal organs, including the heart, were already missing, and a large portion of the larynx was hanging from the mouth, thus indicating

very rapid post-mortem decomposition. Nonetheless, based on these combined observations, it is doubtful that this whale had been dead for more than several days (possibly 1 week to 10 days) when first sighted.

Based on the photos available, at least three of the other carcasses (EG#3, EG#4, EG#6) were also still covered with skin when first sighted at sea. EG#3 had the longest interval (21 days) between first sighting and necropsy and was also the most decomposed. Allowing for a maximum of 10 days for the skin to start sloughing in relatively warm ambient water temperature, this suggests that an interval of roughly a month after death would have been sufficient to result in this very advanced state of decomposition. If these assumptions are correct, the earliest carcass sighted at sea, EG#2 on June 19, had already started to lose some of its skin at that time and had lost its baleen plates when brought ashore on June 29 but was clearly not as decomposed as EG#3, and thus may have died at the earliest in early June.

Necropsy considerations

Necropsies of large whales are always fraught with challenges, the main one being rapid post-mortem decomposition due to the intense heat and pressure generated inside the carcass. As a result, potentially significant pathological changes either disappear or are masked or transformed by processes of post-mortem decomposition. We were conscious of this in our circumspect interpretation of the observations made during the necropsy of the seven right whales and of results of subsequent analyses.

We believe that trauma, presumably caused by collision with vessels, was the most likely cause of death in four of the seven whales examined, and that entanglement in fishing gear represented another potentially fatal threat based on the death of two entangled whales and observations of live entangled animals. Post-mortem decomposition hampered interpretation of the observations in EG#3, which precluded determination of a diagnosis. We have provided, in individual necropsy reports on these seven whales, all the information that could be gathered on these animals, either at the time of necropsy or during subsequent analyses (Annex 9). Critical review of these reports by colleagues in veterinary and biological sciences, as well as discussion on alternative hypotheses are welcome.

A quick response to such mortality events is critical. Literally, every day counts as severe post-mortem decomposition has already occurred three days after death of these large whales and any further delay results in gradual loss of organs through the mouth from internal pressure build-up. In this instance, once DFO decided to proceed with necropsy of the whales, the response to conduct the necropsies was prompt. The DFO response following the discovery of EG#8 was particularly impressive, as the carcass was pulled ashore the next day and the necropsy was completed on the subsequent day. Necropsy of a large whale, let alone of up to three at a given site, requires major logistical arrangements, such as provision of equipment and heavy machinery, travel and accommodations, food and water. This was done impeccably for all seven animals, which facilitated the necropsy work immensely. It is worth considering a similar response to the discovery of carcasses of other species of large whales, especially when these carcasses are found roughly in the same area and at roughly the same time as those of a critically endangered species like the North Atlantic right whale.

Observations made on these carcasses provide some very important information that would help to understand the cause of a major, if not catastrophic, mortality event like this one. This is particularly important as the animals were located in an area of Canada where there has been, to date, very limited effort to understand and mitigate threats from human activities.

Analysis - Gear Entanglements EG#4 and EG#9

EG #4: Catalog 3603, "Starboard", 1 July 2017

On June 21st, a dead female right whale was discovered entangled and anchored in fishing gear (Whale #4). Upon examination, it was confirmed that the gear involved was commercial snow crab fishing gear.

The gear was carefully removed and examined when the animal was brought ashore for necropsy on July 1st, 2017, to understand which gear and how many sets were involved and to gain an understanding of how the animal was entangled. DFO C&P also investigated the source of the buoys found on the animal to gain an understanding of the timeline associated with the entanglement.

Timeline of entanglement

Based on C&P's discussions with fishers (Annex 7a), the timeline is as follows:

- Between June 12th and 16th: the initial entanglement in snow crab gear occurred in the western Gulf of St. Lawrence (Area 12 snow crab fishing area, Grid GW41)
- Between June 16th and 21st: the animal traveled approximately 8.8 nm from the first entanglement and became entangled in a second set of snow crab gear belonging to a second fisherman (Area 12 snow crab fishing area, 48.2342N, -63.0485W)
- June 21st: the dead, entangled animal was first observed by a NOAA Fisheries aerial survey team on 0.12 nm east of the final trap set location

Gear Involved in entanglement

Details regarding the various sightings of the carcass, the changes observed in the entangling gear and its position on the animal's body and the detailed documentation of the gear that was removed during the necropsy on July 1st are provided in Annex 7b.

The animal was entangled in multiple lines and buoys, and for a time, appeared to be anchored in place. Upon initial sighting, there were several taut lines extending from the carcass, potentially to traps below the surface, but a day later, they were no longer present. It is unclear how many traps (and thus, sets) of snow crab gear were involved in the entanglement. The fishers noted four traps at their last sighting on June 26th, whereas fisheries officers only noted two traps on their initial examination on June 24th (they later removed these two traps on June 29th to safely tow the animal for necropsy), although they noted there was a piece of cut rope on the animal when they retrieved it.

Prior to the commencement of the necropsy, the gear was carefully documented and removed from the carcass. The gear was laid out, inspected, photographed and tagged but was not taken apart in any way.

The gear remaining on the whale at the time of the necropsy consisted of 30.2 m of rope and two buoys. Line involved was in 3 segments: 1) approximately 21.8 m of 5/8" float rope, 2) approximately 3.7 m of 3/4" sink line and 3) approximately 4.5 m of 1/2" float rope.

Two buoys remained attached to the carcass when examined on the beach. One was an orange, Polyform LD-2 cylindrical shaped poly buoy while the other was a red, hard plastic cylindrical shaped buoy. There were two other buoys observed on the carcass while floating at sea: a large, white, spherical shaped poly buoy (estimated size=A4) and a large, orange, spherical shaped poly buoy (estimated size=A3). The Vessel Registration Number on these buoys was used by C&P to identify the owners of the gear. *Note: To respect privacy requirements, information that could be used to identify individual fish harvesters (e.g. VRN numbers) has been omitted from this report. The buoy numbers shown in Annexes are not specific to individuals.* Two fishermen were interviewed (as per the timeline above) but the Vessel Registration Number on a third buoy corresponded to an inactive licence. C&P suggested that the gear may have been reused without updating the identification. The origin of this gear could not be determined at this time.

At this time it is unclear what or how much gear was removed or fell off from the carcass prior to it being towed to shore. Based on photographs we know that the line and buoys that remained on the carcass at time of necropsy were a subset of the gear that was originally present.

EG #9: Catalog 4504, 19 Sept 2017

On Sept 15th, a dead female right whale was discovered entangled in fishing gear (Whale #9). Upon examination, it was confirmed that the gear involved was commercial snow crab fishing gear though DFO suggested the trap involved was an older style not typically used in 8-10 years.

The gear was carefully removed and examined when the animal was brought ashore for necropsy on Sept 19th, 2017. No gear was removed during the towing of this animal by the Canadian Coast Guard and DFO C&P.

Timeline of entanglement

DFO C&P onsite during the necropsy determined that the trap which was removed from the animal after towing it ashore did not currently have an active fishing tag. There were also no identifying buoys (either on the beach or at sea when towing commenced). As such, it was not possible to determine the timeline as to when the animal may have encountered the fishing gear or whether the gear was being actively fished at the time of encounter. Given the fishery closure which was implemented July 25th, 2017 and the lack of chronic entanglement scars associated with the current entanglement, it is unlikely the animal was carrying the gear since the active fishing season ended.

Gear Involved in entanglement

Details regarding the entangling gear and its position on the animal's body and the detailed documentation of the gear that was removed during the necropsy on Sept 15th are provided in Annex 7c.

The animal was entangled in a single rope comprised of 3 different kinds of rope (tricolour, yellow and green ropes) spliced together. There was a single snow crab trap attached to the tricolour rope which was removed at the beach to facilitate bringing the animal ashore.

Prior to the commencement of the necropsy, the gear was carefully documented and removed from the carcass. The gear was laid out, inspected, photographed and tagged but was not taken apart in any way except for a few cuts to facilitate its removal from the carcass.

The gear remaining on the whale at the time of the necropsy consisted of ~152.09 m of 3 kinds of rope that were spliced into one length of rope and one snow crab trap. The three lines involved were: 1) ~54.81 m of 3/4" 3-strand tricolor (red, white and blue) rope, 2) ~62.32 m of 7/8" 3-strand yellow rope and 3) ~34.96 m of 3/24" 3-strand green rope. A 6-8' older style trap was attached to the end of the tricolour rope. DFO C&P stated this was an older-style trap which had not regularly been used for 8-10 years. There was no active crab tag on the trap, but an older tag was present (tag was in French only: 088 MPO Crabe).

At this time, it is not known whether the gear was being actively fished (though an active fishing tag was missing from the trap), was derelict (i.e., ghost gear) or there was some other explanation. The presence of fairly new segments of rope (yellow and green) and the lack of fouling suggest this was not gear that had been lost for a long period of time (i.e., old ghost gear).

Whale #4 and #9 entanglement synopsis

Whale #4 and #9, Catalog #3603 and #4504, respectively, were the 4th and 12th of twelve right whale carcasses discovered in the Gulf between early June and mid-September.

The gears attached to both animals were confirmed by DFO C&P to be from the commercial snow crab fishery.

All gear examined during the necropsies has been bagged in its original configuration and retained for future examination by gear experts from DFO or other agencies/stakeholders. Any gear removed from the animal to facilitate towing was retained by DFO.

Discussion

The necropsy findings in four of seven whales were compatible with acute death associated with trauma, likely caused by vessel collision, while two were considered to have died from acute entanglement with subsequent drowning. There were no indications that starvation, infectious disease or biotoxins played a role as primary causes of the mortalities observed.

In addition to the necropsy investigations, the authors also determined there were no seismic surveys for oil and gas exploration authorized in the months prior to or during the time frame over which these incidents occurred in the GSL (DFO Fish Protection Program Gulf and Québec regions, National Energy Board, Canada-Nova Scotia Offshore Petroleum Board, and Canada-Newfoundland and Labrador Offshore Petroleum Board, pers. comm.). As well, there were no major marine development projects or blasting (DFO Fish Protection Program Gulf and Québec regions, pers. comm.).

Vessel collisions and entanglement in fishing gear are the two primary threats to NARWs, and results presented here are consistent with this knowledge.

A recent review of the effectiveness of recovery activities for NARWs in Canada indicates that while there have been several successful measures implemented to reduce the risk of vessel collisions, very little has been done to understand and address the threat from fishing activities (DFO, 2017a).

Mandatory re-routing of traffic lanes in the Bay of Fundy and a voluntary Area To Be Avoided have reduced the risk to right whales in those areas (Vanderlaan et al., 2008; Vanderlaan and Taggart, 2009), however, the risk of lethal collisions and injuries has not been eradicated, even in those areas but particularly not in new areas where whales are being more regularly observed such as the GSL.

The threat of entanglement in fishing gear continues to be an urgent concern for right whales. As discussed in DFO (2017a), efforts to date have largely been reactionary to animals which have become entangled (i.e., disentanglement efforts). While these activities may help an individual whale when it is reported and a response can be mounted, it is not a prevention measure per say, although it can aid in documenting the gear and nature of the entanglement. Few recovery activities focus on entanglement prevention (e.g., spatio-temporal closures) and mitigation (e.g., decreased breaking strength in rope). To date, in other areas of the right whale range, the efficacy of broad-based implemented measures has had limited success in reducing serious injury or lethal entanglements of large whales (e.g., weak links and use of rope with reduced breaking strength; Pace et al 2014). For the most part, mitigation measures have not been explored for use in Canadian fisheries. Significant knowledge gaps remain regarding the mechanism of entanglement and the level of threat associated with different types of fishing activities and the gear used.

The Recovery Strategy for NARWs described their sightings in the GSL as “rare” (DFO 2014). While the lack of sightings in previous years is likely attributable, in part, to lower intensity of surveillance and difficulty in tracking the whales, the 2015, 2016 and, especially, 2017 seasons would suggest that a large portion of the population can be present in the GSL. At the time of preparing this report, at least 114 individual right whales had been documented, through photo-identification, in the southern GSL in 2017 (as reported to DFO).

In 2017, the abundance of NARWs in the southern GSL coincided geospatially and temporally with various human activities, particularly vessel traffic and fishing operations.

Primary Human Activities in the Gulf of St. Lawrence: vessel traffic and fishing

The marine transportation industry in the GSL is a major economic and socioeconomic function that contributes to five provincial economies in Canada. The GSL is a major shipping corridor which serves 15 major international ports and 50 regional ports. In 2016, more than 7 billion dollars in direct Canadian trade flowed through this system. In addition, ferry services in the GSL consist of various routes that meet the transportation needs of residents and non-residents, and cruise ship activity in the GSL is a growing industry comprised of primarily two markets: Canada/New England and Europe. [https://www.tc.gc.ca/eng/policy/transportation-canada-2016.html#atlantic-corridor].

Commercial fishing activity in the Gulf also represents a major contributor to the adjacent provincial economies. It is comprised of a diversity of resources including shellfish (i.e., lobster, crab, and shrimp), groundfish (i.e., cod, Greenland turbot and American Plaice), pelagic (i.e., herring, mackerel, tuna) and other smaller marine fisheries (i.e., marine plants and seals). The southern GSL (south of the Laurentian Channel) represents less than 1% of Canada’s marine waters yet accounts for 15% of the total catch value of Canadian fisheries (http://www.glf.dfo-mpo.gc.ca/Gulf/About-Us). The western side of the southern GSL was also the highest area of NARW concentration in 2017.

Please note: information presented below on the occurrence of fishing and shipping activities in the GSL is meant to provide context as to what was happening regarding these activities at the time the whales were present and the incidents occurred. No analysis with regards to spatio-temporal overlap of the whales and these human activities nor the risk of an incident occurring or injury/mortality resulting was conducted.

Vessel traffic and collisions

“On a per capita basis the North Atlantic right whale is more prone to vessel strikes than all other large whale species (Vanderlaan and Taggart 2007) and vessel strikes have been documented throughout most of the North Atlantic right whale migratory range (Kraus and Rolland 2007, van der Hoop et al. 2013)” [DFO 2017a].

In the GSL, there are in the order of several thousands of vessel transits per year through the area which was frequented by NARWs in 2017. For illustration purposes only, information on vessel traffic, number of unique vessels, and median vessel speed (speed over ground [SOG]) in the GSL from May to July 2017 is shown in Figures 5, 6, and 7, respectively. These figures draw on Satellite-Automatic Identification System (AIS) data provided by exactEarth Ltd. (2017) in partnership with MEOPAR (C. Hilliard) and MEOPAR-WHaLE (C.T. Taggart).

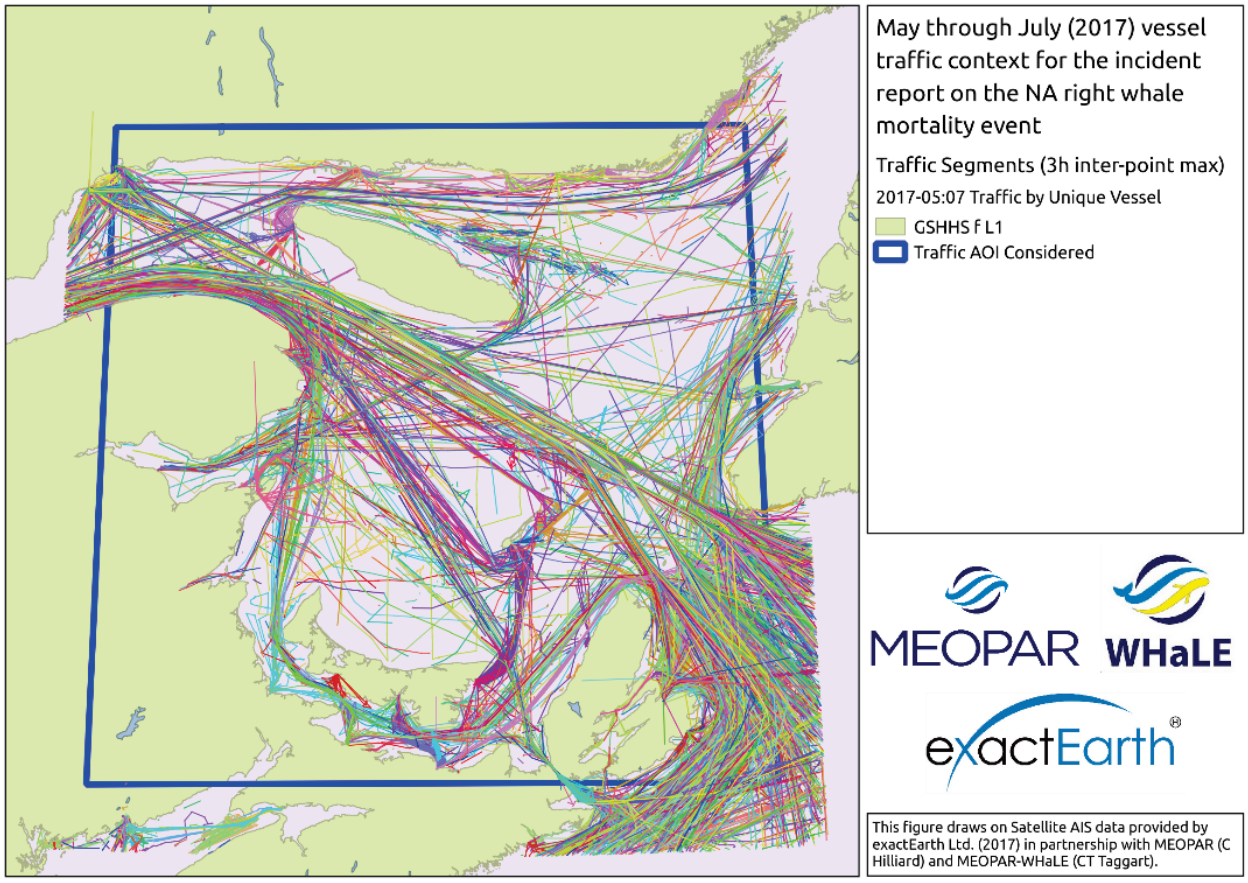

Figure 5. Satellite-AIS class-A and -B unique vessel traffic segments linearly interpolated to no more than 3 hours between AIS reports. Data have not been filtered for zeros or anomalous AIS messages (e.g., geolocation, speed, etc.).

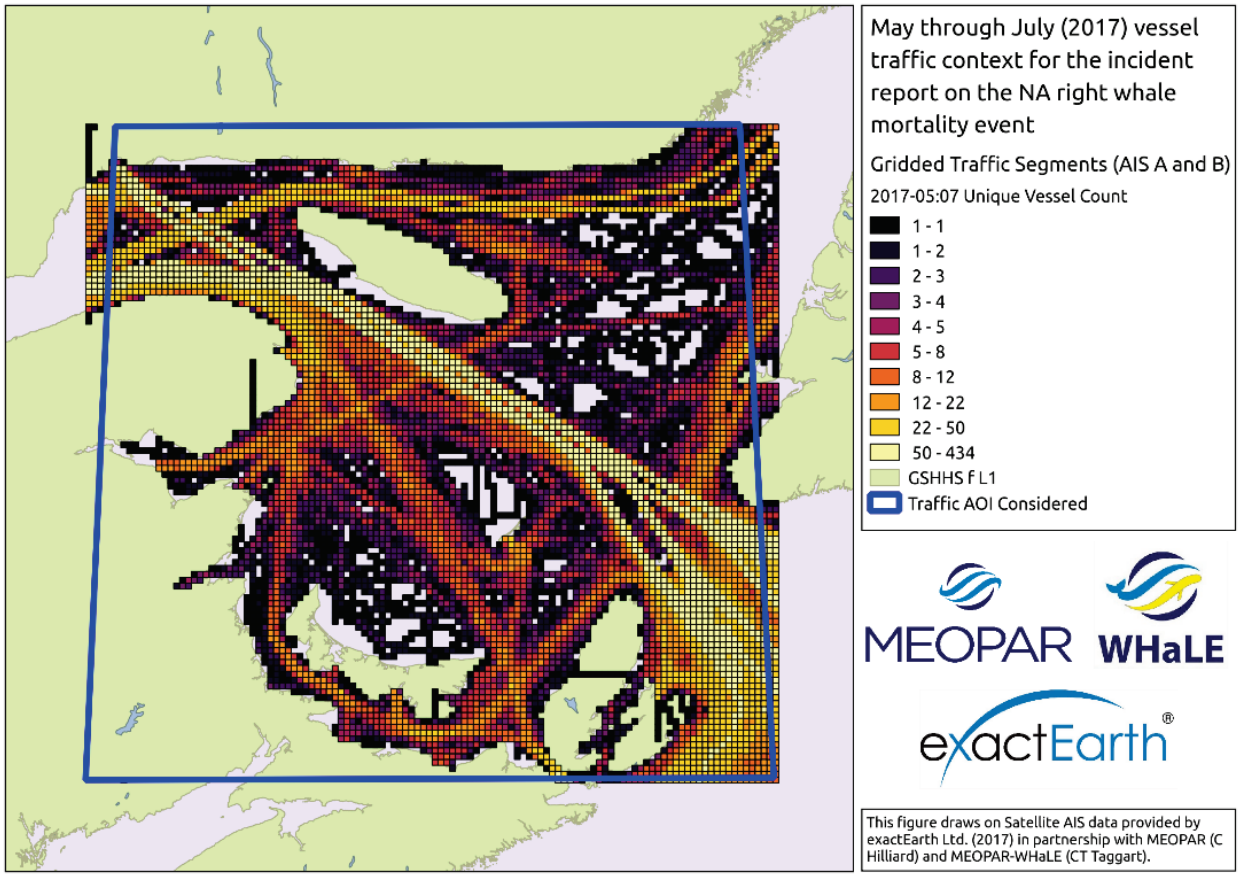

Figure 6. Total number of unique vessels per 5 km grid-cell from traffic segments over the period May through July 2017. Data have not been filtered for zeros or anomalous AIS messages (e.g., geolocation, speed, etc.).

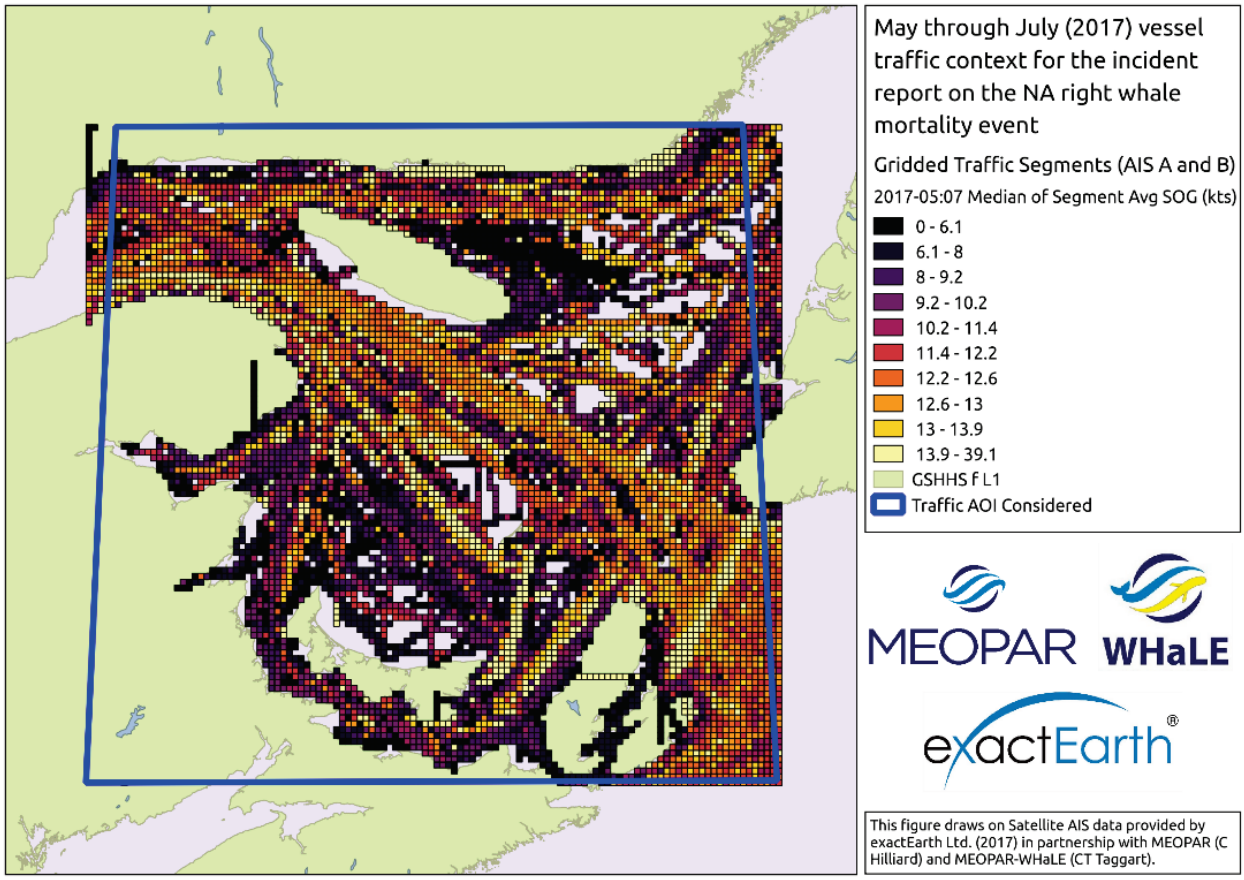

Figure 7. Cell-specific median SOG (knots) derived from unique class-A and -B average vessel speed segments resolved using 5 km grid-cells. Data have not been filtered for zeros or anomalous AIS messages (e.g., geolocation, speed, etc.).

There are no indications that vessel traffic in 2017 was significantly different than 2016 or previous years nor that pattern of use deviated from previously observed. At this time, we do not know the specific time when collisions occurred nor exactly where, though the hindcasting does suggest it was most likely in the western portion of the southern GSL.

Further analyses will be critical to understand what factors contributed to the large number of right whale deaths by vessels in 2017 (e.g., change in whale or vessel distribution, aspects of right whale behaviour at the time making them more susceptible to vessel collisions). As well, to ensure the risk of vessel collisions occurring in the future is minimized or eliminated, enhanced efforts and support of research regarding the whales, risk from human activities and avoidance and mitigation measures are needed.

Fishing activity and entanglements

"*83% of the population shows scarring from fishing gear, and the rate of serious entanglement detected over 30 years has increased significantly*" (Knowlton at al, 2012).

For illustration purposes only, data from the Vessel Monitoring System (VMS) is used as a proxy for fishing activity distribution from June 4th to July 1st (Figure 8). Additional data were not available at the time of report preparation. [Note: This map does not represent a detailed analysis and does not depict a complete assessment of daily fishing in the GSL throughout the annual cycle for different fishing fleets, length classes, and sailing speeds.]

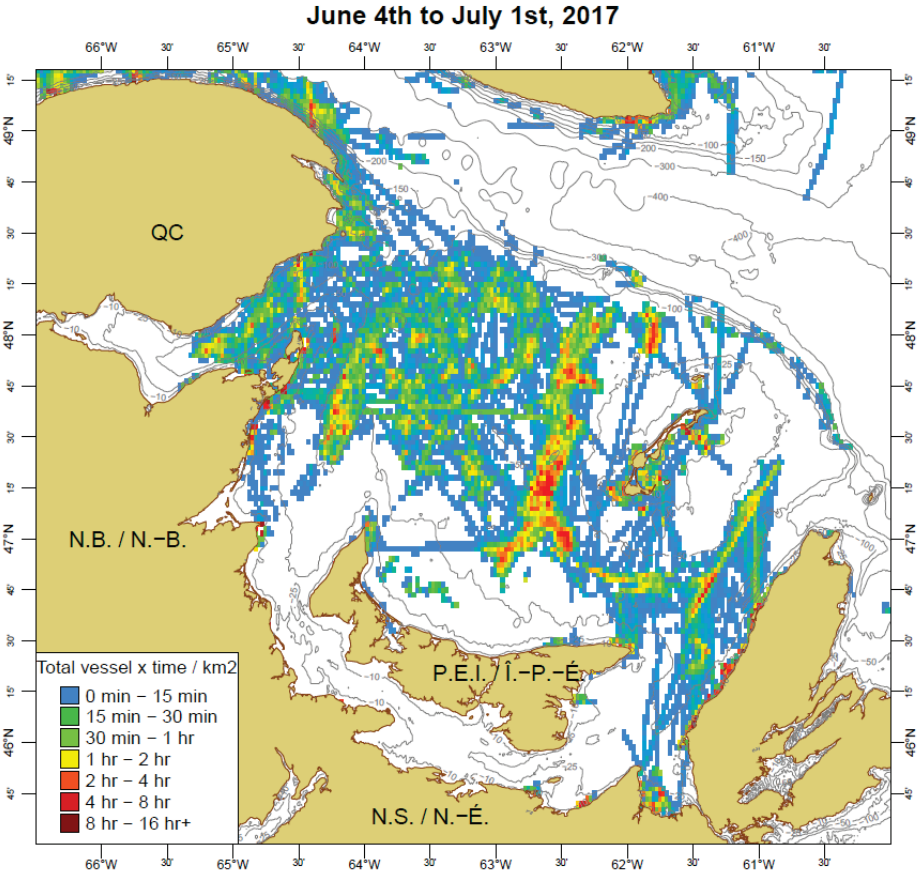

Figure 8. Fishing intensity plotted based on VMS data where speed was less than 6 knots (indicating vessel was engaged in fishing activities versus steaming). The snow crab fishery is the primary fishing activity during this time period. Vessel activity is presented as the total vessel-time (in minutes or hours) spent in each km^2 for the month (DFO, unpublished data).

In the GSL, snow crab fishing gear was implicated in two observed NARW mortalities (EG#4 and EG#9) as well as four of the five observed entanglements of free-swimming animals. In 2017, the snow crab fishery had an exceptional increase in the quota due to a peak in abundance of crab, an increase of 101% compared to 2016 (DFO 2017b). Although access to the fishery is limited and trap numbers are constrained by licence conditions, the overall

intensity of the fishing activity (e.g., traps deployed; length of deployment) increased significantly and extended over a longer period than in typical years. That said, in general, fisheries practices and gear configuration are not considered to have changed significantly from previous years.

Overall, the distribution of NARWs observed in 2017 occurred in areas where snow crab as well as several other fisheries occur and therefore mitigation measures in each of these fisheries should be considered. As with the mortalities due to vessels, we do not specifically understand what factors contributed to the large number of right whale deaths by fishing gear entanglement in 2017. Further analysis is needed to understand the use of the GSL by NARWs and the risk from fishing operations, and adapt fishing strategies and implement measures accordingly.

Conclusion

This incident report represents the culmination of the necropsy findings and an initial description of the context in the GSL at the time when these mortalities occurred. The death of 12 individual right whales is an unsustainable and potentially catastrophic event for this endangered species; especially when annual calving rates vary substantially (e.g., only five newborn calves were observed in the last calving season).

While we conclude that vessel traffic and fishing contributed to the deaths of most of the animals examined, we can only speculate as to exactly why they may have occurred. There are likely a combination of factors which contributed to the increased NARW mortality and their subsequent discovery including:

1. NARW abundance increased in the GSL,
2. NARW exposure to human-activities increased in the GSL,
3. Carcasses were more apt to be discovered as surveillance and survey efforts increased.

Given the severity and complexity of this mortality event, we expect that many more detailed analyses will be required to further explore the threats to NARWs as well as any other underlying issues that might be contributing to the broader decline of the population.

Each necropsy which was performed represented a massive undertaking which required dozens of experts and supporting personnel to conduct effectively and thoroughly. Conducting seven complete necropsies was a monumental, yet extremely valuable undertaking that allowed responding pathologists to develop an extensive catalogue of lesions and post-mortem changes which will facilitate future necropsy responses should they be required. Each necropsy has contributed important insight into the causes of death of NARWs in a way that external observations alone would have never provided. That said, the timely discovery of carcasses, rapid decision to perform a necropsy, towing to shore, and mobilization of the field material are critical to learning as much as possible from a carcass given that decomposition sets in rapidly.

Finally, this report confirms that vessel strikes and fishing-gear entanglement continue to be the key threats to the recovery of NARWs. Again, thorough analyses of both these human impacts to the NARWs are expected to be undertaken in the coming months. Following these in-depth analyses, the development of risk-based models could be used to assess geospatial and temporal overlap of human interaction and NARWs in the GSL in order to support conservation actions and management decision around mitigation measures in the future.

Acknowledgments

In the Gulf of St. Lawrence, incidents of dead, entangled, or distressed marine mammals are reported to either the Marine Animal Response Society (MARS) for the Maritime Marine Animal Response Network (MMARN) in the southern Gulf of St. Lawrence or 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. In Newfoundland, reports are primarily reported to the Whale Release & Strandings program. All organizations work in cooperation with industry, federal agencies, other non-governmental organizations, scientists, and local communities to document all incidents of dead and distressed marine animals and have developed an effective response network to ensure a timely response to all incidents.

DFO personnel (primarily via the Marine Mammal Response Program), MARS, and GREMM/RQUMM facilitated the collaboration with the Canadian Wildlife Health Cooperative (CWHC) to conduct the necropsies. 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 Atlantic and Québec regional nodes of the CWHC participated in all seven of the necropsies conducted in Prince Edward Island, Québec, and New Brunswick in 2017.

We are extremely grateful for the incredible support we have received to conduct the necropsies, discuss the findings and prepare the report. Various colleagues (government, NGOs, academia) contributed to several components of the necropsy report and are listed in the document. In collaboration with the aforementioned network, many governments (municipal, provincial, federal, and international), Indigenous communities, non-government organizations, conservations groups, scientists, private citizens, and educational institutions have contributed to the efforts undertaken in response to the North Atlantic right whale mortality events of 2017. Many thanks to: Lennox Island First Nation, Elsipogtog First Nation, Esgenoopetitj First Nation, University of Prince Edward Island- Atlantic Veterinary College, Université de Montréal- Faculté de médecine vétérinaire, Granby Zoo, Canadian Coast Guard, British Columbia's Ministry of Agriculture and Lands- Animal Health Center/CWHC British Columbia, University of North Carolina Wilmington, Dalhousie University (Halifax and Truro campus), Trent University, New Brunswick Museum, Canadian Food Inspection Agency, Canadian Whale Institute, Marine Mammal Commission, Centre for Coastal Studies, Woods Hole Oceanographic Institution, National Oceanographic and Atmospheric Administration, Campobello Whale Rescue Team, National Air Surveillance Program (NASP)- Marine Aerial Reconnaissance Team (MART), Transport Canada, Environment and Climate Change Canada, Department of National Defense, Province of New Brunswick, Province of Prince Edward Island, Province of Québec – Magdalen Islands, Whale/MEOPAR and Dr. Christopher Taggart, Anderson Cabot Center for Ocean Life at the New England Aquarium, Mingan Island Cetacean Study, Florida Fish and Wildlife Conservation Commission, and the Nova Scotia Department of Natural Resources. MARS activities were partially supported by the Government of Canada via the Habitat Stewardship Program for Species at Risk.

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ANNEXES

Annex 1: Overview of right whale sightings in the Gulf of St. Lawrence- Draft report

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September 28, 2017

Historically, most of the right whale sightings in the Gulf of St. Lawrence have been opportunistic (e.g., from whale watch boats and pleasure craft), the majority of them have been seen in August, and they have mostly been found off the Gaspé Peninsula or Cape Breton. The only long-term survey effort in the Gulf has been by Mingan Island Cetacean Study (MICS) who have, for decades, surveyed the Jacques Cartier Strait north and west of Anticosti Island, Quebec where right whales have been seen periodically over the years (Figure 1a and b).

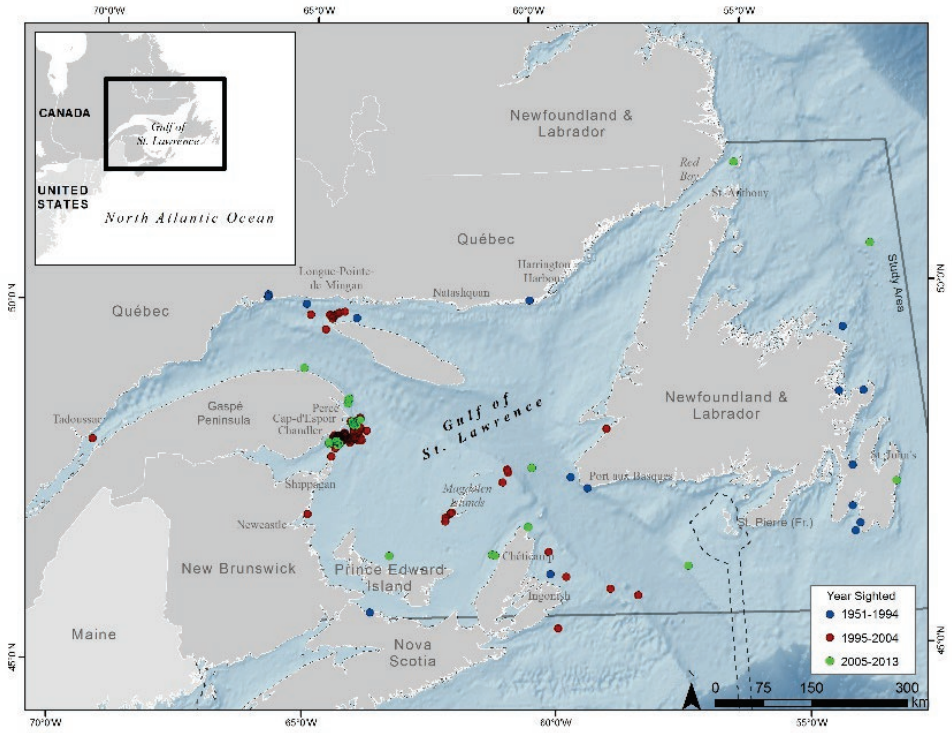


Figure 1a. Right whale sightings in and around the Gulf of St. Lawrence for 1951- 2013 (from Brown et al. 2013 biennial presentation- see abstract at the end of this report). Anticosti Island is the large island northeast of the Gaspé Peninsula. All maps by Brooke Hodge, Anderson Cabot Center for Ocean Life at the New England Aquarium.

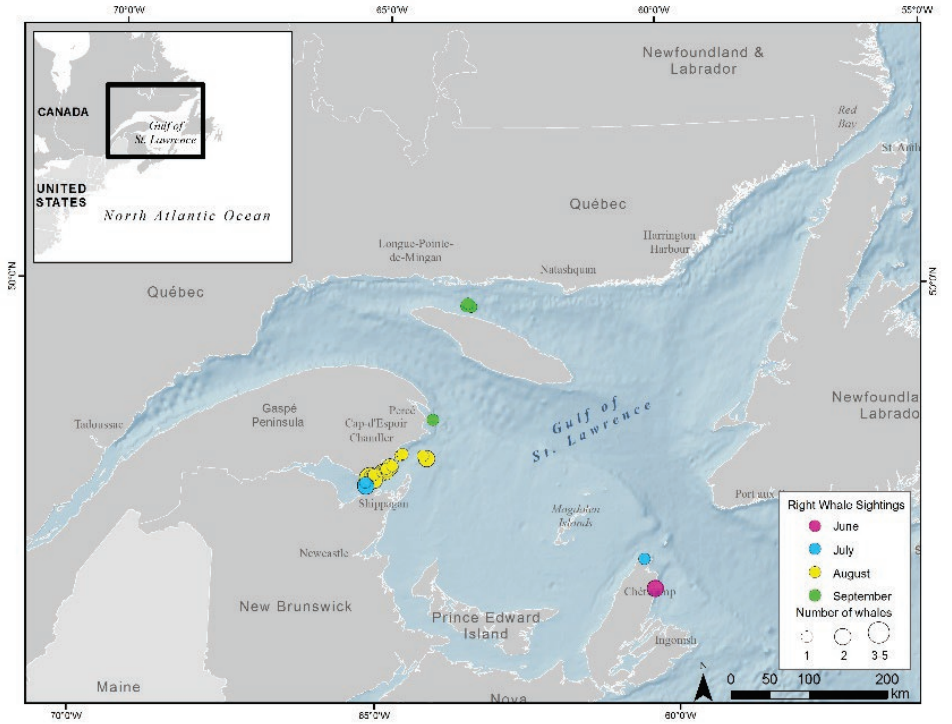


Figure 1b. Right whale sightings in the Gulf of St. Lawrence for 2014. The only dedicated effort was by MICS around Anticosti Island and the Gaspé Peninsula.

Sightings and effort 2015-2017

The dedicated effort over the last three years shows a different pattern (Figures 2 and 3) from that of the previous years. From 2015 to 2017*, the ongoing surveys by MICS were augmented by surveys by the New England Aquarium and Canadian Whale Institute (2015-2017), NOAA Fisheries (2015, 2017), and DFO (2016, 2017- only 2016 data included in this report) for a combined total of 14,349 km in 2015, 49,359 km in 2016, and 44,203 km in 2017. The methodology and focus of these survey efforts varied and were not all comparable.

** Please note, throughout this report, data for 2017 are preliminary. They have not been thoroughly proofed and do not capture ongoing effort and all sightings.*

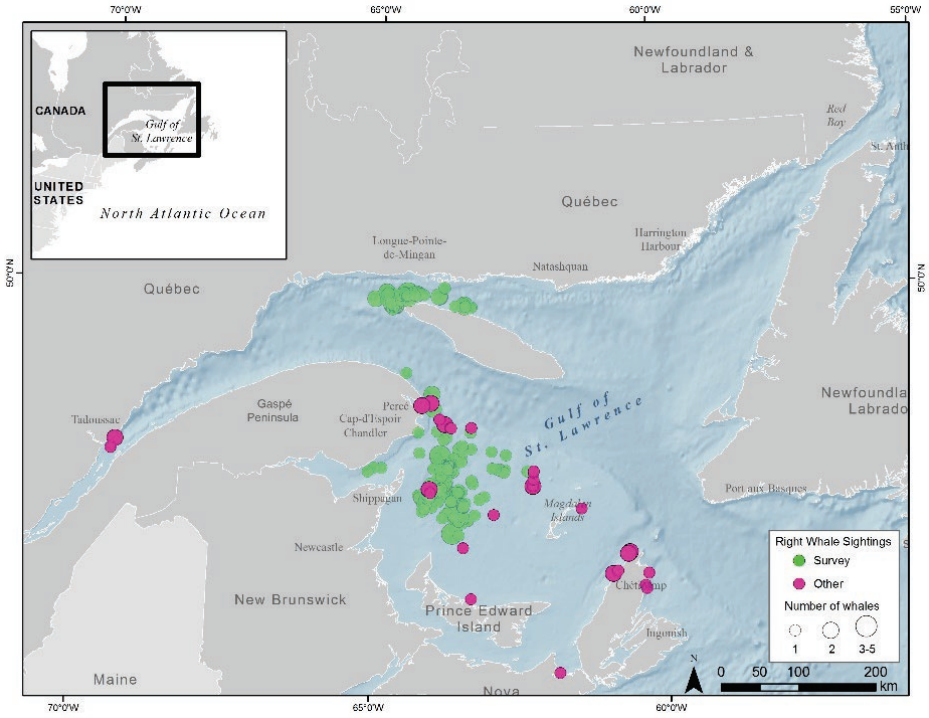
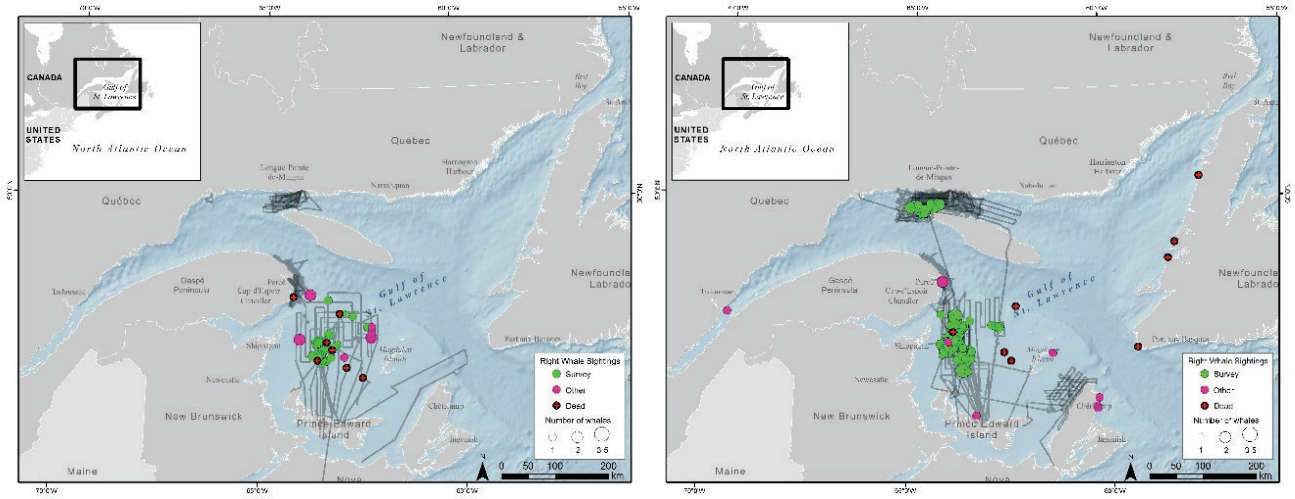


Figure 2. Right whale sightings in the Gulf of St. Lawrence for 2015-2017. Sightings from systematic right whale surveys are green, non-systematic sightings (including Transport Canada and DFO C&P flights) are pink. Sightings of dead whales are not shown. 2017 data not complete.

a. June

b. July



c. August

d. September

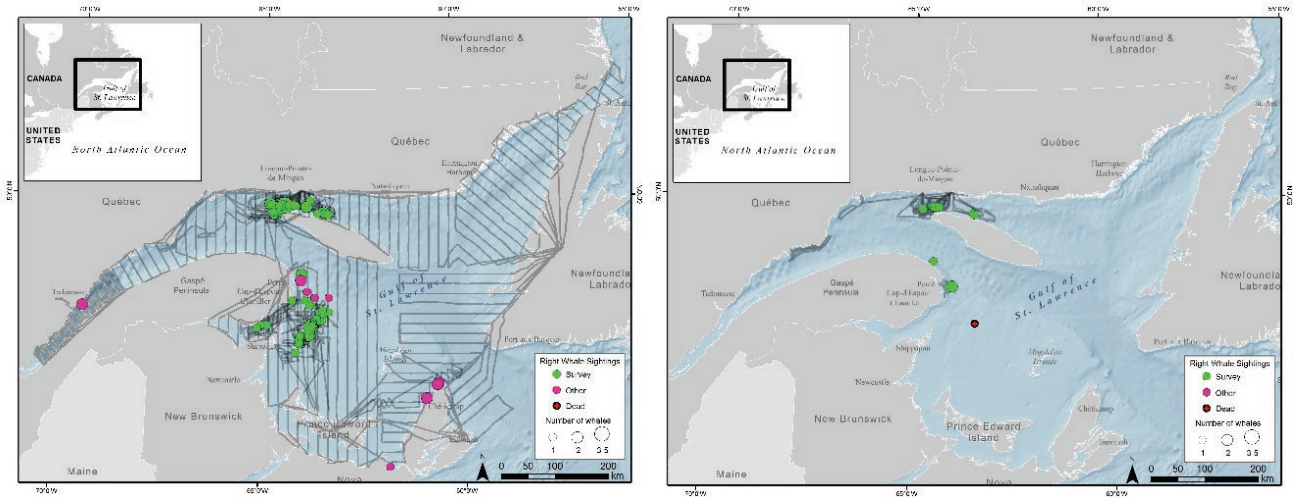


Figure 3. Monthly sightings of right whales in the Gulf of St. Lawrence from 2015 to 2017. Grey lines show survey effort. Data for 2017 not complete (the only aerial data are from NOAA Fisheries flights). The survey effort covering the entire Gulf in August (map c) was conducted by DFO in 2016. No right whales were seen in the Gulf from the DFO surveys.

The survey data show that right whales can be found in large numbers in June in a relatively unstudied area around the Shediac valley and Orpheline Trough east of Shippagan, New Brunswick. This area, hereafter referred to as the offshore area, is visited by few opportunistic platforms that relay sightings information so it is unknown if right whales have used this area in the past. There is some evidence that right whales in the offshore area move north and west as the season progresses; yet only one whale has been identified there and then later off Anticosti. It is unclear how early in the spring right whales arrive in the Gulf. There has only been survey effort in late June in one year in the offshore area, and in 2017, there was an opportunistic right whale sighting near this location as early as May reported from a DFO oceanographic vessel.

One hypothesis is that the concentrations of right whales that have been seen off the Gaspé Peninsula and in the Baie des Chaleurs in the late 1990's and early 2000's, and in 2014, represent whales that have moved from the offshore area into these more inshore waters where they are documented opportunistically.

Photo-analysis of individual right whales for 2015 and 2016 showed that more than 40 individuals were photo-documented each year - a minimum of 74 individuals combined or approximately 15% of the cataloged population. The sex ratio (38% female, 61% male, and 1% unknown) was no different than expected when compared to the cataloged population. Adults were marginally more prevalent than expected (85% adult, 15% juvenile). In 2016, nearly half of all living calves of the year were seen in the Gulf. The photo-analysis for 2017 is not complete, but preliminary analysis suggests that well over 100 right whales were seen; none of the five mother-calf pairs were seen.

So how unusual are the right whale sighting rates and distribution patterns for the Gulf in the past three years? During this period, there were at least 699 sightings of live right whales and all but 30 of those came from directed effort. The number and location of opportunistic sightings is not that unusual compared to many other pre-2015 years. In contrast, MICS has been doing thorough surveys for decades and generally see just one or two right whales in the years they see any (a maximum of 6). In 2016, MICS photographed at least 32 different individuals.

The number of right whales seen in 2017 was more than double that found in 2015 and 2016, but there was three times the amount of search effort in the offshore area than in the previous two years. It is possible that the increase in right whale sightings in 2017 is simply an artifact of the increase in the amount and focus of the survey effort; or it may represent a true shift in the distribution of right whales from their known critical habitat areas, or it could be a combination of these two factors. This report does not include any information from passive acoustic monitoring and those data should be combined with sightings data to better understand the timing and distribution of right whales in the Gulf. Using only data from this report, the only change we can say occurred with some confidence is that there were more right whales documented off Anticosti Island in 2016 than in previous years and they remained there for a longer period of time.

Abstract for Brown et al. 2013 Marine Mammal Biennial presentation

North Atlantic Right Whales in the Gulf of St. Lawrence: seasonal occurrence, implications for management and next steps to further species recovery.

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North Atlantic right whales are known to occur in eastern Canadian waters late spring through autumn. Two areas (Grand Manan and Roseway Basins) have been well studied, identified as critical habitat and conservation measures implemented to reduce the risk of vessel strikes. Right whales are also known to occur in the Gulf of St. Lawrence; however, their presence there is not well understood. From 1981 to 2012, there are 206 photographed right whale sightings of which 150 (73%) were matched to 42 individuals in the Right Whale Photo-identification catalog. The sex and age of the 150 sightings were 42% female, 56% males (2% unknown sex) and 75% adult, 8% juvenile, and 5% calves (12% unknown age). Most of the sightings (87%) were contributed between 1995 and 2005 by whale watch naturalists, researchers, and the public and the whales were located along the south and east coast of Gaspé Peninsula, Québec. These sightings likely vastly under-represent the numbers in the area as there has been virtually no dedicated survey effort. Despite the limited data, there are a number of interesting observations. Seventeen (40%) individuals were seen in more than two years (range 3-6 years), and 13 of the 42 (31%) whales were cows and six of those were seen with a calf. The minimum residency time for 11 whales with multiple sightings ranged from 10 to 52 days (n=13, mean = 23, S.D. = 10.6). The area near the Gaspé Peninsula likely serves as a nursery area/feeding ground for at least July through September. An important consideration is how to provide adequate protection of right whales given that threats known to affect species recovery in other critical habitat areas also exist in the Gulf of St. Lawrence (primarily vessel strikes and fishing gear entanglements) in addition to planned offshore energy exploration.

Annex 2a: Sighting, Incident, and Life History Information of Right Whale Mortality Incidents in Canadian Waters in 2017

Authors: Amy Knowlton[1], Philip Hamilton[1], Monica Zani[1], Marilyn Marx[1] and Tonya Wimmer[2].
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Additional information provided by: Allison Henry (Northeast Fisheries Science Center, NOAA), Brigid McKenna (Center for Coastal Studies) and Hilary Moors-Murphy (DFO-Science)

	Date	Latitude	Longitude	Area	Observer	Comments
Carcass #1						
Catalog #3746						
10 year old male						
Last seen alive	April 23, 2017	41.9677	-70.1250	Cape Cod Bay	Center for Coastal Studies	
Seen dead	June 6, 2017	47.3204	-62.8597	Gulf of St Lawrence	Canadian Coast Guard	Not retrieved
Subsequent carcass sightings	June 25, 2017	47.5776	-59.9620		NOAA Fisheries	
	June 30, 2017	47.6337	61.0738	Port-Aux-Basques, NFLD	NASP-TC/EC plane	
	July 5, 2017	48.1885	-60.3193	Gulf of St Lawrence	Fisheries and Oceans Canada	
Cause of death	Unknown - Not examined					
Field Code	MARS2017-136					
Other information	Previous sightings of #3746 have been in the southeast US where he was seen as a dependent calf, Cape Cod Bay, Bay of Fundy, Great South Channel, southern New England and Roseway Basin. There have been no previous sightings of #3746 in the GoSL.					
Genetic results	Comparison of 4 Newfoundland individuals (Whales #10-13) confirm that none of these individuals are Whale #1					

Photo:

	Date	Latitude	Longitude	Area	Observer	Comments
Carcass #2						
Catalog #1402, Glacier						
33 year old male						
Last seen alive	July 29, 2016	49.9011	-64.6697	Gulf of St Lawrence	Mingan Island Cetacean Study	Seen in GoSL between June 24-29, 2016
Seen dead	June 19, 2017	47.4423	-63.5820	Gulf of St Lawrence	Fisheries and Oceans Canada	
Subsequent carcass sightings	June 27, 2017	47.4318	62.4946	Gulf of St Lawrence	Canadian Coast Guard	Towing for necropsy
	June 29, 2017	47.0116	-64.0431	Norway, PEI	Canadian Wildlife Health Cooperative/ Marine Animal Response Society	Necropsy
Cause of death	Blunt trauma					
Field Code	MARS2017-141					
Other information	Previous sightings of #1402 have been in the Bay of Fundy, Roseway Basin, Great South Channel southeast US, and in 2002, he was seen from Aug 15-30 in the Gulf of St Lawrence at ~48.3/64.4 by GREMM.					
Genetic results	Genetics confirm this individual is Catalog #1402					

Photos:

Photo Credit: DFO C&P aerial surveillance

Photo Credit: Marine Animal Response Society

	Date	Latitude	Longitude	Area	Observer	Comments
Carcass #3						
Catalog #3190, Panama						
>17 year old male						
Last seen alive	April 14, 2017	41.8802	-70.3449	Cape Cod Bay	Center for Coastal Studies	
Seen dead	June 18, 2017	47.7431	-63.3609	Gulf of St Lawrence	Reported by snow crab fisherman	
Subsequent carcass sightings	June 21, 2017	47.8372	-62.8022	Gulf of St Lawrence	Fisheries and Oceans Canada	
	June 22, 2017	47.8029	-62.6818	Gulf of St Lawrence	NOAA Fisheries	Tagged (Argos 159294)
	June 27, 2017	47.4321	-62.4957	Gulf of St Lawrence	NOAA Fisheries	
	July 5, 2017	47.3458	-61.9541	Gulf of St Lawrence	NOAA Fisheries	
	July 9, 2017	47.3401	-61.9517	Magdalen Islands	Canadian Wildlife Health Cooperative	Necropsy
Cause of death	Unknown - advanced decomposition					
Field Code	MARS2017-144					
Other information	First seen in 2000 -unknown age. Previous sightings of #3190 have been in the southeast US, Cape Cod Bay/Mass Bay, Great South Channel, Bay of Fundy, Roseway Basin and the GoSL (2006 and 2016). #3190 has fathered at least one calf (#4160 in 2011).					
Genetic results	Genetics confirm this individual is Catalog #3190					

Photos:

Photo Credit: Canadian Coast Guard

Photo Credit: Réseau québécois d'urgences pour les mammifères marins

	Date	Latitude	Longitude	Area	Observer	Comments
Carcass #4						
Catalog #3603, Starboard						
11 year old female						
Last seen alive	April 23, 2017	41.10560	-70.5752	Southern New England	NOAA Fisheries	
Seen dead	June 21, 2017	48.2335	-63.04506	Gulf of St Lawrence	Fisheries and Oceans Canada	
Subsequent carcass sightings	June 22, 2017	48.22667	-63.03500	Gulf of St Lawrence	NOAA Fisheries	
	June 23, 2017	48.22533	-62.98533	Gulf of St Lawrence	NOAA Fisheries	
	June 27, 2017	48.19596	-62.93649	Gulf of St Lawrence	NOAA Fisheries	
	June 29, 2017	48.16473	-62.83529	Gulf of St Lawrence	NOAA Fisheries	
	July 1, 2017	47.0116	-64.0431	Norway, PEI	Canadian Wildlife Health Cooperative/ Marine Animal Response Society	Necropsy
Cause of death	Entanglement					
Field Code	MARS2017-143					
Other information	Previous sightings of #3603 have been in the southeast US (where she was first seen as a dependent calf but has visited there in other years), Cape Cod Bay/Mass Bay, Bay of Fundy, Great South Channel, southern New England, mid Atlantic, Jeffreys Ledge, Gulf of Maine, and Roseway Basin. Although she has not been observed with a calf, she was just entering reproductive age.					
Genetic results	Genetics confirm this individual is Catalog #3603					

Photos:

	Date	Latitude	Longitude	Area	Observer	Comments
Carcass #5						
Catalog #3512, Contrail						
12 year old female						
Last seen alive	April 24, 2017	41.7831	-70.4223	Cape Cod Bay	NOAA Fisheries	
Seen dead	June 22, 2017	47.1165	-62.3549	Gulf of St Lawrence	Canadian Wildlife Health Cooperative/ Marine Animal Response Society	Not retrieved - Limited sampling at sea
Subsequent carcass sightings	June 22, 2017	47.1501	-62.4634	Gulf of St Lawrence	NOAA Fisheries	
	June 25, 2017	46.9986	-61.7798	Gulf of St Lawrence	NOAA Fisheries	
	June 30, 2017	47.0997	-61.0968	Gulf of St Lawrence	Fisheries and Oceans Canada	
	July 4, 2017	47.3503	-60.7371	Gulf of St Lawrence	NASP-TC/EC plane	
	Confirmed to be Whale #11 - see for additional description					
Cause of death	Unknown					
Field Code	MARS2017-155					
Other information	Previous sightings of #3512 have been in the southeast US (where she was first seen as a dependent calf but has visited there in other years), Bay of Fundy, Great South Channel, mid Atlantic, Gulf of Maine, and Roseway Basin. Although she has not been observed with a calf, she was just entering reproductive age. There is some photographic evidence that this may match the carcass from Cedar Cove, Newfoundland sampled on July 29, 2017 (2017-0096). Genetic analysis pending					
Genetic results	Genetics confirm this individual is Catalog #3512					

Photos:

	Date	Latitude	Longitude	Area	Observer	Comments
Carcass #6						
Catalog #1207						
>37 year old male						
Last seen alive	June 6, 2014	42.2325	-68.7119	Great South Channel	NOAA Fisheries	
Seen dead	June 23, 2017	47.61545	-63.22338		NOAA Fisheries	
Subsequent carcass sightings	June 23, 2017	47.5963	-63.2070		Fisheries and Oceans Canada	
	June 26, 2017	47.70192	-63.08484		NOAA Fisheries	
	June 27, 2017	47.67208	-63.17062		NOAA Fisheries	
	June 29, 2017	47.43562	-63.61719		NOAA Fisheries	Under tow
	June 30, 2017	47.0116	-64.0431	Norway, PEI	Canadian Wildlife Health Cooperative/ Marine Animal Response Society	Necropsy
Cause of death	Blunt trauma					
Field Code	MARS2017-142					
Other information	Previous sightings of #1207 have been in southern New England, Great South Channel, Bay of Fundy, Roseway Basin, Jeffreys Ledge, Grand Manan Banks, Mass Bay/Cape Cod Bay, southeast US, Gulf of Maine, and GoSL (August 1998). #1207 has fathered at least two calves (#3545 in 2005 and #3893 in 2008).					
Genetic results	Genetics confirm this individual is Catalog #1207					

Photos:

	Date	Latitude	Longitude	Area	Observer	Comments
Carcass #7						
Unidentified						
Male						
Last seen alive	Unknown					
Seen dead	July 5, 2017	47.5832	-62.6267		Marine Security Enforcement Team Quebec	
Subsequent carcass sightings	July 8, 2017	47.7255	-61.8383		Fisheries and Oceans Canada	
	July 9, 2017				Canadian Coast Guard	Under tow
	July 10, 2017	47.3401	-61.9517	Magdalen Islands	Canadian Wildlife Health Cooperative	Necropsy
Cause of death	Blunt trauma					
Field Code	MARS2017-145					
Other information	None available					
Genetic results	Genetics did not confirm an identity for this individual					

Photos:

	Date	Latitude	Longitude	Area	Observer	Comments
Carcass #8						
Catalog #2140 - Peanut						
26 year old male						
Last seen alive	June 27, 2017	48.4514	-63.3270	Gulf of St Lawrence	NOAA Fisheries	
Seen dead	July 19, 2017	47.9170	-63.9086	Gulf of St Lawrence	NOAA Fisheries	
Subsequent carcass sightings	July 21, 2017	47.9878	-64.4820	Miscou Island, New Brunswick	Canadian Wildlife Health Cooperative/ Marine Animal Response Society	Necropsy
Cause of death	Blunt trauma					
Field Code	MARS2017-146					
Other information	Previous sightings of #2140 have been in the Bay of Fundy, Cape Cod Bay, Great South Channel and in Southeast US. He had fathered one calf that we know of - #3466, a male born in 2004.					
Genetic results	Genetics confirm this individual is Catalog #2140					

Photos:

Photo Credit: NEFSC taken under SARA Permit #DFO-MAR-2016-02 (Amendment 1) and NMFS Permit # 17355

Photo Credit: Marine Animal Response Society

	Date	Latitude	Longitude	Area	Observer	Comments
Carcass #9						
Catalog #4504						
2 year old female						
Last seen alive	August 7, 2015	47.85810	-63.80783	Gulf of St. Lawrence	NOAA Fisheries	Observed with mom
Seen dead	September 15, 2017	48.1503	-63.5009	Gulf of St Lawrence	Fisheries and Oceans Canada	
Subsequent carcass sightings	September 18, 2017			Miscou Island, New Brunswick		Towed for necropsy
	September 19, 2017	47.9878	-64.4820	Miscou Island, New Brunswick	Canadian Wildlife Health Cooperative/ Marine Animal Response Society	Necropsy
Cause of death	Entanglement					
Field Code	MARS2017-312					
Other information	None available					

Photos:

Photo Credit: DFO C&P aerial surveillance

Photo Credit: Marine Animal Response Society

Additional information regarding carcasses that came ashore in Newfoundland, including images, is provided in Annex 3

	Date	Latitude	Longitude	Area	Observer	Comments
Carcass #10						
Unidentified						
Male						
Last seen alive						
Seen dead	July 21, 2017	49.3485	-58.2350	Newfoundland	Reported by resident	Dead on beach
Subsequent carcass sightings						
Cause of death	Unknown - advanced decomposition					
Field Code	M20170095					
Other information	Near Church Point. Resighted by C&P plane on July 25 and sampled by DFO on July 27 and 29. Very decomposed. Sample collected for genetics					
Genetic results	Genetics did not confirm an identity for this individual; Did confirm animal was not Whale #1					

	Date	Latitude	Longitude	Area	Observer	Comments
Carcass #11 = Carcass #5						
Catalog #3512						
12 year old female						
Last seen alive						
Seen dead	July 24, 2017	49.0903	-58.4250	Newfoundland	Reported by resident	Dead on beach
Subsequent carcass sightings						
Cause of death	Unknown - advanced decomposition					
Field Code	F20170096					
Other information	Near Cedar Cove. Sampled by DFO on July 29. Very decomposed. Sample collected for genetics.					
Genetic results	Genetics confirmed this individual is Catalog #3512 and matches Whale #5					

	Date	Latitude	Longitude	Area	Observer	Comments
Carcass #12						
Unidentified						
Male						
Last seen alive						
Seen dead	July 27, 2017	47.6206	-59.2981	Newfoundland	Reported by mariner	Dead on beach
Subsequent carcass sightings						
Cause of death	Unknown - advanced decomposition					
Field Code	M20170094					
Other information	Near Cape Ray. Sampled by DFO on July 30. Very decomposed. Sample collected for genetics					
Genetic results	Genetics did not confirm an identity for this individual; Did confirm animal was not Whale #1					
		Latitude	Longitude	Area	Observer	Comments
Carcass #13						
Catalog #4111 (*based on genetics)						
6 year old female						
Last seen alive	September 16, 2016	44.4508	-66.6398	Bay of Fundy	Whale watch boat	
Seen dead	July 30, 2017	50.4264	-57.4992	Newfoundland	Fisheries and Oceans Canada	Dead on beach
Subsequent carcass sightings						
Cause of death	Unknown - advanced decomposition					
Field Code	F20170093					
Other information	Near River of Ponds. Sampled by DFO on August 3. Very decomposed. Sample collected for genetics					
	First seen 2011. Calf of 1911. Previous sightings of #4111 have been in Georgia, Florida, Great South Channel, Cape Cod Bay, Bay of Fundy and the Gulf of Maine					
Genetic results	Genetics confirm this individual is Catalog #4111					

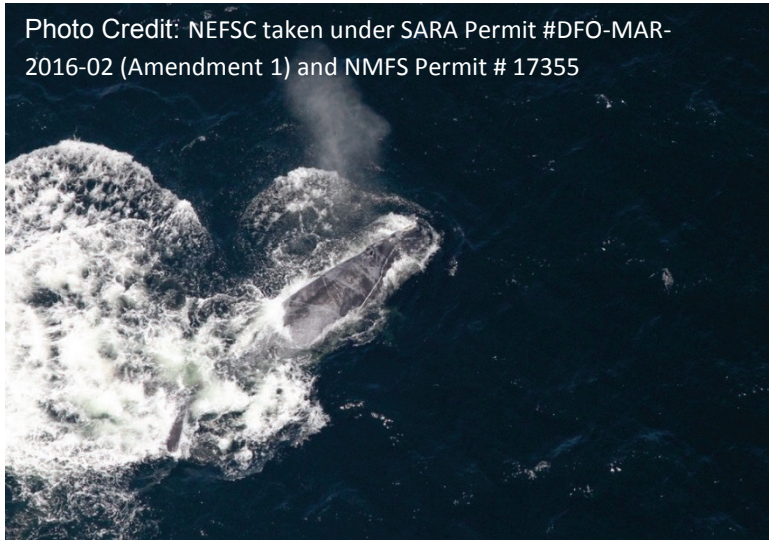
Annex 2b: Sighting, Incident and Life History Information of Right Whale Entanglement Incidents in Canadian Waters in 2017

Authors: Amy Knowlton[1], Philip Hamilton[1], Monica Zani[1], Marilyn Marx[1] and Tonya Wimmer[2].
[1]Anderson Cabot Center for Ocean Life at the New England Aquarium; [2]Marine Animal Response Society

Additional information provided by: Allison Henry (Northeast Fisheries Science Center, NOAA), Brigid McKenna (Center for Coastal Studies) and Hilary Moors-Murphy (DFO-Science)

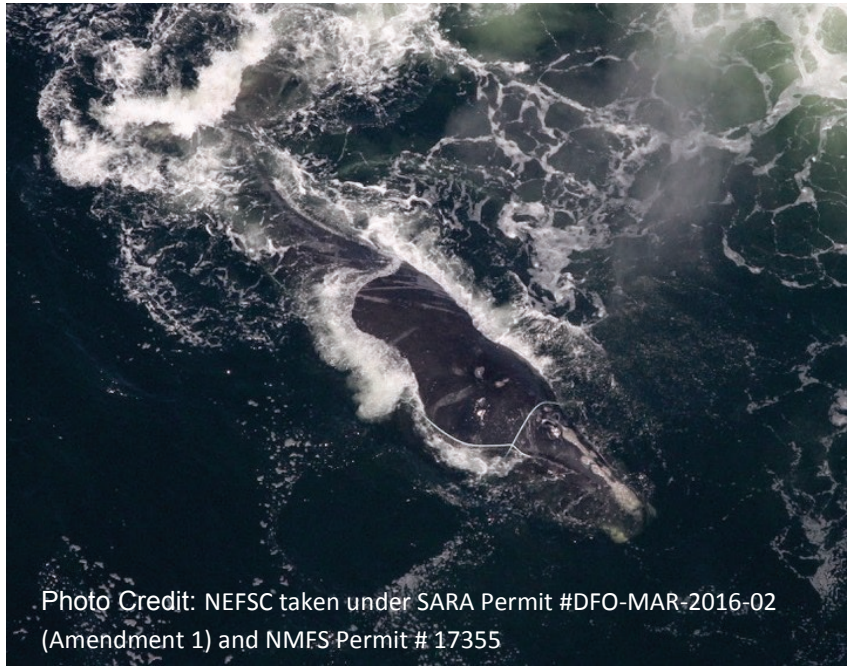
	Date	Latitude	Longitude	Area	Observer	Comments
#1						
Unidentified (BK01BOF2015)						
Unknown sex						
Last seen not entangled	July 7, 2015	44.3233	-66.4148	Bay of Fundy	Whale watch vessel	
Seen entangled	July 5, 2017	47.5167	-63.7117	Gulf of St Lawrence	NOAA Fisheries	
Subsequent sightings	July 5, 2017	47.5167	-63.6928	Gulf of St Lawrence	CWI/NEAq	Disentangled
	July 29, 2017	47.6564	-63.6383	Gulf of St Lawrence	NOAA Fisheries	Gear free
Field Code	MARS2017-175					
Other information	Previous sighting of BK01BOF2015 was in the Bay of Fundy in 2015.					

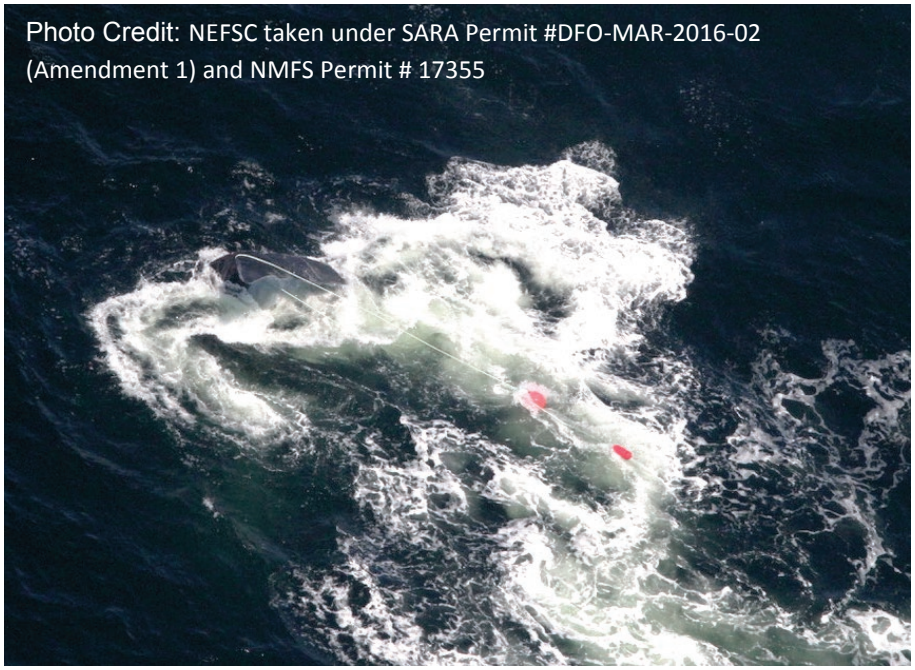
Photos:



	Date	Latitude	Longitude	Area	Observer	Comments
#2						
Catalog #1317						
33 year old male						
Last seen not entangled	April 23, 2017	41.84579	-70.06709	Cape Cod Bay	Center for Coastal Studies	
Seen entangled	July 8, 2017	47.7133	-64.0283	Gulf of St Lawrence	NOAA Fisheries	
Subsequent sightings	July 25, 2017	50.0667	-64.3573	Gulf of St Lawrence	Mingan Island Cetacean Study	Gear shed
	August 18, 2017	48.46833	-63.7603	Gulf of St Lawrence	Transport Canada	
	August 25, 2017	48.74167	-63.8419	Gulf of St Lawrence	Transport Canada	
Field Code	MARS2017-179					
Other information	#1317 was also seen by MICS on July 26, 27, 30, 31, 2017. Previous sightings of #1317 have been in southeast U.S. (as a dependent calf and in other years), Cape Cod Bay, Jeffreys Ledge, Massachusetts Bay, Great South Channel, Roseway Basin, Gulf of Maine, Bay of Fundy, mid Atlantic and Gulf of St Lawrence (2015, 2016). In 2016, he was seen in GoSL on Aug 1, in the Gulf of Maine on September 1, and in the Bay of Fundy on September 10.					

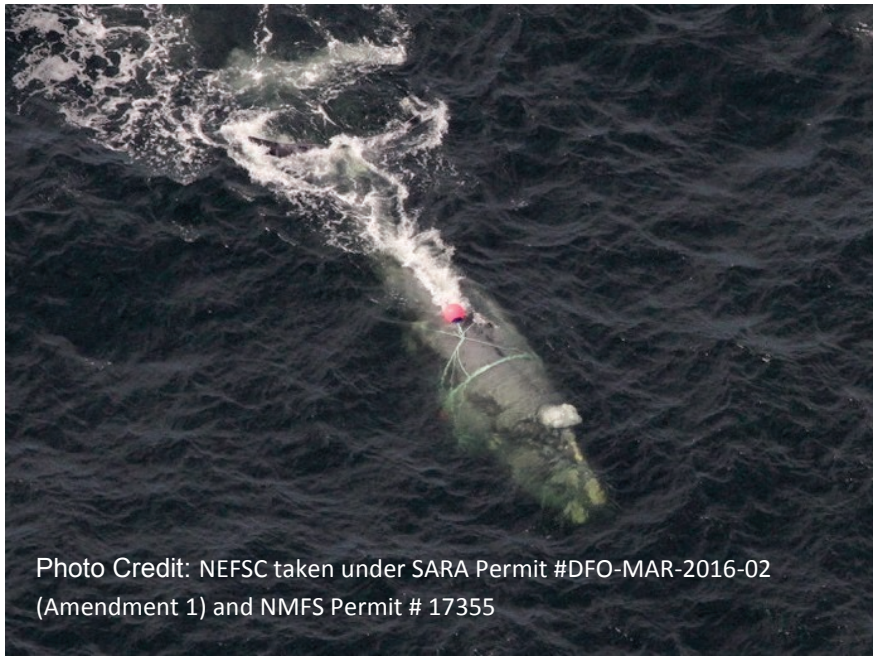
Photos:





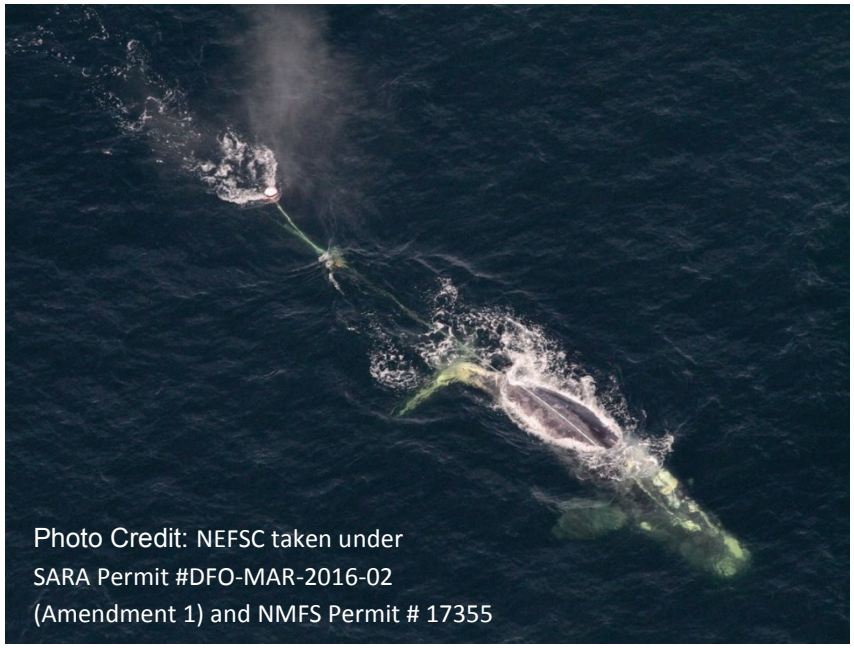
	Date	Latitude	Longitude	Area	Observer	Comments
#3						
Catalog #4123						
6 year old male						
Last seen not entangled	July 8, 2017	47.7025	-64.1237	Gulf of St Lawrence	NOAA Fisheries	
Seen entangled	July 9, 2017	47.7447	-64.0187	Gulf of St Lawrence	Unspecified vessel - Fisherman	
Subsequent sightings	July 10, 2017	47.83946	-64.0396	Gulf of St Lawrence	C&P, NOAA Fisheries	
	July 10, 2017	47.83946	-64.0396	Gulf of St Lawrence	CWI/NEAq	Disentangled
	July 29, 2017	44.7387	-66.5977	Bay of Fundy	New England Aquarium	Gear free
Field Code	MARS2017-185					
Other information	Raw injuries on the peduncle when observed on July 29. Previous sightings of #4123 have been in the mid Atlantic, southern New England, Bay of Fundy, Great South Channel, and the Gulf of Maine.					

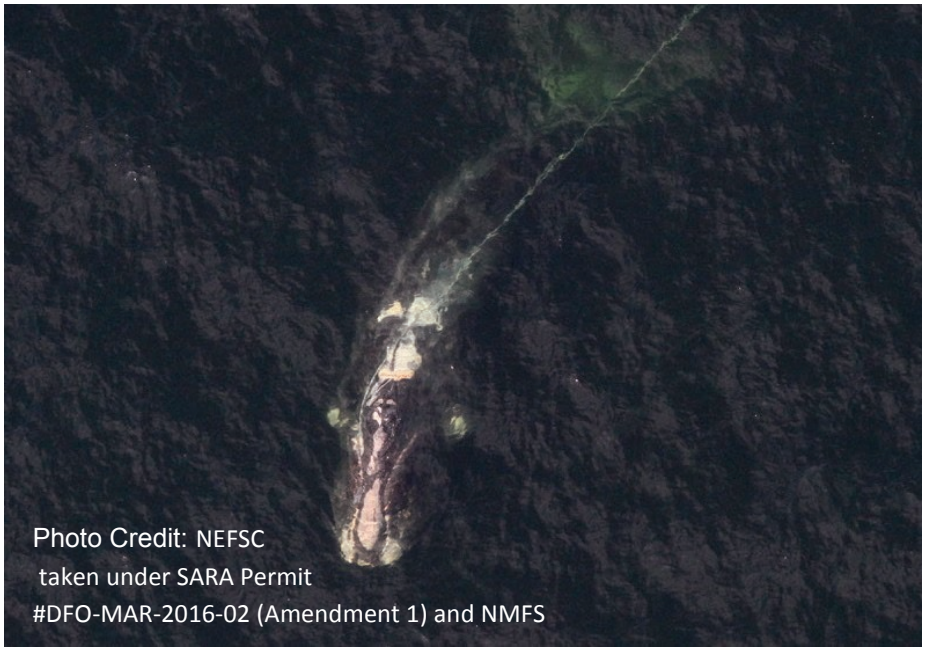
Photos:



	Date	Latitude	Longitude	Area	Observer	Comments
#4						
Catalog #4094 - Mayport						
7 year old female						
Last seen not entangled	April 23, 2017	41.10900	-70.60236	Southern New England	NOAA Fisheries	
Seen entangled	July 19, 2017	47.5733	-63.9900	Gulf of St Lawrence	NOAA Fisheries	No Action Permitted
Subsequent sightings	None					
Field Code	MARS2017-195					
Other information	#4094 has severe injuries on the back and peduncle. Previous sightings of #4094 have been in the southeast U.S. (as a dependent calf and in other years), mid Atlantic, Cape Cod Bay, and the Gulf of St Lawrence (with her calf) in 2016. She had her first, and only to date, calf in 2016 but that calf was killed in Cape Cod Bay in Spring 2017 by a vessel strike.					

Photos:





	Date	Latitude	Longitude	Area	Observer	Comments
#5						
Catalog #3245						
15 year old male						
Last seen not entangled	August 25, 2017	48.7417	-63.8417	Gulf of St Lawrence	Transport Canada	
Seen entangled	August 28, 2017	48.5000	-63.6667	Gulf of St Lawrence	Transport Canada	No Action Permitted
Subsequent sightings	None					
Field Code	MARS2017-264					
Other information	Previous sightings of #3245 have been in the southeast U.S. (as a dependent calf and in other years), mid Atlantic, Great South Channel, Massachusetts Bay, Jeffreys Ledge, Cape Cod Bay, Roseway Basin, and the Gulf of St Lawrence (2015)					

Photos: Both images are captured frames from video. Credit: NASP-MART flight surveillance

Annex 3: Newfoundland Right Whale (NARW) Sampling - 28 July to 3 Aug, 2017

Author: Dr. Jack Lawson, DFO-Science, Newfoundland

Overall Location:
All four NARW whale carcasses were found on the west coast of Newfoundland at locations in the intertidal zone. Most initial discoveries were by reports from local residents or fishers. Identification and sampling were achieved with DFO staff led by Dr. Lawson from July 28th to August 3rd, 2017. During the August 3rd sampling of the River of Ponds whale by Lawson, Goulet conducted a partial aerial survey of the northern Strait of Belle Isle using a King Air reconnaissance aircraft. Imagery of the NARW carcasses has been distributed to DFO Gulf, DFO Maritimes, and MARS, and is available by request from Lawson.

Figure 1. Shoreline locations of four dead NARWs on Newfoundland's west coast in 2017.

Whale Sampling:

Church Point - Dead North Atlantic Right Whale – Male – M20170095 (Whale #10, Table 1)

Location: 49.3485 N -58.235 W

Location Description: This remote, rocky coastal beach is located several miles south of Trout River, NL and ribs and vertebrae from a dead female blue whale that washed ashore in March 2014 were scattered around the carcass.

Original Discovery: Report by resident on 21 July, then sighted/imaged by C&P surveillance flight on 25 July 2017. Attended by D. Shears on 27 July, at which time photographs and a sample were collected. Attended by Lawson and Shears on 28 and 29 July (tried boat approach on 28th, but seas and winds too high; successfully approached by extended land route on 29 July). We arrived at the site at approximately 1000 and spent an hour collected finger bones and measurements.

Animal condition: The adult whale was laying on its back, and was extremely flattened and decayed, with much oil on surrounding rocks and bones protruding through mandibular joints etc. There were no ribs or vertebrae nearby the carcass, except a few from the 2014 blue whale. The epidermis was absent on the exposed portions of the whale, and the remaining integument and underlying blubber and muscle was decomposed and pulling apart (a sample of which was collected by FO Shears on 27 July and is currently frozen at -20C in St. John's). The internal organs were likely gone as I could not see any obvious internal structures when I looked through holes in the integument. There may have been signs of line contact marks around the caudal peduncle, and these can be seen in the relevant photographs. I could not see a penis, but the lack of prominent nipple slits and the distance between the penile slit and the anus are suggestive of this whale being a male. There were no signs of large-scale contusions or bruising, but these signs would be compromised by the poor condition of the carcass. There was no signs of the bonnet or eyebrow callouses. Blubber depth was measured at a lateral belly site at 3.9 cm, but this was indicative that the inner margin of the blubber was poorly-attached to the muscle and there was much decay.

We reached the carcass on foot after a 45 minute traverse over difficult rocky beach terrain, so we did not have any heavy tools or lifting equipment.

Samples: Multiple photographs, a fork length (14 m) and a fluke width (4 m), and four foreflipper bones removed and later frozen at -20C. A dermis/muscle sample was collected by Officer Shears during an earlier visit and is stored at -20C. We shipped a frozen foreflipper bone to Brad Seyler, Lab Manager, Natural Resources DNA Profiling and Forensic Centre on 14 August 2017.

Figure 2. Photograph of Church Point NARW taken by Parks Canada.

Cedar Cove - Dead North Atlantic Right Whale – Female – F20170096 (Whale #5 & 11, Table 1)

Location: 49.0903 N -58.42498 W

Location Description: This remote coastal beach is located SW of Lark Harbour, NL and its narrow opening is oriented towards the WSW.

Original Discovery: Report by resident on 24 July, thereafter C&P took imagery to pass to Lawson; attended by Lawson and Andrews on 29 July (approached by land route)

Animal condition: The adult whale was laying on its back, and was extremely flattened and decayed, with much oil on surrounding rocks and some body tissues dispersed into the rocks. The epidermis was absent on the exposed portions of the whale, and the remaining integument and underlying blubber and muscle was decomposed and pulling apart. The internal organs were likely gone as I could not see any obvious internal structures when I looked through holes in the integument. There were no signs of line or net contact marks on the whale's body, as can be seen in the relevant photographs. I could not see a penis, and the prominent nipple slits on either side of the vaginal opening are suggestive of this whale being a female. There were no signs of large-scale contusions or bruising, but these signs would be compromised by the poor condition of the carcass. There was no signs of the bonnet or eyebrow callouses. Blubber depth could not be measured as the blubber was much decayed. The upper right jawbone was separated from the body and laying >10M away along the beach (it appeared to be mainly intact). There was a sagittal slit in the anterior belly of the whale, but I was unable to detect any footholds cut into the whale as performed by Daoust at sea (see body photographs).

Samples: Multiple photographs, a (likely underestimated) fork length (12.6 m) and fluke width (4 m) collected; three foreflipper bones removed from the right foreflipper and later frozen at -20C; the foreflippers and fluke tips were degraded/eroded so measures were not taken of these. We

reached the carcass on foot at 18:15 after 10-minute approach on a small all-terrain vehicle, so we did not have any heavy tools or lifting equipment. We shipped a frozen foreflipper bone to Brad Seyler, Lab Manager, Natural Resources DNA Profiling and Forensic Centre on 14 August 2017.

Figure 3. Photograph of Cedar Cove NARW.

Cape Ray - Dead North Atlantic Right Whale – Male – M20170094 (Whale #12, Table 1)

Location: 47.6206 N -59.2981 W

Location Description: This rocky intertidal coastal site is located on the SW tip of Newfoundland and is oriented towards the WSW.

Original Discovery: Imaged by vessel 5 n mi offshore near noon on 27 July; subsequently, reported floating just offshore by resident at 1600 on the 27th of July, a C&P surveillance flight with Lawson aboard overflew the site on 29 July during which imagery was collected and Lawson confirmed it was a right whale. Lawson and Andrews attended the site on 30 July (approached by land route). The location of the whale carcass is such that waves washed over it at high tide.

Animal condition: The adult whale was laying on its back, and was extremely flattened and decayed, with oil on surrounding rocks and some body tissues dispersed into the rocks. The epidermis was absent on the exposed portions of the whale, and the remaining integument and underlying blubber and muscle was decomposed and pulling apart. No obvious lesions were seen on the body. The internal organs were likely gone as I could not see any obvious internal structures when I looked through holes in the integument. There were no signs of line or net contact marks on the whale's body, as can be seen in the relevant photographs. Multiple vertebrae had fallen from the carcass and were scattered nearby (and cleaned by local fauna). I could see the remnants of a penis, indicating the whale was a male. There were no signs of large-scale contusions or bruising, but these signs would be compromised by the poor condition of the carcass. There were degraded lower chin and eyebrow callosities (see imagery). Blubber depth could not be measured as the blubber was much decayed. There was a sagittal slit in the anterior belly of the whale, but I was unable to detect any footholds cut into the whale as

performed by Daoust at sea (see body photographs). There were seven “scooped” wounds clustered along the lower rear peduncle, which appeared to be shark bites.

Samples: Multiple photographs, a (likely underestimated) fork length (12.0 m), and four foreflipper bones removed from the right foreflipper and later frozen at -20C; also three vertebrate were collected from nearby and stored in Stephenville at -5C. the foreflippers and fluke tips were degraded/eroded so measures were not taken of these. We reached the carcass on foot at 09:30 at low tide, and did not have any heavy tools or lifting equipment. We shipped a frozen foreflipper bone to Brad Seyler, Lab Manager, Natural Resources DNA Profiling and Forensic Centre on 14 August 2017.

Figure 4. Photograph of Cape Ray NARW.

River of Ponds - Dead North Atlantic Right Whale – Female – F20170093 (Whale #13, Table 1)

Location: 50.42637 N 5-57.49918 W

Location Description: This remote coastal beach is located north of the Gros Morne Park entrance on the west coast of Newfoundland. It is an exposed rocks ledge and cliff system, facing west. The site in not visible from vehicles on the nearby highway.

Original Discovery: Following the field sampling of the Cape Ray whale, Lawson and C&P staff flew a King Air surveillance aircraft from Deer Lake to the coast, then northwards along the coast as far as the NE point of the northern Peninsula, at an altitude of 200 feet. During this flight the team sighted a fourth dead right whale on the shoreline. Lawson, T. Shears, and Andrews attended this whale on 3 August after approaching by an overland route.

Animal condition: As in the other right whale carcasses, this adult whale was laying on its back, and was extremely flattened and decayed, with much oil on surrounding rocks and some body tissues dispersed into the rocks. While we were there the ambient temperature was 27 C and the carcass was bubbling and emitting clear lipids. The carcass was an orange colour, whereas

the other three carcasses were paler yellow/beige. The epidermis was absent on the exposed portions of the whale, and the remaining integument and underlying blubber and muscle was decomposed and pulling apart. The bones in the foreflippers and caudle peduncle were almost exposed. There were no signs of line or net contact marks on the whale's body, as can be seen in the relevant photographs. I could not see a penis, and the prominent nipple slits on either side of the vaginal opening are indicative of this whale being a female. There were no signs of large-scale contusions or bruising, but these signs would be compromised by the poor condition of the carcass. There were blackened remnants of bonnet and eyebrow callouses; the bonnet was exposed as the skin from the upper jaw was opened upwards as it lay on the beach. Blubber depth could not be measured as the blubber was much decayed. There was no sagittal slit in the anterior belly of the whale, and I was unable to detect any footholds cut into the whale as performed by Daoust at sea (see body photographs). During this field sampling period, P. Goulet of the Marine Mammal Section flew offshore in the northern Strait of Belle Isle with the King Air for several hours to search for other carcasses or whales; they sighted a minke whale and multiple feeding humpbacks.

Samples: Multiple photographs, a (likely underestimated) fork length (13.32 m) and fluke width (5.52 m, very debrided), and three foreflipper bones removed from the right foreflipper and later frozen at -20C; the foreflippers and fluke tips were degraded/eroded (right foreflipper length of 2.25 m with a maximum chord of 1.15 m); a dermis/blubber/muscle sample was taken from the right lower tail stock area, but was jellylike. We reached the carcass on foot at 18:15 after 10 minute approach down a slope to the shoreline, so we did not have any heavy tools or lifting equipment.

We shipped a frozen foreflipper bone to Brad Seyler, Lab Manager, Natural Resources DNA Profiling and Forensic Centre on 14 August 2017.

Figure 5. Photograph of River of Ponds NARW.

Sampling participants:

Research Scientist Dr. Jack Lawson (Marine Mammal Section, St. John's)
Biologist Pierre Goulet (Marine Mammal Section, St. John's)
Fishery Officer Jerry Walsh (St. John's)
Fishery Officer Dwayne Shears (Rocky Harbour)
Fishery Officer Ben Andrews (Stephenville)
Fishery Officer Boyd Reid (Rocky Harbour)
Fishery Officer Tracy Shears (Rocky Harbour)
Fishery Officer Adam Gardner (Port aux Choix)
Fishery Guardian Darren Macdonald
Fishery Guardian Chris Billard

Annex 4: DNA Profiling and identification of dead North Atlantic right whales in the Gulf of the St Lawrence

Author: Dr. Brad White, Environment and Life Science Program, Trent University

DNA profiling conducted by: Matthew Harnden and Nguyen Thi Xuan Nguyen, Natural Resources DNA Profiling and Forensic Centre (NRDPFC)

September 28, 2017

Dead right whales are often in such a state decomposition that the carcass cannot be identified using the photo-identification catalogue and so DNA profiles are used to aid in the process. The Natural Resources DNA Profiling and Forensic Centre (www.nrdpfc.ca) at Trent University in Ontario, Canada holds the right whale tissue and DNA bank and the DNA profiles of about 80% of current right whale individuals. These samples have been collected over a period of nearly 30 years with collaborators such as the New England Aquarium, Woods Hole Oceanographic Institution, National Marine Fisheries Service and several US State Agencies and the Canadian Department of Fisheries and Oceans and NGOs. These profiles include sex, a DNA sequence of the mitochondrial control region and the genotypes at 31 microsatellite loci present throughout the genome. The mitochondrial DNA provides information on which of 6 matrilines an individual belongs to and the microsatellite genotypes give individual identification as well as parentage information. DNA from decomposed animals is often of limited quantity and poor quality so we focus on 5 microsatellite loci that give data from degraded DNA from carcasses. In the case of highly decomposed carcasses we extract DNA from bones as it is better preserved than from tissues.

We received and extracted DNA from 11 samples sent to us from the Gulf of St. Lawrence carcasses in 2017 (Table 1). We obtained some complete and some partial DNA profiles depending on levels of degradation. The DNA profiles were developed at the NRDPFC and identifications assessed by Phil Hamilton at the New England Aquarium and Brenna Mcleod at St Mary's University. For those carcasses identified by the New England Aquarium catalogue, the DNA profiles were consistent (NEA 1402, 1207, 3603, 3190, 2140, 3512, 4111). The data confirm that one of the Newfoundland carcasses (one of the floaters, Cedar Cove Whale) is NEA 3512. None of the other Newfoundland carcasses are NEA 3746. NEA3746 is the only unaccounted for (not buried) carcass and so there were at least 11 different dead whales in the Gulf as of July 19, 2017*. The data confirm that the Newfoundland River of Ponds Whale is NEA 4111. We could not obtain a microsatellite profile for the sample from MARS 2017-145 because of poor quality DNA but we are still working on this sample. This was the only unidentified whale of the 8 floaters.

** Please note: the most recent carcass examined on September 19th was not included in this analysis but was confirmed via photographs to be a new individual (NEAq #4504).*

*Table 1. DNA Profiling and identification of dead North Atlantic right whales in the Gulf of the St Lawrence. In **bold** are the dead whale samples. If there is a NEA # in that line, the dead whale was photographically matched by the New England Aquarium to the Right Whale Catalogue. Below each dead whale line are the existing DNA data on file at NRDPFC/Trent for that whale from other genetic samples. The yellow highlight shows a discrepancy in the genotype comparison (likely the discrepancy is an allelic dropout of the larger allele). Field Reference numbers are as per Annex 2a.*

Sample ID	Field Reference No	Response Network ID Code	Collected			Gender	Haplotype	NEA match	TV20		TV17		RW417		GT023		IGF		Submitter
			Day	Month	Year														
204250	**Whale #2**	**MARS2017-141**	**29**	**6**	**2017**	**XY**	**A**	1402	**166**	**166**	**202**	**202**	**123**	**125**	**119**	**119**	**144**	**156**	
						M	A	1402	166	166	202	202	123	125	119	119	144	156	
204251	**Whale #6**	**MARS2017-142**	**30**	**6**	**2017**	**XY**	**A**	1207	**166**	**170**	**202**	**202**	**121**	**121**	**117**	**117**	**146**	**156**	
						M	A	1207	166	170	202	202	121	121	117	117	146	156	
204252	**Whale #4**	**MARS2017-143**	1	7	2017	XX	D	3603	**	**	**	**	**	**	**	**	**	**	
204253	**Whale #3**	**MARS2017-144**	9	7	2017	XY	D	3190	**	**	**	**	**	**	**	**	**	**	
204254	**Whale #7**	**MARS2017-145**	10	7	2017	XY	A		**	**	**	**	**	**	**	**	**	**	
204255	**Whale #8**	**MARS2017-146**	21	7	2017	XY	D	2140	**166**	**166**	**202**	**226**	**121**	**123**	**117**	**119**	**	**	
						M	D	2140	166	166	202	226	121	123	117	119	150	154	
																			Tonya Wimmer (Director, MARS)
204256	**Whale #5**	**MARS2017-155**	**22**	**6**	**2017**	**XX**	**B**	3512	**166**	**170**	**202**	**202**	**121**	**125**	**117**	**117**	**144**	**150**	
						F	B	3512	166	170	202	202	121	125	117	117	144	150	
204257	**Whale #13**	**F20170093**	**3**	**8**	**2017**	**XX**	**D**		**166**	**166**	**200**	**224**	**125**	**127**	**115**	**117**	**150**	**156**	
						F	D	4111	166	170	200	224	125	127	115	117	150	156	
204258	**Whale #12**	**M20170094**	30	7	2017	XY	A		**	**	**200**	**202**	**	**	**117**	**119**	**	**	
								Tried- 2 possible whales											
204259	**Whale #10**	**M20170095**	29	7	2017		A		**166**	**166**	**	**	**	**	**117**	**117**	**	**	
								Tried to match- many possibilities											Dr. Jack Lawson (Research Scientist DFO NAFC)
204260	**Whale #11**	**F20170096**	**29**	**7**	**2017**	**XX**	**B**		**166**	**170**	**202**	**202**	**121**	**125**	**117**	**117**	**144**	**150**	
						F	B	3512	166	170	202	202	121	125	117	117	144	150	

Annex 5: Oceanographic Trajectory hindcasting of the dead North Atlantic Right Whales

Author: Joël Chassé, DFO- Science

Note*: The following represents operational analyses at the time of the incident. A DFO manuscript report has yet to be finalized.

Introduction:

The output of a full 3D hydrodynamic model of the ocean provided the data to hindcast the trajectory of nine dead North Atlantic Right Whales (NARW) observed in the southern Gulf of St. Lawrence (GSL). The model forcing includes river runoff and winds from the Canadian Metorological Center (CMC). A fourth order Runge-Kutta algorithm calculates the trajectories backward in time from the locations where the dead NARW whales were found. The trajectories are calculated using the model currents plus a wind factor. The latter was estimated to be equal to 0.08% of the wind speed after calibration using positions from successive sightings and Argo tags attached to some of the whales. From each dead whale location, 1000 particles were released with a random walk diffusion parameter of 5 m^2/s to account for chaos and small-scale processes. The nine dead NARW trajectories have been hindcasted starting from the locations and times shown in Table 1.

Analysis:

Figure 1 and 2 shows the 14 days hindcast trajectories for the first eight whales. A random selection of the tracks (10) was made for display purposes. In all cases, the sampled tracks encompass most of the areas that would be covered if all the tracks were displayed and there are no missing outstanding tracks from a particular ensemble. The red dots are the locations where the dead whales were observed. It can be seen that most trajectories point to an area on the western side of the sGSL, excepted for NARW #1 which remained mostly near its original position.

A ninth dead whale (named NARW #10 in here) was found beached near Bonne Bay on the west coast of Newfoundland on July 25 (last row of Table 1). A “Reverse simulation” was also made for that whale and because there were uncertainties around the beaching time, 30 particles were released every four hours between July 20 and July 25 (total of 1020 particles). The back tracks are shown in Figure 3. The tracks go right to the southern GSL. There are no back tracks (starting backward in time from July 20-25) going anywhere near the proximity of the Port-aux-Basques (Newfoundland) where other dead whales were seen drifting.

The question whether NARW #10 could have been NARW #1 also arose and a forward simulation was conducted from the position of NARW #1 to investigate the question. The forward tracks from the NARW #1 position are shown in Figure 4. We can see that most particles exit the GSL along Cape Breton after some time. This is due to the strong outward currents in that area. Some of the most northern tracks support the observation that the whale

seen in the middle of Cabot Strait on June 27 and originally thought to be NARW #7 was indeed NARW #1. However, no particles reach the Newfoundland coast and it was suggested that NARW #10 found near Bonne Bay on July 25th is likely not NARW #1.

Lastly, a dead whale was found on Martha's Vineyard Island near Cape Cod on the western side of the Gulf of Maine and it was asked if it could have been either NARW #1 or NARW #5 that had drifted to that location. Figure 5 shows the forward tracks from the last recorded positions of NARW #1 and NARW #5. The tracks end on August 12. As previously, tracks were randomly selected for display purposes. It can be seen that the whales were not predicted to travel very far on the Scotian Shelf. This is mostly due to the winds from the south and south-west that were often prevalent over last few months and precluding far away transport towards the Gulf of Maine.

Possible cause for error in the calculated trajectories:

1) Imperfect ocean model.

2) Error in wind fields from CMC.

3) Variable wind force on the whale itself; A factor of 0.008% of the wind speed was used for all simulations, but this could vary with the size and the state of decomposition of the whale.

Table 1. Location and time of the first recorded position of the dead whales.

Whale	Day	Time (UTC)	Longitude	Latitude
#1	2017/06/06	16:24	-62.8597	47.3204
#2	2017/06/19	17:24	-63.582	47.4423
#3	2017/06/24	16:00	-62.6062	47.8152
#4	2017/06/21	19:28	-63.0457	47.2335
#5	2017/06/22	15:00	-62.355	47.1017
#6	2017/06/23	13:30	-63.2217	47.6167
#7	2017/07/05	18:37	-62.6267	47.5832
#8	2017/07/19	19:10	-63.90333	47.92167
#10	2017/07/25	11:00	-58.24134	-49.3453

Summary:

The hindcast trajectories were provided, as exact date of death could not be determined by the veterinary pathologists due to confounding variables affecting carcass integrity, e.g., air temperature, length of drift prior to necropsy. Most of the trajectories originate to the area on the western side of the southern GSL, excepted for NARW #1 which remained mostly in the same area.

The results of the reverse simulation for NARW #10 show the carcass originated in the southern GSL. There are no back tracks (starting backward in time from July 20-25) originating anywhere

near the proximity of Port-aux-Basques (Newfoundland) where other dead NARW were observed beached.

The forward trajectory prediction for NARW#1 demonstrates that the most northern tracks support the observation that the NARW observed in the middle of Cabot Strait on June 27 and originally thought to be NARW #7 was indeed the resighting of NARW #1. This was confirmed by the New England Aquarium's NARW identification experts. Again, none of the particles forward trajectory reached the Newfoundland coast therefore the suggestion that NARW #10 could be NARW#1 is not supported by the trajectory analysis.

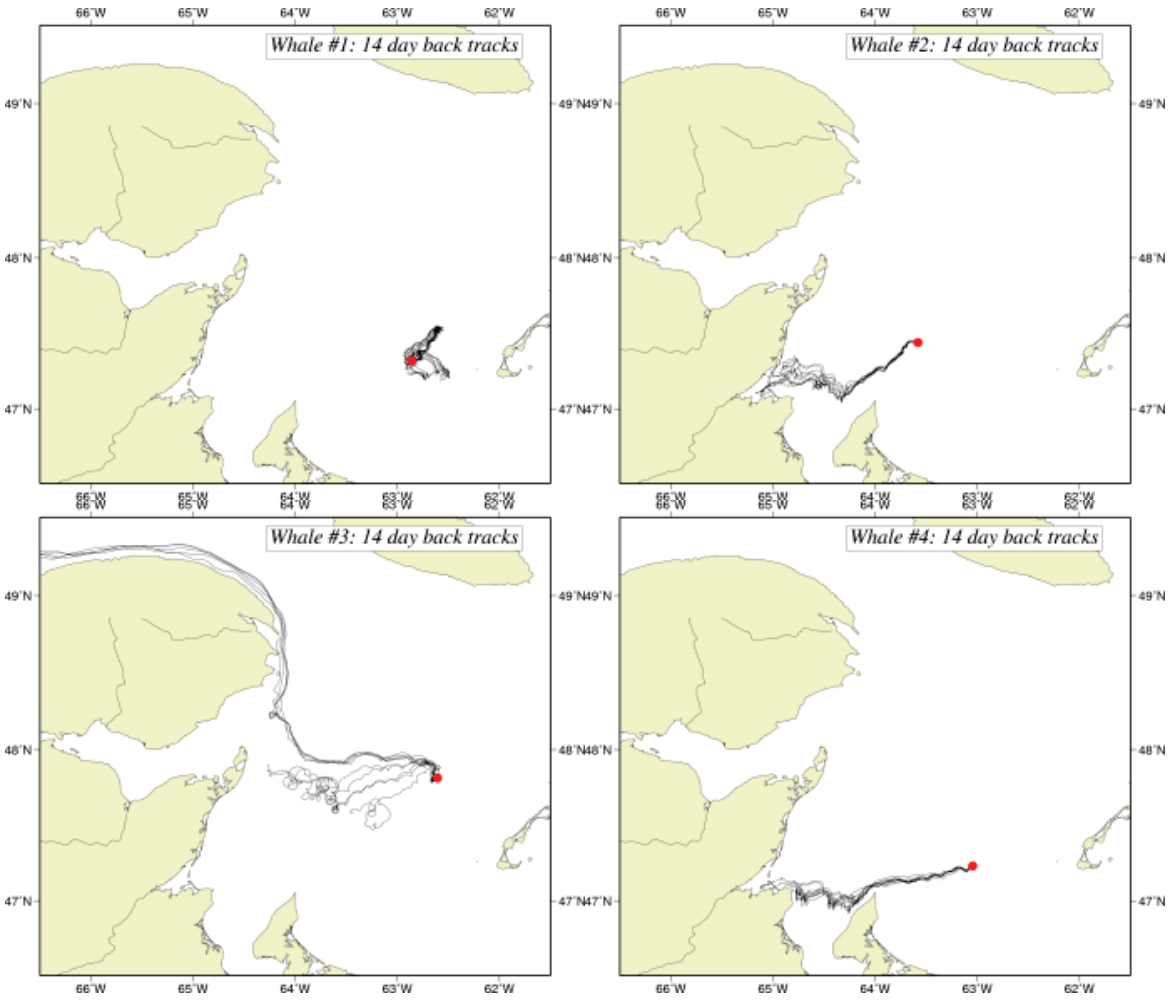


Figure 1 (Part A). Hindcasted reverse trajectories for the first eight dead whales. The trajectories spend 14 days from the time the dead whales were first found. For display purposes, only a subset of the 1000 trajectories are shown for each case, but the samples cover most of the areas from the full ensembles.

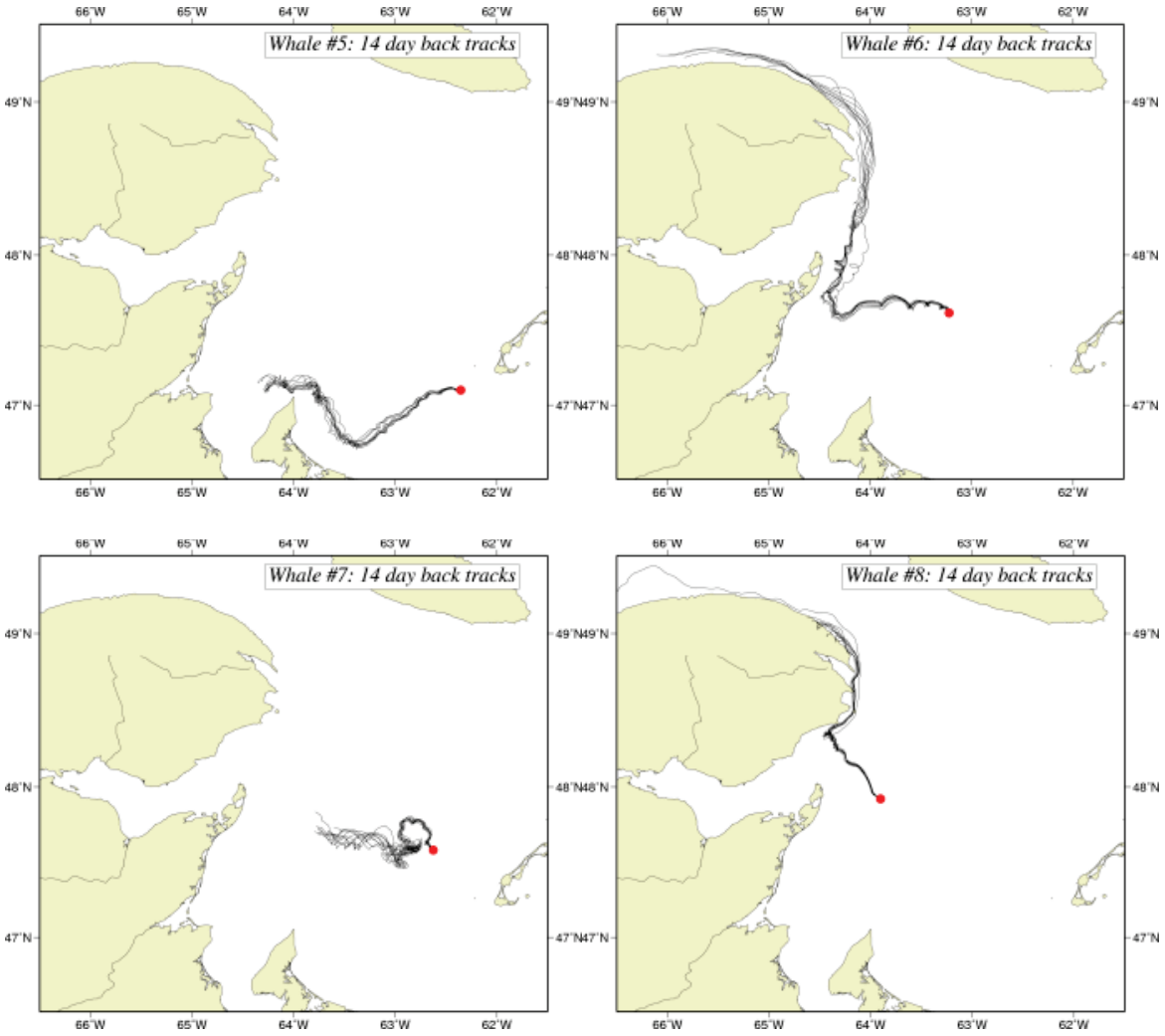


Figure 2 (Part B). Hindcasted reverse trajectories for the first eight dead whales. The trajectories spend 14 days from the time the dead whales were first found. For display purposes, only a subset of the 1000 trajectories are shown for each case, but the samples cover most of the areas from the full ensembles.

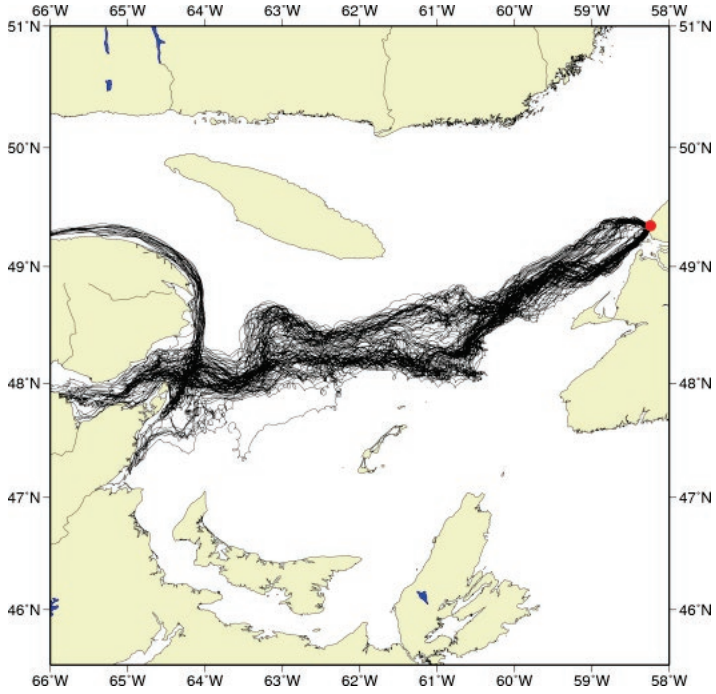


Figure 3. Hindcasted reverse trajectories for whale #10, found near Bonne Bay on the Newfoundland coast on July 25, 2017. A 1020 particles were release between July 20 and July 25, but only 50 trajectories are shown here. The trajectories go back in time to June 6.

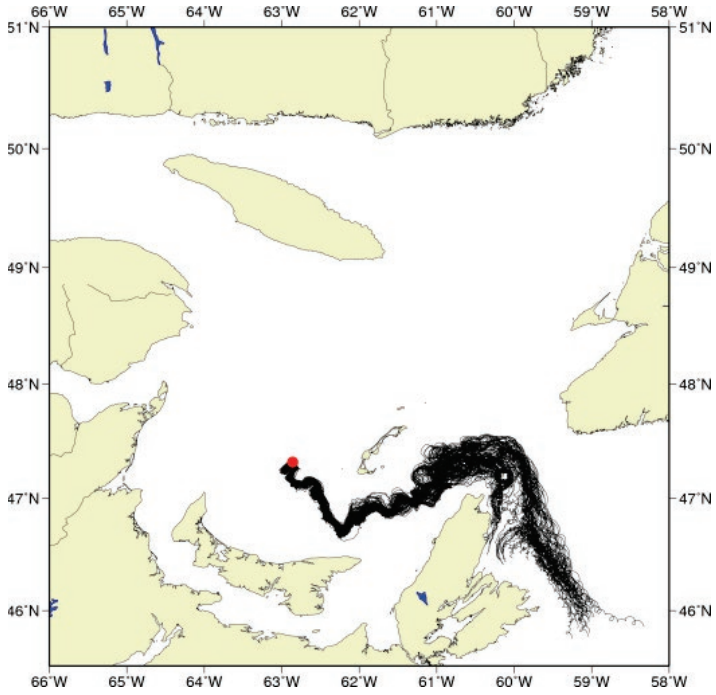


Figure 4. Forward-in-time simulation from the position of NARW #1 (red dot). The simulation covers the period of June 6 to July 25.

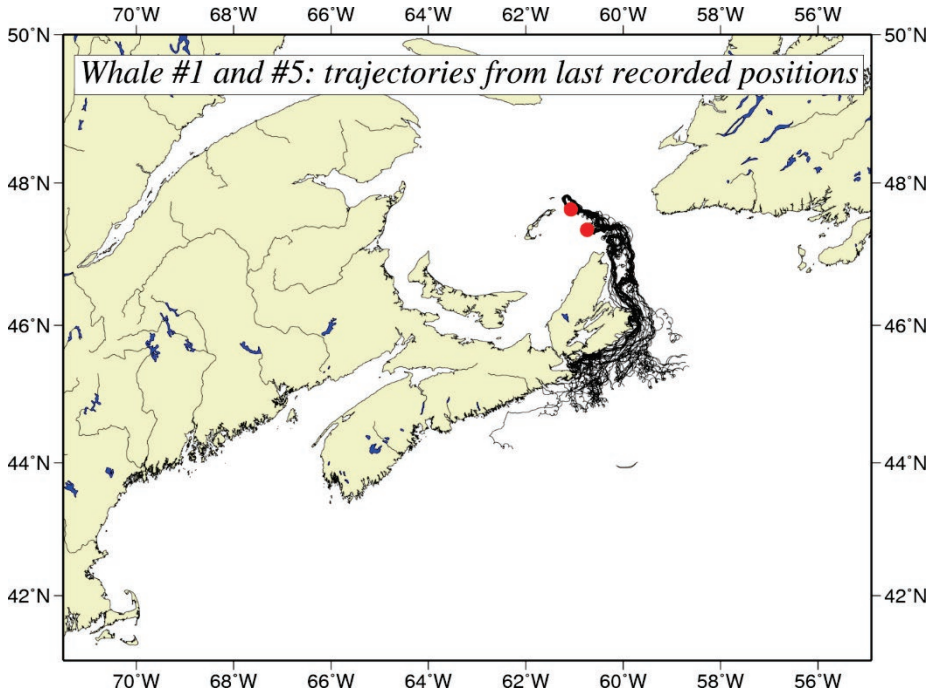


Figure 5. Forward-in-time trajectories for NARW #1 and #5 found dead in the southern Gulf of St. Lawrence. The red dots are the last recorded positions of the dead whales. The trajectories end on August 12, 2017.

Annex 6: Toxic Algae and Phycotoxin Testing during the Right Whale Mortality Event, 2017

Author: Michael Scarratt, Michel Starr, Sonia Michaud, Jean-Yves Couture, and Marjolaine Blais, DFO- Science

Note*: A DFO manuscript report has yet to be finalized.

Analyses:

Following the first report of the dead NARW in the Gulf of St. Lawrence in June 2017, samples were consolidated from available source of potential food for those marine mammals such as samples of phytoplankton and zooplankton from the area where the carcasses were found. Three sources of samples were used (Fig. 1).

1) The annual AZMP/mackerel survey mission aboard CCGS Teleost had passed through the region of the Magdalen Shallows in early- to mid-June, roughly simultaneous with the time the mortalities are presumed to have occurred. During this survey, preserved phytoplankton samples were collected at regular AZMP stations (red dots, transect names indicated), including twice at the Shediac Valley buoy station. These samples were analysed by light microscopy for the presence of known toxic species. We included samples from AZMP transects in areas upstream of the mortality region.
2) The regular harmful algae monitoring program of MLI provided phytoplankton samples from three coastal stations around the Gaspé Peninsula (black dots), including Mont-Louis, Gaspé, and Gascons. We also included samples from Sept-Îles, on the Québec north shore. Sampling occurs approximately every week. Analysis was performed by light microscopy.
3) We obtained frozen zooplankton samples from 32 stations of the mackerel survey (blue stars), covering essentially the entire area west of the Magdalen Islands and north of PEI as far as Gaspé/Chaleur Bay. Saxitoxin, a potent neurotoxin, and some of its derivatives that constitute the paralytic shellfish toxin family (PSP) were measured using Abraxis Enzyme-Linked Immunosorbant Assay (ELISA). This assay has proven to be sensitive, reliable and rapid in similar situations in the past (Starr et al. 2017).

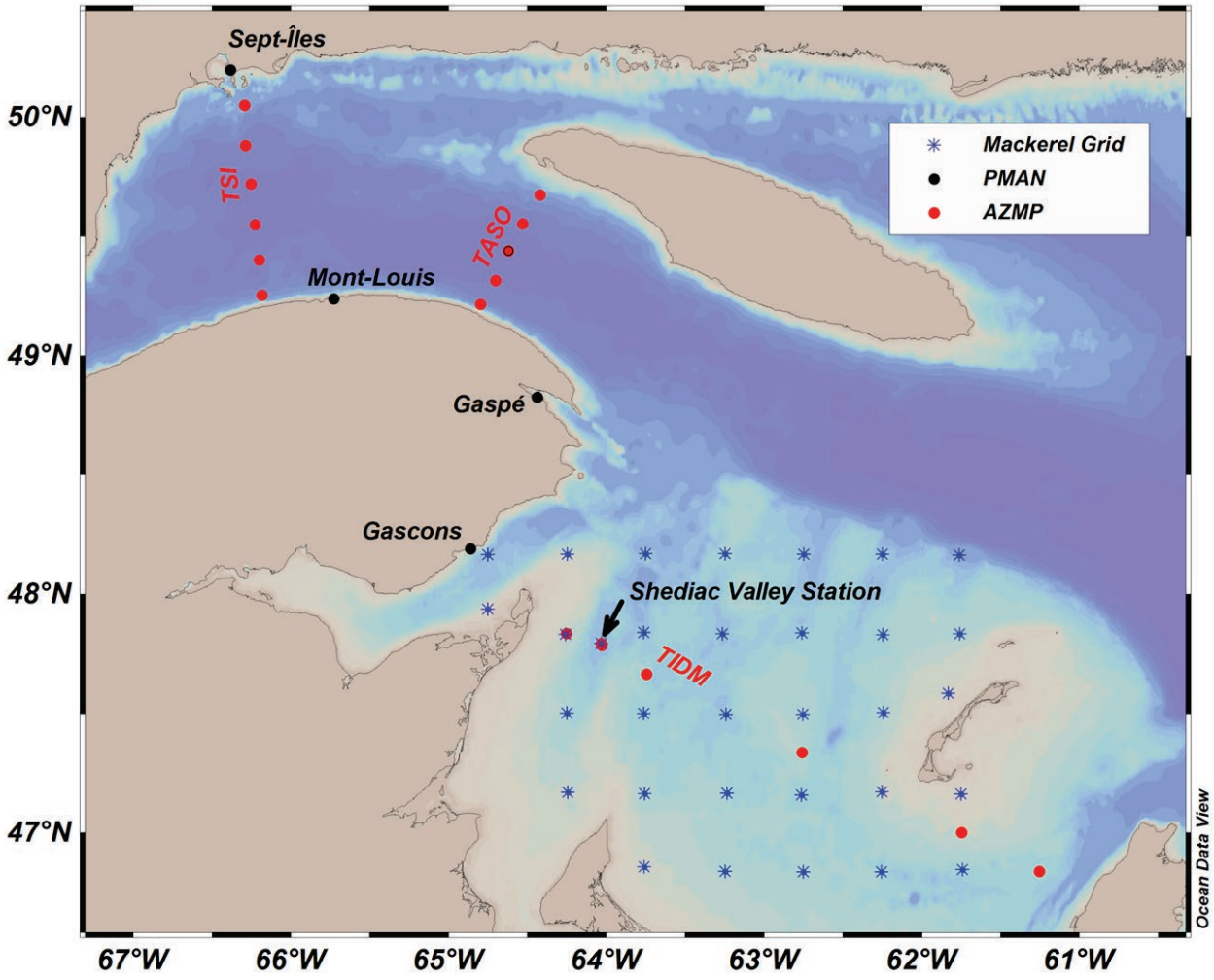


Figure 1: Map of sampling stations

Results:

Phytoplankton:

The dinoflagellate *Alexandrium* spp., which is known to produce PSP toxins in the St. Lawrence, was present at several of the stations sampled, but was considered to be in relatively low concentrations. Abundances reached a maximum of 1340 cells L^{-1} at the Gascons coastal monitoring station on 6 June 2017, and 940 cells L^{-1} at the Shediac Valley buoy on 16 June 2017 (Fig. 2). It should be noted that the Shediac Valley sample was integrated over 4 depths in the water column, so the maximal concentration near the surface could have been as high as 4000 cells L^{-1}. However, while this level is elevated, none of the other offshore stations indicated similar abundances, suggesting that there was not a widespread bloom.

The diatom genus *Pseudo-nitzschia* includes both toxic and non-toxic species. Among them are the source organisms for domoic acid, responsible for Amnesic Shellfish Poisoning (ASP). Cells of *Pseudo-nitzschia* spp. were found by light microscopy in low abundance at the AZMP stations on the Magdalen Shallows, although 2260 cells L^{-1} were observed at the Mont-Louis coastal

station, and much higher levels on the TSI transect and at the Sept-îles coastal station (24900 cells L^{-1}) (Fig. 3). However, these stations are sufficiently far from the area where the whale carcasses were found that the presence of *Pseudo-nitzschia* is unlikely to be linked to the whale mortalities. Moreover, since light microscopy does not allow reliable taxonomic identification to the species, and the toxicity of *Pseudo-nitzschia* spp. is dependent upon the environmental conditions, consequently we cannot be certain of the potential toxicity of those samples.

The Diarrheic Shellfish Poisoning (DSP)-producing species *Dinophysis* spp. and *Prorocentrum* spp. were observed in high abundance at the coastal monitoring stations and along the TIDM transect across the Magdalen Shallows, reaching a maximum concentration of 8880 cells L^{-1} at Gascons on 4 July 2017, and an offshore maximum of 1040 cells L^{-1} on 3 June 2017 (Fig. 4). However it should be noted that while some species of those two genera are known to be toxic, the clinical syndrome observed in humans is not fatal, and to our knowledge the toxins have never been associated with cetacean disease or mortality. Moreover, we did not identify to the species all the cells present in the samples so the potential toxicity is uncertain.

Phycotoxins:

Our results suggest that the zooplankton samples would have tested negative for saxitoxin and some of its derivatives under the conditions of dilution recommended by the ELISA kit manufacturer (Abraxis; 1/1000). When tested at 1/250 dilution, only eight samples of a total of 34 were weakly positive at the detection limit or just above, the highest being only 2.8 µg/100 g (Fig. 5). At 1/250 dilution, the detection limit of the assay was 0.92 µg/100 g, and the regulatory limit for human consumption is 80 µg/100 g, so these are very low levels. Some of those samples were also tested at an intermediate dilution of 1/500 and appeared to be negative, as expected.

The oral lethal dose in humans (LD50) for saxitoxin is around 5.7 µg STX/kg of body weight (Meyer 1953). Considering that a whale (weighting around 100 000 kg) can consume up to 4 000 kg of zooplankton daily (Steele, 2009), and assuming that this zooplankton contained 2.8 µg STX /100 g (the maximum value observed here), we estimate that the oral dose of this individual would be roughly equivalent to 1.1 µg STX/kg body weight. This represents five times less than a human's lethal dose. Assuming a lethal dose similar to that observed in humans, this simple calculation shows that toxin concentrations observed in zooplankton are unlikely to have caused fatal intoxication in whales.

In addition, comparing similar results in the literature from the Bay of Fundy (Turner et al. 2000; Doucette et al., 2005, 2006), we note that the concentrations observed in the current case are more than an order of magnitude below levels previously observed in zooplankton and in the feces of living right whales, suggesting that the animals can tolerate levels far higher than those observed here.

Another point worth noting is that this mortality event appears to have been confined to right whales, whereas if a major toxic bloom were involved, we would expect to find carcasses of other species, including birds, fish and possibly other mammals, as has been observed

elsewhere (Starr et al. 2017). It is unlikely that a biotoxin event would affect only one species of predator.

Fig. 2: Alexandrium spp. cells/L

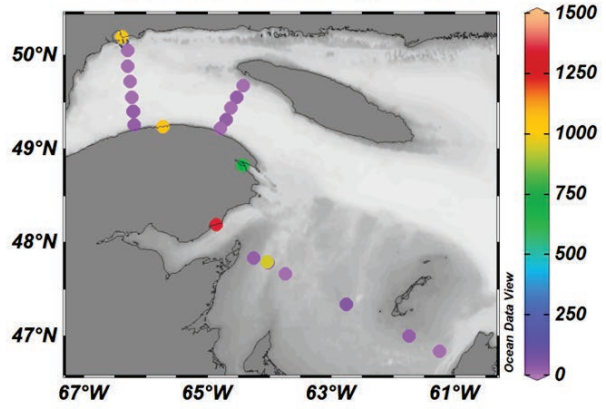


Fig. 4: DSP species cells/L

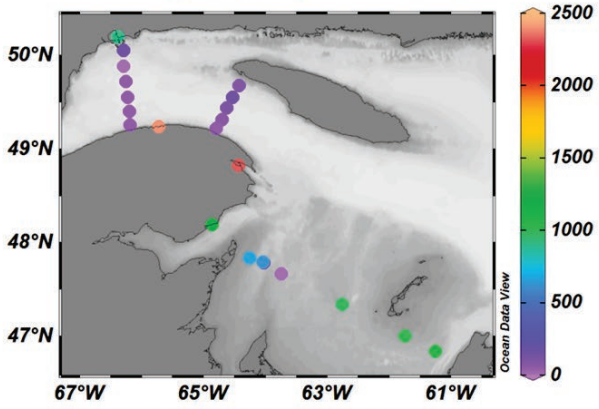


Fig. 3: Pseudo-nitzschia spp. cells/L

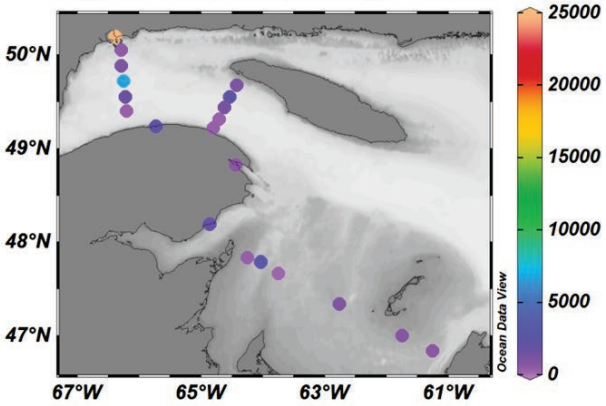
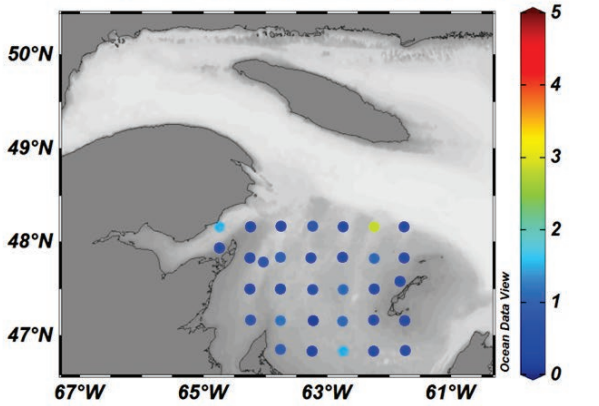


Fig. 5: Zooplankton STXeq µg/100g



Summary:

We tested samples of phytoplankton and zooplankton that may have been potential food for the right whales that were found dead after migrating into the Gulf of St. Lawrence in 2017. The phytoplankton cells of *Alexandrium* spp. (PSP toxins), of *Dinophysis* spp. and *Prorocentrum* spp. (DSP toxins), and of *Pseudo-nitzschia* spp. (ASP toxins), were present but in low abundances and at some stations only. The zooplankton samples tested negative for PSP toxins, with the exception of trace concentrations found in 8 samples out of 34. Those results suggest that intoxication from the plankton was not implicated in this mass mortality. This is consistent with the results from the CFIA who tested for phycotoxins in tissue samples from the right whale carcasses (see their report).

The presence of phycotoxins in the marine food web is well-established and has been shown to be a cause of mortality in cetaceans and other mammals (Flewelling et al. 2005; Lefebvre et al. 2010; Starr et al. 2017). It is also plausible that sub-lethal exposure to phycotoxins may contribute to the accidental deaths of marine mammals by modifying their behaviour or mobility, rendering them more vulnerable to entanglement in fishing gear or collision with ships. While the evidence we present here does not support a conclusion of acute intoxication, we recognise the

possibility that the whales may have become intoxicated outside the Gulf of St. Lawrence during their migration. In this context it is worth noting that the east coast of the US has experienced large blooms of *Pseudo-nitzschia* spp. in late 2016 (http://www.mass.gov/eea/docs/dfg/dmf/marinefisheriesnotices/asp-info-document-102116.pdf; http://www.providencejournal.com/news/20170303/mysterious-toxic-algae-that-shut-down-ri-shellfishing-last-fall-is-back) and large blooms of *Alexandrium* during the spring and summer of 2017 (http://www.pressherald.com/2017/05/23/red-tide-prompts-state-to-close-many-clam-flats/;http://www.pressherald.com/2017/07/20/local-mussels-return-to-menu/). *P. nitzschia* can cause memory loss and brain damage in marine mammals (http://www.nmfs.noaa.gov/pr/pdfs/health/domoic_acid_california.pdf).

Acknowledgements:

We thank Martin Castonguay (MLI) and Dominique Robert (ISMER) for making the frozen zooplankton samples available for testing.

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Annex 7a: Inquiry of entanglement of NARW #4 female Starboard (Necropsy #3)

Author: Ron Belliveau, DFO- Conservation and Protection, Chief Enforcement and Operations

Note: In order to respect privacy requirements, information that could be used to identify individual fish harvesters (e.g. VRN numbers) has been omitted from this report. The buoy numbers shown in Annexes are not specific to individuals.

Introduction:

On July 6th, the captains of Vessel A and Vessel B were questioned regarding buoy # 154 and #252, respectively. Details on the third buoy associated with Vessel C were also investigated. All detailed accounts from fishers were verified using Vessel Monitoring System (VMS) data to corroborate and/or establish geographic locations of the vessels and traps outlined in fishers statements.

Gear report:

1st Buoy: Buoy # 154 set by Vessel A

1. On June 3rd 2017, the snow crab trap with buoy #154 was set in snow crab grid zone GW-41 (no GPS location recorded).
2. Crab trap #154 was fished June 6th in GW-41
3. Fisher noted that crab trap #154 was missing on June 15th
4. VMS data captured Vessel A fishing on June 12th then June 16th.
5. There was no attempt to relocate the gear.

Gear details:	
Gear Type:	7 foot conical trap, approx. weight -200 lbs
Rope Length:	+/- 100 fathoms, 5/8 inches thickness
Depth of water:	55 phantoms of water
Position:	NIL, Grid GW-41
CPU-	Approx. 125 lbs per traps

2nd Buoy: Buoy #252 set by Vessel B

1. On June 16th 2017 at 22h44 local time, the snow crab trap with buoy #252 was set at Lat: 48 14.051' N / Long: 063 02.907'W.
2. Fisher noted that crab trap #252 was missing on following fishing trip.
3. VMS captured vessel in the area on June 22nd 2017 at approximately 07h45 local time.
4. Vessel B searched for missing gear and found it entangled in dead whale NARW #4 approximately ¼ nm southeast of gear set location. No attempt to retrieve gear at this time.
5. Vessel B returned to dead entangled NARW #4 between June 26th and 27th to recover gear. Fisher reported that attempt was unsuccessful and no gear was cut or removed as

line was under extreme tension. The fisher noted there were 4 crab traps entangled in total at this time.

6. Only two crab traps were observed by fishery officers on June 24th and retrieved on June 29th. Fishery Officers stated that there could have been a third trap since one of the ropes was broken off.

Gear details:

Gear Type:	7 feet conical trap, approx. weight -180 lbs
Rope Length:	+/- 100 fathoms, 5/8 inches thickness
Depth of water:	39 phantoms of water
Position:	48 14.051' N / Long: 063 02.907'W (GW-42)
CPU-	Approx. 140 lbs per traps

3rd Buoy-Vessel C

Vessel Registration Number (VRN) noted on this buoy corresponded to a snow crab vessel inactive since 2011. Gear and buoy likely recycled without proper identification. Origin of gear used in 2017 is unknown.

Summary:

The first entanglement occurred between June 12th and June 16th in Grid GW41. The second entanglement transpired approximately 8.8nm from first entanglement between June 16th and June 22nd. The entangled dead NARW was first observed during aerial survey on June 21st, 0.12nm east of recorded trap location; therefore, mortality occurred between June 17th and June 21st, 2017. Number of traps involved in incident is unclear; fisher noted four traps at last sighting on June 26th whereas Fisheries Officer only noted and retrieved 2 on June 24th and June 29th, respectively, although broken rope was observed at retrieval. The Coast Guard MSVP A. LeBlanc retrieved NARW#4 on June 29th. Entangled traps were cut in order to secure the whale for towing to Norway PEI.

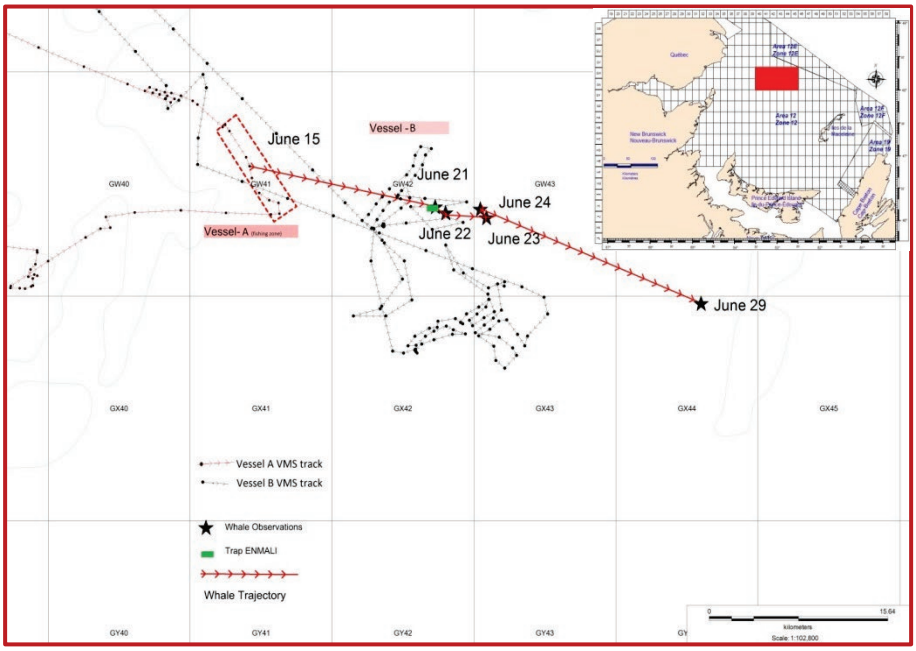


Figure 1- Map of gear entanglement timeline depicting NARW#4 and snow crab gear location. The size of each snow crab grid is approximately 10 nm (latitude) and 6.6 nm (longitude).

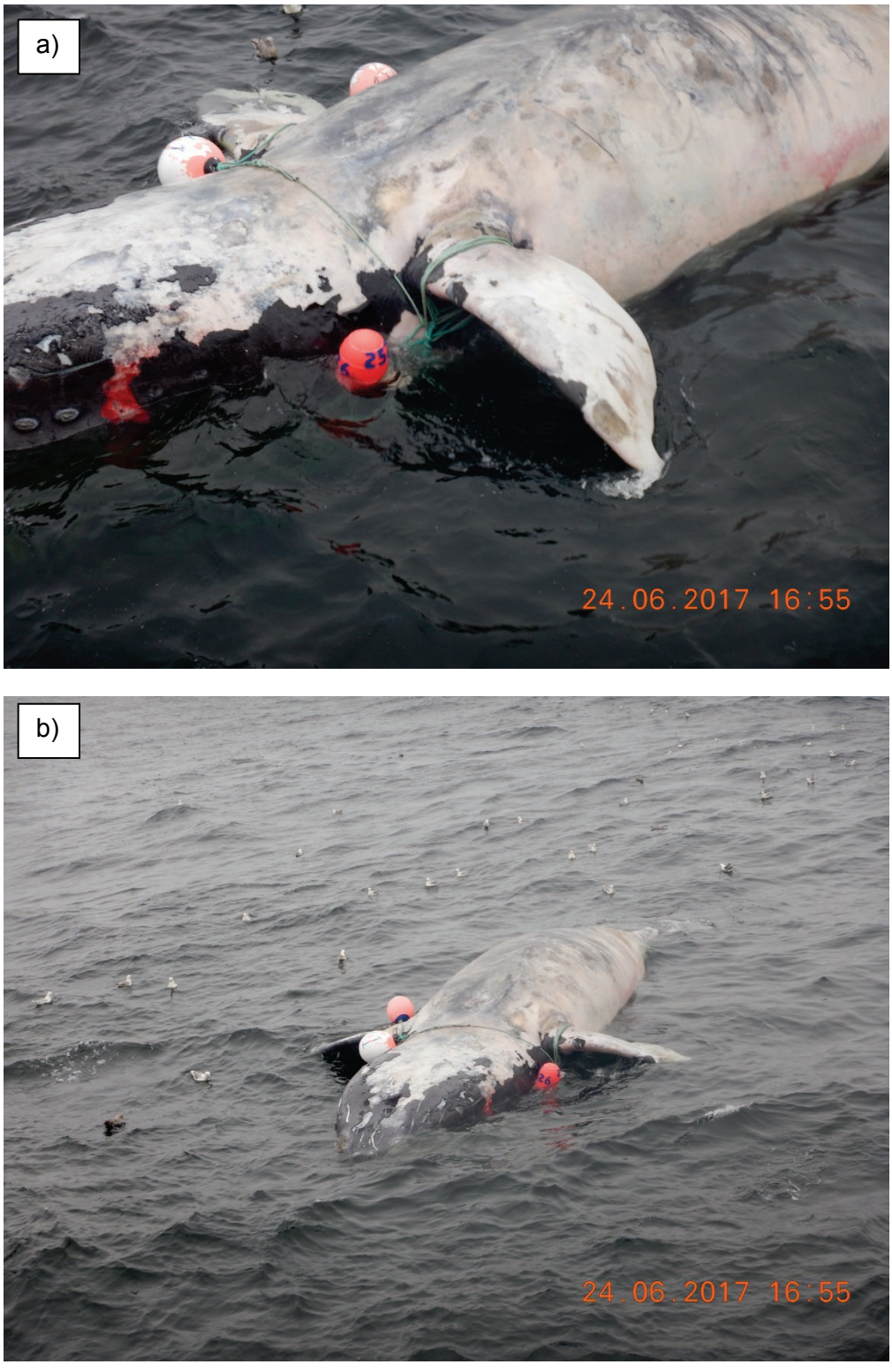


Figure 2- Gear Entanglement observed by fishery officers on June 24th, 2017.

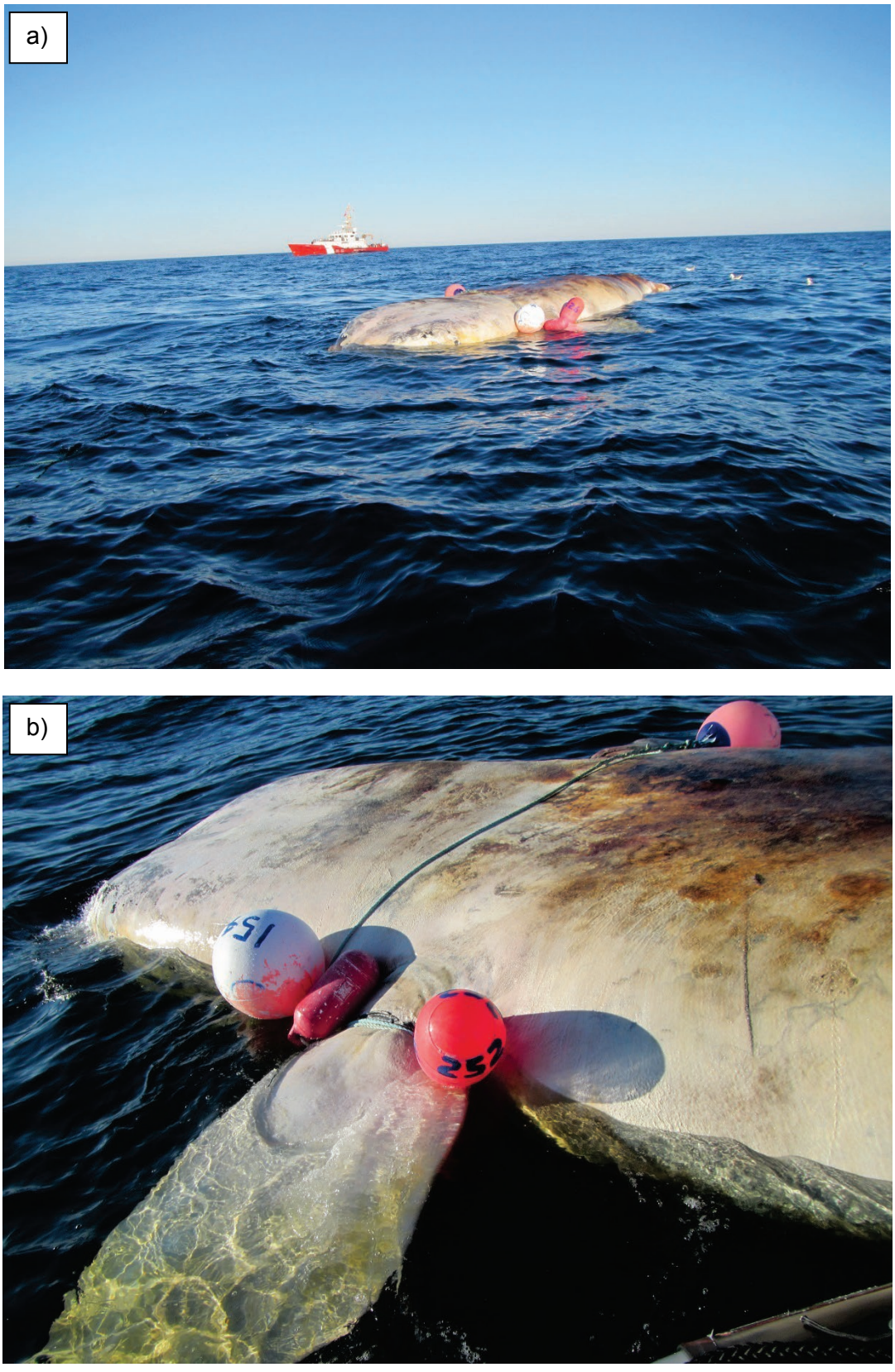


Figure 3- Gear Entanglement observed by fishery officers on June 29th, 2017

Annex 7b: Entangled Right Whale EG#4 Fishing Gear Report, Catalog #3603 "Starboard", MARS2017-143

Author: Jen Jakush, Florida Fish and Wildlife Conservation Commission and
Tonya Wimmer, Marine Animal Response Society

September 16, 2017

Note: In order to respect Federal privacy laws, information that could be used to identify individual fish harvesters (e.g. VRN numbers) has been omitted from this report. The buoy numbers shown in Annexes are not specific to individuals.

Entangled Whale Carcass First Observed:		June 21, 2017, 48.2335N, -63.04506W by DFO C&P surveillance aircraft
Subsequent Sighting #1:		June 22, 2017, ~50.4nm ESE of Perce, QC (48.22981, -63.03216) by NEFSC survey aircraft
Subsequent Sighting #2:		June 26, 2017, ~53nm ESE of Perce, QC (48.22696, -62.96395) by NEFSC survey aircraft
Subsequent Sighting #3:		June 27, 2017, ~54.7nm ESE of Perce, QC (48.19596, -62.93913) by NEFSC survey aircraft
Subsequent Sighting #4:		June 29, 2017, ~59.3nm ESE of Perce, QC (48.16473, -62.83529) by NEFSC survey aircraft
Carcass taken under tow:		June 29, 2017 (48.16473, -62.83529) By Canadian Coast Guard (MSVP A. LeBlanc)
Carcass and Gear Examined:		July 1, 2017 at Phee Beach, Norway, Prince Edward Island, Canada by Canadian Wildlife Health Cooperative and Marine Animal Response Society with Fisheries and Oceans Canada (and many volunteers)
Whale last seen alive without gear:		April 23, 2017, south of Martha's Vineyard by NEFSC survey aircraft.

Initial Sighting and Gear Configuration Changes Observed at Sea

During a surveillance flight over the Gulf of St. Lawrence, a Fisheries and Oceans Canada (DFO) Conservation and Protection (C&P) aircraft sighted the carcass of a North Atlantic right whale entangled in multiple lines and buoys, apparently anchored in place. Based on photographs, the carcass was identified by the New England Aquarium (NEAq) as Catalog #3603, an 11-year-old adult female.

DFO examined the gear and questioned the captains who set the gear on July 6th, 2017. Through these discussions, it was determined that the whale was entangled in at least two sets of snow crab gear that had been set in (potentially 3-4 more as per observations made by one of the fishermen involved). Most fishermen in the southern Gulf of St. Lawrence fish using a single trap arrangement: one trap, a line extending from the trap to a surface buoy, the surface buoy (often an A3 or A4 polyball) and, in many cases, a line from the surface buoy to a smaller gaff buoy (M. Moriyasu, DFO Science, pers. comm.; see Figure 22). A trap has two sets of ropes attached across the trap perpendicularly to each other (the bridle) with 4 connection points on the trap itself. Based on the timing of the setting and loss of the gear, it is likely the animal picked up and moved one gear set between June 12th to16th about 8nm before becoming entangled in the second pot between June 16th to 21st (See Annex 7a for details of discussion, gear and timeline justification).

The carcass was re-sighted and photo documented four additional times between June 22nd and June 29th. Although the carcass was initially thought to be anchored, it drifted almost 9nm to the ESE over the course of 7 days from the first reported position.

Upon initial sighting on 21 June, there appeared to be taut/weighted lines from the whale's head/mouth and right flipper, leading away from the whale in opposite directions and there were three buoys visible on the whale's left side (Figure 1). Approximately 24 hrs later, on June 22nd, the lines and one of the buoys had shifted to the right side of the whale and the taut lines leading to weight subsurface were no longer obvious (Figure 2). By 26 June, the carcass had drifted ~2.75nm and the configuration of the gear appeared relatively similar to the previous sighting (Figure 3). Between the sightings on June 22nd and June 27th, the carcass drifted an additional 2nm and a change in the gear configuration was noted. The two buoys that had been near the whale's left body/flipper had moved toward mid ventral body and there were now two buoys visible at the surface close to the right flipper (Figure 4). Additionally, a long length of line was now floating freely at the surface next to the whale. One end terminated at a knot attached to two short lines with four cut ends (Figure 5). The last aerial sighting of the carcass was on June 29th, at which point the carcass had drifted an additional 4.5nm and the two spherical poly balls had shifted closer to the right flipper (Figure 6).

Carcass Recovery

The carcass was recovered and towed ashore by the Canadian Coast Guard *MSVP A. LeBlanc* on June 29th, 2017 (48.16473N, -62.83529W). For the safety of tow operations, fisheries officers removed two crab traps and indicated there could have been a third set originally attached as one rope was broken off. Information on their procedure, gear cut and removed and images are

provided in Annex 7a. Information regarding what was retained (if anything) and what gear was left on the animal when towing commenced has not yet been provided.

Gear Examination and Disposition

After being towed to shore, the carcass was hauled up onto the beach for examination on July 1st, 2017. Photographs of the remaining entangling gear were taken in situ (Figure 7). The right flipper was removed for further analysis of the lesions associated with the entanglement, as well as the bones/joints involved, and the gear was moved and laid out on a tarp for examination (Figure 8).

Gear Description

The gear remaining on the whale at the time of the necropsy consisted on 30.2 m of rope and two buoys.

Rope

- Segment 1 was approximately 21.8 m of 5/8 in diameter 3-strand synthetic aqua-colored "float" rope (Figure 9)
    - The line originated with a rough/sheared, frayed end and terminated with a clean cut, slightly frayed bitter end (Figure 10)
    - The line encircled the right flipper three times and wrapped around itself four times
    - After the flipper wraps, there was 15.8 m of loose/straight line
    - Shortly before the cut bitter end the line was twisted up/wrapped around (Figure 11) a separate piece of line/gear (Segment 2)
    - Based on aerial photographs of the carcass, it is unclear whether this segment of line may have originally been connected to the two poly balls that were present with the carcass for the duration of its time at sea, and/or a pot/trap at depth.
- Segment 2 was approximately 3.7 m of 3/4 in diameter 3-strand light blue-colored rope with black tracer and lead in all three strands (Figure 12)
    - The line originated with a clean bitter end (wrapped w/ aqua tape and slightly melted) (Figure 13) and terminated in a clean cut, slightly frayed bitter end (Figure 14).
    - The line passed through the poly buoy eye and approximately 110cm of line was doubled back on itself, held together in multiple locations where the line was tucked through one strand (Figure 15).
    - The lead line was connected to a short section of floating line (Segment 3) via a 20cm long splice (Figure 16).
    - The cut frayed end was approximately 260 cm below the buoy.
- Segment 3 was approximately 4.5 m of 1/2 in diameter 3-strand light blue-colored "float" rope with yellow tracer (Figure 17)
    - The line originated with a clean bitter end (wrapped with black tape and slightly melted) and terminated in a 20cm long splice into the lead line.
    - The line passed through the "pick-up" buoy eye and doubled back on itself, held together in multiple locations where the line was tucked through one strand.

Buoys

- Buoy 1 was an orange, Polyform LD-2 cylindrical shaped poly buoy with blue rope hole (Figure 18)
    - The numbers 252 252 and the #VRN were hand written on the buoy in dark blue paint
- Buoy 2 was a red, hard plastic cylindrical shaped buoy
    - No markings were present on this toggle/pick-up buoy (Figure 17)

There were two additional buoys that were attached to the carcass while at sea (Figure 19), but presumably removed by DFO prior to being taken under tow.

- Buoy 3 was a large, white, spherical shaped poly buoy (estimated size= A4) with black rope hole (Figure 20)
    - The buoy was mostly white, but had patchy areas of orange near the rope hole that may be peeling/rubbed off paint/coating.
    - There were numbers hand written on the buoy in blue paint. The number 154 was clearly visible on the top of the buoy but the numbers written on the sides were obscured.
- Buoy 4 was a large, orange, spherical shaped poly buoy (estimated size=A3) with blue rope hole (Figure 21)
    - This buoy was at the terminal end of the line and appeared to be the toggle/pick-up buoy.
    - The buoy was mostly orange, but had patchy areas of white that may have been peeling/rubbed off paint/coating.
    - There were numbers hand written on the buoy is black marker/paint. The number 154 was visible on the top of the buoy but the numbers written on the sides were obscured.

Discussion

During the summer of 2017, an aggregation of over 100 individual right whales was present in the Gulf of St. Lawrence. Catalog #3603 was the fourth of twelve right whale carcasses discovered in the Gulf between early June and mid-September. It was one of two with gear attached. Additionally, there were four live entangled whales discovered in the same general area during a 15-day period in July.

The gear attached to Catalog#3603 was confirmed by C&P to be from the commercial snow crab fishery which was active in Area 12 (Southern Gulf of St. Lawrence) at the time that the carcass was discovered.

At this time, it is unclear what or how much gear was removed from the carcass prior to it being towed to shore. Based on photographs we know that the line and buoys that remained on the carcass at time of necropsy was a subset of the gear that was originally present.

The gear was laid out, inspected, photographed and tagged but was not taken apart in any way. It was bagged in its original configuration in case gear experts from DFO or other agencies/stakeholders want to examine it in the future.

Acknowledgements
Aerial survey team – Tim Cole, Pete Duley, Jen Jakush, and Angelia Vanderlaan
Gear documentation during necropsy – Angelia Vanderlaan

Figures

Figure 1. Carcass of Catalog #3603 on 21 June 2017. Photo provided by Fisheries and Oceans Canada/Conservation & Protection

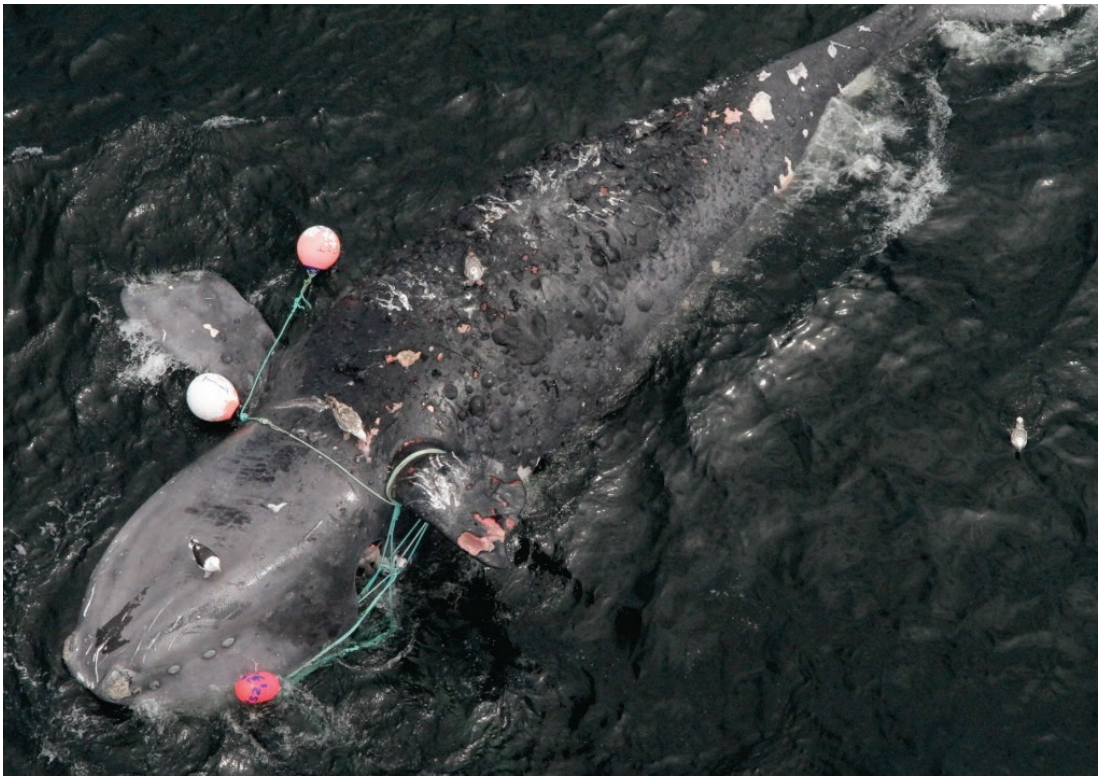


Figure 2. Carcass of Catalog #3603 on 22 June 2017. Photo by NEFSC taken under SARA Permit # DFO-MAR-2016-02 (Amendment 1) and NMFS Permit # 17355

Figure 3. Carcass of Catalog #3603 on 26 June 2017. Photo by NEFSC taken under SARA Permit # DFO-MAR-2016-02 (Amendment 1) and NMFS Permit # 17355

Figure 4. Carcass of Catalog #3603 on 27 June 2017. Photo by NEFSC taken under SARA Permit # DFO-MAR-2016-02 (Amendment 1) and NMFS Permit # 17355

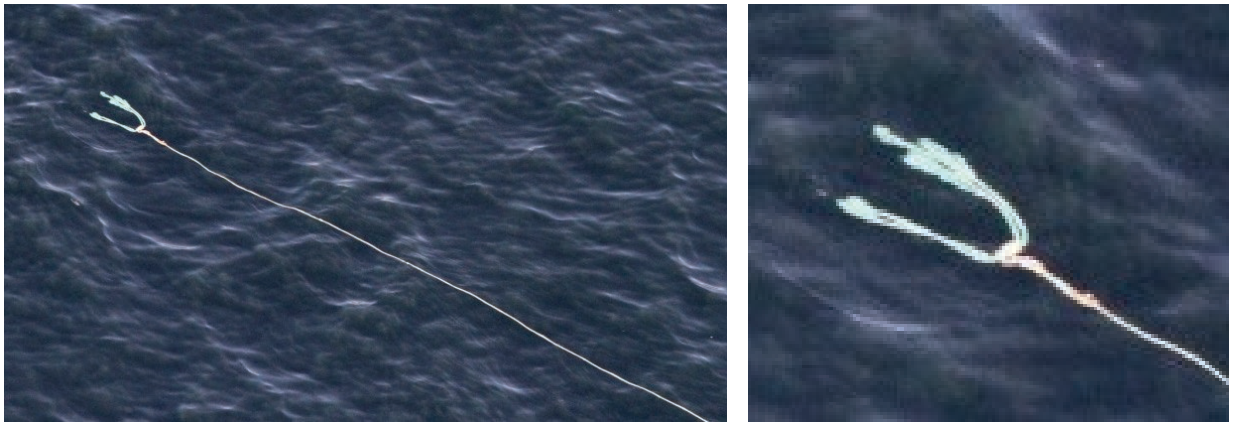


Figure 5. Floating line near carcass with knot and four cut ends

Figure 6. Carcass of Catalog #3603 on 29 June 2017. Photo by NEFSC taken under SARA Permit # DFO-MAR-2016-02 (Amendment 1) and NMFS Permit # 17355

Figure 7. Entanglement in situ on the beach prior to necropsy on 01 July 2017.

Figure 8. All of the gear that was remaining on the carcass when it arrived on the beach on 01 July 2017, laid out on a tarp for inspection and documentation.

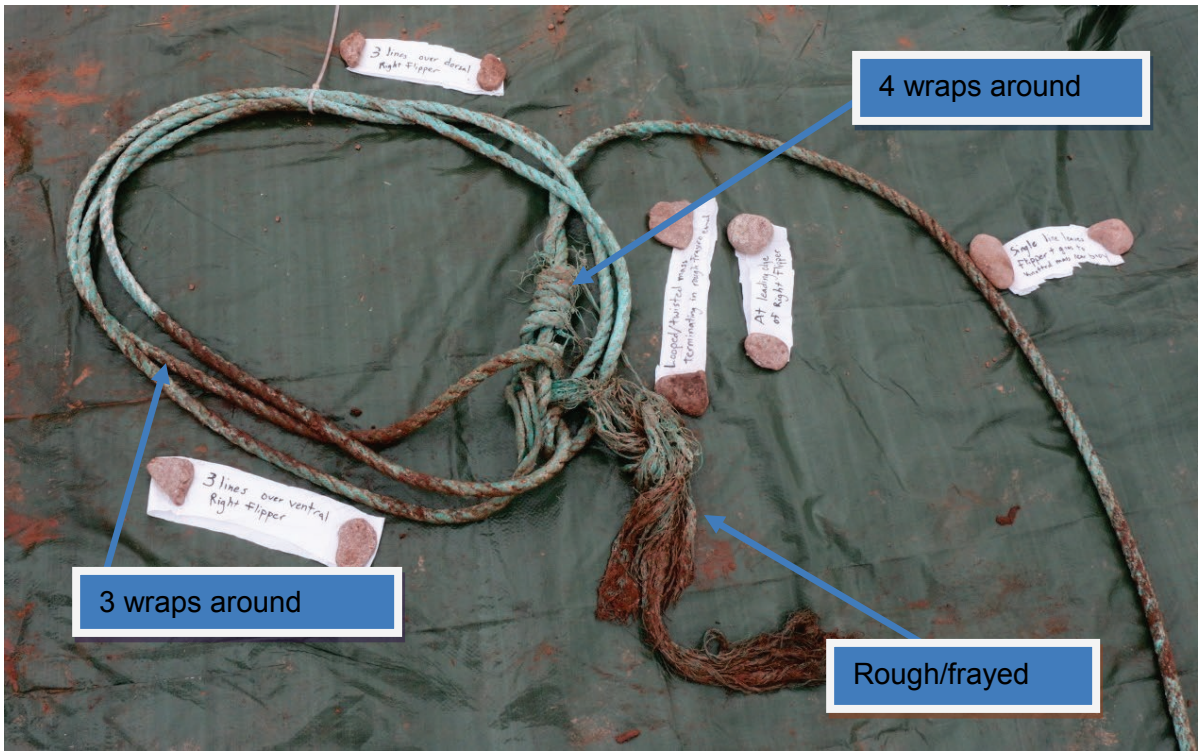


Figure 9. Segment 1- 5/8 in diameter 3-strand synthetic aqua-colored rope.

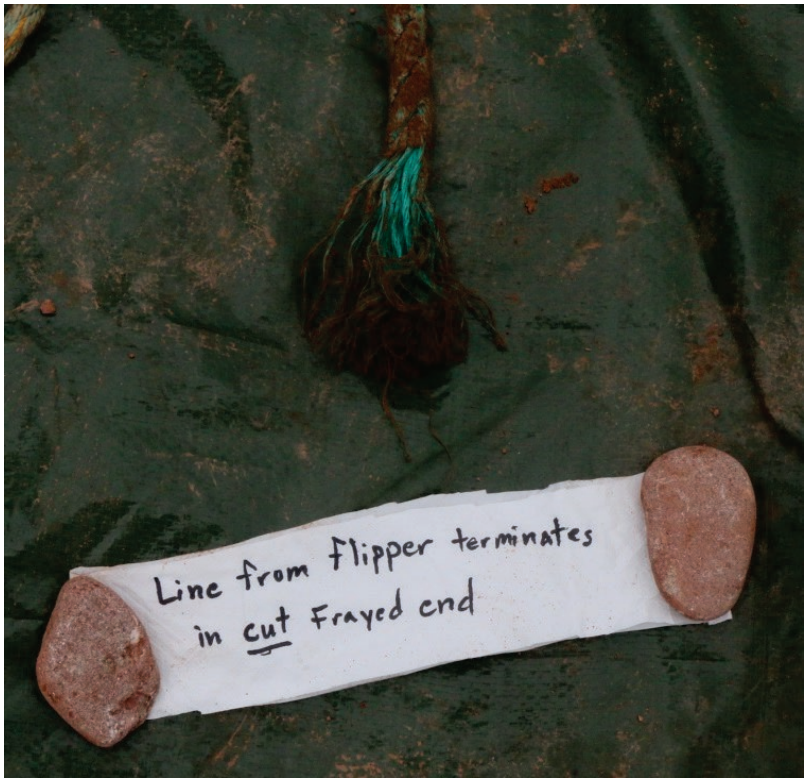


Figure 10. Slightly frayed bitter end of Segment 1

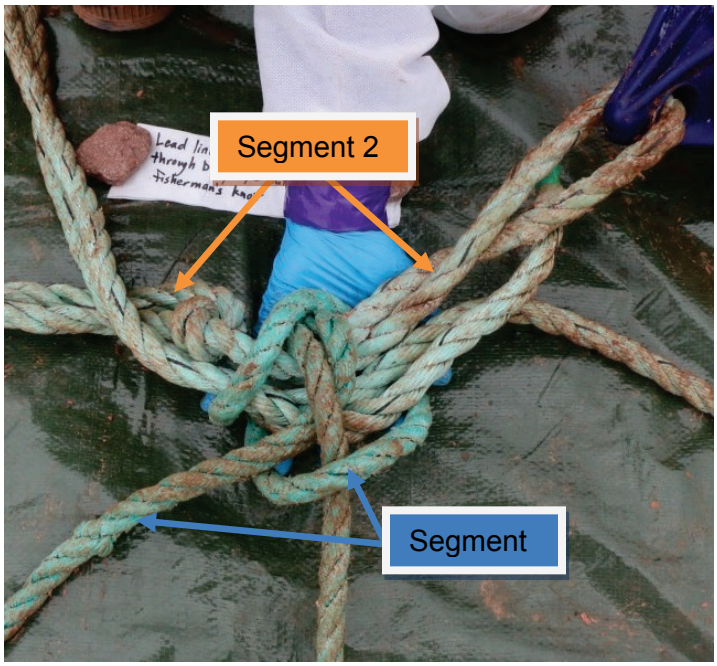


Figure 11. Segment 1 twisted/wrapped around Segment 2, near where it connected to Buoy 1.

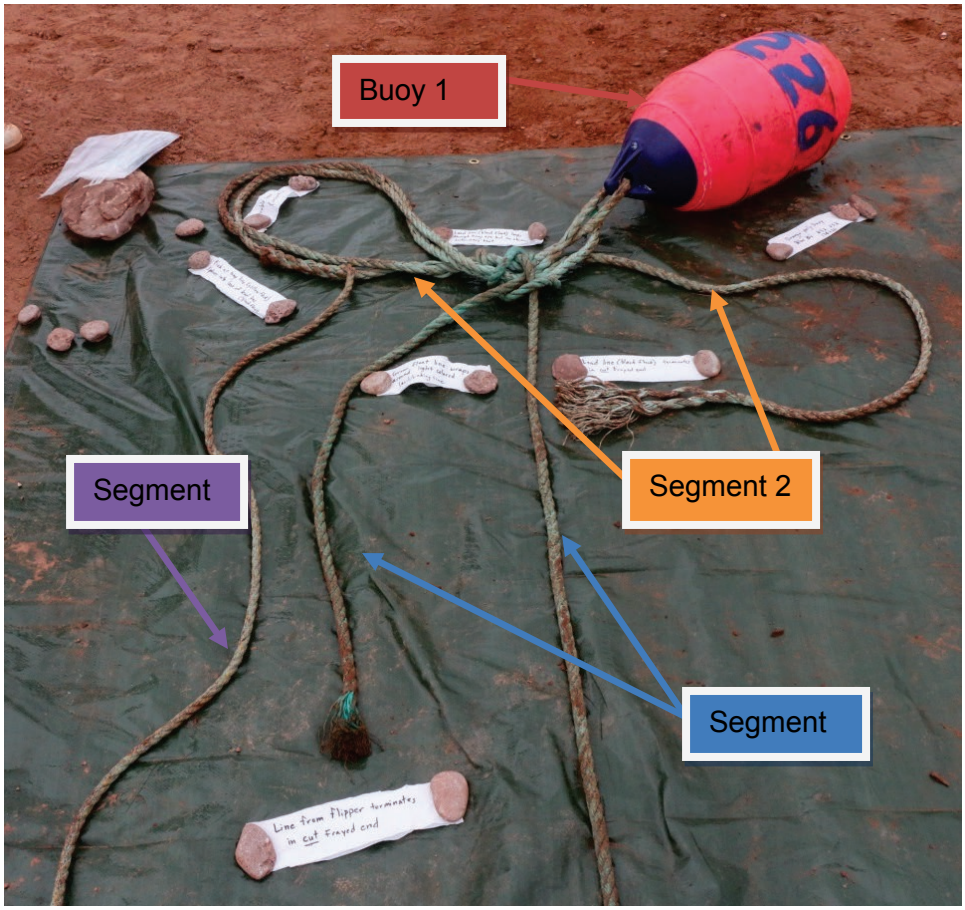


Figure 12. Segment 2- 3/4 in diameter 3-strand, lead weighted, light blue-colored rope with black tracer

Figure 13. Clean/taped bitter end of Segment 2

Figure 14. Cut, slightly frayed bitter end of Segment 2 with lead weight visible.

Figure 15. Lead line doubled back on itself and tucked under one strand in several places rather than knotted.

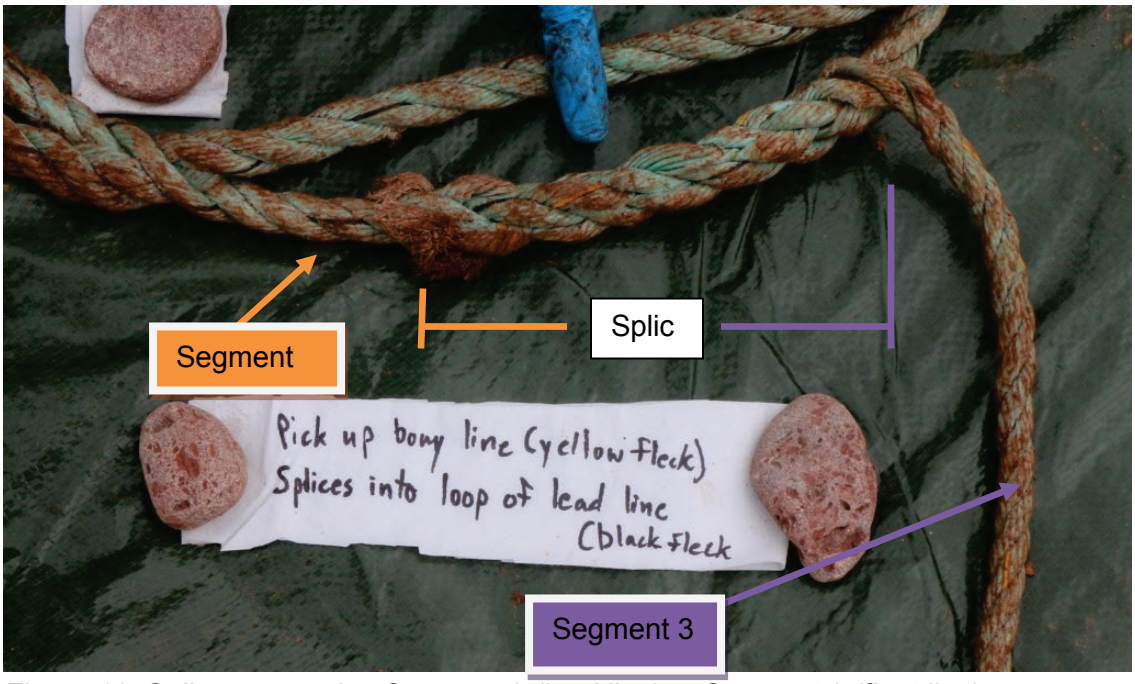


Figure 16. Splice connecting Segment 2 (lead line) to Segment 3 (float line)

Figure 17. Segment 3- 1/2 in diameter 3-strand light blue-colored rope with yellow tracer, with Buoy 2 attached.

Figure 18. Buoy 1- Orange Polyform LD-2 with painted blue numbers 252.

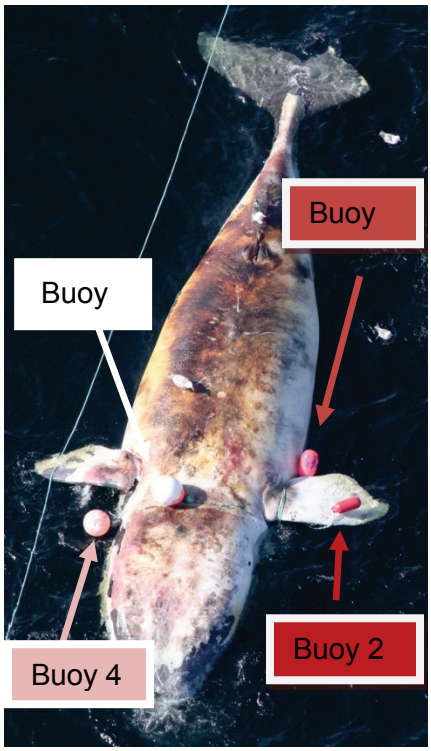


Figure 19. Buoys 1, 2, 3 and 4 present on carcass at sea on 29 June 2017. Photo by NEFSC taken under SARA Permit # DFO-MAR-2016-02 (Amendment 1) and NMFS Permit # 17355

Figure 20. Buoy 3- large, white, spherical shaped poly buoy (estimated size= A4) with black rope hole. Number 154 clearly visible, other numbers present but partially obscured.

Figure 21. Buoy 4- large, orange, spherical shaped poly buoy (estimated size=A3) with blue rope hole.

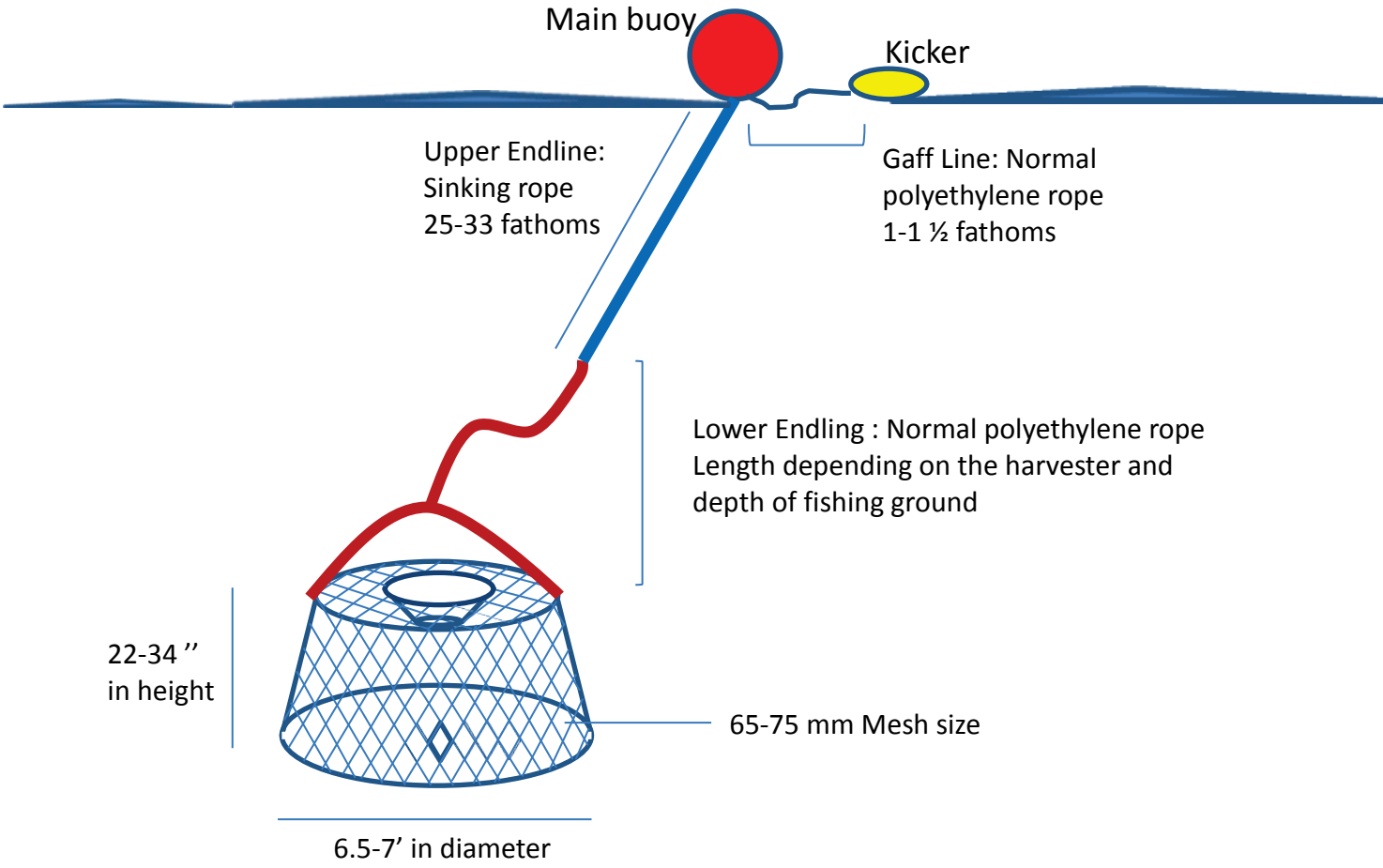


Figure 22. Schematic of the configuration of set snow crab gear in the Gulf of. St. Lawrence (developed in collaboration with Mikio Moriyasu, DFO-Science). 1 fathom = 6 feet

Annex 7c: Entangled Right Whale #9 Fishing Gear Report, Catalog #4504, MARS2017-312

Author: Tonya Wimmer, Marine Animal Response Society

November 23, 2017

Entangled Whale Carcass First Observed:		Sept 15, 2017, 48.1503N, -63.5009W by DFO C&P surveillance aircraft
Carcass taken under tow:		Sept 18, 2017 (48.1503N, -63.5009W) By Canadian Coast Guard
Carcass and Gear Examined:		Sept 19, 2017 at Miscou Island, NB, Canada by Canadian Wildlife Health Cooperative and Marine Animal Response Society with Fisheries and Oceans Canada (and many volunteers)
Whale last seen alive without gear:		August 7, 2015, Gulf of St. Lawrence as a calf with her mother by NOAA survey aircraft.

Initial Sighting and Carcass Recovery

During a surveillance flight over the Gulf of St. Lawrence on September 15th, a Fisheries and Oceans Canada (DFO) Conservation and Protection (C&P) surveillance aircraft sighted the carcass of a North Atlantic right whale entangled in line. Based on photographs, the carcass was identified by the New England Aquarium (NEAq) as the 2-year-old calf of Catalog #1604. This animal later received her own catalog number: #4504.

Upon initial sighting on 15 Sept., there appeared to be a heavier taut line across the ventral surface forward of the flippers (Figure 1). There also appeared to be a smaller line extending from the anterior insertion of the left flipper towards the posterior insertion of the right flipper, across the animal's ventral surface.

The animal was recovered and towed ashore by the Canadian Coast Guard on September 18th. There were no identifying buoys present and no gear was removed from the animal at this time.

Gear Examination and Disposition

After being towed to shore, the carcass was hauled up onto the beach for examination on Sept 19th, 2017. At this time, a single trap was removed by DFO from a tricolour trailing rope (red, white and blue rope). Photographs of the remaining entangling gear were taken in situ (Figure 2-15). While the necropsy was completed quite quickly due to state of decomposition and size of the animal, examining the entanglement took a fair amount of time as ropes were around both flippers, the rostrum and through the mouth (Figures 2-3). The examination was dependent

on carcass position, and manipulation of the head was necessary to completely understand the nature of the entanglement and gear involved. This and the towing of the carcass onto the beach resulted in some of the ropes shifting from their original perceived position (determined by position of scars). The entire length of gear was removed from the animal (several cuts had to be made to facilitate its removal) and laid out for examination and documentation. Figure 4 illustrates the findings.

Gear configuration on animal

Images and video taken while examining and removing the rope from the animal enabled the recreation of the probable configuration of the entanglement. This is illustrated in Figures 5 – 7.

The entire entanglement was comprised of one length of rope comprised of 3 different kinds of rope (tricolour, yellow and green ropes) spliced together. Upon examination at the beach, it was determined that only the yellow rope (the middle segment) was involved in the wraps observed around the various parts of the animal (both flippers, the rostrum and the body). The tricolour and green ropes were spliced to the yellow rope, but neither was found to be wrapped around the animal.

There was a scar from a line extending from the anterior insertion of the left flipper towards the posterior insertion of the right flipper, across the animal's ventral surface. Upon examination on the beach, no line was present in that area, but it could have been from the end of the yellow rope that was eventually spliced to the tricolour rope (ending in the trap; see potential location indicated by an * in Figure 5).

Gear Description

The gear remaining on the whale at the time of the necropsy consisted of ~152.09 m of 3 kinds of rope that were spliced into one length of rope and one snow crab trap.

Rope Segments

- Segment 1 was ~54.81 m of 3/4" 3-strand tricolor (red, white and blue) rope (Figure 8)
    - This rope was originally attached to a snow crab trap. The trap was removed by DFO C&P to facilitate bringing the carcass ashore. The rope was cut close to the trap and ~ 0.3 m of rope remaining on the trap (Figure 9).
    - 0.61 m of rope at the other end of this segment was spliced together with the yellow rope (Segment 2).
    - To facilitate removal of the rope from the carcass, this rope was cut at ~9.12 m from the end spliced with the yellow rope (cuts labelled R6a/b).

- Segment 2 was ~62.32 m of 7/8" 3-strand yellow rope (Figure 10)
    - The line originated with a 0.61 m splice with the tricolour rope (Segment 1) and terminated in a 0.96 m looped splice with the green rope (Segment 3, Figure 11).
    - A 1.22 m tied-off loop was located at 24.53 m from the end spliced with the tricolour rope (Figure 4). The loop was tied with a small piece of string (Figure 12

and 13). This loop was present on the left, ventral side of the carcass when it was observed on the beach (Figure 13 and 14).
    - To facilitate removal of the rope from the carcass, this rope was cut once within the first 19.81 m from the end spliced with the tricolour rope (cuts labelled 2a/b) and 18.3 m from the end which was spliced with the green rope (cuts labelled 1a/b).
    - Only this segment of rope was involved in the entanglement and wraps on the animal's body at the time of examination.
    - One thing of note is that the end of the yellow rope that eventually became spliced with the tricolour rope and trap was threaded through the tied-off loop mentioned above (Figure 7, indicated by #2). Given the size of the trap, it is unlikely this occurred because of the animal encountering and then becoming wrapped up in the gear.

- Segment 3 was ~34.96 m of 3/24" 3-strand green rope (Figure 10)
    - The line originated with a 0.96 m looped splice with the yellow rope (Segment 2, Figure 11).
    - The line terminated with a frayed end which was taped in situ.

Trap

A 6-8' older style trap was attached to the end of the tricolour rope (Figure 9). DFO C&P stated this was an older-style trap which had not regularly been used for 8-10 years. There was no active crab tag on the trap but an older tag was present (tag was in French only: 088 MPO Crabe #####; Figure 15).

Discussion

During the summer of 2017, an aggregation of over 100 individual right whales was present in the Gulf of St. Lawrence. Catalog #4504 was the 12th of twelve right whale carcasses discovered in the Gulf between early June and mid-September. It was one of two with gear attached. Additionally, there were five live entangled whales discovered in the same general area in July and August.

The gear attached to Catalog#4504 was confirmed by C&P to be from the commercial snow crab fishery. However, at this time, it is not known whether the gear was being actively fished (though an active fishing tag was missing from the trap), was derelict (i.e., ghost gear), or there was some other explanation. The presence of fairly new segments of rope (yellow and green) and the lack of fouling suggests this was not gear that had been lost for a long period of time (i.e., old ghost gear).

The gear was laid out, inspected, photographed and tagged but was not taken apart in any way, outside of the few cuts mentioned above. It was bagged in its original configuration in case gear experts from DFO or other agencies/stakeholders want to examine it in the future.

Acknowledgements
Gear documentation during necropsy – Pam Emery and Galaxina Renaud

Figures

Figure 1. Carcass of Catalog #4504 on 15 Sept 2017. Photo provided by Fisheries and Oceans Canada/Conservation & Protection

Figure 2. Entanglement in situ on the beach prior to necropsy on 19 September 2017. © Marine Animal Response Society

Figure 3. Entanglement in situ on the beach prior to necropsy on 19 September 2017. © Marine Animal Response Society

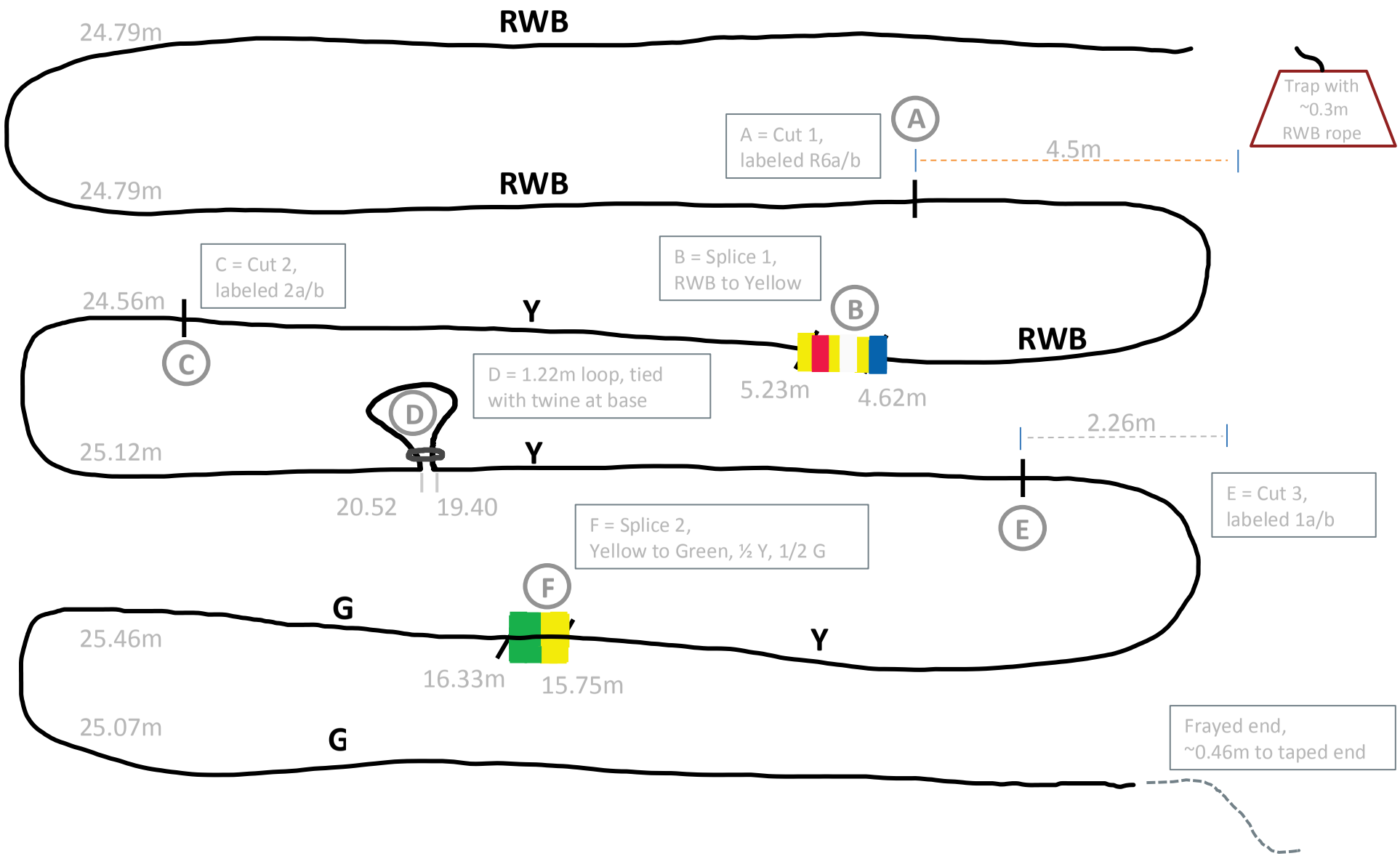


Figure 4. Illustration of the rope removed from the right whale necropsied 19 September 2017. RWB = tricolour (red, white and blue) rope; Y = Yellow rope; G = Green rope © Marine Animal Response Society

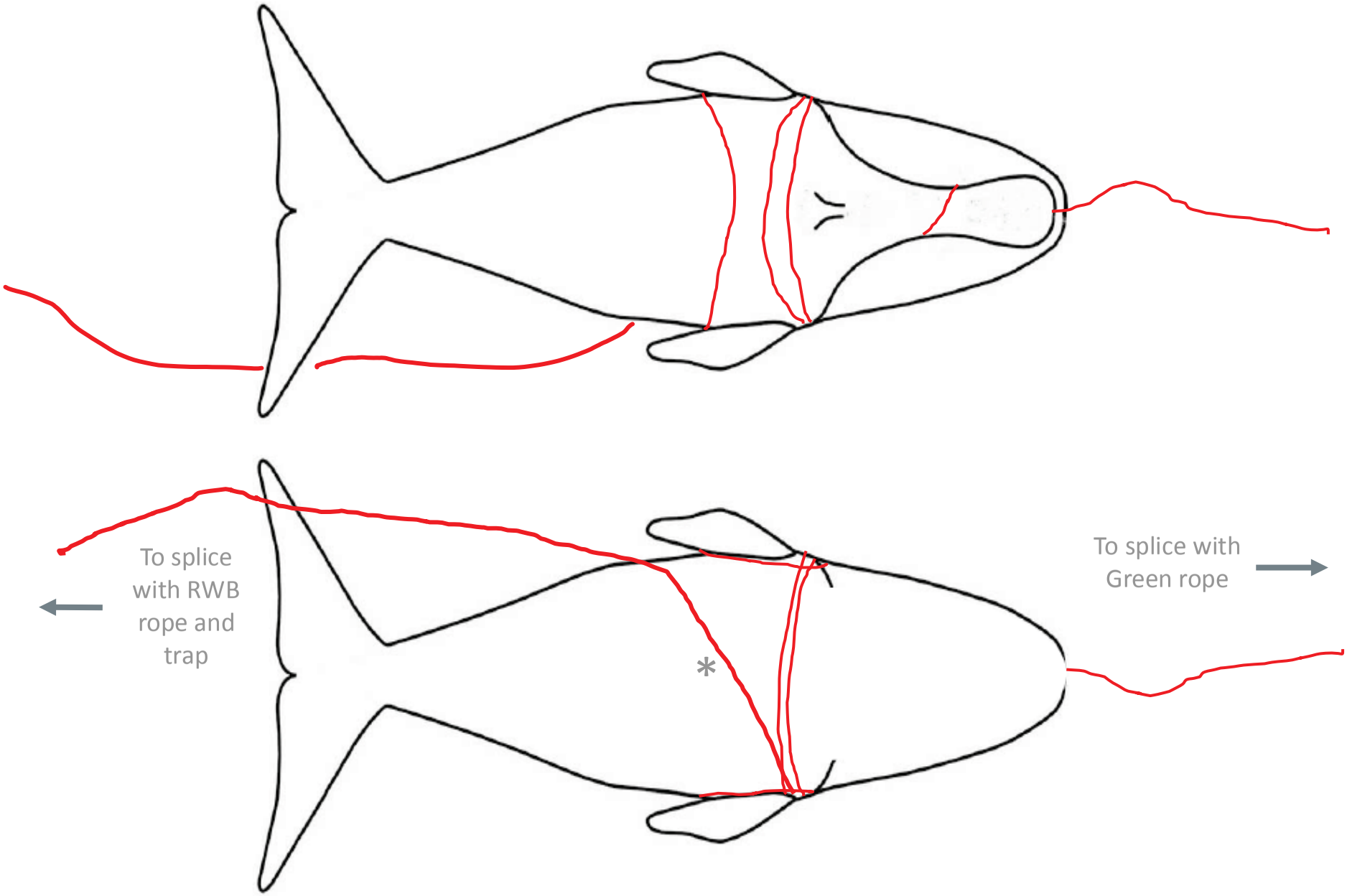


Figure 5. Illustration of rope entanglement configuration from ventral (top) and dorsal (bottom) surfaces. * on ventral surface indicates the probable location of end of rope given scar across the carcass at time of examination. © Marine Animal Response Society

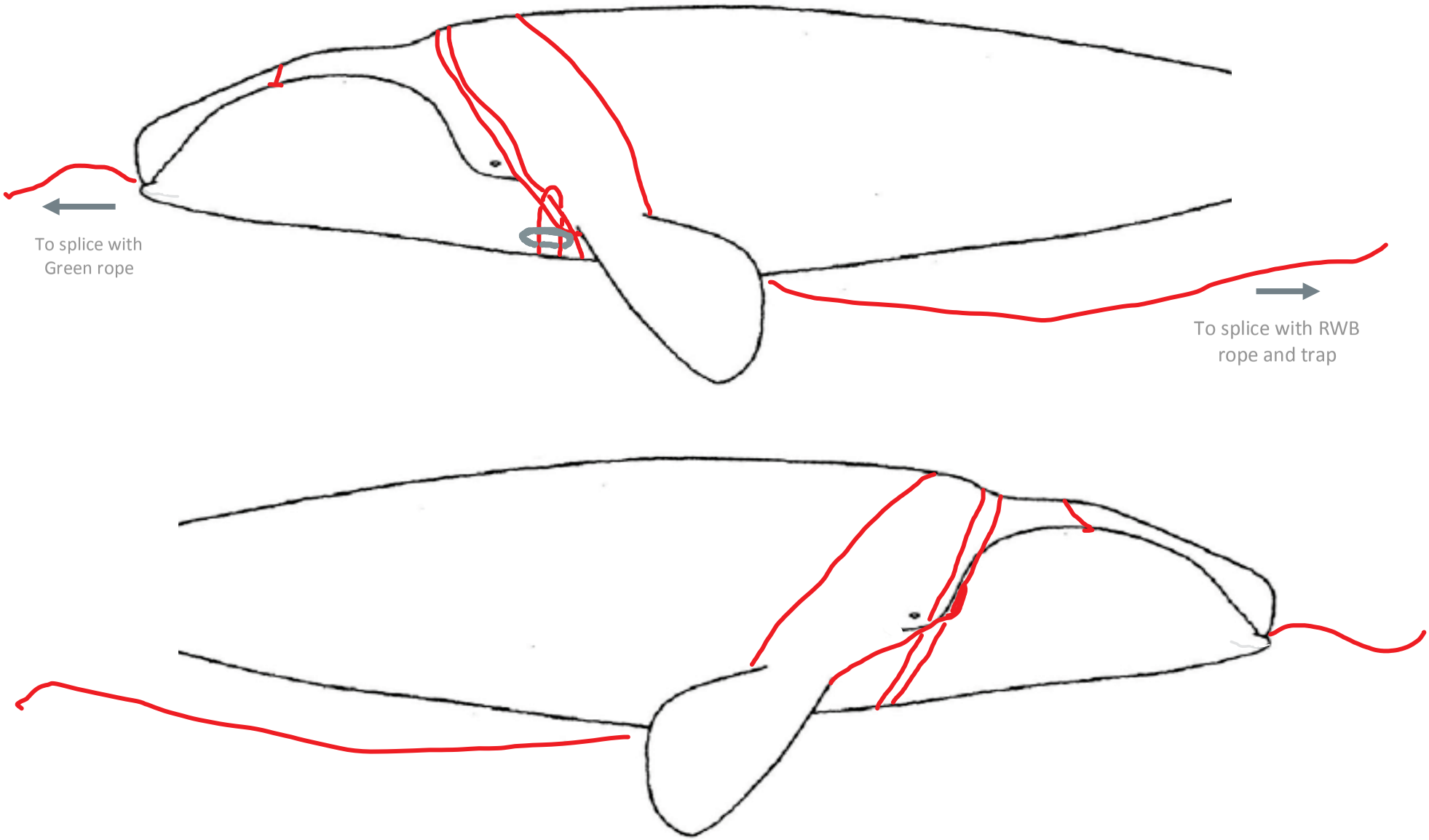


Figure 6. Illustration of rope entanglement configuration from left (top) and right (bottom) surfaces. © Marine Animal Response Society

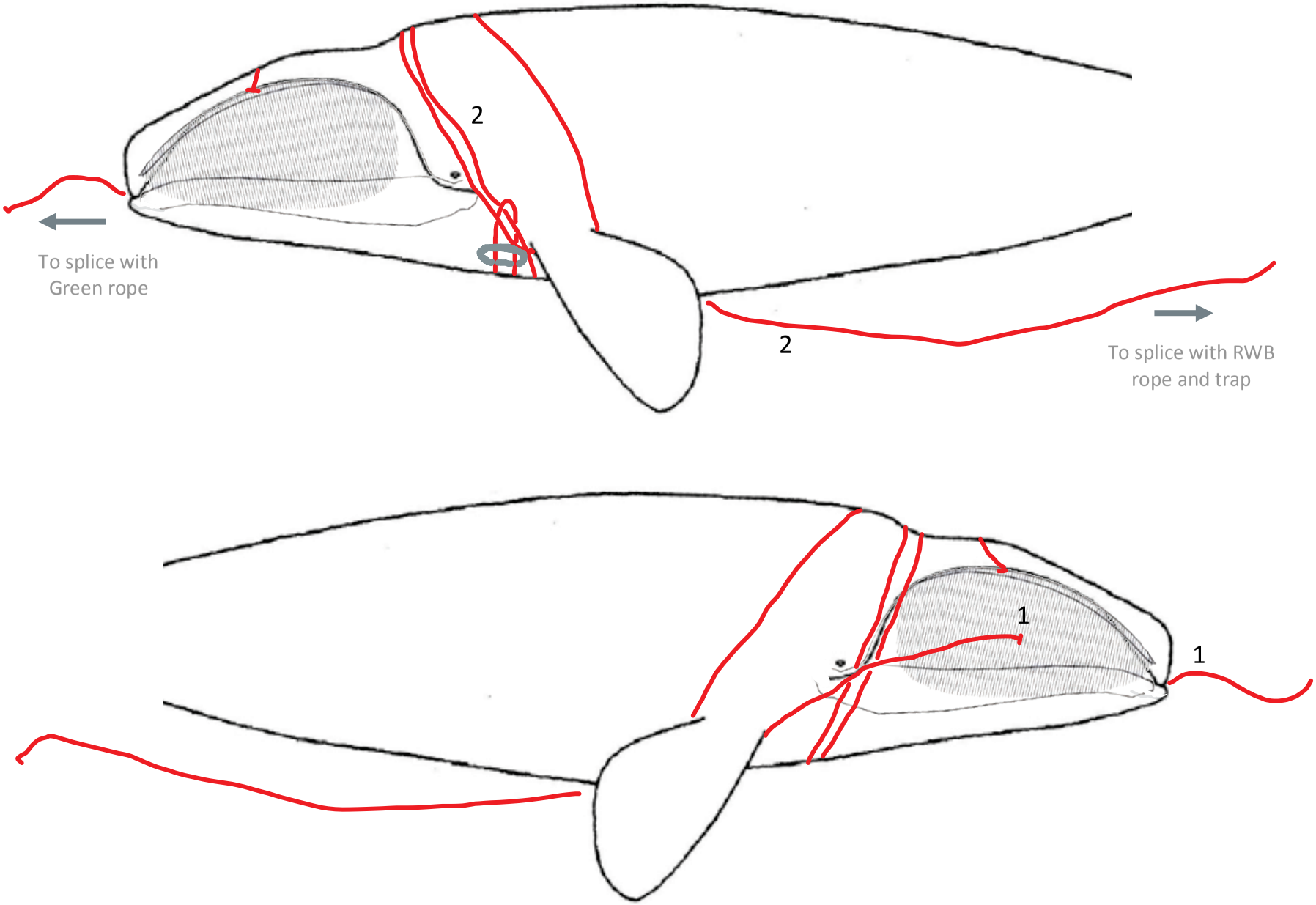


Figure 7. Illustration of rope entanglement configuration from left (top) and right (bottom) surfaces with mouth entanglement indicated. Numbers on diagram indicate the continuation of the same pieces of trailing ends of rope. © Marine Animal Response Society

Figure 8. Tricolour (red, white and blue) rope attached to right whale necropsied 19 Sept 2017 © Marine Animal Response Society.

Figure 9. Snow crab trap removed from tricolour (red, white and blue) rope that was attached to right whale necropsied 19 Sept 2017 © Marine Animal Response Society.

Figure 10. Yellow and green ropes attached to right whale necropsied 19 Sept 2017 © Marine Animal Response Society.

Figure 11. Splice between yellow and green ropes © Marine Animal Response Society.

Figure 12. String tied to create a 1.22m loop in the yellow rope. Cable ties and labels added by examination team © Marine Animal Response Society.

Figure 13. Location of string tied to create a 1.22m loop in the yellow rope on the ventral surface of carcass. © Marine Animal Response Society.

Figure 14. Ventral surface of the carcass indicating location of loop in yellow rope created by string tied. © Marine Animal Response Society.

Figure 15. Trap tag attached to snow crab trap. © Marine Animal Response Society.

Annex 8: Glucocorticoid Assay Results for Fecal Samples Collected from North Atlantic Right Whales during the 2017 Mortality Event

Authors: Dr. Rosalind Rolland and Katherine Graham, Anderson Cabot Center for Ocean Life at the New England Aquarium, Boston, MA

Revised October 31, 2017

Background:

Fecal samples were collected during necropsy from five North Atlantic right whales (NARW) in the Gulf of St. Lawrence (GSL) between 22 June and 19 September, 2017 (see Table 1). Samples were shipped by Dr. Pierre-Yves Daoust to the New England Aquarium (NEAq) Endocrine Laboratory, and samples were processed and analyzed for fecal glucocorticoid metabolites. Fecal glucocorticoids represent an integrative measure of a whale's recent (i.e. ~1-2 days prior) average circulating hormone concentrations and can provide insights into the relative health of the whale, as well as the time course of death (i.e. acute vs. chronic).

Methods:

Fecal samples were analyzed using the NEAq laboratory standard processing protocol for NARW fecal samples, and a previously validated radioimmunoassay (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. Processed samples were then measured using a commercial corticosterone assay kit (MP Biomedicals #07-120103), which has broad cross-reactivity with glucocorticoid metabolites in a wide range of taxa. Fecal glucocorticoid (fGCs) results are reported in nanograms of immunoreactive hormone metabolite per gram of feces (ng/g).

Results:

Fecal glucocorticoid concentrations for each whale are presented in Table 1, along with sample collection data and preliminary necropsy findings. All of these samples were also re-assayed or re-extracted a second time to verify the initial results (see section below).

Table 1. Whale information and fGC concentrations for five postmortem NARW fecal samples.

Carcass ID	Location	Sample Date	Cause of death	fGC (ng/g)
Eg#4	Norway, PEI, CAN	1 Jul 2017	Entanglement in fishing gear	15.9
Eg#5	At sea, GSL, CAN	22 Jun 2017	Undetermined	19.7
Eg#7	Magdalen Island, Quebec, CAN	10 Jul 2017	Probable blunt trauma	16.3
Eg#8	Miscou Island, New Brunswick, CAN	21 Jul 2017	Suspected blunt trauma	19.0
Eg#9	Miscou Island, New Brunswick, CAN	19 Sep 2017	Entanglement in fishing gear	26.7

Fecal glucocorticoid concentrations for all five samples ranged between 15.9 and 26.7 ng/g. These concentrations are within the normal, or baseline, range for healthy NARWs (Hunt et al. 2006; Rolland et al., in press). Rolland et al. (in press) showed that whales which died rapidly from vessel strikes did not show a significant increase in fGC concentrations compared to living, healthy NARWs. In contrast, NARWs which were chronically entangled in fishing gear or live-stranded for several days, showed very significant elevations of fGCs reflecting adrenal activation (Fig. 1). This is due to the lag time for an increase in circulating glucocorticoids to be reflected in the glucocorticoid concentrations in feces, which is based primarily on gastrointestinal transit time for the species (estimated at 1-2 days for NARWs). Thus, whales which experienced an acute death (e.g. ship strike) died too rapidly for an elevation of glucocorticoids to appear in the feces, while whales which experienced a chronic (or prolonged) time course to death (e.g. chronic entanglement in fishing gear or live-stranding) showed significantly elevated fGCs (Rolland et al., in press).

Figure 1 compares fGC concentrations in the five carcass samples with fGCs in living, healthy NARWs, right whales that died from ship strike (acute), and right whales that were chronically entangled in fishing gear or live-stranded (prolonged). The fGC concentrations in the carcass samples fall within the range of both healthy NARW and those which died acutely from ship strike, which are not significantly different from each other. These results suggest that the five sampled NARWs experienced rapid deaths (estimated < 1-2 days), and there was no evidence of activation of the adrenal gland–mediated stress response prior to death. The Eg#4 sample was from an entangled whale with evidence of chronic pathology on necropsy (i.e., fibrosis at the insertion of the right flipper), however, fGC concentrations were not elevated in this whale. Possible explanations for the lack of an elevated adrenal response include a rapid death from a second entanglement event (i.e., the chronic lesions were from a pre-existing sub-lethal entanglement), or that the fecal sample assayed contained an insufficient mass of fecal matter to be representative of the whale's physiologic condition (although the weight of the sample was above our laboratory's > 0.2 g dry weight threshold for accurate fecal hormone analyses). Fishing gear entanglement was also determined to be the cause of death for Eg#9. In this case, necropsy results suggested a rapid death for this small whale entangled in fishing lines attached to a heavy snow crab pot, which is consistent with the baseline levels of fGCs measured in this fecal sample.

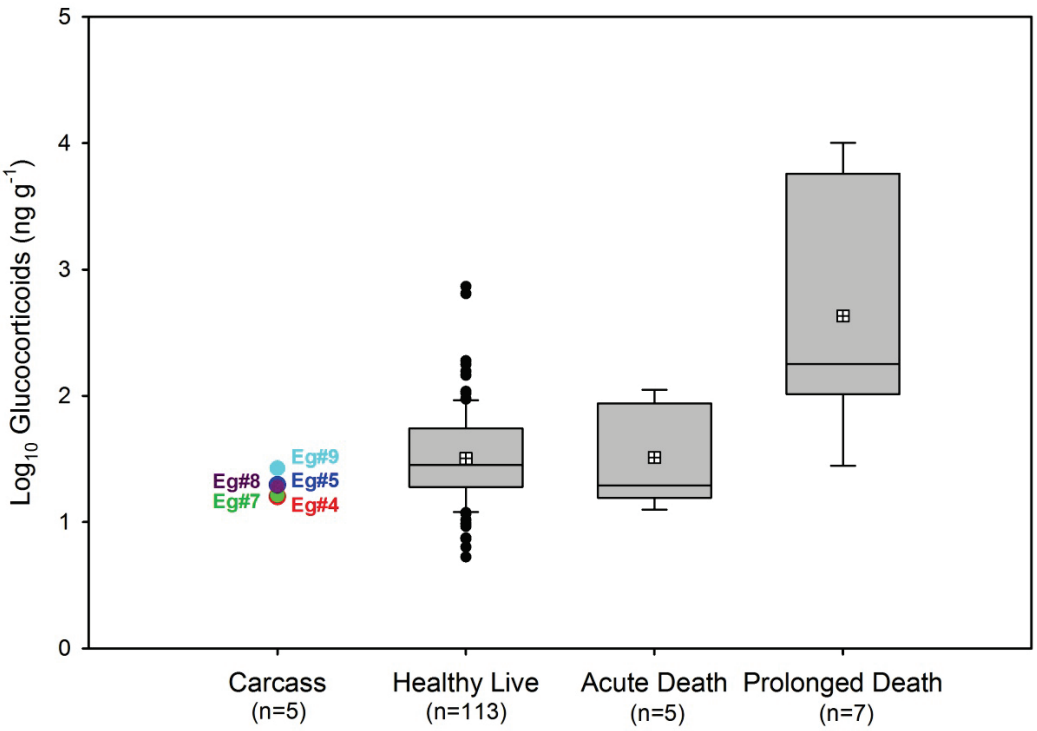


Figure 1. Log_{10} fGC values for the five NARW samples from the 2017 unusual mortality event compared with fGCs in healthy NARW, NARW which died an acute death (e.g. ship strike), and NARW which experienced a prolonged time course to death (e.g. chronic entanglement, live-stranding) (Rolland et al, in press). The horizontal line within the boxes shows median values, means are indicated by the small hatched box, the whiskers show the variability outside the upper and lower quartiles, and outliers are shown as dark circles.

Re-Assay of Fecal Samples

Extracts of the fecal samples from the first four carcass samples were re-assayed for fGCs a second time to verify the initial results. In addition, freeze-dried feces from Eg #4 and Eg #9 were re-extracted and these new extracts were also re-assayed for fGCs. Given that each extract is assayed in duplicate, the sample from Eg#4 was assayed a total of 6 times, and the remaining samples were assayed 4 times each. Results from the original assays and the re-assays are presented in Table 2, and compared in Figure 2. The fGC concentrations remained well within the baseline range in all whales (Table 3). The inter-assay coefficients of variation were generally low, and inter-extract coefficients of variation averaged 5% or 15% for samples Eg#4 and Eg#9, respectively, well within our quality control standards.

Table 2. Fecal glucocorticoid (fGC) results from the initial assay and re-assays. Samples from Eg#4 and Eg#9 were re-extracted (using the original sample) and re-assayed a second time to verify results.

Sample ID	Sample Collection Date	Initial Run fGCs (ng/g)	Re-run fGCs (ng/g)	Re-extracts fGCs (ng/g)
Carcass Eg #4	1-Jul-17	15.88	15.75	17.08
Carcass Eg #5	22-Jun-17	19.70	20.00	
Carcass Eg #7	10-Jul-17	16.29	18.90	
Carcass Eg #8	21-Jul-17	19.03	18.95	
Carcass Eg #9	19-Sep-17	26.67		21.57

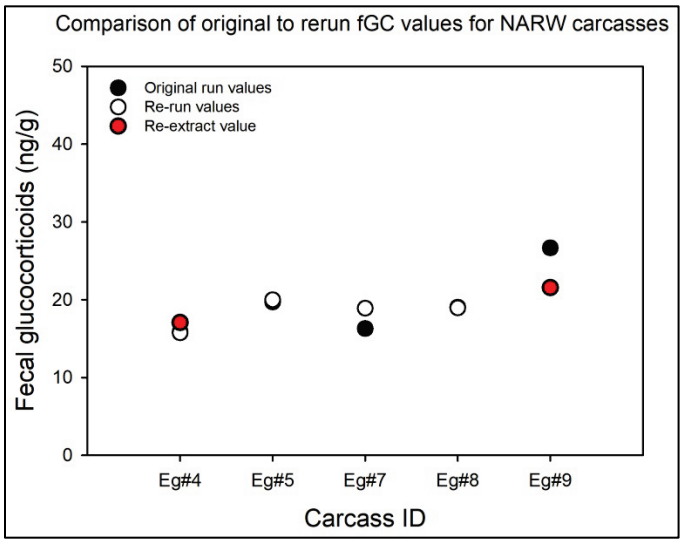


Figure 2. Comparison of fecal glucocorticoid results (ng/g) from all original assays, re-assay values, and re-extraction assays.

Table 3. Mean (± SE) and median fecal glucocorticoid (fGC) levels (ng g^{-1}) in healthy North Atlantic right whales categorized by sex, age-class and reproductive status (Rolland et al., in press). Mean fGC concentrations in groups with the same superscript letter were not significantly different (Tukey Test, p > 0.05).

Sex (n)	**Age-class/status (n)**	**Mean fGC (± SE)**	**Median fGC**
Female (75)			
	Juvenile (20)	18.2 ± 1.7[a]	16.2
	Resting (17)	19.1 ± 3.1[a]	15.3
	Lactating (25)	38.6 ± 4.1[c, d]	29.8
	Pregnant (13)	181.0 ± 64.4[e]	94.6
Male (38)			
	Juvenile (16)	26.0 ± 2.8[a,c]	22.1
	Adult (22)	64.5 ± 7.1[d,e]	64.0

References

Hunt KE, Rolland RM, Kraus SD, Wasser SK (2006). Analysis of fecal glucocorticoids in the North Atlantic right whale (*Eubalaena glacialis*). General and Comparative Endocrinology 148:260-272.

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

Annex 9: Individual Necropsy Reports

Wildlife Diagnostic Report – EG#2

Necropsy #: EG#2; MARS2017-141; NEAq Catalog #1402- ("Glacier") – 33 year old male

Incident Information

Species: North Atlantic Right Whale (*Eubalaena glacialis*)
Age: Adult
Sex: Male
Necropsy date: 29 June 2017
Location: Norway, Prince Edward Island, Canada

Submitted Information

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

Information Provided with Specimen

First sighted in GoSL on June 19, 2017. He was born in 1984, with frequent sightings in the Bay of Fundy and Great South Channel. He was seen in the GoSL in 2002, which is also the location of his last known sighting, on 29 July 2016. Named for a large white scar on his back.

Diagnosis and Interpretation

Final Diagnosis

Acute internal hemorrhage compatible with blunt trauma (suspected)

Interpretation

The carcass of this whale was ascribed a decomposition condition code of 4, and therefore observations and their interpretations were made with caution. This animal was considered in good body condition for the season, based on its blubber thickness. A presumptive diagnosis of acute internal hemorrhage was made mainly on the basis of the following observations: 1) presence of abundant dark brown to black putty-like material, compatible with clotted blood (cooked by internal heat and pressure generated by post-mortem decomposition), along the right side of the thoracic vertebrae, external to the thoracic cavity, presumably coming from the very extensive network of blood vessels ("rete mirabile") within intercostal muscles in the cranial region of the thorax which then extends into the vertebral canal; and 2) perhaps more importantly, presence of similar material in the thoracic and cervical regions of the vertebral canal and filling the occipital foramen; hemorrhage in this location could indeed have resulted from damage to the same rete mirabile surrounding the spinal cord and representing the main blood supply to the cetacean brain. No fracture was identified in this whale. Several vertebrae were dislocated, but this could have happened as the carcass was pulled onshore.

There was an abundant amount of red-tinged fluid between blubber and muscle mass (but not involving the muscle tissue itself) along the right lateral wall of the carcass, extending dorsally and along the cranial region of the left lateral wall, associated with discrete areas of red discoloration of the overlying blubber. This could be interpreted as further evidence of blunt trauma. However, we are particularly cautious in interpreting this change as it could also occur from post-mortem accumulation of fluid tinged by hemoglobin from lyzed red blood cells in dependent parts of the carcass floating at sea.

A number of unusual changes were observed on surface of the tongue and inner surface of the lips, which could raise the prospect of an underlying viral infection of undetermined clinical significance. Unfortunately, because of autolysis, none of these changes could be well characterized on microscopic examination.

Test Results

Necropsy (29 June 2017)

Standard length: 14.07m (several dislocated vertebrae – may not be reliable)
Rostrum to blowhole: 2.60m
Rostrum to eye: 3.40m
Rostrum to angle of mouth: 3.40m
Rostrum to flipper insertion: 3.30m
Rostrum to genital slit: 8.20m
Rostrum to anus: 10.80m
Anus to fluke notch: 4.20m
Flipper length at base: 0.90m
(See Appendix 1)

Flipper length (leading): 2.10m
Flipper length (trailing): 1.40m
Flipper width: 1.30m
Tail width: 4.20m
Left fluke width: 2.30m
Right fluke width: 1.90m (small portion of tip missing [scavenged?])
Notch to tail insertion: 0.90m
Fluke depth: 1.20m

Blubber thickness was measured at seven locations from mid dorsal to mid ventral at eight levels from cranial to caudal. Averages were taken of the seven locations at each level: nuchal crest, 17.0cm; axilla, 14.0cm; 1/2 axilla-umbilicus, 18.13cm; umbilicus, 18.0cm; 1/2 umbilicus-anus, 21.25cm; anus, 16.75cm; 1/2 anus-tail insertion, 13.33cm; tail insertion, 7.0cm. (See Appendix 2)

Adult male (33 years old). The animal presented with seasonally robust blubber (23cm on the mid-ventrum) and did express lipid from cut blubber surfaces (Miller et al. 2011). Decomposition condition code 4. No baleen plate present. Portions of heart, lung, and liver recognized, but no kidney.

Conspicuous observations at necropsy included:

- old superficial scars on peduncle (Figure 1) and possibly also along right side of body wall (Figure 2), presumably from previous entanglement;
- multifocal to coalescing circular areas of apparent erosion, 3-4cm diameter, on inner surface of left and right lips, characterized by a laminated central area of pallor and pigmented margins (Figure 3) (histopathology slides 9a/b/c);

- circular region of red discoloration (hyperemia?), approx. 40cm in diameter, with central area of possible erosion on dorsal surface of rostral portion of the tongue (Figure 4) (histopathology slide 10);
- multiple small areas of epithelial depression along the right lateral surface of the tongue (Figure 5) (histopathology slide 11);
- sharply demarcated area of red discoloration on section of the right lateral side of the tongue (Figure 6) (histopathology slide 12);
- accumulation of an abundant amount of red-tinged fluid between blubber and muscle mass along the right lateral wall, extending dorsally and along the cranial region of the left lateral wall, associated with discrete areas of red discoloration of overlying blubber (Figure 7);
- abundant amount of dark brown to black putty-like material, compatible with clotted blood, along right side of thoracic vertebrae, external to the thoracic cavity (Figure 8);
- similar putty-like material in thoracic and cervical regions of vertebral canal and also filling the occipital foramen (Figure 9);
- thin layer of dark brown to black putty-like material on surface of several vertebral bodies and ribs (Figure 10).

(See Appendix 3 for detailed description of observations made in the carcass.)

(See Figures 11a and 11b for a diagrammatic representation of observations possibly associated with blunt trauma.)

Histology (AVC X15391-17)

Total of 27 tissues embedded in paraffin blocks (numbers generally correspond to gross observations). Total of 17 slides examined (*):

1a. Non-pigmented epidermis = lesion; layer of fibrosis under epidermis. Pigmented epidermis = normal. Paraffin block available; no histological slide prepared.
1b. Lesion(?) = paler color. [Section on glass slide will not be as wide as normal(?) section.] Paraffin block available; no histological slide prepared.
1c. On glass slide, normal section will be wider than abnormal(?) section. Paraffin block available; no histological slide prepared.
2. Paraffin block available; no histological slide prepared.
3. Paraffin block available; no histological slide prepared.
*4-1. Blubber.
*4-2. Muscle. No congestion or hemorrhage can be recognized, but some interstitial fluid present (including some strongly acidophilic amorphous material) along the muscle tissue?
*5a. Dense fibrous tissue.
*5b. Blubber. Some interstitial fluid present (including some densely acidophilic amorphous material)?
7. Paraffin block available; no histological slide prepared.
8. Paraffin block available; no histological slide prepared.
*9a/b/c. All that can be seen are thin layers of bacteria and possibly other fewer microorganisms (yeasts?) on the epidermal surface.
*10. No lesion visible. A few deposits of strongly acidophilic amorphous material.

*11. (Changes clearly visible grossly in trimmed sample.) Only change seen consists of focal loss of superficial portion of epidermis, with no associated reaction in the underlying dermis.
*12. No lesion visible. Very loose tissue - post-mortem gas build-up?
14. Intercostal muscle. Paraffin block available; no histological slide prepared.
*16. Lung. Tissue markedly washed out.
*17. Liver. Tissue markedly washed out and autolyzed.
*18. Testis. Not recognizable – tissue washed out.
*19. Epididymis. Not recognizable – tissue washed out.
20. Diaphragm. Paraffin block available; no histological slide prepared.
*21. Epaxial muscle. Myofibers extensively fragmented and autolyzed.
22. Body wall. Paraffin block available; no histological slide prepared.
*23. Blubber body, left.
*24. Blubber body, right. Mainly dense fibrous tissue.

Other Tests

Liver: Biotoxins (paralytic shellfish toxins, amnesic shellfish toxins [domoic acid], lipophilic shellfish toxins) – all negative (CFIA, Dartmouth, NS).

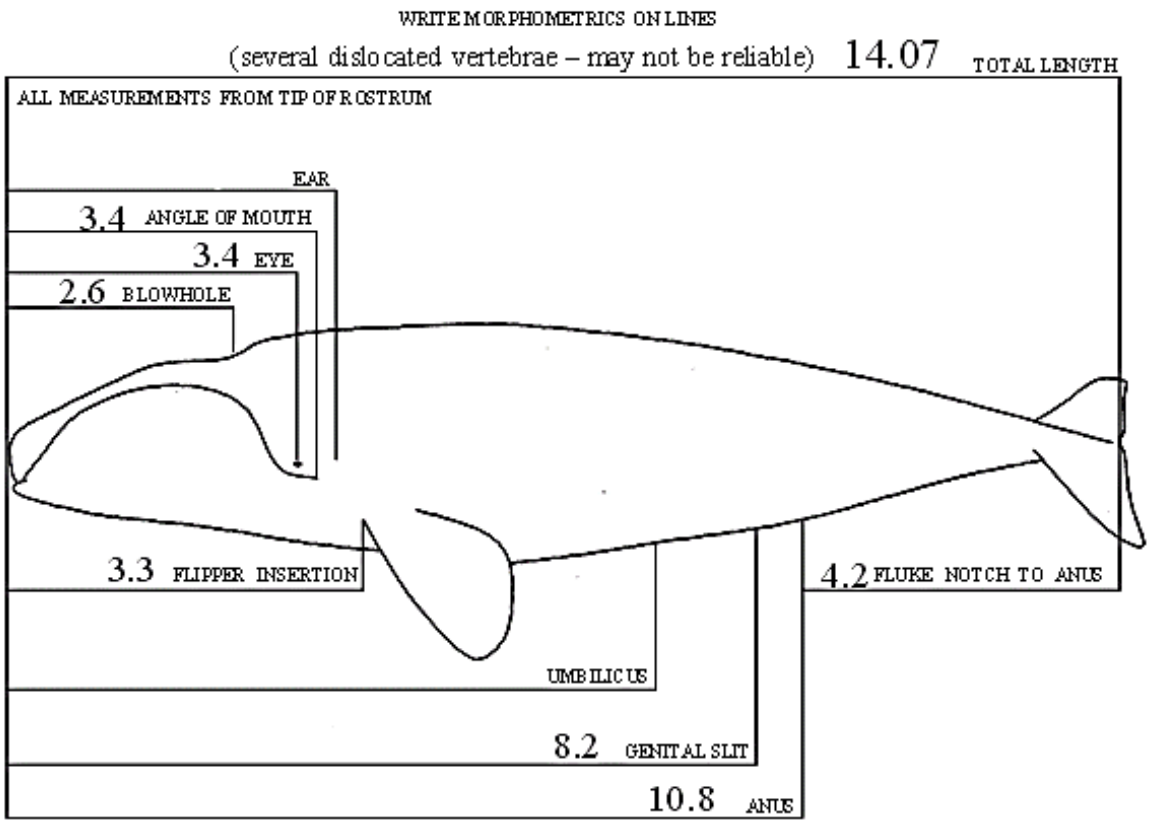
Inventory of frozen samples

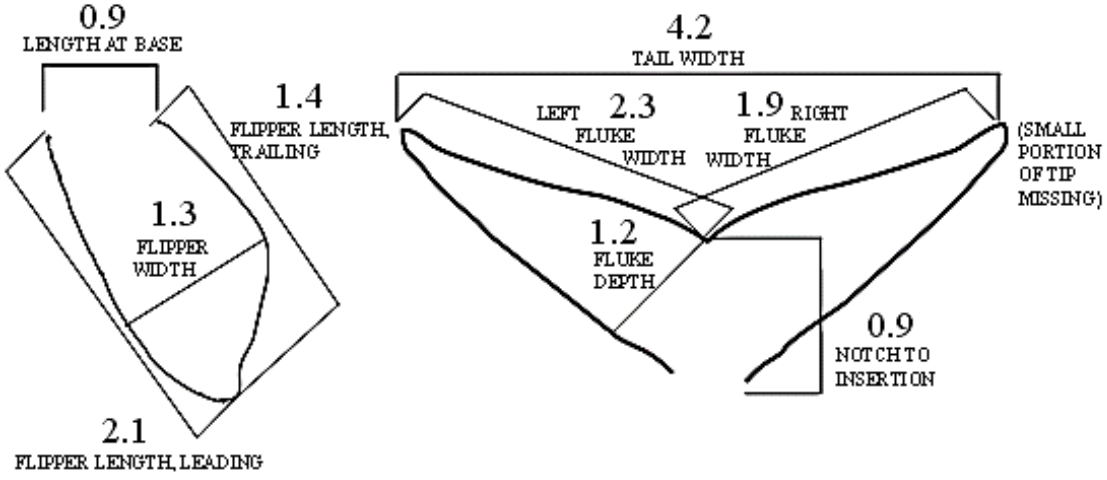
- Left Pectoral, lesion 6 (swab and fluid)
- Thoracic blood?
- Buccal Mucosa a, b and c (observation 9)
- Tongue x2, (observations 10 and 11)
- Blubber x4 – to MARS
- Muscle – to MARS
- Finger bones – to MARS
- Lung x2
- Abdominal fluid?
- Vessel, dorsal abdominal cavity
- Right eye
- Right eye aqueous humor
- Intercostal muscle (very small)
- Pericardial fluid
- Liver – to CFIA for biotoxins
- Liver x2
- Dia (not sure what this means or is)
- Skin x2 (genetics) – to MARS
- Testis
- Epididymis

References

Miller CA, D Reeb, PB Best, AR Knowlton, MW Brown, MJ Moore. 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 (2011): 267-283.

Appendix 1. Right Whale EG#2 External Morphometrics

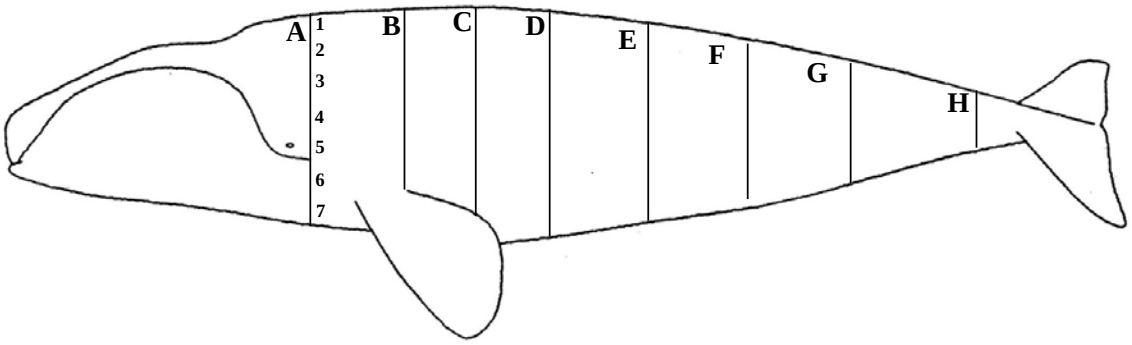




*measures in meters

Appendix 2. RIGHT WHALE EG#2 BLUBBER THICKNESS

Field# MARS2017-141 **Side Examined** _____ **Observer** _____ **Date** 29 June 2017



	A Nuchal Crest	B Axilla	C 1/2 Axilla-Umbilicus	D Umbilicus	E 1/2 Umbilicus-Anus	F Anus	G 1/2 Anus-Tail Insertion	H Tail Insertion
Dorsal								
1	_____	_____	13	_____	_____	_____	_____	_____
2	12	14	13	_____	_____	20	20	3
3	14.5	16	_____	19	20	19.5	15.5	4.5
4	22	14	_____	_____	_____	13.5	12.5	5
5	24.5	14	14	15	19	13.5	10.5	9
6	10	13	19.5	17	23	14	11.5	11.5
7	19	13	13	21	23	20	10	13
Ventral								
Average	17.0	14.0	18.13	18.0	21.25	16.75	13.33	7.0

Note: all measurements are in cm

APPENDIX 3: External and internal observations by number

(Asterisks indicate observations of potential clinical significance)

Observation number	Physical location	Description	Photos taken (Y/N)	Histology taken (Y/N)
1	Caudal 1/3 of peduncle	Grey-brown, raised linear transverse and oblique ridges in dermis, compatible with fibrosis. Lesions located mid-ventrally, but extend mid-laterally on the left. Consistent with previous entanglement wound.	Y	Y
2	Right axilla	Single grey-brown, raised linear ridge in dermis, compatible with fibrosis; approx. 0.90m long. Extends caudally along lateral surface from ventral aspect of axilla. Consistent with previous entanglement wound.	Y	Y
3	Right mid-lateral body, at level of genital slit	Multiple small pieces of epidermis adhered to underlying dermis; approx. 10-20cm in diameter. Consistent with entanglement wounds.	Y	Y
4*	Cervico-thoracic region, right lateral	Caudal to flipper and extending dorsally, at level of T14-T15, on cut surface of blubber, discrete red discoloration of blubber extending to overlying dermis; locally extensive accumulation of red-tinged fluid between blubber and muscle mass; >1m in diameter.	Y	Y
4a*	Caudal continuation of Lesion 4?			
5*	Left lateral, cranial to peduncle	Locally extensive area of accumulation of red-tinged fluid between blubber and muscle mass; approx. 1m in diameter, 10-25cm thick.	Y	Y
5a	Normal left lateral region for comparison with Lesion 4?			
6	Left scapulo-humoral joint	Large accumulation of gas and approximately 500mL of tan brown opaque fluid at ventral aspect of joint	Y	Y
7	Right scapulo-humoral joint	Dorsal capsule: large mass of very dense fibrous tissue attached to approx. 1/4 of humeral head. Black discoloration of synovial tissue and linear marks. The capsule also contains red-tinged fluid and filamentous	Y	Y

Observation number	Physical location	Description	Photos taken (Y/N)	Histology taken (Y/N)
		material. Chronic arthritis from previous entanglement site? or normal (similar large mass of fibrous attached to left humeral head)?		
8	Left scapulo-humoral joint	Thickened joint capsule (?)	Y	Y
9	Inner surface of left lip	Multifocal to coalescing circular lesions of apparent erosion, 3-4cm diameter, characterized by a laminated central area of pallor and pigmented margins (infectious etiology [herpes, pox]?)	Y	Y
9b	Inner surface of right lip	Same as on left side		
10	Rostral tongue, dorsal aspect	Circular region of red discoloration (hyperemia?), approx. 40cm in diameter, with central square of possible erosion; extends approx. 10mm on section	Y	Y
11	Right lateral tongue	Multiple small areas of epithelial depression, 2-4mm in diameter.	Y	Y
12	Right lateral tongue	Sharply demarcated area of red discoloration on section, approx. 1.0m long by 0.6m wide - site of hemorrhage?	Y	Y
13	C1 vertebra	Locally extensive dark brown putty-like material between fascial sheet and periosteal surface on ventral surface of C1; approx. 25.5cm in diameter – hemorrhage?	Y	N
14	Right third to last rib	Multifocal areas of black putty-like material on periosteal surface - blood clots?	Y	Y
15	Mid-dorsal surface, region of thoracic vertebrae	Anvil-shaped depression of outer surface of blubber, approx. 75cm long, 40cm at the widest part, and 15cm at the narrowest part. On section, blubber is notably thinner (about 5.5cm) compared to unaffected surrounding blubber (13cm).	Y	N
16	Vertebral bodies	Dislocation of thoracic vertebrae at T3/T4, T12/T13, and T13/T14 - presumably post-mortem as the carcass was pulled onshore. Possible dislocation at L3/L4. Black putty-like material on surface of several vertebral bodies.	Y	N
17*	Atlanto-occipital joint	Subluxation of right occipital condyle presumably post-mortem as the carcass was pulled onshore. Locally extensive area of	Y	N

Observation number	Physical location	Description	Photos taken (Y/N)	Histology taken (Y/N)
		deposition of black putty-like material along the right surface of the occipital region of the cranium and right and ventral surface of the atlas. Foramen magnum is filled with similar material.		
N/A (but see 16)*	Thoracic vertebrae	Abundant amount of putty-like material along right side of vertebrae, seemingly extrathoracic.	Y	N

Figures (35 other photos available)

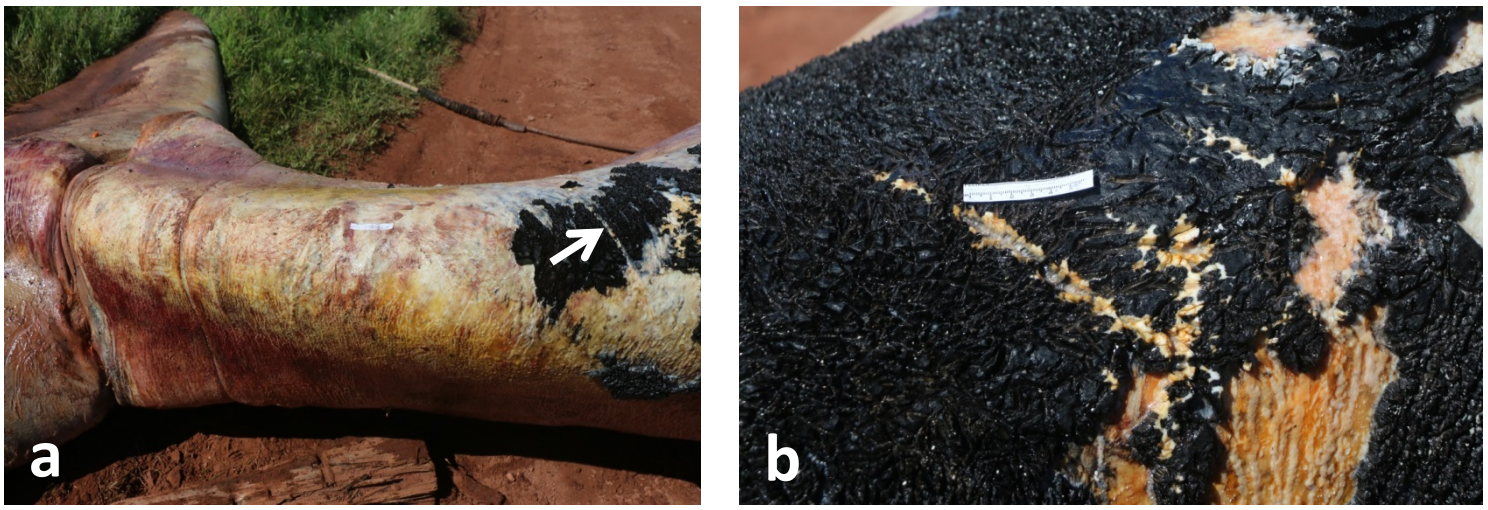


Figure 1. a) Old superficial scar on peduncle (arrow), presumably from previous entanglement. b) close-up of the scar.

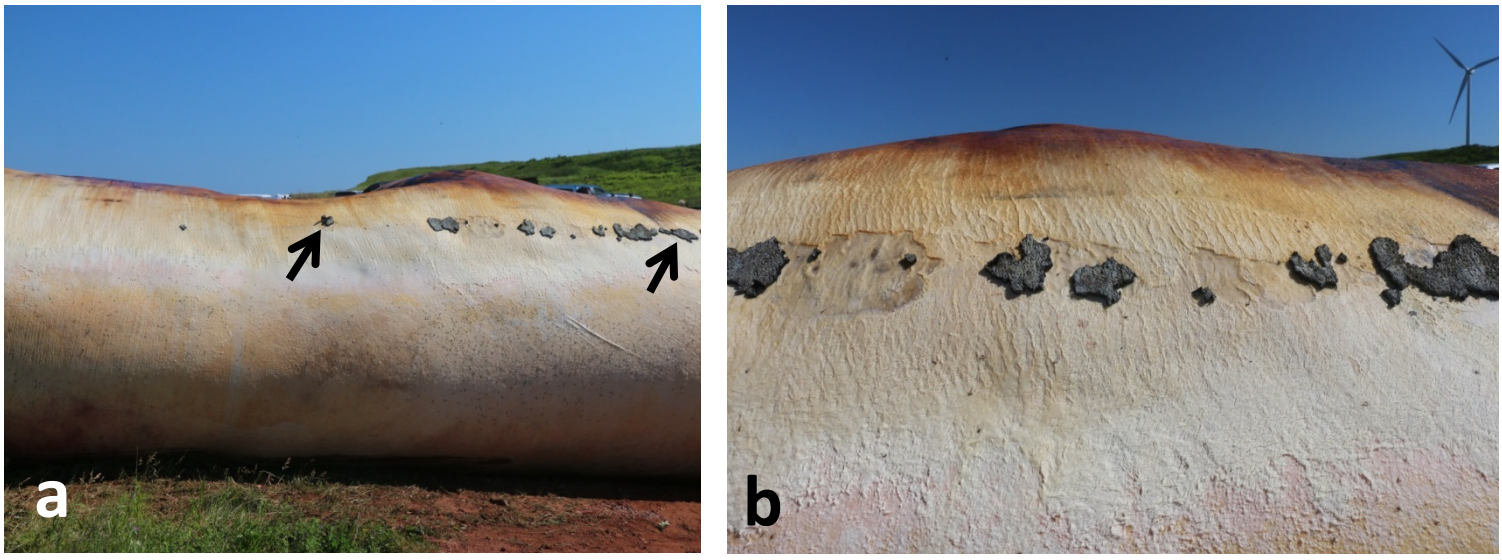


Figure 2. a) Potential old superficial scar where multiple small pieces of epidermis (between arrows) have remained attached to the underlying dermis despite post-mortem sloughing of the rest of the epidermis, suggestive of a previous entanglement wound. b) close-up of the adhering pieces of epidermis.

Figure 3. Multifocal to coalescing circular areas of discoloration, 3-4cm in diameter, on inner surface of the left lip. Histological examination of these areas was unrewarding.

Figure 4. Large circular area of red discoloration (hyperemia?) of the dorsal surface of the rostral portion of the tongue, approx. 40cm in diameter, with central area of possible epithelial erosion. Histological examination of this area was unrewarding.

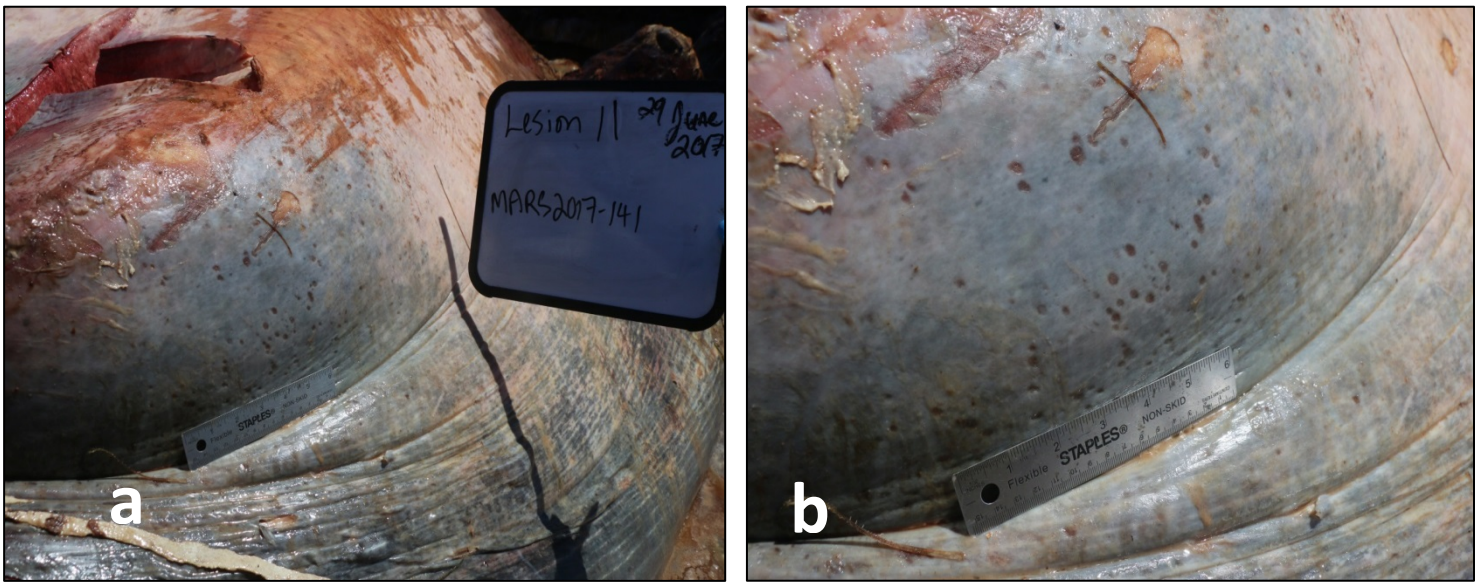


Figure 5. a) Multiple small areas of epithelial loss along the right lateral surface of the tongue. b) close-up of these areas. Epithelial loss was confirmed by histological examination, but this examination was otherwise unrewarding.

Figure 6. Sharply demarcated area of red discoloration on section of the right lateral side of the tongue (hemorrhage?). Histological examination of this area was unrewarding.

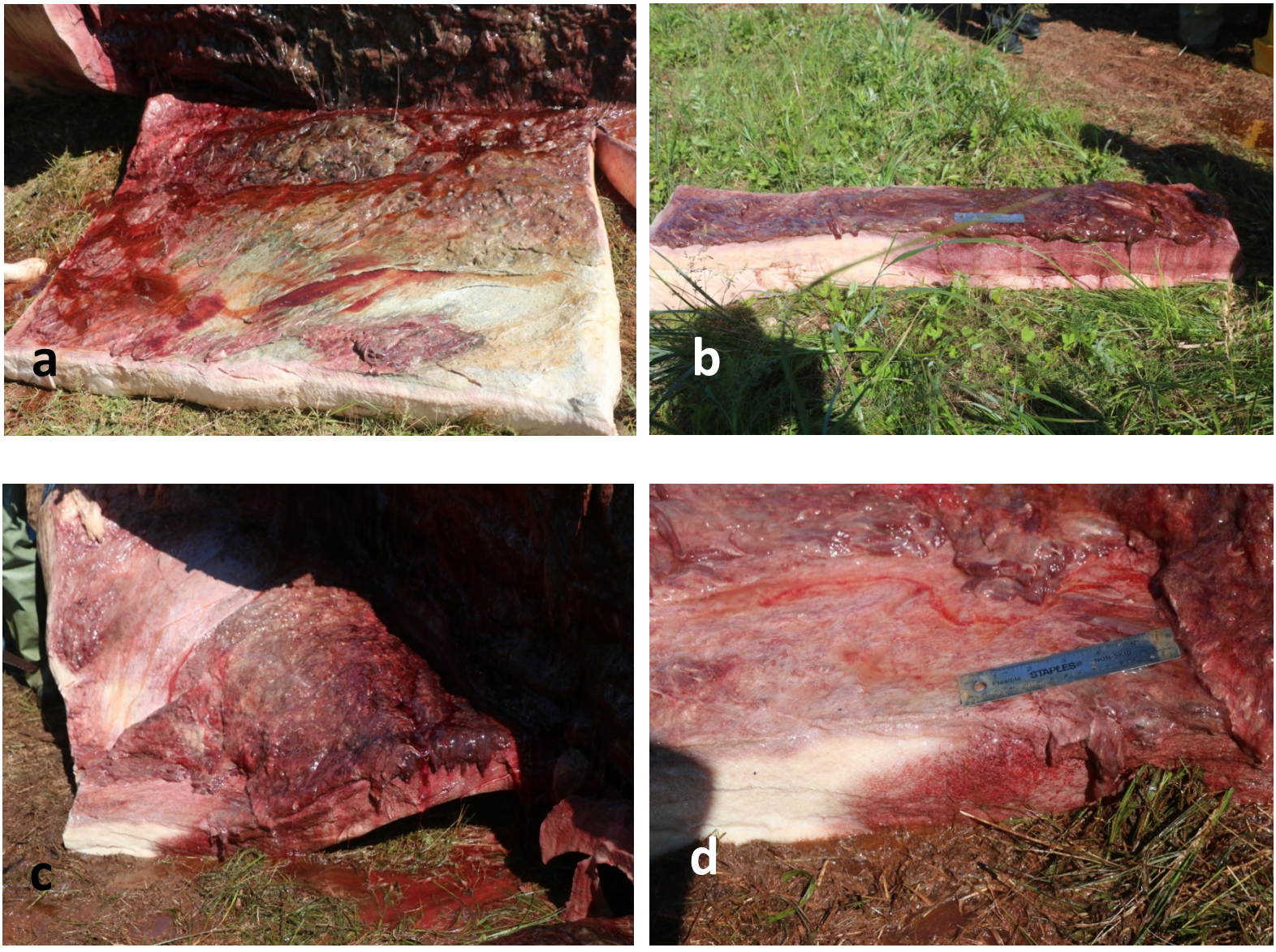
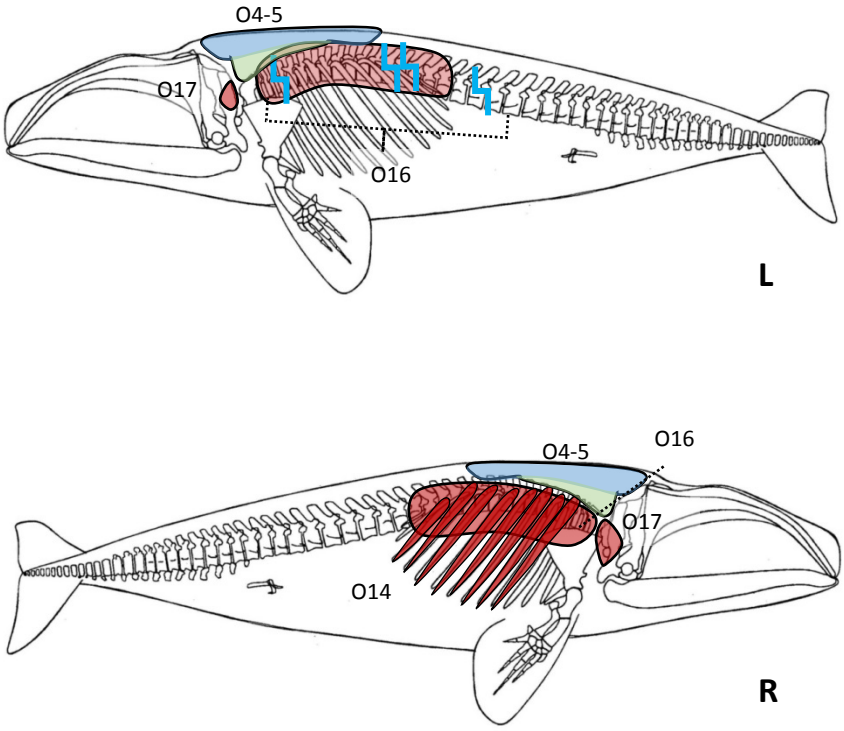


Figure 7. a) to d). Accumulation of an abundant amount of red-tinged fluid between blubber and muscle along the right lateral wall, extending dorsally and along the cranial region of the left lateral wall, associated with discrete areas of red discoloration of the overlying blubber.

Figure 8. Abundant amount of dark brown to black putty-like material (arrow), compatible with clotted blood, along right side of thoracic vertebrae. Some of the vertebrae are dislocated, but this may have happened as the carcass was pulled ashore.

Figure 9. Putty-like material similar to that found along the right thoracic vertebrae completely fills the occipital foramen (arrow).

Figure 10. a) Thin layer of dark brown to black putty-like material on surface of several thoracic vertebral bodies (arrow). b) Similar, but paler, material on ventral surface of first cervical vertebra (arrow).



Dislocation

O16: T3-t4, T12-T13-T14
L3-L4 (Uncertain)
*illustrated only on left side

Putty-like material

O14: right ribs
O16: vertebral bodies, including inner surface of thoracic cavity
O17: foramen magnum, right occipital region

Red-tinged fluid

O4 -5: right lateral wall between blubber and muscle mass, extending dorsally and along the cranial region of the left lateral wall
*illustrated only dorsally

Blubber contusion

O4: right cervico-thoracic region, discrete areas of red discoloration of the blubber
*illustrated only dorsally

Figure 11a. EG#2. Distribution of observations potentially associated with blunt trauma.

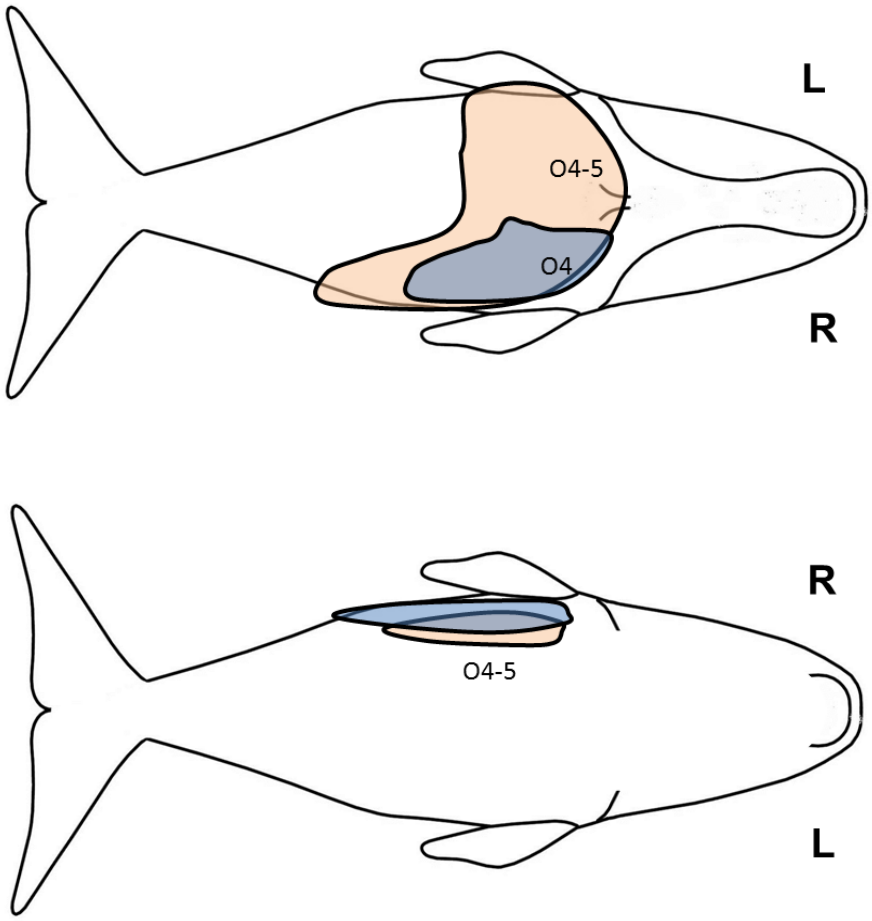


Figure 11b. EG#2. Distribution of observations potentially associated with blunt trauma.

Biotoxin analysis

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

CANADIAN FOOD INSPECTION AGENCY
REPORT OF ANALYSIS
FISH PRODUCTS SAMPLING SUBMISSION
Version 6.3.0
Serial: 000004364064

System ID:	2017FFI-0000046385-4	*Receptions by all Labs:*	1
Reference No.:	2017FFIS-0000049703-4	*Number of Jobs Authorized:*	1

Laboratory No.: DAR-FD-2017-CH-02543 *Date Received:* 2017-07-25 *Job Status:* Authorized

Laboratory: (1981) DARTMOUTH LABORATORY - CHEMISTRY
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Submitted By: CFIA Inspector
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Fax:
Cell:
Email: ALEXIS.JOHNSON@INSPECTION.GC.CA

Sampled By: CFIA Inspector
(12450) ALEXIS JOHNSON
1992 AGENCY DRIVE
DARTMOUTH, NS B3B 1Y9
Telephone: (902) 426-2110
Fax:
Cell:
Email: ALEXIS.JOHNSON@INSPECTION.GC.CA

Program: FISH	*Function:* DOMESTIC
Sampling Plan:	2017_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 #2 NECROPSIED, NORWAY PEI, JUNE 29-JULY1 (LIVER)
Date Sampled:	2017-06-29
Date Received:	2017-07-25
Risk Category:	Bivalve Molluscan
Harvest Date:	2017-07-25 08:29 AM
Lab Sample No.: DAR-FD-2017-CH-02543-0001	*Inspection Sample No.:*
Primary Process:	FREEZING
Sample Type:	Tissue - Liver
Identification Code:	EG # 2
Species:	NORTH ATLANTIC RIGHT WHALE - EUBALAENA GLACIALIS
Sample Assessed:	No Decision
Method: TOX-DA-LC / 1 : Domoic Acid	Analysis of Domoic Acid in Molluscs by Liquid Chromatography- SOM-DAR-CHE-001 Not detected at the reporting limit.
Test Assessed:	No Decision

System ID: 2017FFI-0000046385-4 **Receptions by all Labs:** 1
Reference No.: 2017FFIS-0000049703-4 **Number of Jobs Authorized:** 1

Laboratory No.: DAR-FD-2017-CH-02543 **Date Received:** 2017-07-25 **Job Status:** Authorized

Method: TOX-DSP-LC / 1 : Analysis of Lipophilic Shellfish Toxins by Liquid Chromatography- SOM-DAR-CHE-002

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

Method: TOX-PCOX / 1 : Post-column Oxidation (PCOX) Method for the Determination of Paralytic Shellfish Toxins in Mussels, Clams, Oysters and Scallops-SOM-DAR-CHE-052

Gonyautoxin-4	Not detected at the reporting limit.
Gonyautoxin-1	Not detected at the reporting limit.
Decarbamoylgonyautoxin-3	Not detected at the reporting limit.
Gonyautoxin-5	Not detected at the reporting limit.
Decarbamoylgonyautoxin-2	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: 2017-08-04 **Authorized By:** Melanie Casey **Authorized**
Job Assessed: No Decision **Date Assessed:** 2017-08-04

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

*** END OF REPORT ***

Necropsy report
from

Canadian Wildlife Health Center
Faculté de médecine vétérinaire, Université de Montréal
3200, rue Sicotte
Saint-Hyacinthe, Québec J2S 2M2
Tél: (450) 773-8521 poste 8346

PATHOLOGY No: P2298-17
DATE: 2017-09-16
IDENTIFICATION: EG2017-03

Submitted to (send report to):
Stéphanie Ratelle
Species at Risk / Marine Mammals
DFO-MPO Gulf Region, Science
343 University Avenue, Moncton NB, E1C 9B6
Canada
Tel: 506-851-4335
Email: Stephanie.ratelle@dfo-mpo.gc.ca

IDENTIFICATION AND HISTORY

Identification:
Specie: North Atlantic Right Whale
Identification: Catalog #3190 “Panama”
Mortality event identification: EG2017-03
Sex: male
Length: 14.5 m **overestimation likely*
Age: > 17 years old / young adult

- First seen in 2000 at unknown age
- Presence of unfused vertebral growth plates

History: The carcass was first sighted in the Gulf of Saint-Lawrence on 2017-06-18 and beached on the shore of the Magdalen Islands on 2017-07-04. Large quantities of dark putty like material have been reported to emerge from the carcass while it was beached. This animal was last seen alive on 2017-02-14 by CCS feeding in Cape Cod Bay. Previous sightings of #3190 have been in the southeast United States, Cape Cod Bay/Mass Bay, Great South Channel, Bay of Fundy, Roseway Basin and the Gulf of Saint-Lawrence (2006 and 2016). #3190 has fathered at least one calf (#4160 in 2011).

FINAL DIAGNOSTICS AND INTERPRETATION

Diagnostics:

- Cause of the death undetermined
- Old, inactive entanglement scars

Interpretation and comments
Damage to the carcass, such as the defect in the dorsal thoracic wall and the fracture of the petrotympanic complexes and maxilla, may have occurred while it was beached and moved around by the surf for a few days. Also, as the blubber and muscle were too decomposed to properly assess the presence of hemorrhages and contusions associated with these observations, it is impossible to determine if they occurred *peri-* or *post-mortem.* Although the presence of putty-like material has been attributed to hemorrhages in other whales

necropsied in this unusual mortality event, in this particular individual at least a portion of this material was composed of degraded muscle and connective tissue. It was therefore impossible to determine the nature (muscle or a combination of blood and muscle) of this material, especially considering the complete degradation of all tissues (except bones and dermis) in the abdominal and thoracic area. The advanced state of decomposition also precluded interpretation of the body condition. All biotoxins tested were not detected in the large intestine submitted from this individual and no fecal material could be sampled for the analysis of glucocorticoid concentration. The precise timing of death is impossible to determine considering all the different variables that affect decomposition rate in these aquatic megavertebrates. Based on the first sighting of this carcass, we know that this animal died at least 16 days prior to the necropsy.

The scars noted on the lips and tail peduncle are likely associated with previous entanglement event(s) from which the whale would have disentangled itself. These chronic, superficial and inactive lesions suggest that they did not impact the whale's health at time of death. This is not an unusual finding, as 82,9% of North Atlantic Right Whales have been entangled at least once in their life (Knowlton 2012).

In conclusion, the advanced state of decomposition of this carcass markedly hampered the interpretation of gross and histopathologic findings in this case, including the timing (*peri-mortem* or *post-mortem* occurrence) of some. Therefore, the cause of death of this individual remains undetermined.

References

- Knowlton, A.R., Hamilton, P.K., Marx, M.K., Pettis, H.M., and Krauss, S.D. 2012. Monitoring North Atlantic right whale *Eubalaena glacialis* entanglement rates: A 30 yr retrospective. Marine Ecology Progress Series 466: 293-302.

DETAILLED REPORT

Necropsy was realised at l'Étang-du-Nord, Magdalen Islands on 2017-07-09
Carcass conservation code: 4.5

MACROSCOPIC EXAMINATION

This was the most decomposed carcass to receive a complete necropsy examination in this mortality event. Complete morphologic measurements may be found in **Appendix I** while pictures and general distribution of the different observations (O) noted thorough this description are found in **Appendix II**.

Morphologic measurements

Blubber thicknesses were measured at seven locations from mid dorsal to mid ventral at eight levels from cranial to caudal. This young adult presented with relatively thin blubber (15.5 cm on the mid-ventrum) (*comm.* William McLellan), but the carcass was also markedly decomposed and the blubber layer was partially damaged. Total length is likely to be an overestimation of the actual length considering that thoracic vertebrae were detached from the spine (loose in the body cavities).

External examination

The epidermis is entirely sloughed off and no baleen plate are present. The surface of the exposed dermis is creamy white to pink in color, with darker brown regions on the ventral surface. The dermal surface is irregular and friable; soft bubbles of gas can be palpated diffusively on the carcass, especially on the flukes. The caudal peduncle was almost completely severed at the fluke insertion during the attempt to beach the whale. A mandibular bone was ripped after trying to bring the head back on shore with the machinery. Several linear ridges of firm and white dermis, considered to be scar tissue, are noted on the dermal surface:

- Dorsal and ventral to the caudal third of the tail peduncle; several scars of 10 to 30 cm in length (O1 and O2, respectively).
- Left oral commissure (white arrow); scar at least 50 cm in length and 1 cm thick (O3).
- Inner surface of left lip, between the rostral and middle thirds; three irregularly surfaced scars, 10 to 30 cm in length are associated with a moderate indentation of the lip margin (O4).

A 10 by 40 cm white area of superficial discoloration of the dermis noted at the inner surface of the right lip (O5). Lastly, a 20 cm in diameter complete perforation of the blubber layer is noted on the dorsal right portion of the thoracic region. In this area, the panniculus is thinner and filamentous and the dermal surface is extensively irregular (O8).

Internal examination
Upon flensing the dorsal blubber at the base of the caudal peduncle, a few small masses of dark, putty-like material are noted between the panniculus and underlying muscle (O6). Massive quantities of dark brown and thick fluids are flowing out of the thoracic and abdominal area when the blubber is removed. The cavity is also filled with a very large quantity of dark, putty-like material with scattered white fibers of connective tissues (O7/ O9).
A comminutive fracture of the edge of the right occipital bone is noted. This fracture is surrounded by dark muscles and extensive accumulation of dark, putty-like material (O10). The foramen magnum and brain case(O11) as well as both sides of the vomer (O12) are filled with a dark putty-like material. Bone pieces, presumably from the bilaterally fractured petrotympanic complexes (O13) are found in the brain case. The maxilla and premaxilla are fractured at the base of the skull (O14). No other fracture detected. Axial bones are free within the body cavities.
With the exception of a small segment of the rectum, none of the internal viscera are recognizable (including the diaphragm and the abdominal and thoracic musculature).

HISTOPATHOLOGY
Marked *post-mortem* changes are present on all microscopic sections examined and are associated with significant artifacts which hampers the interpretation of the microscopic examination.

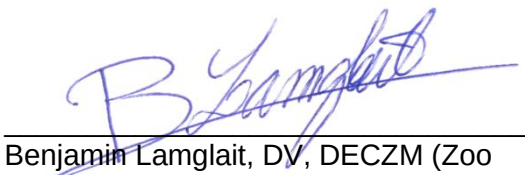
Observation 1 (scar – dorsal tail peduncle; I): The connective tissue is denser when compared with other sections of skin examined. This could be consistent with inactive scar tissue or could be associated with the different location of the sample.
Observation 2 (scar – ventral tail peduncle; J): Same observation as O1.
Observation 7 ("putty-like material" from thoracic cavity; D and K to M): Numerous fragments of granular acidophilic material are observed on D, K1, L and M. On slide K2 and M, connective tissue fibers are recognizable. What appears to be markedly fragmented muscle fibers embedded within the connective tissue is also noted (K2). Bacterial growth (*post-mortem*) is important on these slides. This suggest that muscle and fascia may compose part of the observed black, putty-like material in this animal, but the structures observed on the slide may not be representative of all the material as part of it was likely washed away. Based on observations in other whales, decomposed and cooked blood may also compose part of this material.
Observation 8 (Defect in thoracic body wall; O): The deeper layers of connective tissue are disorganized; basophilic and sand particles are noted within them. There is no active inflammatory reaction. *Post-mortem* change likely.
No significant anomaly detected in the muscle (A, B), pharyngeal cavity (C) dermis and epidermis (E to H) and blubber (N).

Biotoxin testing (Complete results may be found in Appendix III):
CFIA Reference No. 2017FFIS-0000049700-4: Paralytic shellfish toxins, amnesic shellfish toxin (domoic acid) and lipophilic shellfish toxins were not detected in the large intestine of this individual.

Fecal glucocorticoid assay: Not performed (No adequate sample obtained)

Émilie L. Couture, DMV, IPSAV, DES

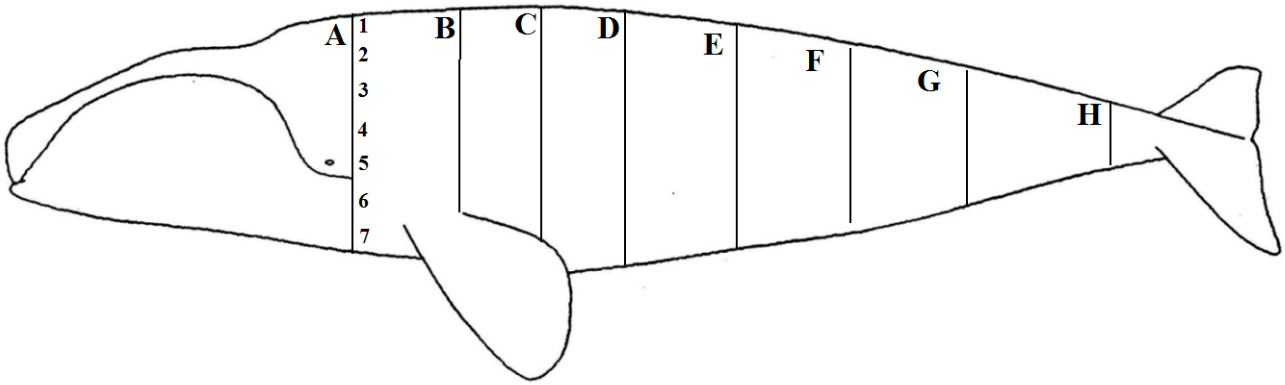
Stéphane Lair DMV, Diplomate ACZM



Benjamin Lamglait, DV, DECZM (Zoo management)

RIGHT WHALE EG#3 BLUBBER THICKNESS

Field# CQSAS EG_2017-03 **Side Examined: Left Observer :Ashley. Date** 9 July 2017



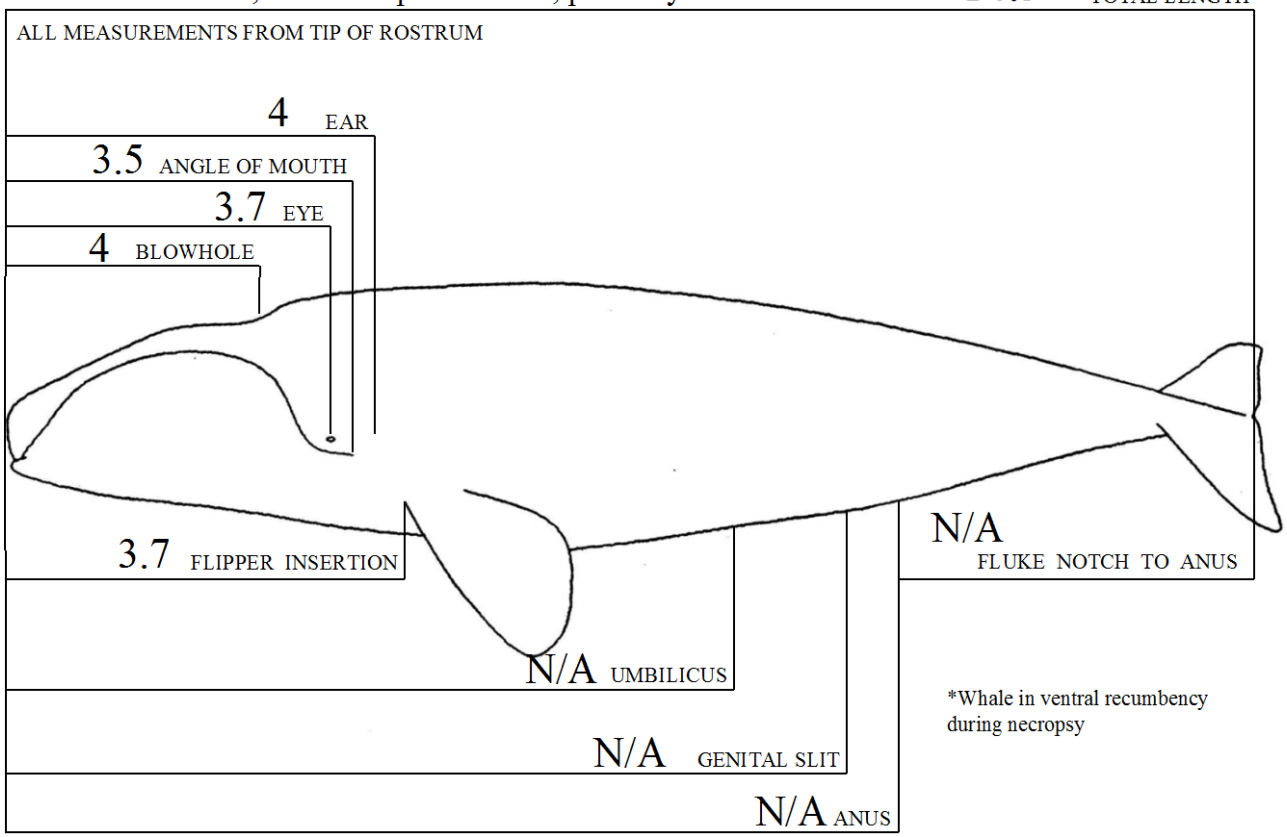
	A	B	C	D	E	F	G	H
Dorsal	Nuchal Crest	Axilla	1/2 1/2 Axilla-Umbilicus	Umbilicus	1/2 Umbilicus-Anus	Anus	1/2 1/2 Anus-Tail Insertion	Tail Insertion
1	7.8	9.5	9.5	8	12	12.5	11	9.6
2	6.5	7.5	6.8	10	8	14	10	4.8
3	8.2	7.5	4	---------	11.5	11.6	12	7.2
4	6.8	8	--------	8	16	13	9	6
5	8	7.8	9.5	9	13.6	13.8	9.5	7
6	7.4	9.5	12.5	12	13.8	14.4	10	5
7	10	15.2	--------	13	15.5	14.8	12.5	4.4
Ventral								
Average	7.8	9.3	8.5	10	12.9	13.4	10.6	6.3

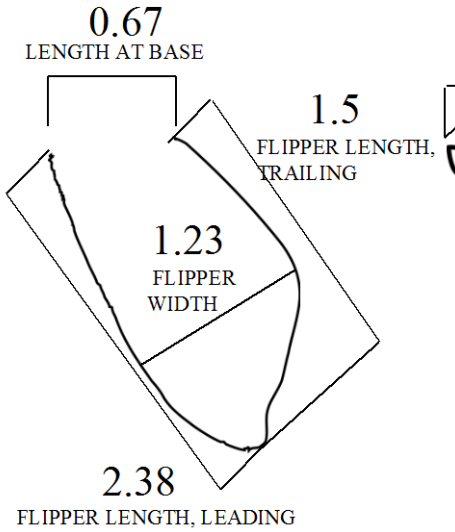
Note: all measurements are in cm

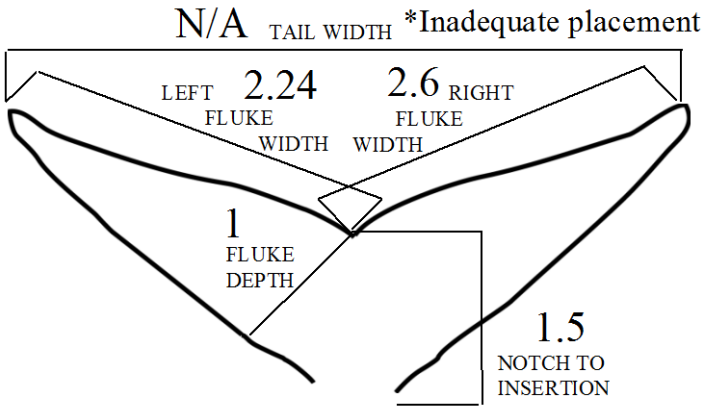
Right Whale EG#3 External Morphometrics

WRITE MORPHOMETRICS ON LINES

*vertebraes dislocated, advanced putrefaction, probably an overestimation 14.5 TOTAL LENGTH





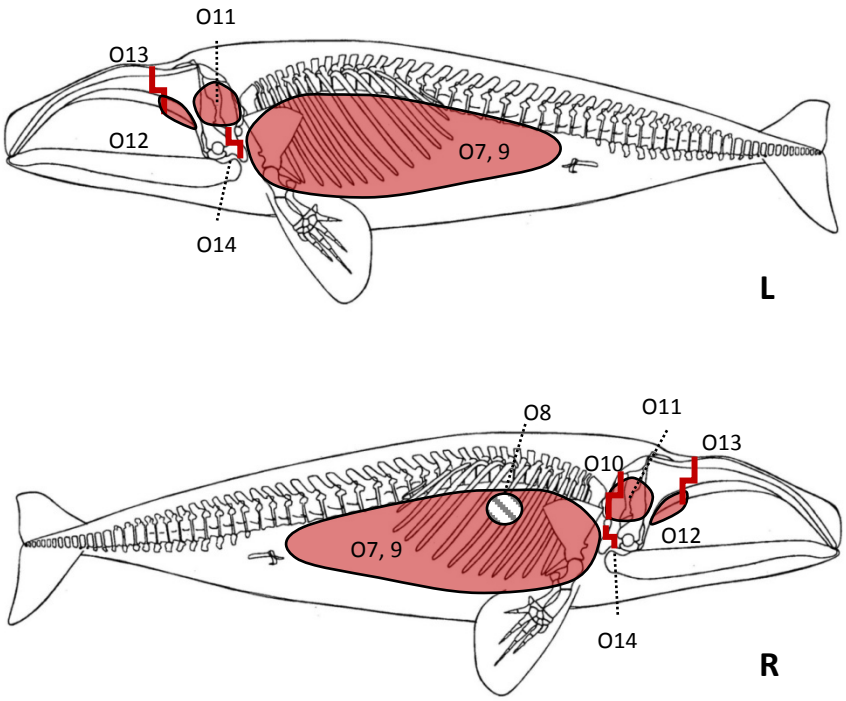


*tip of right fluke damaged

*measures in meters

Distribution of observations suggestive of blunt trauma

Field # EG2017-03 Date 2017-07-09



Fracture

O10: right occipital bone, associated with putty-like material
O13: petrotympanic complex, bilateral
O14: base of maxilla, premaxilla, vomer

Putty-like material

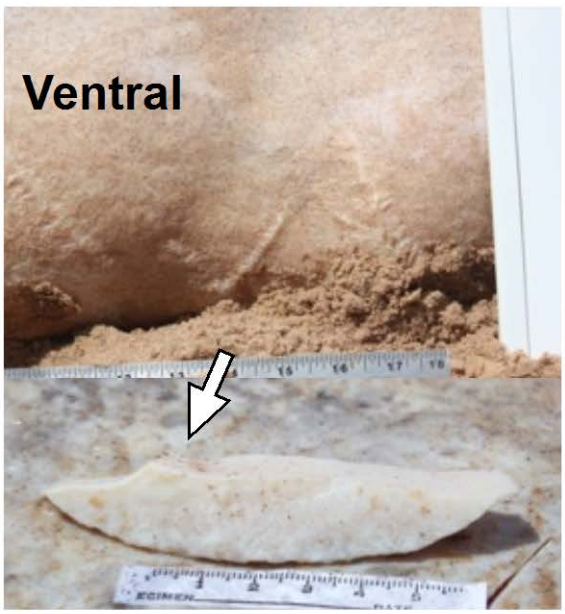
O7,9: thoracic and abdominal cavity
O11: foramen magnum and brain case (associated with bone pieces)
O12: either side of the vomeronasal bone

Skin laceration

O8: Right dorsal thoracic area

Observation 1 and 2

Linear ridge of firm and white dermis, considered to be scar tissue located dorsally and ventrally to the caudal third of the tail peduncle; several scars of 10 to 30 cm in length are present.

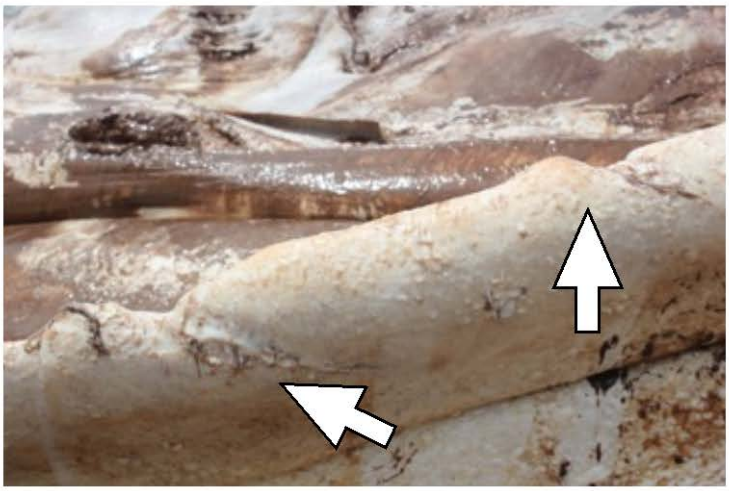


Observation 3

A linear ridge of firm and white dermis is located along the left oral commissure (white arrow). The scar at least 50 cm in length and 1 cm thick.

Observation 4

Linear ridge of firm and white dermis, located at the inner surface of left lip, between the rostral and middle thirds. Three irregularly surfaced scars, 10 to 30 cm in length are associated with a moderate indentation of the lip margin (white arrow).



Observation 5

A 10 by 40 cm white area of superficial discoloration of the dermis noted at the inner surface of the right lip.

Observation 6

Upon flensing the dorsal blubber at the base of the caudal peduncle, a few small masses of dark, putty-like material are noted between the panniculus and underlying muscle.

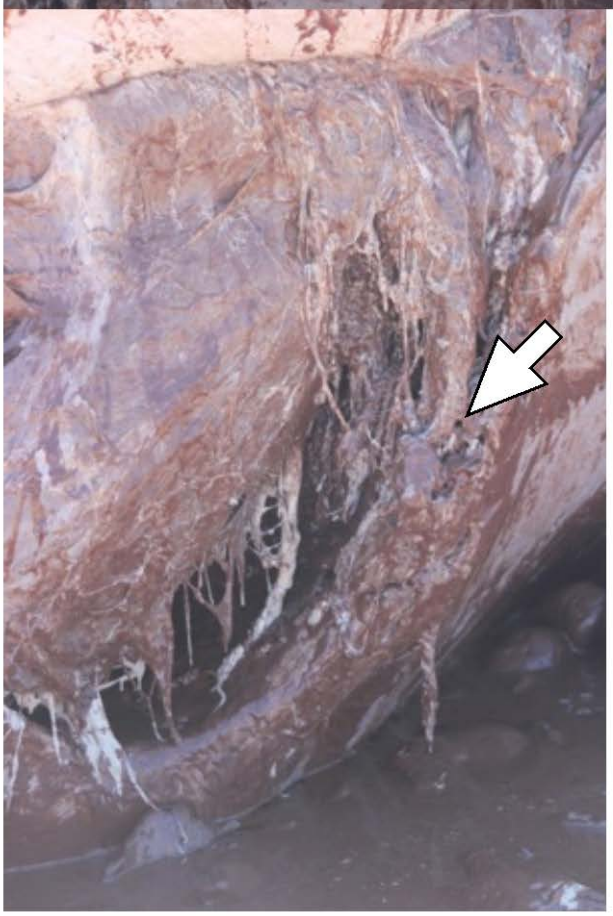
Observation 7/9

Massive quantities of dark brown and thick fluids are flowing out of the thoracic and abdominal area when the blubber is removed (white arrow). The cavity is also filled with a very large quantity of dark, putty-like material with scattered white fibers of connective tissues (black arrows).

Observation 8

A 20 cm in diameter complete perforation of the blubber layer is noted on the dorsal right portion of the thoracic region. In this area, the panniculus is thinner and filamentous and the dermal surface is extensively irregular.

Observation 10

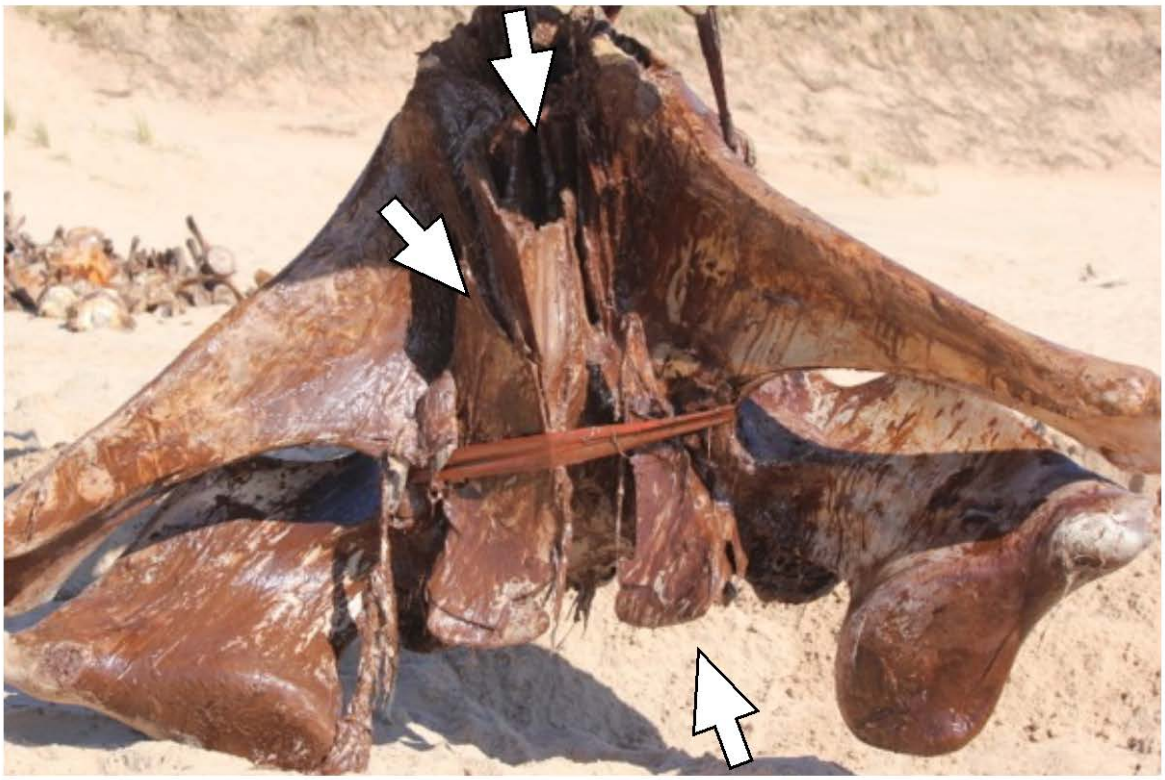


A fracture is present on the right occipital bone (white arrow). This fracture is surrounded by dark muscles and extensive accumulation of dark, putty-like material.

Observation 11, 12, 14

The foramen magnum and brain case are completely filled with a dark putty-like material, as well as both sides of the vomer. White arrows point at location of this material.

The maxilla and premaxilla are fractured at the base of the skull (bottom picture).



Appendix III- Biotoxin analysis

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

CANADIAN FOOD INSPECTION AGENCY
REPORT OF ANALYSIS
FISH PRODUCTS SAMPLING SUBMISSION
Version 6.3.0
Serial: 000004364057

System ID: 2017FFI-0000046382-4 ***Receptions by all Labs:*** 1
Reference No.: 2017FFIS-0000049700-4 ***Number of Jobs Authorized:*** 1

Laboratory No.: DAR-FD-2017-CH-02541 ***Date Received:*** 2017-07-25 ***Job Status:*** Authorized

Laboratory: (1981) DARTMOUTH LABORATORY - CHEMISTRY
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Submitted By: CFIA Inspector
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Fax:
Cell:
Email: ALEXIS.JOHNSON@INSPECTION.GC.CA

Sampled By: CFIA Inspector
(12450) ALEXIS JOHNSON
1992 AGENCY DRIVE
DARTMOUTH, NS B3B 1Y9
Telephone: (902) 426-2110
Fax:
Cell:
Email: ALEXIS.JOHNSON@INSPECTION.GC.CA

Program: FISH ***Function:*** DOMESTIC
Sampling Plan: 2017_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 #3 NECROPSIED, MAGDALEN ISLAND, QUEBEC, JULY 9-10 2017 (LARGE INTESTINE)

Date Sampled: 2017-07-09
Date Received: 2017-07-25
Risk Category: Bivalve Molluscan
Harvest Date: 2017-07-25 08:25 AM

Lab Sample No.: DAR-FD-2017-CH-02541-0001 ***Inspection Sample No.:***

Primary Process: FREEZING
Sample Type: Other
Identification Code: EG # 3
Species: NORTH ATLANTIC RIGHT WHALE - EUBALAENA GLACIALIS

Sample Assessed: No Decision

Method: TOX-DA-LC / 1 : Analysis of Domoic Acid in Molluscs by Liquid Chromatography- SOM-DAR-CHE-001
Domoic Acid Not detected at the reporting limit.
Test Assessed: No Decision

System ID: 2017FFI-0000046382-4 **Receptions by all Labs:** 1
Reference No.: 2017FFIS-0000049700-4 **Number of Jobs Authorized:** 1

Laboratory No.: DAR-FD-2017-CH-02541 **Date Received:** 2017-07-25 **Job Status:** Authorized

Method: TOX-DSP-LC / 1 : Analysis of Lipophilic Shellfish Toxins by Liquid Chromatography- SOM-DAR-CHE-002

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

Method: TOX-PCOX / 1 : Post-column Oxidation (PCOX) Method for the Determination of Paralytic Shellfish Toxins in Mussels, Clams, Oysters and Scallops-SOM-DAR-CHE-052

Gonyautoxin-4	Not detected at the reporting limit.
Gonyautoxin-1	Not detected at the reporting limit.
Decarbamoylgonyautoxin-3	Not detected at the reporting limit.
Gonyautoxin-5	Not detected at the reporting limit.
Decarbamoylgonyautoxin-2	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: 2017-08-04 **Authorized By:** Ryan Gibbs **Authorized**
Job Assessed: No Decision **Date Assessed:** 2017-08-04

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

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

Wildlife Diagnostic Report – EG#4

Necropsy #: EG#4; MARS2017-143; NEAq Catalog #3603 ("Starboard") – 11 year old female

Incident Information

Species: North Atlantic Right Whale (*Eubalaena glacialis*)
Age: Adult
Sex: Female
Necropsy date: 1 July 2017
Location: Norway, Prince Edward Island, Canada

Submitted Information

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

Information Provided with Specimen

First sighted in the GoSL on June 22, 2017. She is anchored in fishing gear (most likely snow crab gear) with rope through her mouth and around her right flipper and leading to depth. Previous sightings of #3603 have been in the southeast US (where she was first seen as a dependent calf but has visited there in other years), Cape Cod Bay/Mass Bay, Bay of Fundy, Great South Channel, southern New England, mid Atlantic, Jeffreys Ledge, Gulf of Maine, and Roseway Basin. Although she has not been observed with a calf, she was just entering reproductive age. Named Starboard for her severed right fluke.

Diagnosis and Interpretation

Final Diagnosis

Acute entanglement in fishing gear and subsequent drowning (probable)

Previous chronic entanglement in fishing gear (suspected)

Interpretation

Although the carcass of this whale was ascribed a decomposition condition code of 4, this did not prevent confirmation of the final diagnosis of entanglement in fishing gear. This was based on some key observations: 1) rope from fishing gear (including two buoys) still wrapped around the base of the right flipper; 2) conspicuous scar tissue (fibrosis) in dermis underlying the rope, which would probably have taken at least a few weeks to form; 3) locally extensive area of marked erosion of the articular cartilage of the right humeral head, indicative of arthritis and presumably caused by abnormal tension on, or movement of, the scapulo-humeral joint anchored by the fishing gear; this again would have taken at least a few weeks to form; and 4) superficial scar tissue in dermis also observed at base of left flipper and in rostral region of the mandible (the rope was seen to pass through the animal's mouth at sea).

Moreover, this animal had thin blubber, suggesting a poor body condition presumably caused by decreased ability to feed due to entanglement.
Because the cause of death of this whale was confirmed, its necropsy was also useful for comparison with those of the other right whales involved in the mortality event, for which the cause of death was not as obvious. For example, there was no description of the presence of red-tinged fluid between blubber and muscle mass along the body, suggesting that in at least some cases this change may indeed be ante-mortem. A thin layer of dark brown to black material was found on surface of several vertebral bodies and ribs, suggesting that this is a post-mortem change of some unknown nature, rather than suggestive of blunt trauma. Finally, a few small clumps of dark brown putty-like material were found in the thoracic cavity. Whereas an abundant amount of this material could suggest clinically significant internal hemorrhage, a few clumps could escape from major blood vessels as internal organs were ripped out of their attachments by the post-mortem pressure buildup within the carcass.

ADDENDUM to EG#4 (NEAq catalogue #3603)

In light of the timeline of entanglement revealed by the fishing gear analysis made available in annexes 7a and 7b, an addendum to this necropsy report is warranted. Due to the presence of chronic scars and emaciation, EG#4 was originally believed to have died from emaciation caused by chronic entanglement in two sets of snow crab fishing gear identified at necropsy. However, inquiry into the specific dates when the corresponding snow crab pots were set indicated that EG#4 must have become entangled somewhere between June 12 and June 21 (the date when its floating carcass was first sighted). As well, it can be seen from the photo of EG#4 when it was first sighted (see Annex 2a) that the skin was already blistering and lifting from the ventral surface of the carcass, suggesting that this animal had been dead for at least 1 to 2 days prior to the date when it was first sighted. These observations thus suggest that the greatest possible post-mortem interval between death and entanglement was 7 to 8 days. This timeline is problematic for two reasons: Firstly, one week may not be sufficient to have resulted in the obvious scars present around the insertions of EG#4's flippers and, secondly, it may take weeks to months for chronic entanglement to result in emaciation of a right whale, depending on the time of year when it became entangled (i.e., early or late in the feeding season). In conversation with Dr. Scott Kraus (New England Aquarium), it was noted that the gear in which EG#4 was entangled in at the time of necropsy was relatively intact and not fouled by marine organisms or clinging fragments of abraded blubber (conditions which typically increase over the course of entanglement). It is therefore evident that the short timeline over which EG#4 must have become entangled conflicts with some of the chronic lesions identified at necropsy. An alternative explanation is that perhaps EG#4 had been entangled in another set of gear prior to becoming entangled in the gear that was identified at the time of necropsy. A previous chronic entanglement could account for the lesions of scarification and emaciation. EG#4 may have been unable to carry the final set of gear that it became entangled in (identified at necropsy), which would have led to its acute drowning. However, its already emaciated and thus weakened state would have greatly exacerbated this problem. This earlier set of gear may have been shed on its own (as occasionally happens), or it may have been cut off (a suggestion supported by comments from a fisherman who identified four sets of crab pot gear on EG#4 when he first discovered the carcass). Based on all this information, it must at least be acknowledged that EG#4's history is incomplete, and that the hypothesis of a previous chronic entanglement could best resolve the discrepancy between the lesions identified at necropsy and the reported short timeline of gear entanglement.

Test Results

Necropsy (1 July 2017)

Standard length: 13.3m[1]
Rostrum to angle of mouth: 2.50m
Rostrum to eye: 2.90m
Rostrum to flipper insertion: 3.30m
Rostrum to umbilicus: 8.70m
Rostrum to genital slit: 8.90m
Rostrum to anus: 9.30m
Anus to fluke notch: 4.30m
Flipper length at base: 0.90m
Flipper length (leading): 1.70m
Flipper length (trailing): 1.18m
Flipper width: 1.50m
Tail width: 3.60m
Left fluke width: 2.35m
Right fluke width: 1.30m (large portion of tip severed)
Notch to tail insertion: 1.10m
Fluke depth: 1.08m

[1] possibly affected by multiple vertebral dislocations

(See Appendix 1)

Blubber thickness was measured cranial to caudal at eight locations down the dorsal midline: nuchal crest, 11.5cm; axilla, 11.5cm; ½ axilla-umbilicus, 13.0cm; umbilicus, 12.5cm; ½ umbilicus-anus, 7.5cm; anus, 7.5cm; ½ anus-tail insertion, 20.5cm; tail insertion, 9.0cm. (See Appendix 2)

Adult female (11 years old). The animal presented with thin blubber (7.5cm on the mid-dorsum) and did not express lipid from cut blubber surfaces (Miller et al. 2011). Its blubber was the thinnest of all six whales necropsied, although this was based on a limited number of sites measured on the carcass. This suggested a poor body condition presumably caused by decreased ability to feed due to entanglement, although this blubber thickness may have been distorted as the carcass was stretched from being pulled on the beach or may have been affected by the degree of decomposition of the carcass. Decomposition condition code 4. No baleen plate present. Dislocation of multiples ribs and vertebrae (presumably post-mortem). Most or all of the vertebral epiphyses are un-fused – presumably normal for a female at this length and age. Heart and portions of lung identified. No liver identified. Digestive tract limited to some loops of small intestine and caudal portion of large intestine. Vagina and caudal portion of uterus retrieved. No putty-like material observed in occipital foramen. Conspicuous observations at necropsy included:

- several linear scars (including good macroscopic evidence of fibrosis) visible externally: base of right flipper (at site of fishing gear entanglement still present on the carcass) (Figure 1), base of left flipper (Figure 2), rostral regions of mandible (Figure 3) and rostrum (Figure 4); several triangular areas of discoloration along leading edged of ventral surface of left fluke (slashes from ropes?) (Figure 5);
- locally extensive area of marked erosion of articular cartilage and eburnation of subchondral bone involving dorsal region of right humeral head (Figure 6); diffuse fibrous texture on articular surface of right scapula (Figure 7);
- several areas of deposition of relatively small amount of dark brown putty-like material on surface of ribs and vertebral bodies (Figure 8); relatively small number of small clumps of dark brown putty-like material in thoracic cavity (Figure 9).

See Appendix 3 for detailed description of observations made in the carcass.

Entanglement (as described by Jen Jakush, NOAA)

Aqua colored float line, 5/8 inches (600+1580 = 2180 cm): 3 wraps around insertion of right flipper. Starting at rough frayed end, the line loops around the flipper and wraps 4x around another central line. After wrapping, it goes through a loop and wraps around the flipper. Near the frayed end, it loops and goes back around the flipper in the opposite direction. It loops over the frayed end again and becomes the central line with 4x wraps, then exits the wraps between two of the loops that are around the flipper. Then, it goes towards the buoy. Near the buoy, it wraps around 2 sets of braided lead line, comes up, wraps over itself under the 2 braids, then around and under the braids and under itself, then terminates in a cut frayed end. This aqua float line is not connected to buoys.

Light blue-colored line with black tracer and lead in all 3 strands, 3/4 inch diameter (110 [loop]x2 + 150 = 370 cm): Starting at cut frayed end, the line (a short distance from taped bitter end) is tucked/braided through, then goes to another tuck/braid, then to splice with the pick-up buoy line (yellow tracer), then to another tuck/braid, then loops into orange poly buoy eye, twists around itself, back through the tucked/braided loop and terminates in the taped bitter end. The orange poly buoy bears numbers 252, 176, and 226.

Light blue-colored line with yellow tracer, 1/2 inch diameter (470 cm): starts at splice in lead line and goes to smaller, hard plastic red pick-up buoy.

Histology (AVC X15392-17)

Total of 34 tissues embedded in paraffin blocks (numbers generally correspond to gross observations). Total of 7 slides examined (*):

1. Soft tissues from base of right flipper (1-1 – 1-4, caudal region; 1-5 and 1-6, dorsal region; 1-7, dorsal region, normal and abnormal). Paraffin blocks available; no histological slide prepared.
2. 3. 4-1. 4-2. 5-1. 5-2. 6. 7-1. 7-2. 8. Paraffin blocks available; no histological slide prepared.
15-1 (cranial). 15-2 and 15-3 (caudal). Paraffin blocks available; no histological slide prepared.
16. Dorsal, near head. Paraffin blocks available; no histological slide prepared.
17. Blubber, right pectoral. Paraffin blocks available; no histological slide prepared.
18. Blubber, left pectoral. Paraffin blocks available; no histological slide prepared.
19. Blubber, right body. Paraffin blocks available; no histological slide prepared.
20. Blubber, left body. Paraffin blocks available; no histological slide prepared.
21. Aorta, dorsal. Paraffin blocks available; no histological slide prepared.
22. Aorta, first branch. Paraffin blocks available; no histological slide prepared.
23. Bladder. Paraffin blocks available; no histological slide prepared.
*24-1, *24-2 and *24-3. Right humeral head, normal. In section 24-1, the articular cartilage is covered by a thick layer of fibrous tissue (as seemed to be the case grossly for the whole articular surface of the scapula).
*25-1, *25-2 and *25-3. Right humeral head, abnormal. The thickness of the articular cartilage is greatly reduced as compared to normal areas, and its surface is generally very ragged. Other changes, such as reduced staining density of the tissue and necrosis or proliferation of chondrocytes, cannot be assessed

(presumably due to post-mortem changes). Reactive changes in the underlying bone tissue are not evident in the sections examined.
*26. Left humeral head, normal.

Other Tests

Colon content and feces: Biotoxins (paralytic shellfish toxins, amnesic shellfish toxins [domoic acid], lipophilic shellfish toxins) – all negative (CFIA, Dartmouth, NS).

Fecal samples: Baseline levels of fecal glucocorticoids, used as potential indicator of chronic stress (more than 2 days, based on gastro-intestinal transit time in this species) were found in this whale, suggesting that it died before an elevated response to stress by the adrenal glands could be reflected in a rise in fecal glucocorticoids (Endocrine Laboratory, New England Aquarium). This information is at odds with the morphological evidence of chronic entanglement in this whale, but it needs to be evaluated more closely in the context of the precise history of the whale's entanglement, once further details are obtained. The possibility that the sample analyzed was a poor representative of fecal material must also be considered.

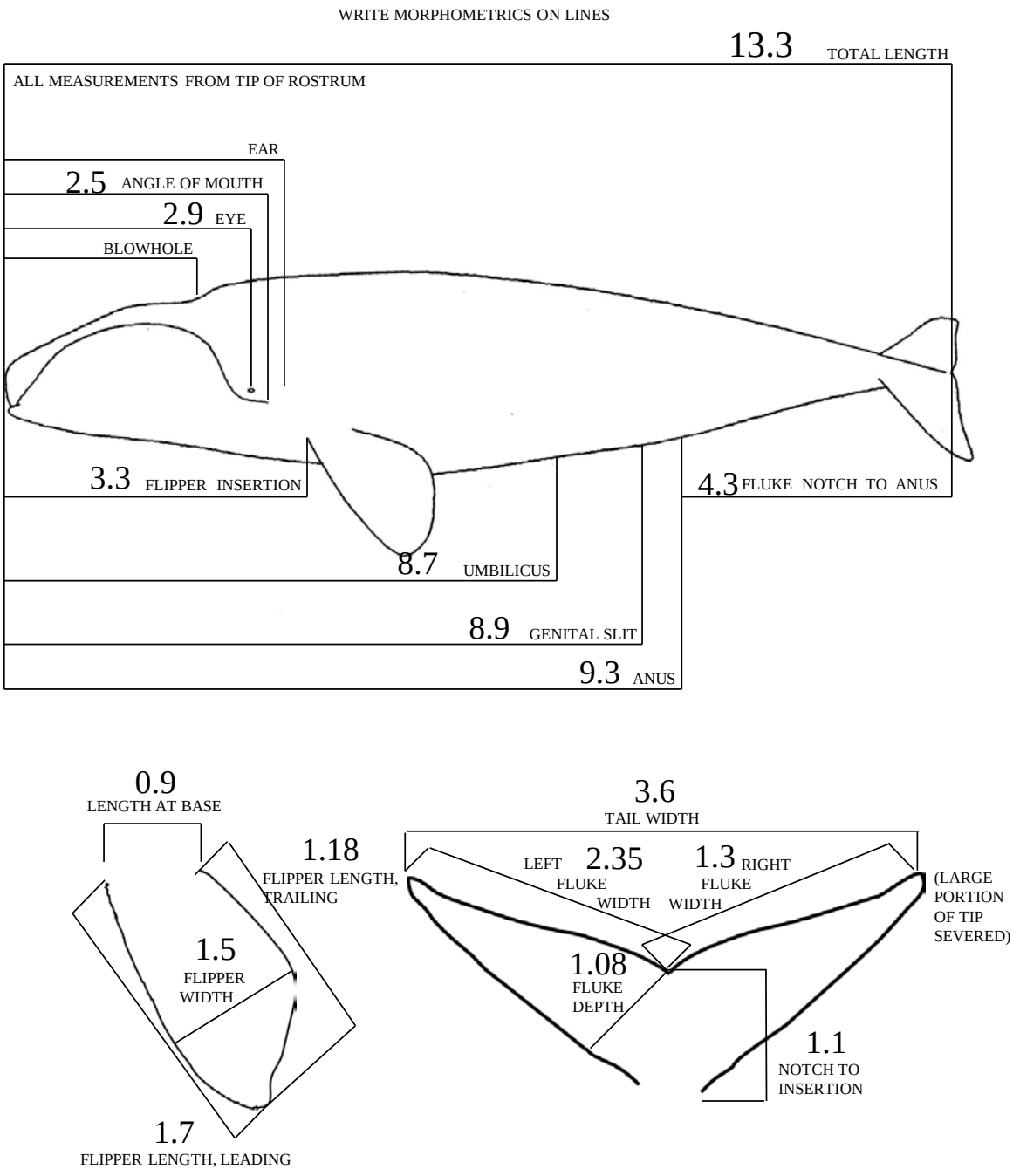
Inventory of Frozen Samples

- Blubber x4
- Skin
- Waxy black material around vertebrae
- Cyamids on head
- Bladder
- Lesion 1 x3
- Lesion 9 x2
- Left humerus
- Epaxial Muscle
- *Colon content x2
- *Thoracic fluid
- *Urine
- *Feces x2
- *Vaginal Fluid
- *Small Intestine content
- Clitoris (for Dr. Dara Orbach, Dalhousie U.)

References

Miller CA, D Reeb, PB Best, AR Knowlton, MW Brown, MJ Moore. 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 (2011): 267-283.

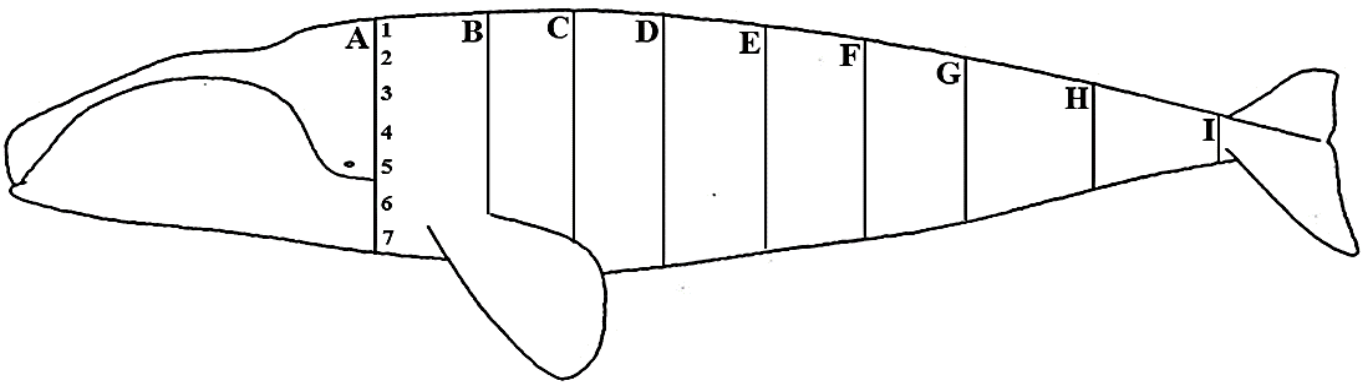
Appendix 1. Right Whale EG#4 External Morphometrics



*measures in meters

Appendix 2. Right Whale EG#4 Blubber Thickness

Field # MARS2017-143 **Side Examined** ____ **Observer** _____ **Date** 1 July 2017



	A Nuchal Crest	B Axilla	C 1/3 Axilla-Umbilicus	D 2/3 Axilla-Umbilicus	E Umbilicus	F 1/2 Umbilicus-Anus	G Anus	H 1/2 Anus-Notch	I Insertion
Dorsal									
1	11.5	11.5	13	12.5	7.5	7.5	20.5	9	
2	_____	_____	_____	_____	_____	_____	_____	_____	_____
3	_____	_____	_____	_____	_____	_____	_____	_____	_____
4	_____	_____	_____	_____	_____	_____	_____	_____	_____
5	_____	_____	_____	_____	_____	_____	_____	_____	_____
6	_____	_____	_____	_____	_____	_____	_____	_____	_____
7	_____	_____	_____	_____	_____	_____	_____	_____	_____
Ventral									

Note: all measurements are in cm

APPENDIX 3: External and internal observations by number

(Asterisks indicate observations of potential clinical significance)

Observation number	Physical location	Description	Photos taken (Y/N)	Histology taken (Y/N)
1*	Right flipper	Tan linear depression ventrally around base of right flipper associated with fishing line; linear portions of epidermis adherent to depressions, more prominent dorsally. Change is more patchy on dorsal surface. On section, there is good evidence of fibrous tissue as indicated by white discoloration of underlying dermis, most prominent in trailing edge. In leading edge, there is a large area of pale discoloration on section.	Y	Y
2	Rostral mandible (chin)	Narrow epidermal laceration on right side, 50-60cm long, from chin extending caudo-ventrally; some evidence of fibrosis in underlying dermis.	Y	Y
3	Rostral mandible (chin)	Old, tan to white, raised ridge (scar), approx. 2cm wide and 30cm long, slightly curved along midline. Does not extend into dermis on section.	Y	Y
4	Rostral mandible (chin)	Multiple areas of white linear epithelial depigmentation, each approx. 10cm long.	Y	Y
5*	Left ventral axilla	Brown linear area of depression, 20-40cm long and 5cm wide, extending to trailing edge of axilla. Thin area of white discoloration on section, consistent with fibrosis, at level of depression.	Y	Y
6	Left commissure of mouth at level of mandible	Linear area of brown discoloration, approx. 30cm long and 5cm wide. No lesion visible on section.	Y	Y
7	Left fluke, ventral surface, leading edge	Several triangular areas of slight depression of dermis, between 3 and 20cm long cranio-caudally. Areas cream to white, lined by black pigmentation. Some pieces of epidermis still adherent. Very little evidence of white discoloration on section. (Slashes from rope[s] from previous entanglement? [WA McLellan])	Y	Y
8	Cranial-ventral to peduncle	Narrow linear areas of black pigmentation, 20-30cm long and 2-3cm wide; do not extend on section.	Y	Y

Observation number	Physical location	Description	Photos taken (Y/N)	Histology taken (Y/N)
9*	Right humeral head	Locally extensive area of marked erosion of articular cartilage and eburnation of subchondral bone, approx. 25cm diameter, in dorsal region (irregular and nodular surface). Cartilage is approx. 3mm thick over area of erosion; for comparison, normal cartilage is 1cm thick. (Left humeral head normal.) (Articular surface of right scapula has a diffuse fibrous texture – seemingly covered by a thin layer of fibrous tissue)	Y	Y
10	Peduncle	Post-mortem indentation from rope	Y	N
11a	Left scapula	Small amount of black putty-like material mixed with connective tissue in soft tissues underneath the scapula, approx. 30cm long and 30cm wide.	Y	N
11b	Left ribs, beneath left scapula	Multiple (approx. 4) plaques of black putty-like material adhered to lateral surfaces of ribs.	Y	N
12a	Thoracic vertebrae	Black putty-like material, sub-periosteal. Multiple vertebral dislocations, probably post-mortem.	Y	N
12b	Thoraco-lumbar vertebrae	Black putty-like material, sub-periosteal. Multiple vertebral dislocations, probably post-mortem.	Y	Y
13	Hyoid apparatus	Black putty-like material adhered to surface of hyoid bones	Y	N
14	Thoracic cavity	Multifocal clumps of black putty-like material in thoracic cavity	Y	N
15*	Rostrum (maxilla)	Approx. 1/3 up maxilla from tip of rostrum are two white circumferential linear depressions, approx. 2-3cm wide, crossing each other, around maxilla. Approx. 45cm caudal to these depressions is another white linear depression.	Y	Y
16	Caudal to head, right of median dorsal surface	Raised white to tan linear ridge, consistent with a scratch, approx. 60cm long and 2cm wide	Y	Y

Figures (43 other photos available)

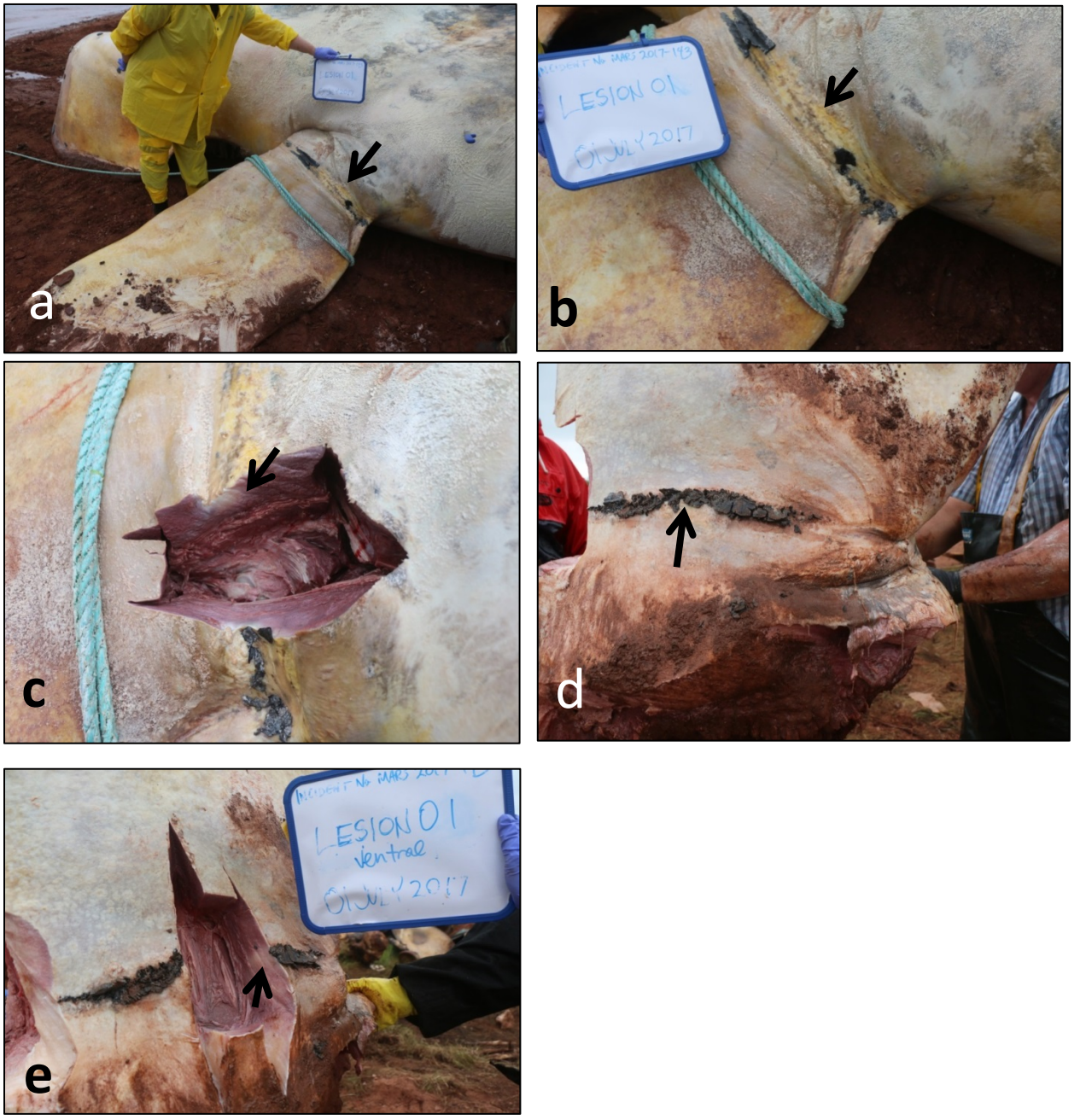


Figure 1. a) and b) Linear scar at base of right flipper ventrally (arrow), at the site of rope entanglement. c) White discoloration of dermis at the level of the scar ventrally (arrow), indicative of fibrosis of repair. d) Dorsal surface of base of right flipper. Whereas the epidermis has sloughed off everywhere else as a result of post-mortem decomposition, the linear band of epidermis still attached to the dermis at this level (arrow) suggests the presence of a scar. e) White discoloration of dermis at the level of the scar dorsally (arrow), indicative of fibrosis of repair.

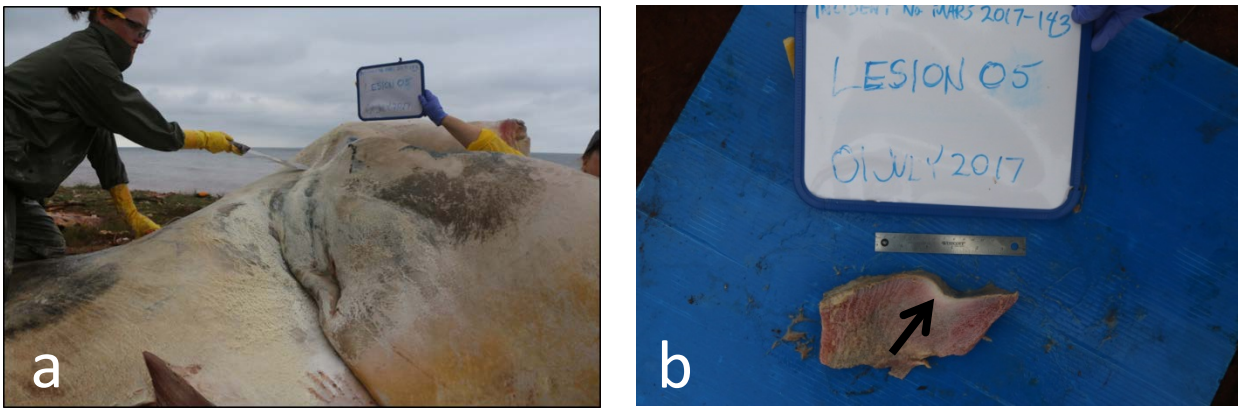


Figure 2. a) Linear scar along base of left flipper ventrally, compatible with entanglement in fishing gear. b) White discoloration of dermis at the level of the scar ventrally (arrow), indicative of fibrosis of repair.

Figure 3. Two linear scars (arrows) in rostral region of mandible, compatible with entanglement in fishing gear.

Figure 4. Linear scar (arrows) in rostral region of rostrum, compatible with entanglement in fishing gear.

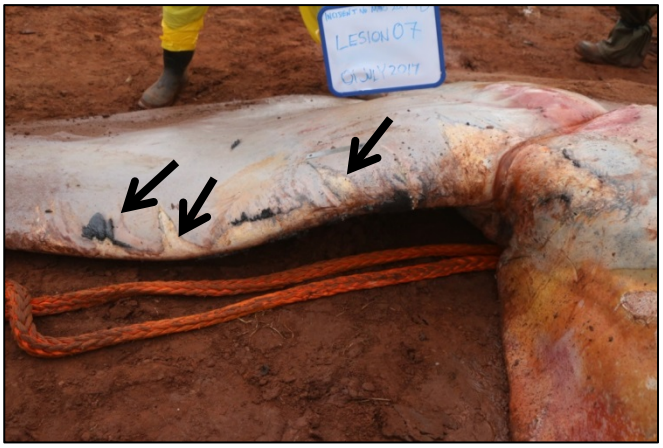


Figure 5. Several triangular areas of discoloration (arrows) along leading edge of ventral surface of left fluke (slashes from ropes?).

Figure 6. a) Locally extensive area of marked erosion (arrow) of dorsal region of articular cartilage of the right humeral head. b) Two sections of the articular surface of the right humeral head. The section above is abnormal, showing a very irregular surface. The section below was taken at the junction of normal (right) and abnormal (left) cartilage; the normal cartilaginous surface (arrow) is much thicker than the abnormal surface.

Figure 7. Diffuse fibrous texture on articular surface of right scapula.

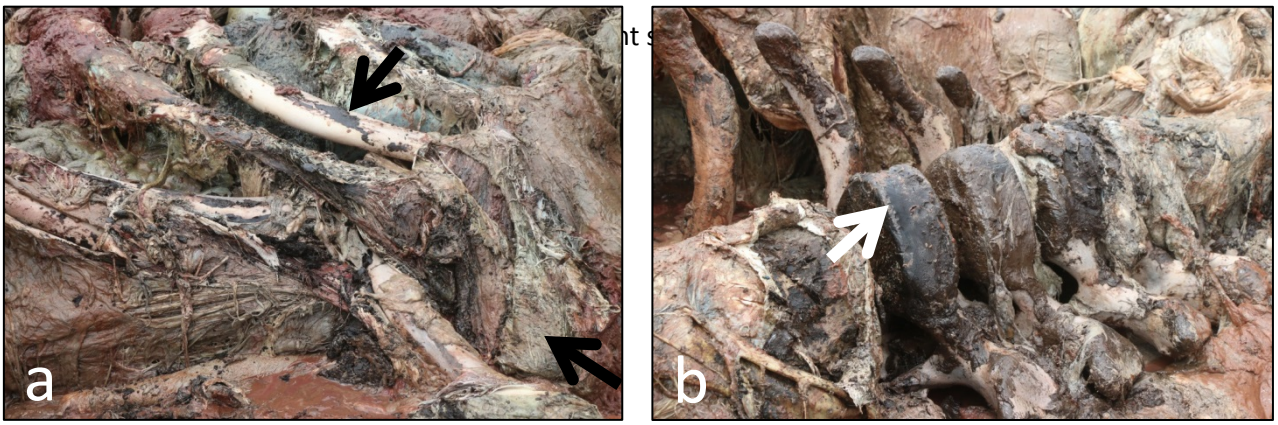


Figure 8. a) Several areas of deposition of a thin layer of dark brown putty-like material on surface of the ribs (arrow). b) Deposition of similar material on the surface of vertebral bodies (arrow); several vertebrae are dislocated, but this may have happened as the carcass was pulled ashore.

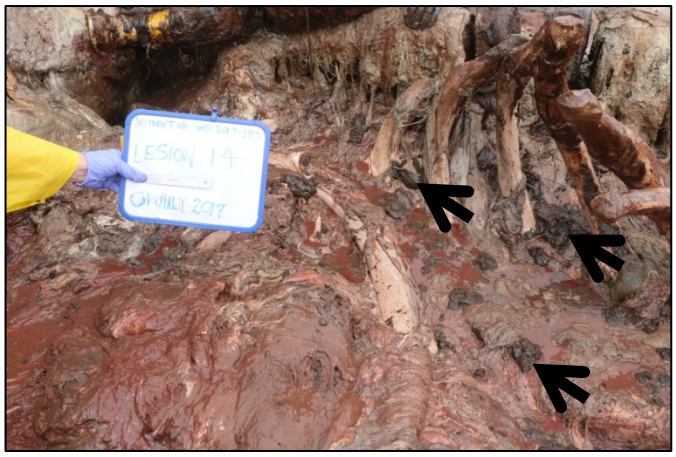


Figure 9. Small number of small clumps of dark brown putty-like material (arrows) in thoracic cavity.

Biotoxin analysis

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

CANADIAN FOOD INSPECTION AGENCY
REPORT OF ANALYSIS
FISH PRODUCTS SAMPLING SUBMISSION
Version 6.3.0
Serial: 000004364067

System ID:	2017FFI-0000046384-4	*Receptions by all Labs:*	1
Reference No.:	2017FFIS-0000049702-4	*Number of Jobs Authorized:*	1

Laboratory No.: DAR-FD-2017-CH-02544 *Date Received:* 2017-07-25 *Job Status:* Authorized

Laboratory: (1981) DARTMOUTH LABORATORY - CHEMISTRY
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Fax: (902) 536-1018

Submitted By: CFIA Inspector
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Fax:
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Email: ALEXIS.JOHNSON@INSPECTION.GC.CA

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Telephone: (902) 426-2110
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Cell:
Email: ALEXIS.JOHNSON@INSPECTION.GC.CA

Program: FISH	*Function:* DOMESTIC
Sampling Plan:	2017_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 #4 NECROPSIED, NORWAY, PEI, JUNE29-JULY 1 (FECES, SMALL INTESTINE, LARGE INTESTINE)
Date Sampled:	2017-06-29
Date Received:	2017-07-25
Risk Category:	Bivalve Molluscan
Harvest Date:	2017-07-25 08:30 AM
Lab Sample No.: DAR-FD-2017-CH-02544-0001	*Inspection Sample No.:*
Primary Process:	FREEZING
Sample Type:	Feces
Identification Code:	EG # 4
Species:	NORTH ATLANTIC RIGHT WHALE - EUBALAENA GLACIALIS
Sample Assessed:	No Decision
Method: TOX-DA-LC / 1 : Domoic Acid	Analysis of Domoic Acid in Molluscs by Liquid Chromatography- SOM-DAR-CHE-001 Not detected at the reporting limit.
Test Assessed:	No Decision

System ID: 2017FFI-0000046384-4 **Receptions by all Labs:** 1
Reference No.: 2017FFIS-0000049702-4 **Number of Jobs Authorized:** 1

Laboratory No.: DAR-FD-2017-CH-02544 **Date Received:** 2017-07-25 **Job Status:** Authorized

Method: TOX-DSP-LC / 1 : Analysis of Lipophilic Shellfish Toxins by Liquid Chromatography- SOM-DAR-CHE-002

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

Method: TOX-PCOX / 1 : Post-column Oxidation (PCOX) Method for the Determination of Paralytic Shellfish Toxins in Mussels, Clams, Oysters and Scallops-SOM-DAR-CHE-052

Gonyautoxin-4	Not detected at the reporting limit.
Gonyautoxin-1	Not detected at the reporting limit.
Decarbamoylgonyautoxin-3	Not detected at the reporting limit.
Gonyautoxin-5	Not detected at the reporting limit.
Decarbamoylgonyautoxin-2	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

Lab Sample No.: DAR-FD-2017-CH-02544-0002 **Inspection Sample No.:**

Sample Type: Tissue - Other
Species: NORTH ATLANTIC RIGHT WHALE

Sample Assessed: No Decision

Method: SOM-DAR-CHE-052

Gonyautoxin-4	Not detected at the reporting limit.
Gonyautoxin-1	Not detected at the reporting limit.
Decarbamoylgonyautoxin-3	Not detected at the reporting limit.
Gonyautoxin-5	Not detected at the reporting limit.
Decarbamoylgonyautoxin-2	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

Method: SOM-DAR-CHE-001

Domoic Acid	Not detected at the reporting limit.

Test Assessed: No Decision

System ID: 2017FFI-0000046384-4 **Receptions by all Labs:** 1
Reference No.: 2017FFIS-0000049702-4 **Number of Jobs Authorized:** 1

Laboratory No.: DAR-FD-2017-CH-02544 **Date Received:** 2017-07-25 **Job Status:** Authorized

Method:	SOM-DAR-CHE-002	
	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

Lab Sample No.: DAR-FD-2017-CH-02544-0003 **Inspection Sample No.:**

Sample Type: Tissue - Other
Species: NORTH ATLANTIC RIGHT WHALE

Sample Assessed: No Decision

Method:	SOM-DAR-CHE-052	
	Gonyautoxin-4	Not detected at the reporting limit.
	Gonyautoxin-1	Not detected at the reporting limit.
	Decarbamoylgonyautoxin-3	Not detected at the reporting limit.
	Gonyautoxin-5	Not detected at the reporting limit.
	Decarbamoylgonyautoxin-2	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
Test Assessment Comments:		Colon Content
Method:	SOM-DAR-CHE-052	
	Gonyautoxin-4	Not detected at the reporting limit.
	Gonyautoxin-1	Not detected at the reporting limit.
	Decarbamoylgonyautoxin-3	Not detected at the reporting limit.
	Gonyautoxin-5	Not detected at the reporting limit.
	Decarbamoylgonyautoxin-2	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
Test Assessment Comments:		Straight Colon Content
Method:	SOM-DAR-CHE-001	
	Domoic Acid	Not detected at the reporting limit.
Test Assessed:		No Decision
Test Assessment Comments:		Colon Content
Method:	SOM-DAR-CHE-001	
	Domoic Acid	Not detected at the reporting limit.
Test Assessed:		No Decision
Test Assessment Comments:		Straight Colon Content

System ID: 2017FFI-0000046384-4 **Receptions by all Labs:** 1
Reference No.: 2017FFIS-0000049702-4 **Number of Jobs Authorized:** 1

Laboratory No.: DAR-FD-2017-CH-02544 **Date Received:** 2017-07-25 **Job Status:** Authorized

Method:	SOM-DAR-CHE-002	
	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 O/H 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
Test Assessment Comments:		Colon Content
Method:	SOM-DAR-CHE-002	
	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 O/H 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
Test Assessment Comments:		Straight Colon Content

Job Authorized: 2017-08-04 **Authorized By:** Melanie Casey **Authorized**
Job Assessed: No Decision **Date Assessed:** 2017-08-04

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

*** END OF REPORT ***

Wildlife Diagnostic Report – EG#5

Necropsy #: EG#5; MARS2017-155; NEAq Catalog #3512 ("Contrail") – 12 years old female

Incident Information

Species: North Atlantic Right Whale (*Eubalaena glacialis*)
Age: Adult
Sex: Female
Sampling date: 22 June, 2017
Location: At-sea

Submitted Information

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

Information Provided with Specimen

First sighted in the GSL on June 22, 2017. She was floating at sea. Previous sightings of #3512 have been in the southeast US (where she was first seen as a dependent calf but had visited there in other years), Bay of Fundy, Great South Channel, mid Atlantic, Gulf of Maine, and Roseway Basin. Although she had not been observed with a calf, she was just entering reproductive age. Genetic evidence that this carcass is a match to the carcass from Cedar Cove, Newfoundland sampled on July 29, 2017 (2017-0096).

Diagnosis and Interpretation

Final Diagnosis

Acute death

Interpretation

Fecal material from EG#5 was collected at sea directly from its anus, with no potential for contamination by other components of the carcass, and was probably the most reliable fecal sample taken from among the whales examined. Fecal glucocorticoid levels were found to match normal baseline levels thus suggesting an acute death of this animal. No biotoxins detected.

Biotoxin analysis

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

CANADIAN FOOD INSPECTION AGENCY
REPORT OF ANALYSIS
FISH PRODUCTS SAMPLING SUBMISSION
Version 6.3.0
Serial: 000004364060

System ID:	2017FFI-0000046379-4	*Receptions by all Labs:*	1
Reference No.:	2017FFIS-0000049696-4	*Number of Jobs Authorized:*	1

Laboratory No.: DAR-FD-2017-CH-02542 *Date Received:* 2017-07-25 *Job Status:* Authorized

Laboratory: (1981) DARTMOUTH LABORATORY - CHEMISTRY
1992 AGENCY DRIVE
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Telephone: (902) 536-1004
Fax: (902) 536-1018

Submitted By: CFIA Inspector
(12450) ALEXIS JOHNSON
1992 AGENCY DRIVE
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Telephone: (902) 426-2110
Fax:
Cell:
Email: ALEXIS.JOHNSON@INSPECTION.GC.CA

Sampled By: CFIA Inspector
(12450) ALEXIS JOHNSON
1992 AGENCY DRIVE
DARTMOUTH, NS B3B 1Y9
Telephone: (902) 426-2110
Fax:
Cell:
Email: ALEXIS.JOHNSON@INSPECTION.GC.CA

Program: FISH	*Function:* DOMESTIC
Sampling Plan:	2017_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
Submitter Comments:	EG #5 SAMPLED AT SEA, GULF OF ST. LAWRENCE, JUNE 22, 2017 (FECES)
Date Sampled:	2017-06-22
Date Received:	2017-07-25
Risk Category:	Bivalve Molluscan
Harvest Date:	2017-07-25 08:27 AM
Lab Sample No.: DAR-FD-2017-CH-02542-0001	*Inspection Sample No.:*
Primary Process:	FREEZING
Sample Type:	Feces
Identification Code:	EG # 5
Species:	NORTH ATLANTIC RIGHT WHALE - EUBALAENA GLACIALIS
Sample Assessed:	No Decision
Method: TOX-DA-LC / 1 : Domoic Acid	Analysis of Domoic Acid in Molluscs by Liquid Chromatography- SOM-DAR-CHE-001 Not detected at the reporting limit.
Test Assessed:	No Decision

System ID: 2017FFI-0000046379-4 **Receptions by all Labs:** 1
Reference No.: 2017FFIS-0000049696-4 **Number of Jobs Authorized:** 1

Laboratory No.: DAR-FD-2017-CH-02542 **Date Received:** 2017-07-25 **Job Status:** Authorized

Method: TOX-DSP-LC / 1 : Analysis of Lipophilic Shellfish Toxins by Liquid Chromatography- SOM-DAR-CHE-002

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

Method: TOX-PCOX / 1 : Post-column Oxidation (PCOX) Method for the Determination of Paralytic Shellfish Toxins in Mussels, Clams, Oysters and Scallops-SOM-DAR-CHE-052

Gonyautoxin-4	Not detected at the reporting limit.
Gonyautoxin-1	Not detected at the reporting limit.
Decarbamoylgonyautoxin-3	Not detected at the reporting limit.
Gonyautoxin-5	Not detected at the reporting limit.
Decarbamoylgonyautoxin-2	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: 2017-08-04 **Authorized By:** Melanie Casey *Authorized*
Job Assessed: No Decision **Date Assessed:** 2017-08-04

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

*** END OF REPORT ***

Wildlife Diagnostic Report – EG#6

Necropsy #: EG#6; MARS2017-142; NEAq Catalog #1207 - >37 year old male (first seen in 1980 at unknown age)

Incident Information

Species: North Atlantic Right Whale (*Eubalaena glacialis*)
Age: Adult
Sex: Male
Necropsy date: 30 June 2017
Location: Norway, Prince Edward Island, Canada

Submitted Information

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

Information Provided with Specimen

First sighted in GoSL on June 23, 2017. The carcass was fresh with blood in the water apparently coming from the genital region. Previous sightings of #1207 have been in southern New England, Great South Channel, Bay of Fundy, Roseway Basin, Jeffreys Ledge, Grand Manan Banks, Mass Bay/Cape Cod Bay, southeast US, Gulf of Maine, and GoSL (August 1998). #1207 has fathered at least two calves (#3545 in 2005 and #3893 in 2008).

Diagnosis and Interpretation

Final Diagnoses

Acute internal hemorrhage compatible with blunt trauma (probable)
Mild renal parasitism (nematodes) (incidental)

Interpretation

Observations in this whale were comparable to those in EG#2. The carcass was ascribed a decomposition condition code of 4, and therefore observations and their interpretations were made with caution. This animal was considered in good body condition for the season, based on its blubber thickness. A presumptive diagnosis of acute internal hemorrhage was made mainly on the basis of the following observations: 1) presence of an abundant amount of dark brown to black putty-like material, compatible with clotted blood (cooked by internal heat and pressure generated by post-mortem decomposition), within the thoracic cavity and possibly within one of the lungs; and 2) presence of similar material filling the occipital foramen; hemorrhage in this location could have resulted from damage to the very extensive network of blood vessels ("rete mirabile") derived from intercostal muscles and representing the main blood supply to the cetacean brain. In addition, a fracture of the left

tympano-periotic complex (middle-inner ear) was observed, and black putty-like material was found around this ear complex. This fracture may have happened after death as the carcass was pulled onshore, due to strong tension at the junction of head and vertebral column. However, Moore et al. (Journal of Cetacean Research and Management 6(3):199-214, 2004) reported multiple fractures of ear bone complexes or multiple bone fragments in their proximity in two right whales that had presumably died from a vessel collision.

There was an abundant amount of red-tinged fluid between blubber and muscle mass, but not involving the muscle tissue itself, along the right lateral wall of the carcass, associated with discrete areas of red discoloration of the overlying blubber. This could be interpreted as another evidence of blunt trauma. However, we are particularly cautious in interpreting this change as it could also occur from post-mortem accumulation of fluid tinged by hemoglobin from lyzed red blood cells in dependent parts of the carcass floating at sea, although in this case it would be difficult to explain why this red-tinged fluid would have been confined to the right side in a carcass that was floating on its back.

An interesting finding, but incidental (i.e., probably of no clinical significance), was the presence within what was identified as renal tissue of some nematode parasites (still recognizable microscopically despite the very advanced decomposition of the tissue).

Test Results

Necropsy (30 June 2017)

Standard length: 15.1m
Rostrum to blowhole: 3.40m
Rostrum to eye: 4.40m
Rostrum to angle of mouth: 3.20m
Rostrum to ear: 4.10m
Rostrum to flipper insertion: 3.70m
Rostrum to umbilicus: 6.90m
Rostrum to genital slit: 9.10m
Rostrum to anus: 10.80m
Anus to fluke notch: 4.45m

Flipper length at base: 0.90m
Flipper length (leading): 2.40m
Flipper length (trailing): 1.35m
Flipper width: 1.40m
Tail width: 5.30m
Left fluke width: 2.60m
Right fluke width: 2.70m
Notch to tail insertion: 1.30m
Fluke depth: 1.30m

(See Appendix 1)

Blubber thickness was measured at seven locations from mid dorsal to mid ventral at eight levels from cranial to caudal. Averages were taken of the seven locations at each level: nuchal crest, 17.7cm; axilla, 15.7cm; 1/2 axilla-umbilicus, 20.3cm; umbilicus, 20.9cm; 1/2 umbilicus-anus, 22.06cm; anus, 14.25cm; 1/2 anus-tail insertion, 12.01cm; tail insertion, 6.07cm. (See Appendix 2)

Adult male (>37 years old). The animal presented with seasonally robust blubber (20.5cm on the mid-ventrum) (Miller et al. 2011). Decomposition condition code 4. No baleen plate left. Portions of heart, lung, liver and kidney recognized. Conspicuous observations at necropsy included:

- old superficial scars on right caudal margin of rostrum (Figure 1) and on peduncle (Figure 2), presumably from previous entanglement;

- accumulation of an abundant amount of red-tinged fluid between blubber and muscle mass along most of the right lateral wall, but mainly its cranial region, associated with discrete areas of red discoloration of overlying blubber (Figure 3);

- very abundant amount of black putty-like material, compatible with clotted blood, in thoracic cavity, also possibly in (left?) lung and liver; same black putty-like material at thoracic inlet (around right jugular vein?) (Figure 4);

- foramen magnum and possibly much of cranial cavity filled with black putty-like material; similar material on outer surface of right and left sides of occipital bone (Figure5);

- fracture of left tympano-periotic complex (middle-inner ear) (bone fragments) (ante- or post-mortem?) (Figure 6); black putty-like material around this ear complex;
- several areas of deposition of a relatively thin layer of brown putty-like material, somewhat paler than in other locations, on surface of thoracic vertebral bodies (Figure 7);
- a few masses of mineralized material, some of very irregular shape, in kidney, some of them associated microscopically with autolyzed remnants of nematode parasites (*Crassicauda* sp.?)(Figure 8).

(See Appendix 3 for detailed description of observations made in the carcass.)

(See Figures 9a and 9b for a diagrammatic representation of observations possibly associated with blunt trauma.)

Histology (AVC X15393-17)

Total of 22 tissues embedded in paraffin blocks (numbers 1-3, 6 and 14 correspond to gross observations). Total of 17 slides examined (*):

1-1.1-2. 2-1. 2-2. 2-3. Paraffin blocks available; no histological slide prepared.
*3-1. *3-2. Normal blubber. No pathological process identified.
*4. heart. No pathological process identified. Numerous bacterial rods throughout the sections (post-mortem).
*5. muscle. No pathological process identified.
*6-1. blubber. Many deposits of strongly acidophilic amorphous material – hemorrhage?
*6-2. muscle. No pathological process identified.
*7. blubber, right body. Normal. No pathological process identified; no evidence of congestion or hemorrhage. Numerous bacteria (post-mortem).
*8. blubber, left body. Normal. No pathological process identified.
*9. blubber, right peduncle. Normal. No pathological process identified.
*10. blubber, left peduncle. Normal. No pathological process identified.
*11-1. *11-2. preputial gland. Nothing recognizable as a gland; fibrous tissue only.
*12. left kidney stone, soft tissue. All that can be seen is dense fibrous tissue, although there is some mineralized material scattered within it.
*13-1. *13-2. *13-3. Kidney. These slides are composed mainly of dense fibrous tissue; no renal tissue is recognized. However, in two of these slides, the fibrous tissue surrounds structures that are clearly

indicative of remnants of parasitic cuticular walls and of clusters of nematode ova. In one of these two slides, small aggregates of basophilic particulate material that could be interpreted as autolyzed remnants of inflammatory cells are between the parasitic remnants and the fibrous tissue.
*14. esophagus. No pathological process identified. Very loose tissue. Several areas of the mucosa or submucosa are tentatively identified as aggregates of adipocytes. Could the mucosa have been torn artefactually after death to account for the multiple small slightly depressed areas seen grossly?

Other tests

Colon content/scraping and left kidney (dubious): Biotoxins (paralytic shellfish toxins, amnesic shellfish toxins [domoic acid], lipophilic shellfish toxins) – all negative (CFIA, Dartmouth, NS).

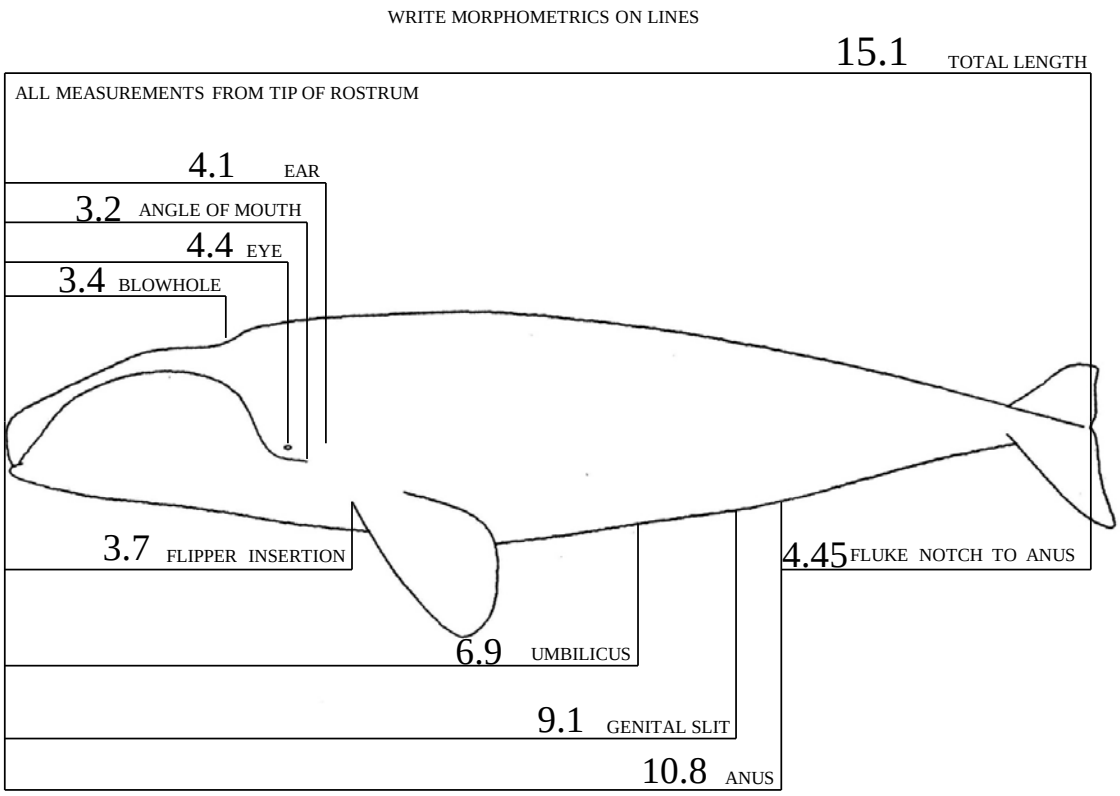
Inventory of frozen samples

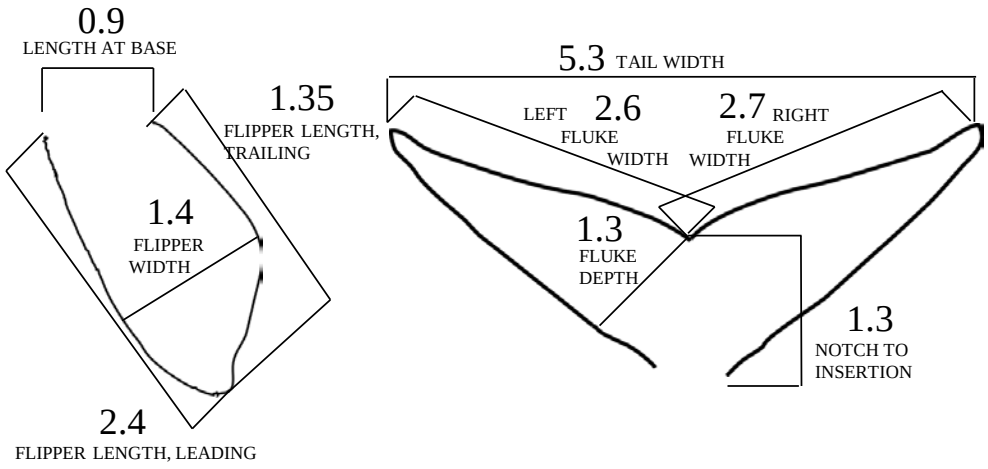
- Right Eye
- Left Eye
- Right Subscapular Fluid
- Blood Clot, Thoracic Cavity
- Hemorrhagic lesion 5, Thoracic Cavity
- Left Kidney (dubious)
- Finger Bone – to MARS
- Large intestine content/scraping
- Kidney Stone Left?
- Muscle, lesion 6
- Small tubular organ, ureter?
- Sero-hemorrhagic, lesion 6
- Temporo-mandibular joint, fluid and swab
- Blubber x4
- Muscle x2 – to MARS
- Kidney Stone

References

Miller CA, D Reeb, PB Best, AR Knowlton, MW Brown, MJ Moore. 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 (2011): 267-283.

Appendix 1. Right Whale EG#6 External Morphometrics

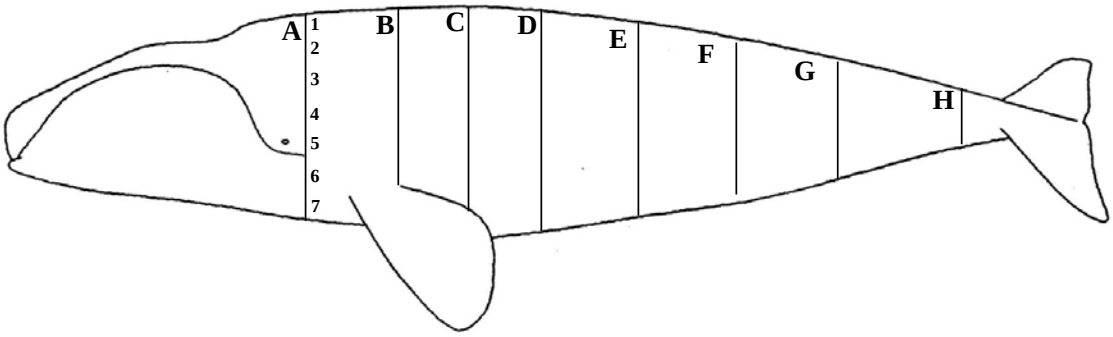




*measures in meters

Appendix 2. RIGHT WHALE EG#6 BLUBBER THICKNESS

Field# MARS2017-142 **Side Examined** _____ **Observer** _____ **Date** 30 June 2017



	A Nuchal Crest	B Axilla	C 1/2 Axilla-Umbilicus	D Umbilicus	E 1/2 Umbilicus-Anus	F Anus	G 1/2 Anus-Insertion	H Insertion
Dorsal								
1	_____	_____	_____	_____	_____	_____	_____	4.3
2	_____	_____	_____	_____	_____	11.6	10	6.8
3	17.5	10.5	16	19	20.5	12.2	9.8	4.7
4	14.5	11	18	21	20	15	12	5.5
5	13.5	14.5	14	21	25.5	15.5	11	7.3
6	18	20.5	24	23.5	23.8	12.7	9.3	5.3
7	25	22	29.5	20	20.5	18.5	20	8.6
Ventral								
Average	17.7	15.7	20.3	20.9	22.06	14.25	12.01	6.07

Note: all measurements are in cm

APPENDIX 3: External and internal observations by number

(Asterisks indicate observations of potential clinical significance)

Observation number	Physical location	Description	Photos taken (Y/N)	Histology taken (Y/N)
1	Right caudal margin of rostrum	Multiple (approx. 5) raised tan-white ridges, 0.25-0.5m long by 1.7mm wide, extending caudally from caudal margin of maxilla.	Y	Y
2A	Ventral caudal peduncle	Six linear tan-white raised ridges, ranging from 1.4 to 1.5cm long by 0.5 to 0.9cm wide, from mid ventral region extending to the left lateral side, approx. 30cm apart from each other	Y	Y
2B	Dorsal surface of peduncle	15 raised scars, 2-5cm apart	Y	Y
3	Right lateral wall	On cut surface of blubber, irregular area of relatively well-demarcated red discoloration (hyperemia?), approx. 6x20cm.	Y	Y
4*	Ureter/kidney region	Multifocal, firm to hard, white-tan masses, 2-3cm in diameter, adhered to the tissue. Possible urolith.	Y	Y
5	Left thorax, level of 4th Rib	Approximately 250L of dark red, slightly opaque, fluid containing suspended gelatinous black material (blood clots?).	Y	Nalgene
6a*	Right lateral body wall	Blubber-muscle interface is expanded by red-tinged gelatinous fluid, approx. 5cm thick. Tissue (fascia? muscle?) is gelatinous on cut surface and oozes red-tinged fluid (edema). Blubber shows relatively discrete red-brown discoloration.	Y	Nalgene
6b,c*	Caudal extension of 6a	Lesion not extending as far laterally as 6a; extends to level of prepuce / genital opening (Lesion 3?). On cut surface, blubber shows no obvious red discoloration.		
7*	Caudal region of thorax at level of second to last rib	Locally extensive mass of putty-like material, approx. 60cm in diameter; may involve the liver.	Y	Y
8*	Left rib cage	Locally extensive mass of red/black putty-like material, approx. 5cm thick, adhered to parietal surface; extends along the entire rib cage.	Y	N
9	Atlanto-occipital joint	Luxation of the A-O joint on the right side. Moderate amount of black putty-like material	Y	Y

Observation number	Physical location	Description	Photos taken (Y/N)	Histology taken (Y/N)
		around a major blood vessel at the thoracic inlet, possibly the right jugular vein, and around the larynx bilaterally.		
10	Occipital bone	Thin layer of black putty-like material covering the right outer surface of the occipital bone (also the left outer surface [visible in photo 11]).	Y	Y
11*	Foramen magnum	Filled with dark red/black putty-like material (blood clot?). Cranial cavity apparently filled with this as seen through the foramen magnum.	Y	Y
12*	Cranial region of thorax	Mass of black material (resembling cooked frank blood [Bill McLellan]), approx. 50x10cm.	Y	N
13*	Lung (possibly left)	Filled with black gelatinous material.	Y	Y
14	Intrathoracic portion of esophagus	Middle to caudal part of mucosa contains multiple, small, circular, slightly depressed areas (ulcers?).	Y	Y
15	Thoracic vertebral bodies	Sub-periosteal layer of dense dark putty-like material, firm and waxy (fat and blood?), covering several vertebral bodies.	Y	N
16L	Left tympanic bulla	Possible fracture (bone fragments); also black putty-like material around ear complex	Y	N
16R	Right tympanic bulla	Possible fracture (because it could easily be taken off the skull)	Y	N
17	Left mandible, rostral to joint	Abundant amount of pale red opaque fluid, approx. 2L.	Y	Nalgene
N/A	Left ribs 5, 7, 6	Dorsal articulation dislocated from the vertebral bodies (post-mortem?).	N	N

Figures (56 other photos available)

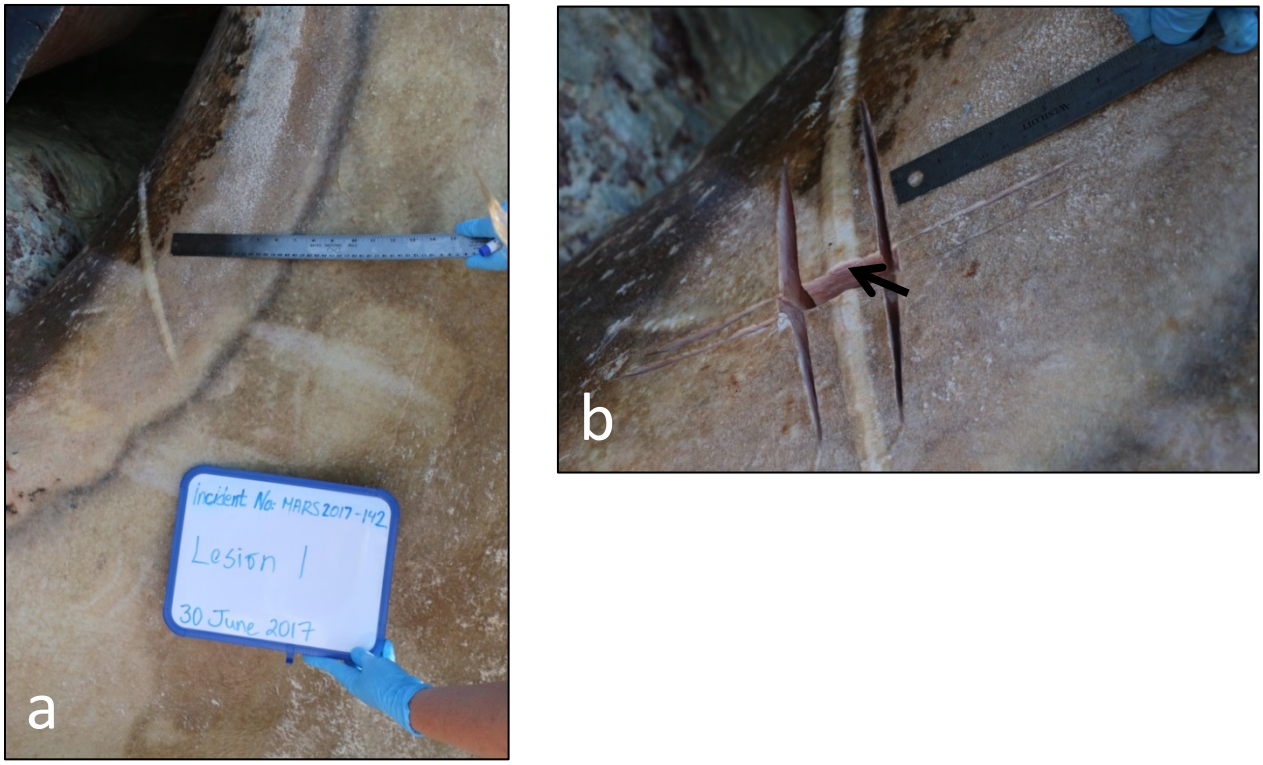


Figure 1. a) Old superficial scar on right caudal margin of rostrum, presumably from previous entanglement. b) cut surface shows a thin zone of white discoloration compatible with scar tissue (fibrosis) (arrow).

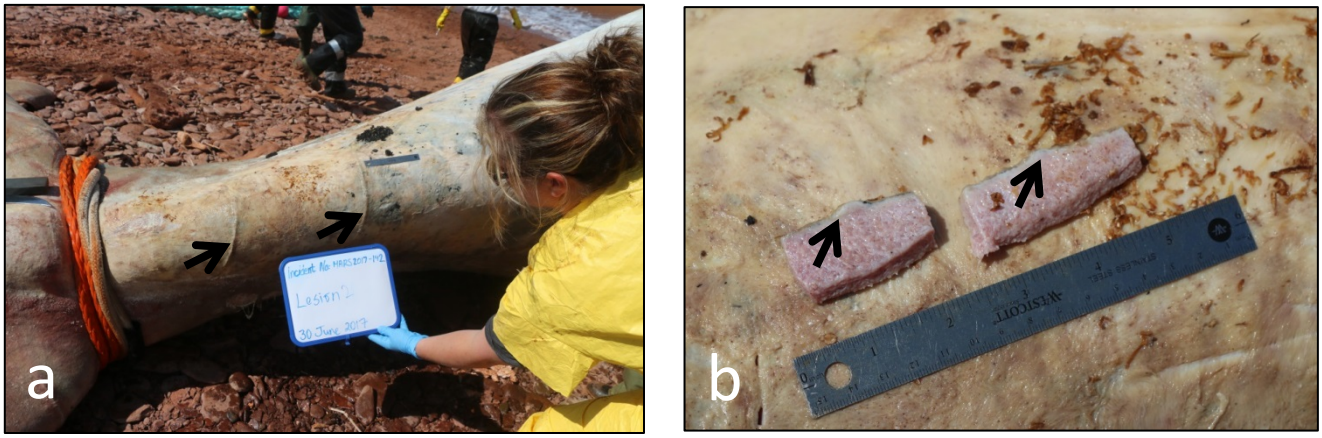


Figure 2. a) Old superficial scars on peduncle (arrows), presumably from previous entanglement. b) cut surface of each of these scars shows a thin zone of white discoloration compatible with scar tissue (fibrosis) (arrows).

Figure 3. a) b) and c) Accumulation of an abundant amount of red-tinged fluid between blubber and muscle mass along most of the right lateral wall, mainly in its cranial region.

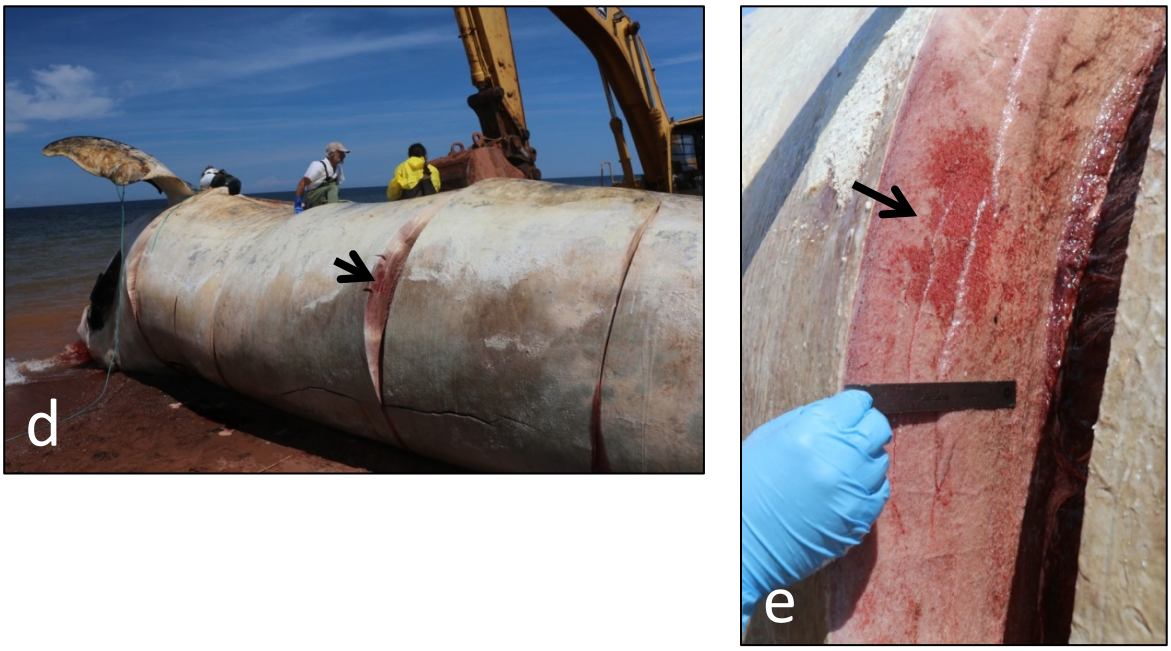


Figure 3 (cont'd). d) and e) Discrete area of red discoloration of blubber over the right lateral wall; the arrow in each photo points to the same area.

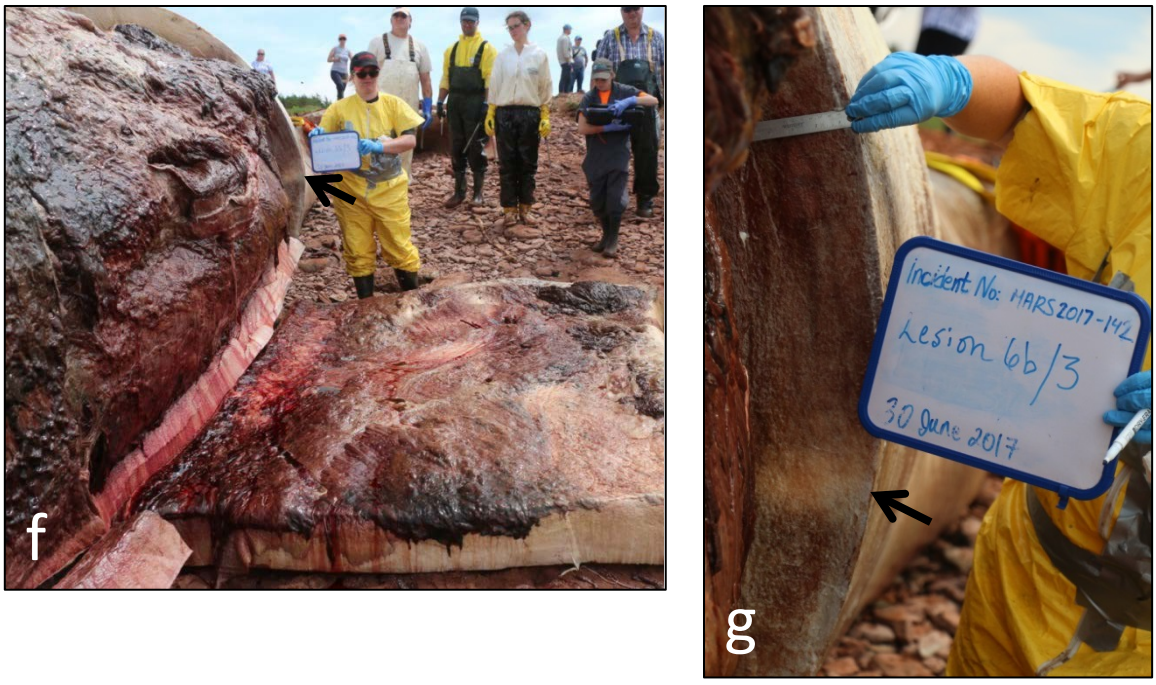


Figure 3 (cont'd). f) and g) Large areas of red discoloration of blubber over the right lateral wall; the arrow in each photo points to the same patch of blubber of a more normal white color.

Figure 4. a) Very abundant amount of black putty-like material, compatible with clotted blood, in thoracic cavity (arrow). b) Same material also possibly in (left?) lung. c) Same material at thoracic inlet (around right jugular vein?) (arrow).

Figure 5. The foramen magnum and possibly much of the cranial cavity are filled with black putty-like material (arrow). Similar material is also on the outer surface of the occipital bone (arrowheads).

Figure 6. Fracture of left tympano-periotic complex (middle-inner ear).

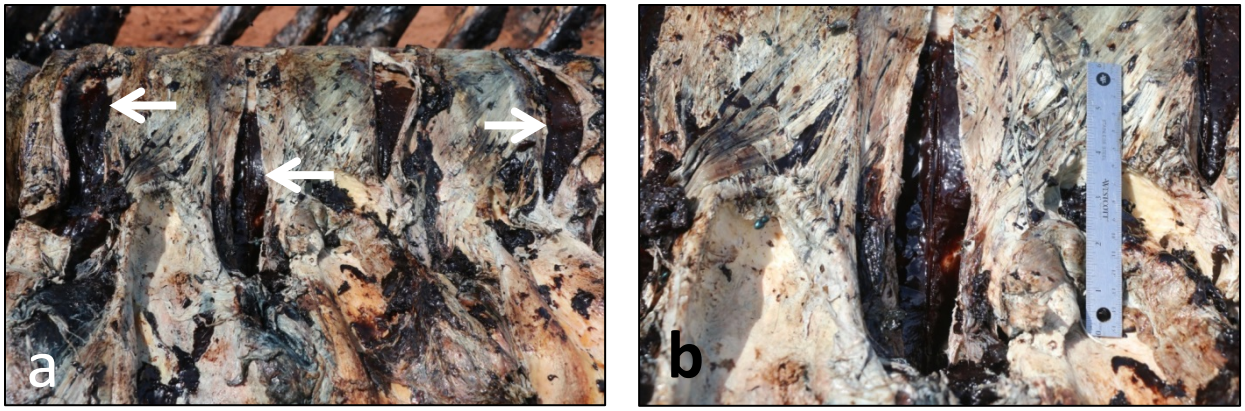
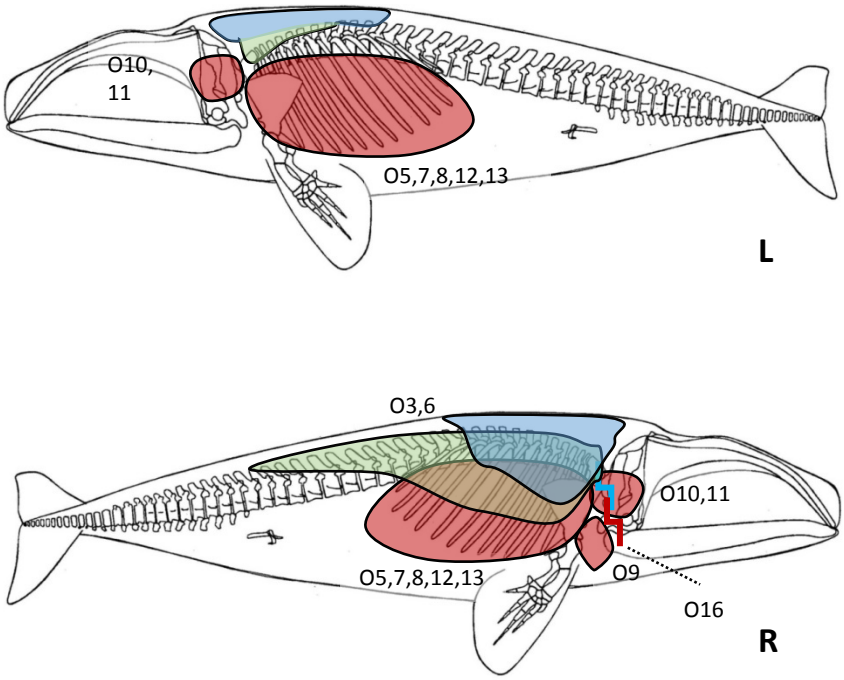


Figure 7. a) Deposition of a relatively thin layer of brown putty-like material, somewhat paler than in other locations, on surface of several thoracic vertebral bodies (arrows); b) close-up of one of the vertebral bodies.

Figure 8. A few masses of mineralized material in kidney, some of very irregular shape (arrow). Microscopically, some of these masses were associated with autolyzed remnants of nematode parasites.



Dislocation
O9: luxation of atlanto-occipital joint on right side

Fracture
O16: right tympano-periotic complex

Putty-like material
O5,7,8,12,13: whole thoracic region, liver and lung
O9: associated with rupture of right jugular vein
O10,11: occipital surface, foramen magnum, cranial cavity

Red-tinged gelatinous fluid
O6: right lateral wall, extends to level of prepuce

Blubber contusion
O3,6: right lateral wall

Figure 9a. EG#6. Distribution of observations potentially associated with blunt trauma.

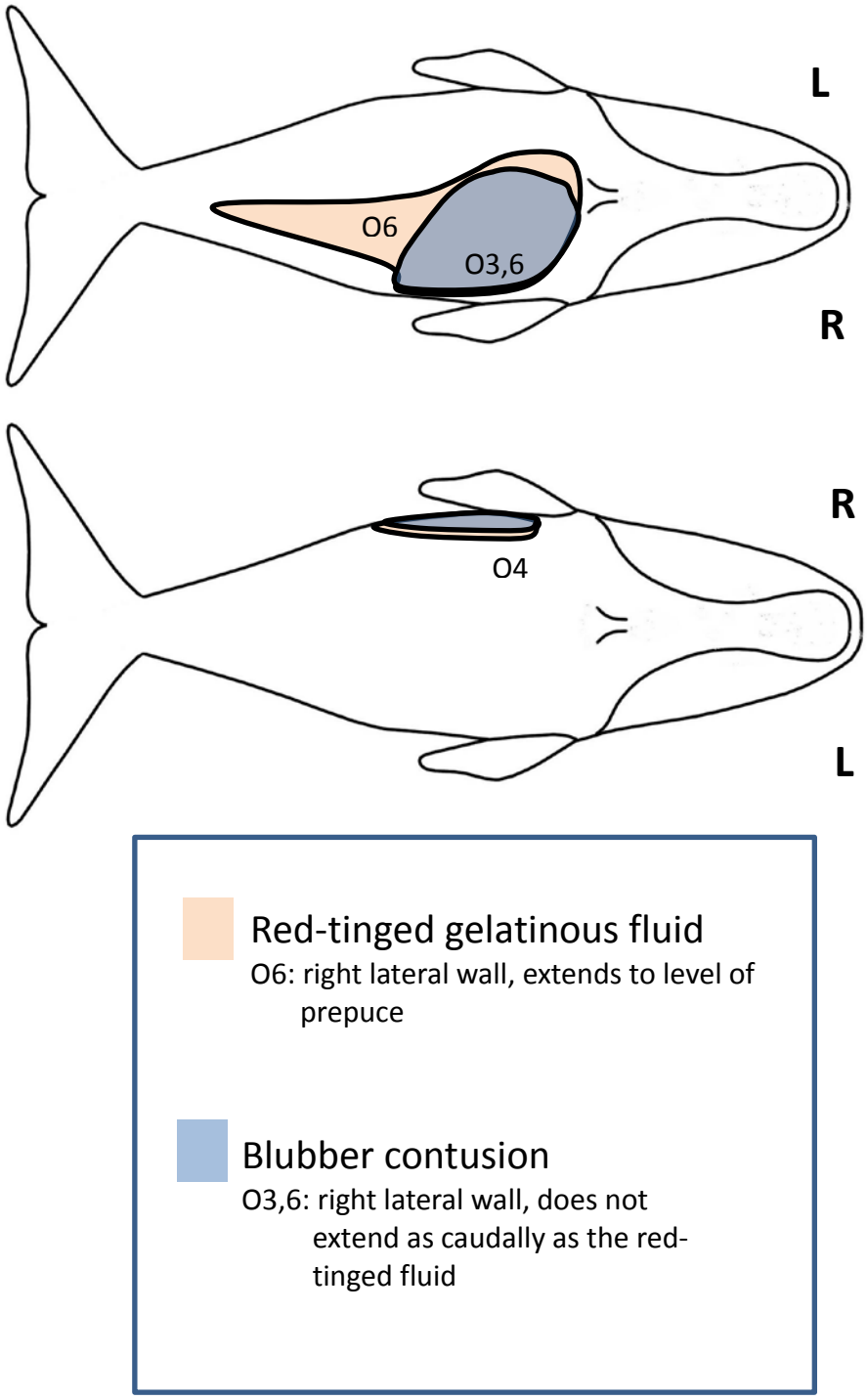


Figure 9b. EG#6. Distribution of observations potentially associated with blunt trauma.

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

CANADIAN FOOD INSPECTION AGENCY
REPORT OF ANALYSIS
FISH PRODUCTS SAMPLING SUBMISSION
Version 6.3.0
Serial: 000004364068

System ID:	2017FFI-0000046383-4		***Receptions by all Labs:*** 1
Reference No.:	2017FFIS-0000049701-4		***Number of Jobs Authorized:*** 1
Laboratory No.:	DAR-FD-2017-CH-02545	***Date Received:*** 2017-07-25	***Job Status:*** Authorized

Laboratory: (1981) DARTMOUTH LABORATORY - CHEMISTRY
1992 AGENCY DRIVE
DARTMOUTH, NS B3B 1Y9
Telephone: (902) 536-1004
Fax: (902) 536-1018

Submitted By: CFIA Inspector
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Sampled By: CFIA Inspector
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Telephone: (902) 426-2110
Fax:
Cell:
Email: ALEXIS.JOHNSON@INSPECTION.GC.CA

Program: FISH	***Function:*** DOMESTIC
Sampling Plan:	2017_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 NECROPSIED, NORWAY, PEI, JUNE 29-JULY 1 2017 (KIDNEY, LARGE INTESTINE)
Date Sampled:	2017-06-29
Date Received:	2017-07-25
Risk Category:	Bivalve Molluscan
Harvest Date:	2017-07-25 08:30 AM
Lab Sample No.: DAR-FD-2017-CH-02545-0001	***Inspection Sample No.:***
Primary Process:	FREEZING
Sample Type:	Tissue - Kidney
Identification Code:	EG # 6
Species:	NORTH ATLANTIC RIGHT WHALE - EUBALAENA GLACIALIS
Sample Assessed:	No Decision
Method: TOX-DA-LC / 1 : Domoic Acid	Analysis of Domoic Acid in Molluscs by Liquid Chromatography- SOM-DAR-CHE-001 Not detected at the reporting limit.
Test Assessed:	No Decision

System ID: 2017FFI-0000046383-4 **Receptions by all Labs:** 1
Reference No.: 2017FFIS-0000049701-4 **Number of Jobs Authorized:** 1

Laboratory No.: DAR-FD-2017-CH-02545 **Date Received:** 2017-07-25 **Job Status:** Authorized

Method: TOX-DSP-LC / 1 : Analysis of Lipophilic Shellfish Toxins by Liquid Chromatography- SOM-DAR-CHE-002

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

Method: TOX-PCOX / 1 : Post-column Oxidation (PCOX) Method for the Determination of Paralytic Shellfish Toxins in Mussels, Clams, Oysters and Scallops-SOM-DAR-CHE-052

Gonyautoxin-4	Not detected at the reporting limit.
Gonyautoxin-1	Not detected at the reporting limit.
Decarbamoylgonyautoxin-3	Not detected at the reporting limit.
Gonyautoxin-5	Not detected at the reporting limit.
Decarbamoylgonyautoxin-2	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

Lab Sample No.: DAR-FD-2017-CH-02545-0002 **Inspection Sample No.:**

Sample Type: Other
Species: NORTH ATLANTIC RIGHT WHALE

Sample Assessed: No Decision

Method: SOM-DAR-CHE-002

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:	2017FFI-0000046383-4		***Receptions by all Labs:*** 1
Reference No.:	2017FFIS-0000049701-4		***Number of Jobs Authorized:*** 1

Laboratory No.: DAR-FD-2017-CH-02545 ***Date Received:*** 2017-07-25 ***Job Status:*** Authorized

Method:	SOM-DAR-CHE-052	
	Gonyautoxin-4	Not detected at the reporting limit.
	Gonyautoxin-1	Not detected at the reporting limit.
	Decarbamoylgonyautoxin-3	Not detected at the reporting limit.
	Gonyautoxin-5	Not detected at the reporting limit.
	Decarbamoylgonyautoxin-2	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
Method:	SOM-DAR-CHE-001	
	Domoic Acid	Not detected at the reporting limit.
Test Assessed:		No Decision

Job Authorized: 2017-08-04 ***Authorized By:*** Melanie Casey ***Authorized***
Job Assessed: No Decision ***Date Assessed:*** 2017-08-04

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

*** END OF REPORT ***

Necropsy report
from

Canadian Wildlife Health Cooperative
Faculté de médecine vétérinaire, Université de Montréal
3200, rue Sicotte
Saint-Hyacinthe, Québec J2S 2M2
Tél: (450) 773-8521 poste 8346

NO. DE PATHOLOGIE: P2299-17
DATE: 2017-09-16
NO. D'IDENTIFICATION: EG2017-07

Submitted to (send report to):
Stéphanie Ratelle
Species at Risk / Marine Mammals
DFO-MPO Gulf Region, Science
343 University Avenue, Moncton NB, E1C 9B6
Canada
Tel: 506-851-4335
Email: Stephanie.ratelle@dfo-mpo.gc.ca

IDENTIFICATION AND HISTORY

Identification:
Specie: North Atlantic Right Whale
Identification: Not identified – male
Mortality event identification: EG2017-07
Sex: male
Length: 12.9 m
Age: unknown

History:
Carcass first sighted in the Gulf of Saint-Lawrence on 2017-07-05. The carcass was then towed to the Magdalen islands on 2017-07-10. Beaching of the carcass was smooth and quick.

FINAL DIAGNOSTICS AND INTERPRETATION

Cause of death: Probable skull (maxilla, premaxilla) fracture due to blunt trauma

Interpretation and comments
Several different observations, when considered together, are suggestive of blunt trauma in this case. The amount of clotted blood ('putty like material') noted in the dorsal thoracic cavity could be a normal finding considering the presence of the *rete mirabile*, although a mild hemorrhage of this vascular network cannot be excluded. Blunt trauma is more convincingly supported by the asymmetric distribution of the small amounts of clotted blood found in different muscle groups and their association with hemorrhagic gelatinous tissue and contused blubber over the dorsal muscles. This likely dorsal blow's most noticeable damage is located on the head, where it fractured the skull at its base and was forceful enough to result in a laceration of the rostral oral surface of the maxilla and caudal oral surface of the mandible. The laceration of the upper oral cavity likely caused an important laceration of the oral *rete*, resulting in a fatal external hemorrhage whose evidence will have been washed away with the sea. The extensive oral lacerations resulted in the exteriorisation of the fractured maxilla bones, immediately or in *post-mortem*. Considering the freshness and the uneventful towing and beaching of the carcass, these observations are not considered to be artefactual *post-mortem* traumatic lesions and they correlate with findings in reported cases of blunt trauma in this specie (Campbell – Malone

2008). Death was immediate or occurred within a few minutes following the trauma as there was no cellular changes, apart from acute hemorrhages, associated with the traumatic lesions. An acute death is also supported by fecal glucocorticoid concentrations within the normal range for healthy specimens of this specie. According to available references, the body condition of this whale may not have been optimal (Miller 2011, McLellan, *pers. comm*). This could be normal considering this whale died relatively early in the summer feeding season. However, a suboptimal body condition could also reflect suboptimal feeding rates prior to death. The precise timing of death is impossible to determine considering all the different variables that affect decomposition rate in these aquatic megavertebrates. This animal may have died anywhere from 5 days to 3 weeks prior to the necropsy, considering the usually fast decomposition rate in these whales and the relatively good state of the carcass.

This animal presented with a moderate decomposition state and interpretation of these observations were made with caution. Blunt trauma is considered to be the most likely cause of death and no predisposing systemic condition was identified. Notably, all biotoxins tested were not detected in various tissues submitted from this individual.

References

- Campbell-Malone, Regina, et al. "Gross and histologic evidence of sharp and blunt trauma in North Atlantic right whales (*Eubalaena glacialis*) killed by vessels." *Journal of Zoo and Wildlife Medicine* 39.1 (2008): 37-55.
- Miller, Carolyn A., 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.

DETAILLED REPORT

Necropsy was realised at l'Étang-du-Nord, Magdalen Islands on 2017-07-10
Carcass conservation code: 3.5

MACROSCOPIC EXAMINATION

This carcass was one of the freshest examined from this mortality event, despite the absence of thoracic organs and significant decomposition of most abdominal viscera. The thoracic organs were likely expulsed orally following the increase in internal pressure associated with decomposition. Complete morphologic measurements may be found in **Appendix I** while pictures and general distribution of the different observations (O) noted thorough this description are found in **Appendix II**.

Morphologic measurements

Blubber thicknesses were measured at seven locations from mid dorsal to mid ventral at eight levels from cranial to caudal. When comparing to other necropsies performed in this specie, the thickness of the blubber seemed subjectively low (12.0 cm on the mid-ventrum) (*comm.* William McLellan). Average blubber thickness on the dorsum of 30 to 50 % of the body length from the snout (B1, C1, D1) is 15.17 cm. This is in the upper range (1999: 13.25 ± 1.77 cm, n = 10, 2000: 13.98 ± 1.21 cm, n = 3) measured in adult males of this specie at the end of the summer feeding season, but these data were acquired in years of below average *C. finmarchius* abundance (Miller *et al* 2011*)*.

External exam

Very little epidermis remains on the carcass. The surface of the exposed dermis is creamy to pink in color, with darker brown regions on the ventral surface. Linear ridges of firm and white dermis, considered to be scar tissue, are noted on the dermal surface:

- Caudal to the anus, left side of the body, 30 cm in length (O1).
- Caudally and ventrally to mandibular symphysis, right side, 25 cm in length (O4).

Bilaterally on the lateral surfaces of the mandible, multiple round raised nodular areas considered to be associated with callosities are observed. They are of 10-15 cm in diameter and present an irregular surface (O2). Several slightly elevated rounded areas of the dermis are linearly arranged on the ventral portion of the left lip and in the intermandibular region. On cut section, these regions are associated with focal clusters of a thick, waxy, translucid to opaque brown material located in the superficial dermis (O3). A linear, transverse laceration of the superficial panniculus is noted bilaterally on the mandible, just rostral to the angle of the mouth. This laceration exposes the mandibular bone on the left. In transverse section, the most superficial muscle layer presents with a gelatinous texture on both sides (O11). Extensive lacerations are present on the

oral surface of the maxilla (O13). The whole region of the head is covered in a thick and creamy pale brown liquid.

Musculoskeletal system

Multiple to coalescent areas of well-defined red discoloration of the deep blubber layers are observed over the dorsal aspect of the thoracic cavity. In the same area, a red to brown gelatinous material is found between the panniculus and the muscle fascia (O5). The presence of a dark, putty like material, presumably clotted blood, is observed in various locations:

- Bilaterally, between scapula and the thoracic musculature; asymmetric distribution with a more extensive area of accumulation associated with the left scapula (O6).
- Right hypaxial muscle, level of the anus; focally extensive accumulation (O7).
- Left cervical area; large accumulation (O8).
- Bilateral dorsal thoracic cavity lining; relatively thin layer of accumulation associated with large amount of filamentous structures, presumably vascular wall remnants of the thoracic *rete mirabile* (O9/12).

The maxilla and premaxilla are fractured at the base of the skull and their rostral fragment is not found on the carcass (O14). The petrotympanic complexes are also fractured at their base (O15).

Thoracic and abdominal cavity

The stomach, colon and liver are visible and were sampled. On the mucosal surface of the stomach wall, multiple circular depressions of 2-3 cm in diameter are noted in association with a raised rim packed with black putty-like material (O10). No other internal organs identified.

HISTOPATHOLOGY

Moderate to marked changes associated with decomposition may mask significant histologic findings.

Liver (F): Multifocally, small amounts of golden brown pigments are noted within hepatocytes (possibly hemosiderin).

Stomach (G): No histological change observed; the mucosa is absent (*post-mortem*). This section may not be representative of the gross circular depressions observed on the stomacal mucosa (see observation 10).

Colon (H): No histological change observed; the mucosa is absent (*post-mortem*).

Observation 1 (scar- left side of body; I): The connective tissue of the superficial dermis is more compact when compared to grossly normal sections of skin. No signs of active inflammation present. The epidermis is not present on the sections examined (*post-mortem* sloughing). This is consistent with inactive scar tissue considering the gross appearance of the lesion.

Observation 2 (mandibular callosities; J, K): Numerous papilliform projections extends from the superficial to deeper layers of the dermis. These projections are homogenous and are not associated with any signs of inflammation. The epidermis is not present on the sections examined (*post-mortem* sloughing).

Observation 3 (waxy material accumulation, superficial dermis; L, V): A focally extensive and irregular disruption of the connective tissue below the dermal surface is noted (V). The waxy material seems to have washed away during histologic preparation. On the other section examined (L), the most superficial section of the dermis observed is irregular and is associated with long lamellar basophilic structures. Dermal fragments are observed on the slide, suggesting that the most superficial portion of the dermis noted over the waxy material may have been damaged during slide preparation.

Observation 5 (dorsum, red discolouration of deep blubber; M, N): On one section, the adipose tissue is multifocally and extensively infiltrated by numerous round acidophilic structures resembling red blood cells (N). This is highly suggestive of hemorrhages within the blubber. No signs of active inflammation present, indicating an acute change.

Observation 6 (tissue under left scapula; O): A central cartilaginous layer is flanked on each side by subsequent layers of lamellar connective tissue and muscle. On one side, the muscle tissue is mostly autolyzed when compared with the other. There is no histologic evidence of blood accumulation; it is possible that the material noted on gross examination was washed away during slide preparation.

Observation 7 (“putty-like material” - hypaxial muscle near anus; P): Small quantities of heterogeneous acidophilic granular material. The density observed on the section is not representative of what was preserved during the macroscopic exam.

Observation 10 (stomach wall; Q, R): Muscular and connective tissues are present on these sections and normal layered cellular architecture is completely disrupted. The muscle fibers appear to be mildly to moderately spaced and are often completely replaced accumulation of granular acidophilic material. A moderate quantity of bacteria is present in this material. No mucosa identified.

Observation 13 (skin laceration, oral surface; S): There if a focal increase in the density of the connective tissues in the superficial layers of the dermis compared to other sections of skin examined. This may be associated with the different location of the skin sampled. This section may not be representative of the laceration observed on gross examination.
Observation 14 (fractured bone at the base of skull; T, U): This is composed of numerous trabeculae of histologically normal compact bone. No sign of active inflammation detected. Numerous bacteria (*post-mortem*) are present.
No histological change detected upon examination of the following tissues; muscle(A), diaphragm (B), skin (C), and blubber (D, E).

Biotoxin testing (Complete results may be found in Appendix III) :
CFIA Reference No. 2017FFIS-0000049699-4: Paralytic shellfish toxins, amnesic shellfish toxin (domoic acid) and lipophilic shellfish toxins were not detected in the liver, feces, stomach content and large intestine of this individual.

Fecal glucocorticoid assay results: 16.3 ng/g

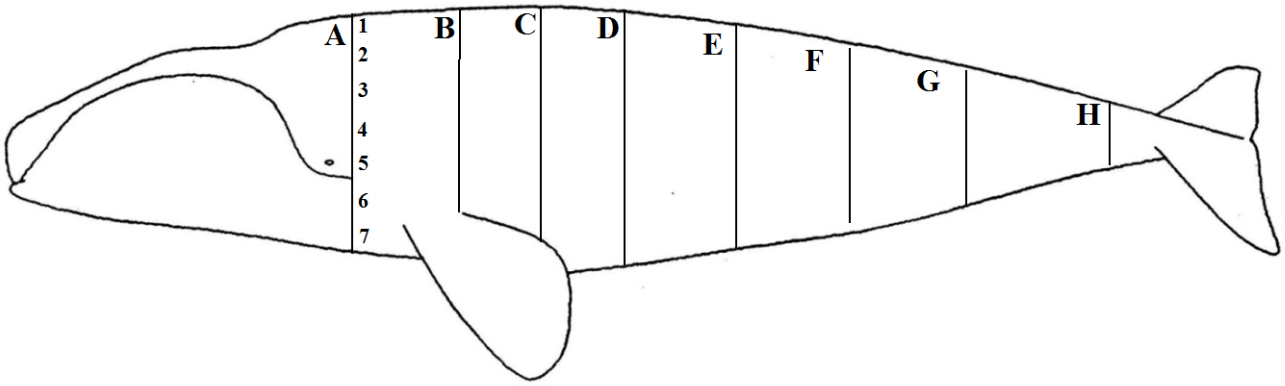
Émilie L. Couture, DMV, IPSAV, DES

Stéphane Lair DMV, Diplomate ACZM

Benjamin Lamglait, DV, DECZM (Zoo management)

RIGHT WHALE EG#7 BLUBBER THICKNESS

Field# CQSAS EG_2017-07 **Side Examined: Left** **Observer :Andrew Reid** **Date** 10 July 2017

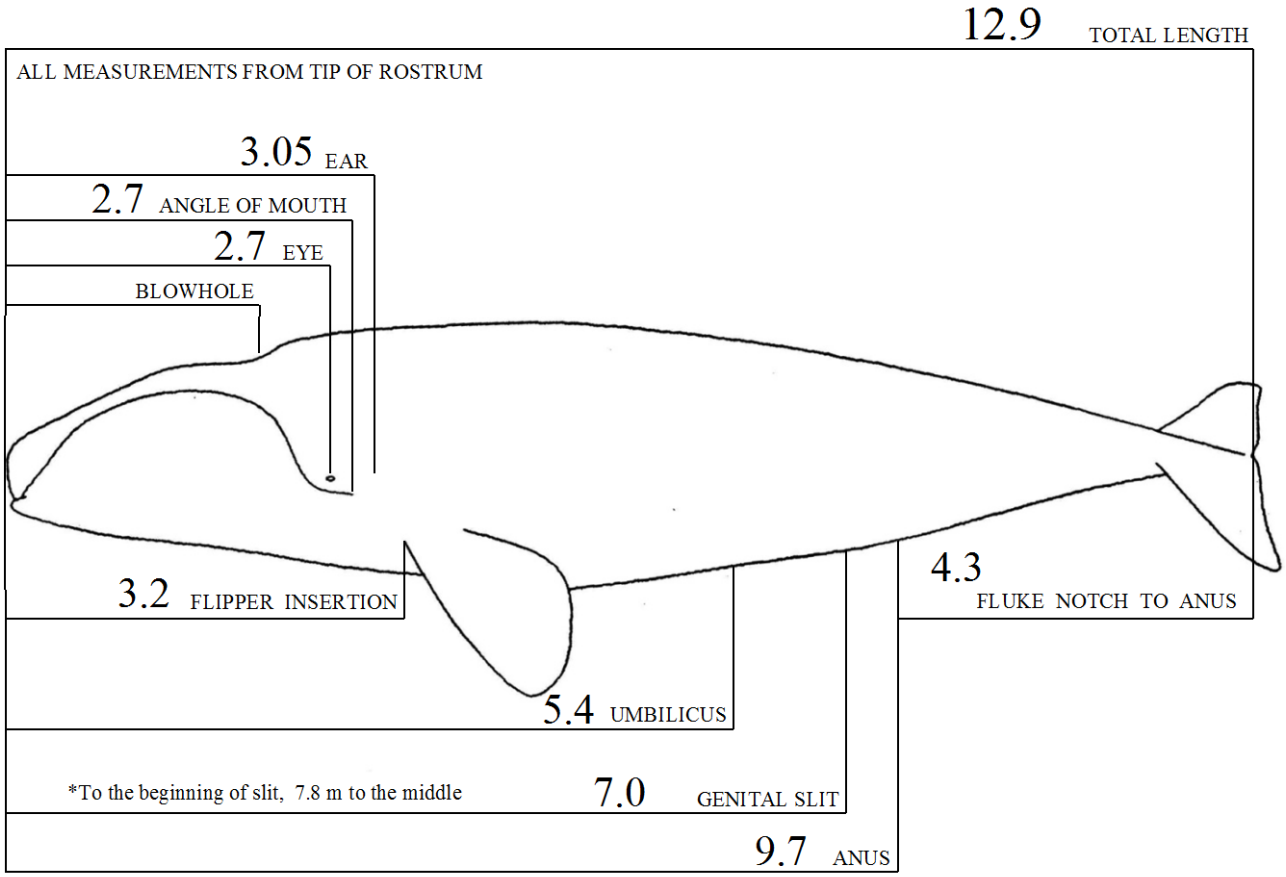


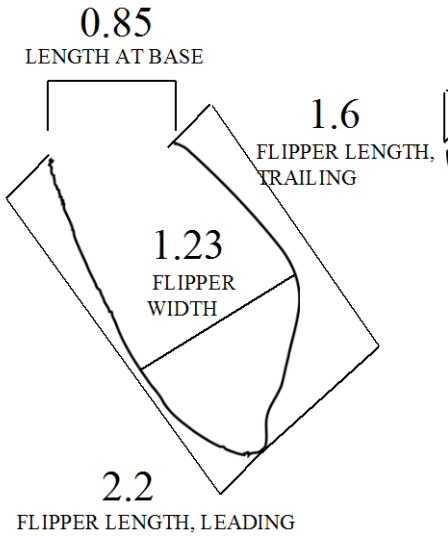
	A	B	C	D	E	F	G	H
Dorsal	Nuchal Crest	Axilla	1/2 1/2 Axilla-Umbilicus	Umbilicus	1/2 Umbilicus-Anus	Anus	1/2 1/2 Anus-Tail Insertion	Tail Insertion
1	13.0	17.5	15.0	13.0	17.0	14.0	14.5	———
2	18.0	20.0	16.0	15.0	15.0	13.0	10.0	———
3	20.0	15.0	14.0	17.0	14.5	13.5	9.0	———
4	20.0	13.0	13.5	16.0	16.0	12.5	8.5	———
5	13.0	12.8	13.5	17.0	19.0	12.5	12	———
6	12.0	12.5	14.0	15.5	13.0	13.0	13.0	———
7	14.0	11.0	12.5	14.0	12.0	13.0	14.0	———
Ventral								
Average	15.7	14.5	14.0	15.4	15.2	13.1	11.6	———

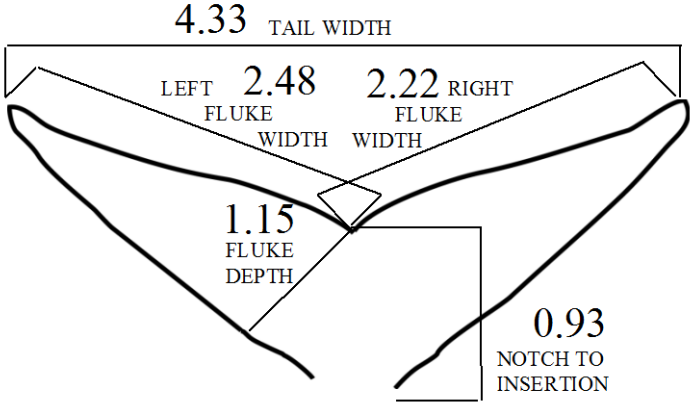
Note: all measurements are in cm

Right Whale EG#7 External Morphometrics

WRITE MORPHOMETRICS ON LINES





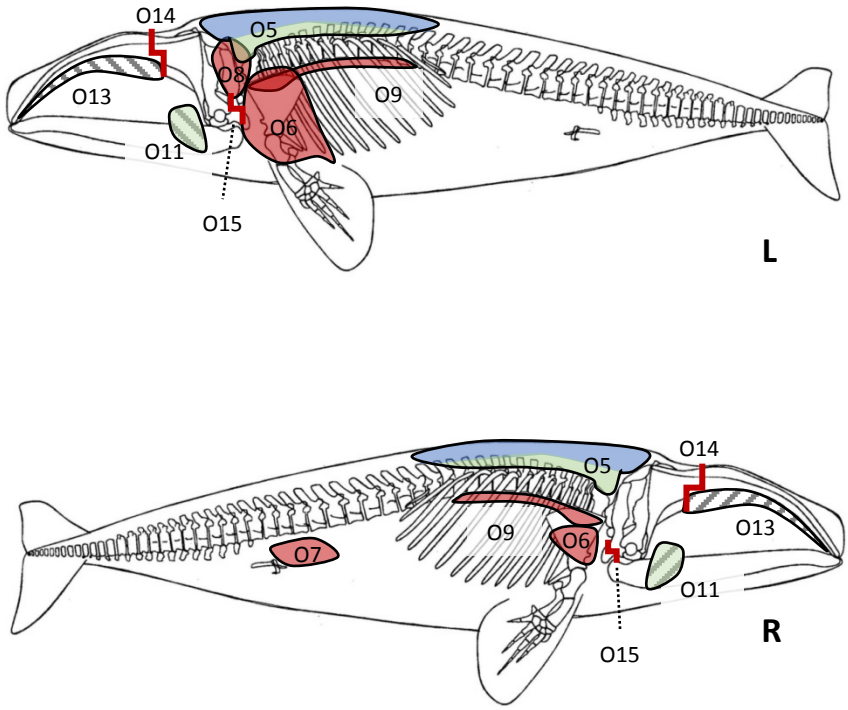


*written as on sheet, missmatch between fluke depth and notch to insertion?

*measures in meters

Distribution of observations suggestive of blunt trauma

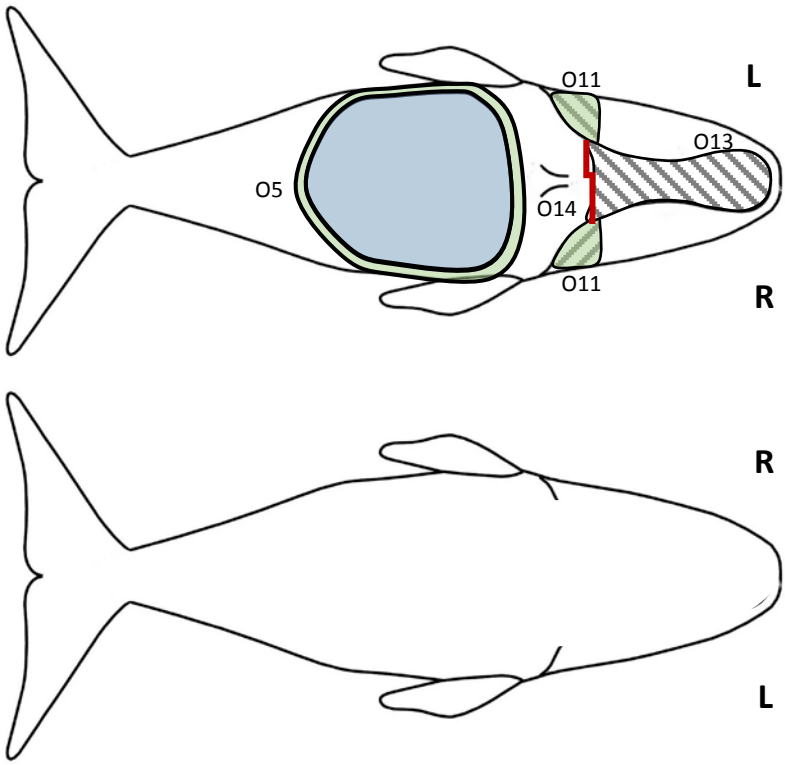
Field # EG2017-07 Date 2017-07-10



- **Fracture**
  - O14: base of maxilla, premaxilla, vomer
  - O15: petrotympanic complex, bilateral
- **Putty-like material**
  - O6: asymetric distribution, scapulas
  - O7: right hypaxial muscle, anus
  - O8: left cervical muscles
  - O9: dorsal thoracic cavity
- **Red-tinged gelatinous fluid**
  - O5: dorsum, gelatinous material between blubber and muscle
  - O11: oedematous muscle, bilateral, under mandible skin laceration
- **Blubber contusion**
  - O5: dorsum, multifocal to coalescent
- **Skin laceration**
  - O11: mandibular angle of the mouth, bilateral
  - O13: oral surface, maxillary

Distribution of observations suggestive of blunt trauma

Field # EG2017-07 Date 2017-07-10



Fracture
O14: maxillary bone

Red-tinged gelatinous fluid
O5: dorsum, gelatinous material between blubber and muscle
O11: oedematous muscle, bilateral, under mandible skin laceration

Blubber contusion
O5: dorsum, multifocal to coalescent

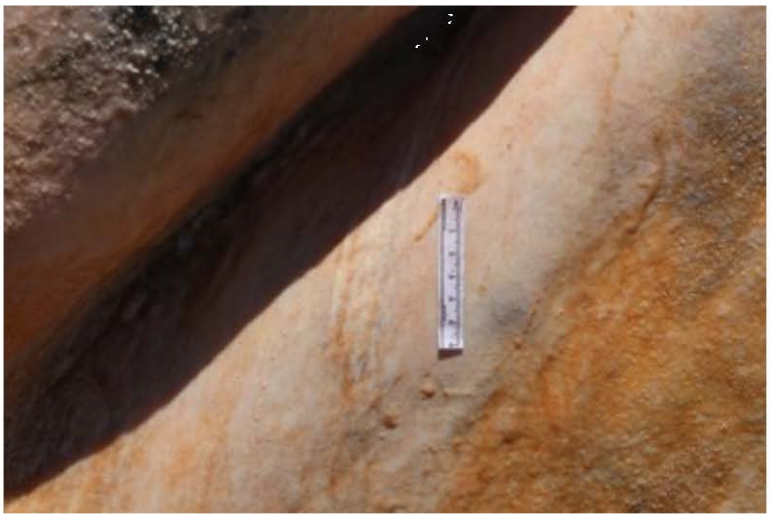
Skin laceration
O11: mandibular angle of the mouth, bilateral
O13: oral surface, maxillary

Observation 1

Linear ridge of firm and white dermis, considered to be scar tissue located caudal to the anus on the left side of the body, 30 cm in length

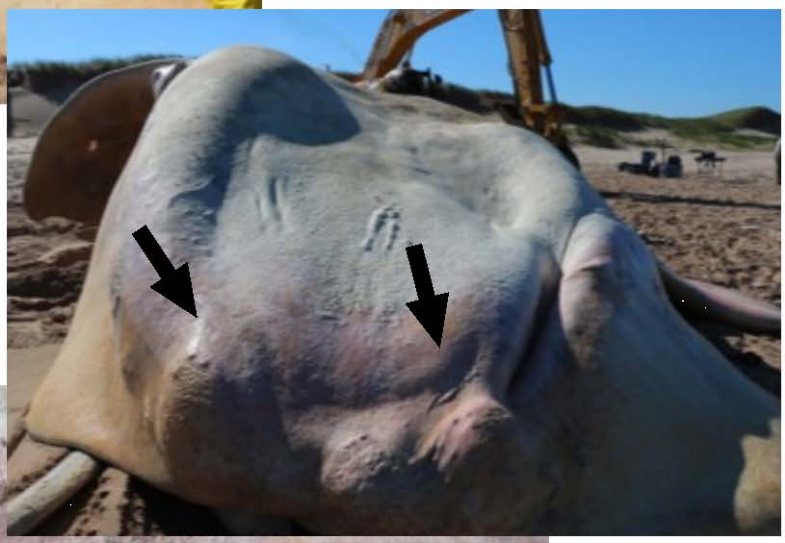
Observation 4

Linear ridge of firm and white dermis, considered to be scar tissue located caudally and ventrally to mandibular symphysis (location indicated by black arrow), right side, 25 cm in length



Observation 2

Bilaterally on the lateral surfaces of the mandible, multiple round raised nodular areas considered to be associated with callosities are observed (black arrows point at some of these observations). They are of 10-15 cm in diameter and present an irregular surface.



Observation 3

Several slightly elevated rounded areas of the dermis are linearly arranged on the ventral portion of the left lip and in the intermandibular region (location indicated by black arrow). On cut section, these regions are associated with focal clusters of a thick, waxy, translucid to opaque brown material located in the superficial dermis

Observation 5

Multiple to coalescent areas of well-defined red discoloration of the deep blubber layers are observed over the dorsal aspect of the thoracic cavity. In the same area, a red to brown gelatinous material is found between the panniculus and the muscle fascia (indicated by black arrow)

Observation 6

Dark, putty like material, presumably clotted blood, is observed bilaterally, between scapula (visible surface pointed by white arrow) and the thoracic musculature. Distribution is asymmetric with a more extensive area of accumulation associated with the left scapula

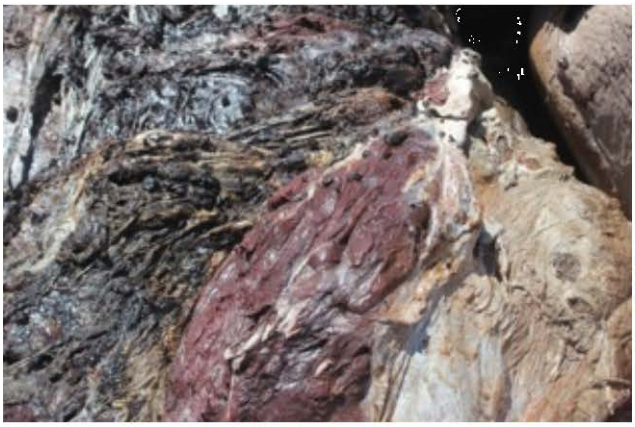
Observation 7

A focally extensive accumulation of dark, putty like material is observed at the level of the anus, within the right hypaxial muscle

Observation 9/12

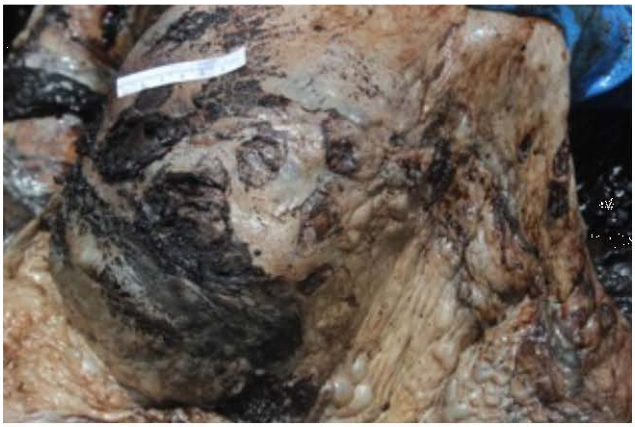
A thin accumulation of dark, putty like material is observed bilaterally in the dorsal thoracic cavity lining. This is associated with large amount of filamentous structures, presumably vascular wall remnants of the thoracic *rete mirabile*

Observation 8



A large accumulation of dark, putty like material is observed in the left cervical area

Observation 10



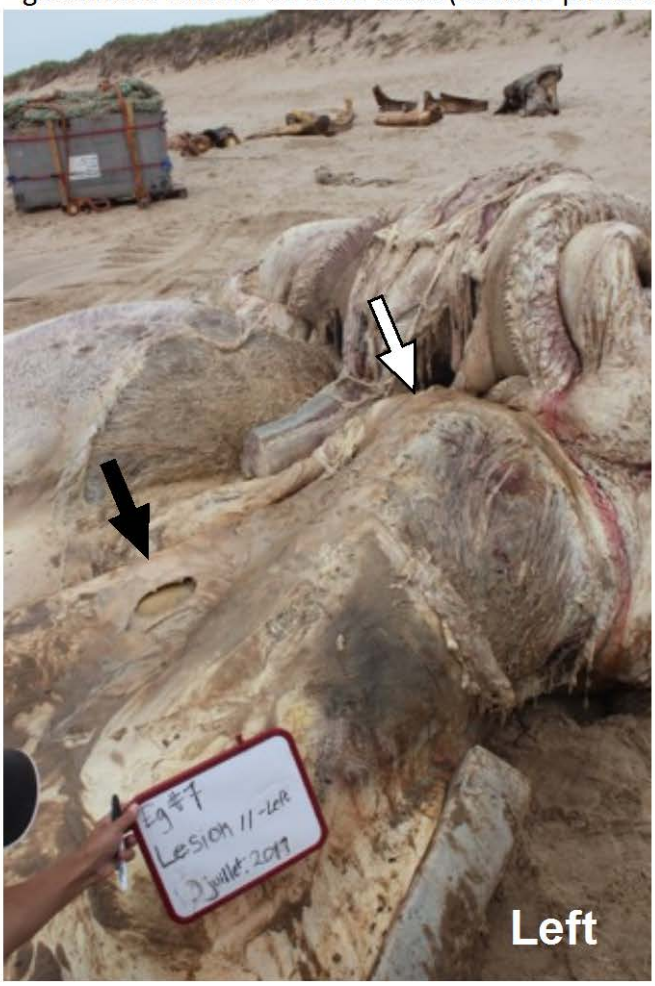
Multiple circular depressions of 2-3 cm in diameter are noted in association with a raised rim packed with black putty-like material on the mucosal surface of the stomach wall

Observation 15

The petrotympanic complexes are fractured at their base

Observation 11

A linear, transverse laceration of the superficial panniculus is noted bilaterally on the mandible (white arrow), just rostral to the angle of the mouth. This laceration exposes the mandibular bone on the left (black arrow). In transverse section, the most superficial muscle layer presents with a gelatinous texture on both sides (bottom pictures).



Observation 13

Extensive lacerations are present on the oral surface of the maxilla. The whole region of the head is covered in a thick and creamy pale brown liquid.

Observation 14

The maxilla and premaxilla are fractured at the base of the skull and their distal fragment is not found on the carcass.

Appendix III - Biotoxin analysis

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

CANADIAN FOOD INSPECTION AGENCY
REPORT OF ANALYSIS
FISH PRODUCTS SAMPLING SUBMISSION
Version 6.3.0
Serial: 000004364070

System ID: 2017FFI-0000046381-4 ***Receptions by all Labs:*** 1
Reference No.: 2017FFIS-0000049699-4 ***Number of Jobs Authorized:*** 1

Laboratory No.: DAR-FD-2017-CH-02546 ***Date Received:*** 2017-07-25 ***Job Status:*** Authorized

Laboratory: (1981) DARTMOUTH LABORATORY - CHEMISTRY
1992 AGENCY DRIVE
DARTMOUTH, NS B3B 1Y9
Telephone: (902) 536-1004
Fax: (902) 536-1018

Submitted By: CFIA Inspector
(12450) ALEXIS JOHNSON
1992 AGENCY DRIVE
DARTMOUTH, NS B3B 1Y9
Telephone: (902) 426-2110
Fax:
Cell:
Email: ALEXIS.JOHNSON@INSPECTION.GC.CA

Sampled By: CFIA Inspector
(12450) ALEXIS JOHNSON
1992 AGENCY DRIVE
DARTMOUTH, NS B3B 1Y9
Telephone: (902) 426-2110
Fax:
Cell:
Email: ALEXIS.JOHNSON@INSPECTION.GC.CA

Program: FISH ***Function:*** DOMESTIC
Sampling Plan: 2017_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 #7 NECROPSIED, MAGDALEN ISLAND, QUEBEC, JULY 9-10 2017 (LIVER, FECES, STOMACH CONTENT, LARGE INTESTINE)

Date Sampled: 2017-07-09
Date Received: 2017-07-25
Risk Category: Bivalve Molluscan
Harvest Date: 2017-07-25 08:31 AM

Lab Sample No.: DAR-FD-2017-CH-02546-0001
Inspection Sample No.:

Primary Process: FREEZING
Sample Type: Tissue - Liver
Identification Code: EG # 7
Species: NORTH ATLANTIC RIGHT WHALE - EUBALAENA GLACIALIS

Sample Assessed: No Decision

Method: TOX-DA-LC / 1 : Analysis of Domoic Acid in Molluscs by Liquid Chromatography- SOM-DAR-CHE-001
Domoic Acid Not detected at the reporting limit.
Test Assessed: No Decision

System ID: 2017FFI-0000046381-4 **Receptions by all Labs:** 1
Reference No.: 2017FFIS-0000049699-4 **Number of Jobs Authorized:** 1

Laboratory No.: DAR-FD-2017-CH-02546 **Date Received:** 2017-07-25 **Job Status:** Authorized

Method: TOX-DSP-LC / 1 : Analysis of Lipophilic Shellfish Toxins by Liquid Chromatography- SOM-DAR-CHE-002

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

Method: TOX-PCOX / 1 : Post-column Oxidation (PCOX) Method for the Determination of Paralytic Shellfish Toxins in Mussels, Clams, Oysters and Scallops-SOM-DAR-CHE-052

Gonyautoxin-4	Not detected at the reporting limit.
Gonyautoxin-1	Not detected at the reporting limit.
Decarbamoylgonyautoxin-3	Not detected at the reporting limit.
Gonyautoxin-5	Not detected at the reporting limit.
Decarbamoylgonyautoxin-2	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

Lab Sample No.: DAR-FD-2017-CH-02546-0002 **Inspection Sample No.:**

Sample Type: Feces
Species: NORTH ATLANTIC RIGHT WHALE

Sample Assessed: No Decision

Method: SOM-DAR-CHE-052

Gonyautoxin-4	Not detected at the reporting limit.
Gonyautoxin-1	Not detected at the reporting limit.
Decarbamoylgonyautoxin-3	Not detected at the reporting limit.
Gonyautoxin-5	Not detected at the reporting limit.
Decarbamoylgonyautoxin-2	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

Method: SOM-DAR-CHE-001

Domoic Acid	Not detected at the reporting limit.

Test Assessed: No Decision

System ID: 2017FFI-0000046381-4 ***Receptions by all Labs:*** 1
Reference No.: 2017FFIS-0000049699-4 ***Number of Jobs Authorized:*** 1

Laboratory No.: DAR-FD-2017-CH-02546 ***Date Received:*** 2017-07-25 ***Job Status:*** Authorized

Method:	SOM-DAR-CHE-002	
	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

Lab Sample No.: DAR-FD-2017-CH-02546-0003 ***Inspection Sample No.:***

Sample Type:		Tissue - Other
Species:		NORTH ATLANTIC RIGHT WHALE
Sample Assessed:		No Decision
Method:	SOM-DAR-CHE-052	
	Gonyautoxin-4	Not detected at the reporting limit.
	Gonyautoxin-1	Not detected at the reporting limit.
	Decarbamoylgonyautoxin-3	Not detected at the reporting limit.
	Gonyautoxin-5	Not detected at the reporting limit.
	Decarbamoylgonyautoxin-2	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
Method:	SOM-DAR-CHE-001	
	Domoic Acid	Not detected at the reporting limit.
Test Assessed:		No Decision
Method:	SOM-DAR-CHE-002	
	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

Lab Sample No.: ***Inspection Sample No.:***

System ID: 2017FFI-0000046381-4 ***Receptions by all Labs:*** 1
Reference No.: 2017FFIS-0000049699-4 ***Number of Jobs Authorized:*** 1

Laboratory No.: DAR-FD-2017-CH-02546 ***Date Received:*** 2017-07-25 ***Job Status:*** Authorized

DAR-FD-2017-CH-02546-0004

Sample Type:		Tissue - Other
Species:		NORTH ATLANTIC RIGHT WHALE
Sample Assessed:		No Decision
Method:	SOM-DAR-CHE-052	
	Gonyautoxin-4	Not detected at the reporting limit.
	Gonyautoxin-1	Not detected at the reporting limit.
	Decarbamoylgonyautoxin-3	Not detected at the reporting limit.
	Gonyautoxin-5	Not detected at the reporting limit.
	Decarbamoylgonyautoxin-2	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
Method:	SOM-DAR-CHE-001	
	Domoic Acid	Not detected at the reporting limit.
Test Assessed:		No Decision
Method:	SOM-DAR-CHE-002	
	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

Job Authorized: 2017-08-04 ***Authorized By:*** Melanie Casey ***Authorized***
Job Assessed: No Decision ***Date Assessed:*** 2017-08-04

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

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

Wildlife Diagnostic Report – EG#8

Necropsy #: EG#8; MARS2017-146: NEAq Catalog #2140 ("Peanut") - 26 year old male

Incident Information

Species: North Atlantic Right Whale (*Eubalaena glacialis*)
Age: Adult
Sex: Male
Necropsy date: 21 July 2017
Location: Miscou Island, New Brunswick

Finder/Submitter Information

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

Information Provided with Specimen

First sighted in GoSL on July 19, 2017. He was born in 1991 and was seen frequently over the years in the Bay of Fundy, Cape Cod Bay, Great South Channel and in Southeast US. He had fathered one calf that we know of - #3466, a male born in 2004. Last seen by NEFSC aerial survey on June 27, 2017 in GoSL. Named for a peanut-shaped scar on the front of his head.

Diagnosis and Interpretation

Final Diagnoses

Acute internal hemorrhage compatible with blunt trauma (suspected)
Cranial exostosis (incidental)

Interpretation

Observations in this whale were comparable to those in EG#2 and EG#6. The carcass was ascribed a decomposition condition code of 4, and therefore observations and their interpretations were made with caution. This animal was considered in good body condition for the season, based on its blubber thickness. A presumptive diagnosis of acute internal hemorrhage was based mainly on the presence of an abundant amount of dark brown to black putty-like material, compatible with clotted blood (cooked by internal heat and pressure generated by post-mortem decomposition), within the thoracic cavity. This material was comparable in location and abundance to that in EG#6. In contrast to EG#2 and EG#6, the foramen magnum of this whale was not filled with similar material. However, as in EG#6, this whale had a fracture of the right (instead of the left) tympano-periotic complex (middle-inner ear)

characterized by the presence of several small pieces of bone in its proximity, although black putty-like material was not found around this ear complex as it was in EG#6. As with EG#6, this fracture may have happened after death as the carcass was pulled onshore, but it may also have resulted from blunt trauma (see: Moore et al. Journal of Cetacean Research and Management 6(3):199-214, 2004).

As with EG#2 and EG#6, there was an abundant amount of red-tinged fluid between blubber and muscle mass, this time along the left lateral wall of the carcass and extending to the dorso-lateral region of the right body wall. Interestingly, what was interpreted as a locally extensive area of hemorrhage was observed in the epaxial muscle mass of the dorso-lateral region of the right body wall, whereas in the two other whales accumulation of red-tinged fluid between blubber and muscle was not associated with any evidence of muscle hemorrhage. As with the two other whales, interpretation of the significance of this accumulation of red-tinged fluid remains uncertain.

An interesting observation was the presence of a conspicuous exostosis on the right side of the caudal surface of the skull. This exostosis was closely associated with a mass of fibrous tissue that enclosed several small pieces of bone of irregular shapes. This was clearly an old lesion, probably of little to no significance, but its cause was undetermined. The sequel of a focal trauma would come to mind, but this is a very deep region of the animal for such a localized trauma to have occurred.

Test Results

Necropsy (21 July 2017)

Standard length: 14.54m
Rostrum to ear: ~3.7m
Rostrum to angle of mouth: 3.4m
Rostrum to eye: 3.0m
Rostrum to blowhole: 2.9m
Rostrum to flipper insertion: 3.67m
Rostrum to umbilicus: ~6.2m
Rostrum to genital slit: 8.1m
Rostrum to anus: 10.28m
Anus to fluke notch: 4.12m

Flipper length at base: 0.86m
Flipper length (leading): 2.3m
Flipper length (trailing): 1.4m
Flipper width: 1.25m
Tail width: 4.47m
Left fluke width: 2.37m
Right fluke width: 2.14m
Notch to tail insertion: 1.1m
Fluke depth: 1.16m

(See Appendix 1)

Blubber thickness was measured at seven locations from mid dorsal to mid ventral at eight levels from cranial to caudal. Averages were taken of the seven locations at each level: nuchal crest, 14.9cm; axilla, 14.4cm; 1/2 axilla-umbilicus, 16.4cm; umbilicus, 16.8cm; 1/2 umbilicus-anus, 18.5cm; anus, 17.5cm; 1/2 anus-tail insertion, 14.3cm; tail insertion (single measurement, as the tail insertion was broken when the carcass was pulled on shore by the excavator), 8.5cm. (See Appendix 2)

Adult male (26 years old). Much pressure still present internally, as revealed on first cuts of the blubber. The animal presented with seasonally robust blubber (20.5cm on the mid-ventrum) (Miller et al. 2011). Decomposition condition code 4. Two populations of cyamid noted and collected; one orange and spikey, the other tan and smooth. All baleen plates are still present. Large portion (whole?) of larynx (epiglottis clearly recognizable) outside of oral cavity, still loosely attached to the carcass by connective tissue. Portion of small intestine found in right side of oral cavity; several portions also found internally. Very small amount of tan, clear material in the right pleural cavity; possibly congealed pleural fluid. Small portion of lung located. Heart not found. Most of the liver still appears to be present. Portion of stomach located; completely empty; mucosal surface almost dry. One kidney located; very decomposed. Testicles located. Fairly long segment of caudal region of colon located; contains small amount of material (feces? collected). Clean separation of cranial epiphysis (growth plate) of one of the caudal lumbar vertebral bodies (L9?) when the carcass (by then stripped of much of its flesh) was pulled further up the shore. Both ear plugs located and collected in 10% formalin (to DFO, Mont-Joli, Québec). Conspicuous observations at necropsy included:

- numerous linear areas of epidermal depigmentation, with no associated change in underlying dermis (previous entanglement?): ventral surface of right mandible, upper border of right lip, caudal region of right axilla, left caudo-ventral surface of rostrum (Figure 1);
- accumulation of an abundant amount of red-tinged fluid between blubber and muscle mass (but not involving the latter) along the whole left lateral wall, associated with discrete areas of red discoloration of overlying blubber (Figure 2); this red-tinged fluid and associated discrete areas of red discoloration of blubber extend to the dorso-lateral region of the right body wall and include a locally extensive area of hemorrhage in epaxial muscle at this level (Figure 3); examination of muscle and blubber on the right side of the carcass was not as extensive as on the left side since this was the very last part of the necropsy;
- abundant amount of black putty-like material in thoracic cavity (Figure 4);
- large exostosis of very irregular shape firmly attached to caudal surface of skull, right of the occipital bone (squamosal bone?), easy to cut a large portion of it with a small handsaw (Figure 5) (exposed by Dr. France Boily, DFO, Mont-Joli, Québec); immediately medial to the exostosis and irregularly attached to it, mass of fibrous tissue containing several, relatively smooth, discrete, small pieces of bone of irregular shapes (Figure 5); possibly from old trauma?
- several small discrete pieces of bone free around the right tympano-periotic complex (middle-inner ear); in most of these pieces, one facet shows what appears to be a recent fracture (Figure 6) (ante-mortem or post-mortem?);
- large mass of rete mirabile removed from cranial cavity, but no putty-like material;
- thin layer of brown putty-like material covering transverse processes of some thoracic vertebrae (Figure 7);
- thick, brown material mixed with hypaxial muscle tissue along left ventral body wall, interpreted as liquefied/autolyzed muscle (Figure 8); this appeared very quickly after the muscle mass had been exposed to air (oxidative process?).

(See Appendix 3 for detailed description of observations made in the carcass.)

(See Figures 9a and 9b for a diagrammatic representation of observations possibly associated with blunt trauma.)

Histology (AVC X16849-17)

Total of 15 tissues embedded in paraffin blocks (numbers 4 and 10 correspond to gross observations). Total of 13 slides examined (*):

*1-1. *1-2. Intracranial rete mirabile. Abundant amount of strongly acidophilic amorphous material that may very well represent blood.
*2. myocardium. This is instead very autolyzed skeletal muscle, with fragments of large striated myofibers.
*3-1. *3-2. lung. Alveolar interstitium filled with capillaries?
4. ventral peduncle. Paraffin block available; no histological slide prepared.
*5. liver. No lesion visible.
*6. kidney. Organ barely recognizable; tissue markedly washed out.
*7. epaxial muscle. No lesion visible. Tissue not as autolyzed as in section 2 or as in other right whales examined.
*8. hypaxial muscle. No lesion visible. Degree of autolysis seems to be between those of sections 2 and 7.
*9. testicle. The microscopic appearance of this section is compatible with that of a glandular organ, but no further details can be recognized.
10. right flipper, dorsal surface near axilla, trailing edge. Paraffin block available; no histological slide prepared.
*11-1. *11-2. *11-3. muscle, right lateral body wall, hemorrhage. No clearly evident hemorrhage, but some acidophilic granular material in the interstitium could possibly pass as remnants of red blood cells.

Other Tests

Content of caudal region of colon: Baseline levels of fecal glucocorticoids, used as potential indicator of chronic stress (more than 2 days, based on gastro-intestinal transit time in this species) were found in this whale, suggesting that it died before an elevated response to stress by the adrenal glands could be reflected in a rise in fecal glucocorticoids (Endocrine Laboratory, New England Aquarium). This result would be compatible with an acute death resulting from blunt trauma. However, the possibility that the sample analyzed was a poor representative of fecal material cannot be ruled out.

Cranial exostosis: Computer tomography scan – very porous bone, many of the cavities probably being filled with lipid material.

Inventory of Frozen Samples

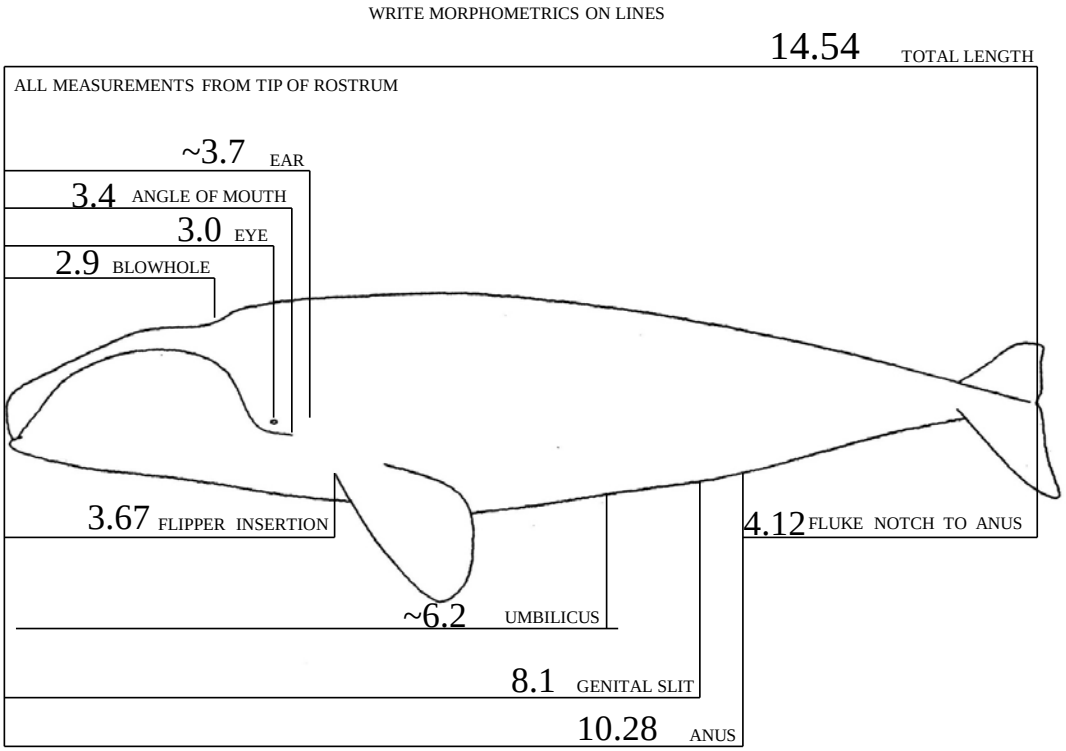
- Right and left middle-inner ears, for Don MacAlpine, NB Museum
- Sternum?, for Don MacAlpine, NB Museum
- Pelvis – to MARS
- Exostosis
- Bones x2 – to MARS
- Lungs x2
- Kidney

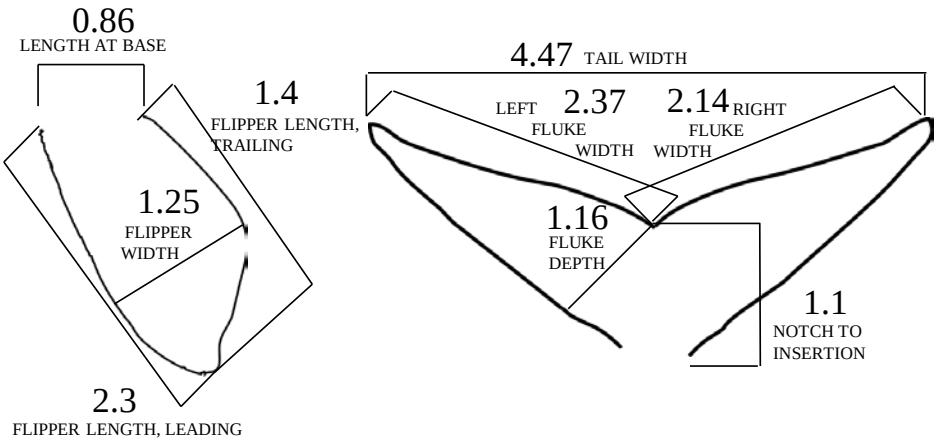
- Eye x2
- Caudal colon content
- Epaxial muscle
- Blubber
- Exostosis
- Liver x3
- Left thoracic cavity putty-like material, lesion 12
- Ventral thoracic cavity putty-like material
- Intracranial rete mirabile / brain? x3
- Putty-like material in thorax

References

Miller CA, D Reeb, PB Best, AR Knowlton, MW Brown, MJ Moore. 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 (2011): 267-283.

Appendix 1. Right Whale EG#8 External Morphometrics

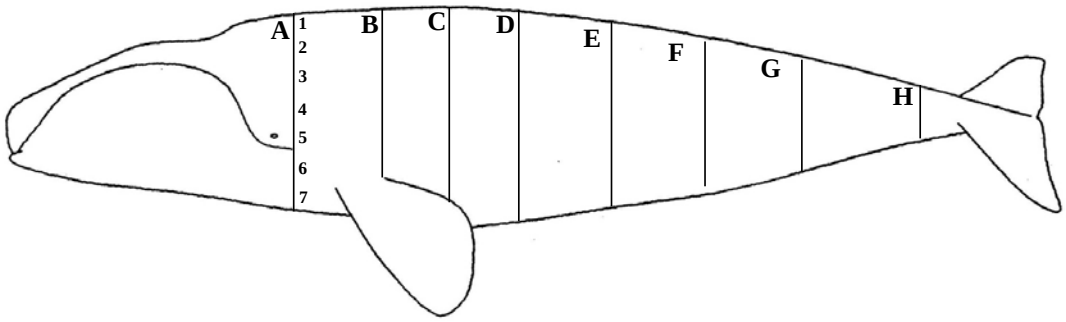




*measures in meters

Appendix 2. RIGHT WHALE EG#8 BLUBBER THICKNESS

Field# MARS2017-146 **Side Examined** _____ **Observer** _____ **Date** 21 July 2017



	A	B	C	D	E	F	G	H[1]
	Nuchal Crest	Axilla	1/2 1/2 Axilla-Umbilicus	Umbilicus	1/2 Umbilicus-Anus	Anus	1/2 1/2 Anus-Tail Insertion	Tail Insertion
Dorsal								
1	13.2	11.5	13	15.5	20	16.5	19	_____
2	14	11.5	13.5	12.5	15.5	14	11	_____
3	11.5	10.5	13.5	15	16.5	12.8	9	_____
4	15	12	13.5	16.5	19	15	10.5	_____
5	14.5	19	20	18.5	17	17	16	8.5
6	16.5	18	23	21	21	23.6	19.8	_____
7	19.5	18	18	18.3	20.5	23.5	15	_____

[1] Tail insertion broken when carcass pulled on shore by the excavator.

Ventral								
Average	14.9	14.4	16.4	16.8	18.5	17.5	14.3	8.5

Note: all measurements are in cm

APPENDIX 3: External and internal observations by number

(Asterisks indicate observations of potential clinical significance)

Observation number	Physical location	Description	Photos taken (Y/N)	Histology taken (Y/N)
1	Right mandible, ventral surface	Numerous long, narrow linear areas of epidermal depigmentation (white), 20-40cm long by 2-3cm wide. On section, extend through thickness of epidermis; no change in dermis.	Y	N
2	Right flipper, leading edge	Approximately 7 short narrow linear areas of epidermal depigmentation, spaced 30cm apart	Y	N
3	Right flipper insertion	Wide area of epidermal depigmentation, 30cm long by 7cm wide, extending along the trailing edge of the right axilla. On section, extends through thickness of epidermis; no change in dermis.	Y	N
4	Ventral peduncle	According to Bill McLellan, evidence of scarring around peduncle (prior entanglement) in photo taken at sea. However, the peduncle was torn during towing. On section, thin area of white discoloration in dermis.	Y	Y
5	Left side of rostrum, caudal-ventral surface, at angle of mouth	Linear area of depigmentation, approx. 30cm long by 5cm wide.	Y	N
6	Left flipper, leading edge	Multifocal to confluent areas of epidermal depigmentation (white).	Y	N
7*	Left lateral body wall	Large area of accumulation of red-tinged fluid between blubber and muscle mass, extending from flipper to anus; does not extend into the underlying muscle mass. Patchy red discoloration of blubber, most obvious dorsally.	Y	N
8	Ventral body wall	Large area of dark red discoloration of dermis, midway between peduncle and anus. Very superficial.	Y	N
9	Left flipper, ventral surface of leading edge	Epidermal tear, approx. 50cm long by 8cm wide; probably post-mortem. Remaining epidermis is tightly adhered to dermis.	Y	N
10	Right flipper,	40cm by 50cm area where epidermis was	Y	Y

	dorsal surface, proximal trailing edge, near axilla	removed, some epidermis still adhered (presumed post-mortem). No change on cut surface. (See Lesion 3.)		
11	Left, ventral body wall / hypaxial muscle mass, thoracic region	Thick, brown material mixed with muscle tissue. Interpreted as melted/autolyzed muscle.	Y	N
12*	Thoracic cavity, left dorsal-caudal pleural surface, caudal ribs	Large amount of dark brown putty-like material	Y	Y
13	Kidney, possibly left	Some mineral deposition?	Y	Y
14*	Thoracic cavity, dorsal-cranial aspect	Large amount of dark brown putty-like material, most prominent of level of the first five rib pairs NOTE: Some photos are labeled "13"	Y	Y
15	Cranial cavity	Abundant rete mirabile	Y	Y
16	Thoracic vertebrae	Brown putty-like material covering some transverse processes	Y	N
17a	Right lateral body wall (examined near the end of the necropsy)	Some areas of red discoloration of blubber associated with underlying red-tinged fluid; more prominent in dorsal region; does not seem as widespread as on the left side (Lesion 7).		
17b*	Right body wall, dorso-lateral surface, level of anus	Large linear area of intramuscular hemorrhage, epaxial muscle mass	Y	N
18*	Laterally, right of occipital bone (squamosal bone?)	Large and very irregular exostosis (nothing at all comparable on left side); easy to cut a large portion of it with a small handsaw. Immediately medial to the exostosis and irregularly attached to it, mass of fibrous tissue containing several somewhat irregular, relatively smooth, individual discrete pieces of bone (5-8cm in diameter). Possibly from old trauma?	Y	Portion of bone sawed off
19*	Right tympanic bulla	Several (approx. 6) individual discrete pieces of bone free around the bulla, each 3-4cm in diameter by 1cm wide; in most of these pieces, one facet shows what appears to be a recent fracture (post-mortem?).	Y	N
20	Right mandible	Linear epidermal depigmentation, 15cm long	Y	N

	margin	by 2-4cm wide, close to mandibular symphysis
21*	Ventral thoracic cavity	Large amount of dark brown putty-like material

Figures (73 other photos available)

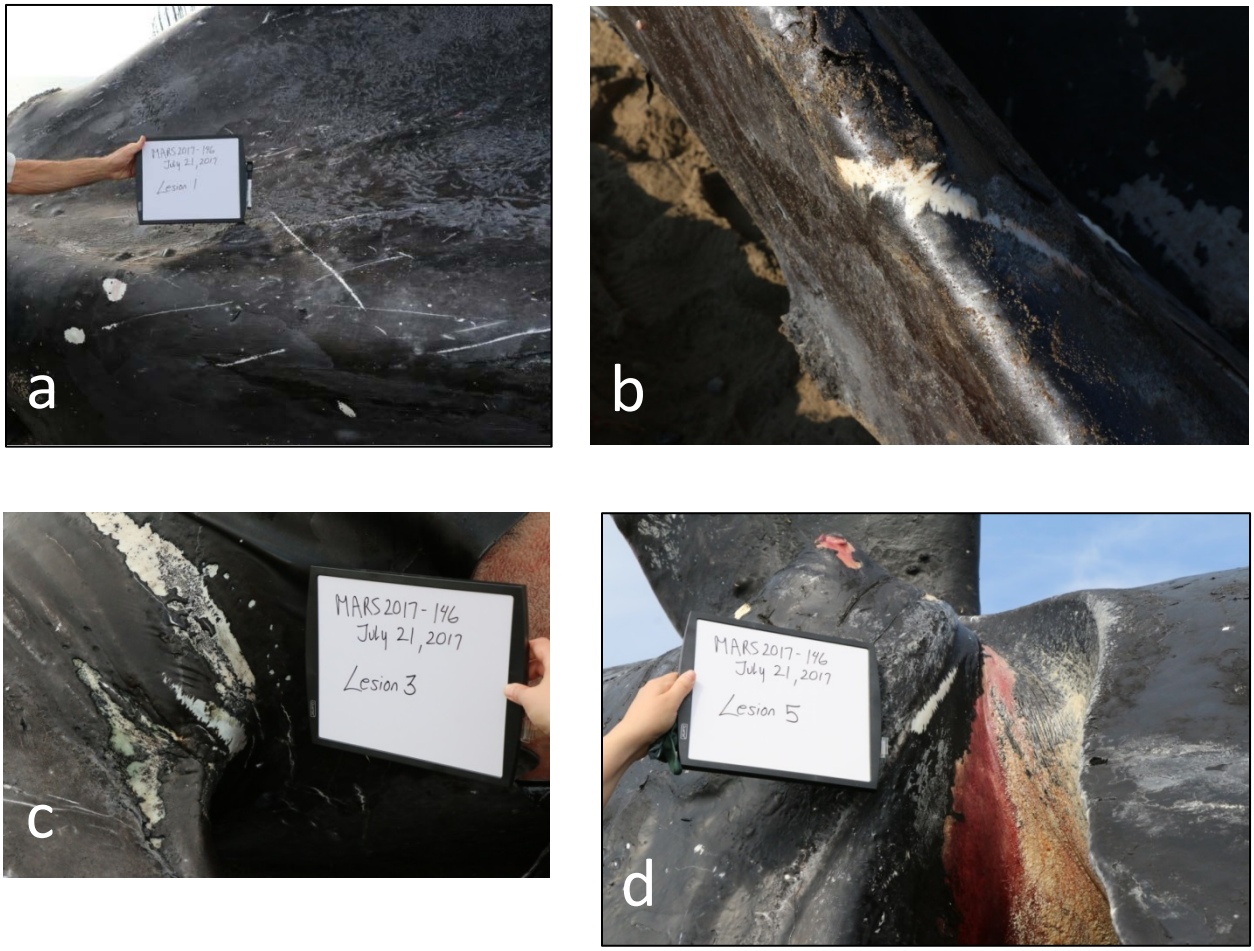


Figure 1. Linear areas of epidermal depigmentation on: a) ventral surface of right mandible; b) along upper border of right lip; c) along caudal region of right axilla; and d) left caudo-ventral surface of rostrum.

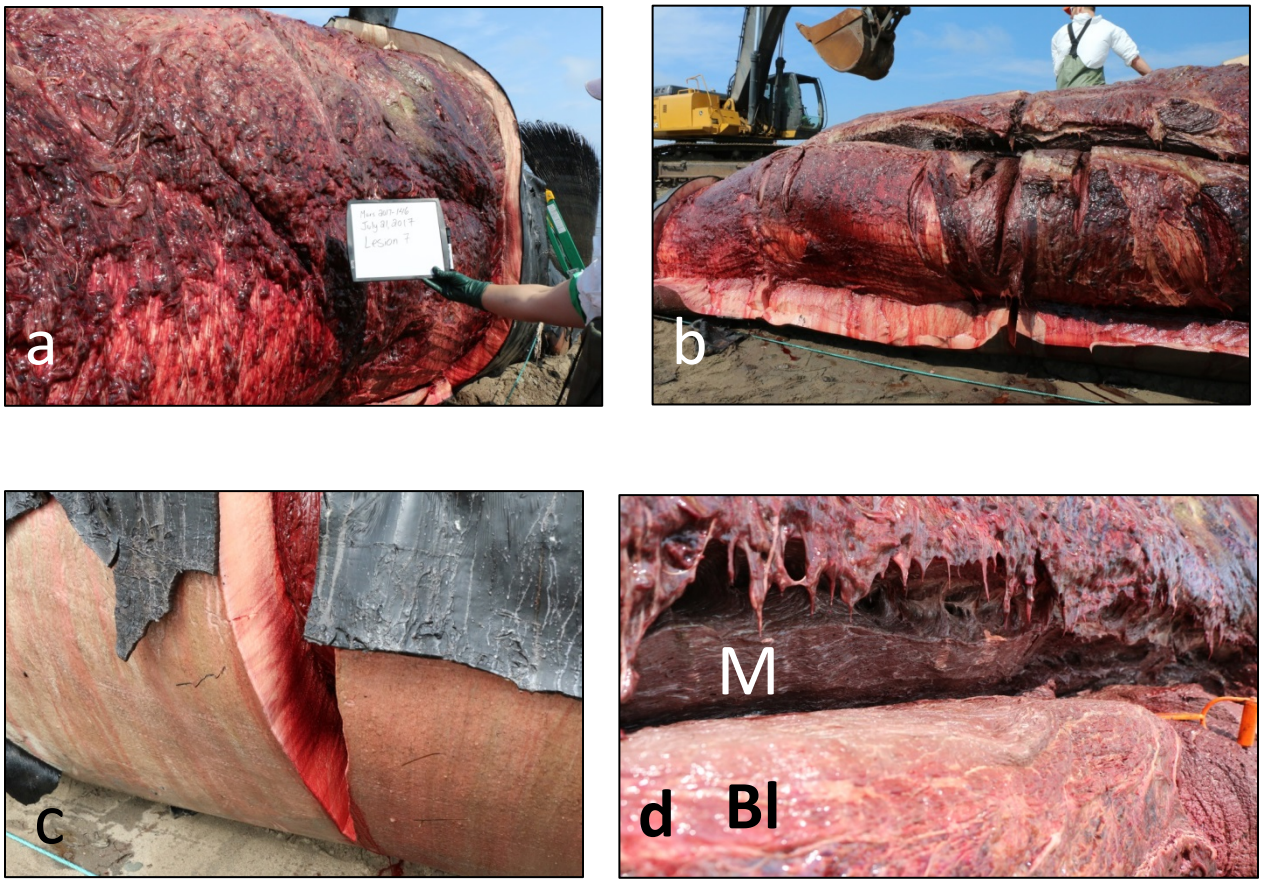


Figure 2. Accumulation of an abundant amount of red-tinged fluid between blubber and muscle along the whole left lateral wall. a) Cranial region of left side of carcass. b) Caudal region of left side of carcass. c) This accumulation of red-tinged fluid is associated with discrete areas of red discoloration of the overlying blubber. d) The muscle mass (M) is not involved in this accumulation of fluid. Bl, blubber.

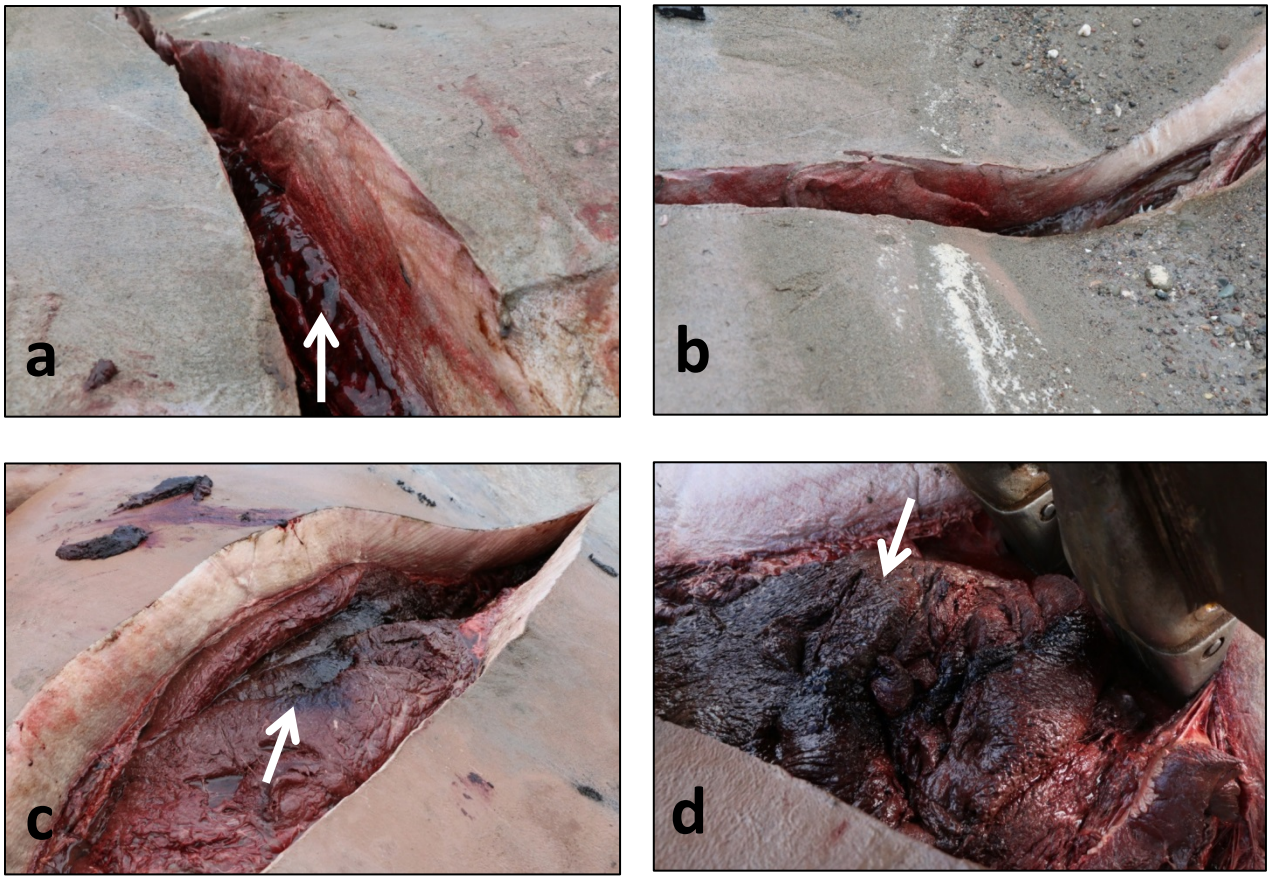


Figure 3. a) and b) The accumulation of red-tinged fluid between blubber and muscle (arrow) extends to the dorso-lateral region of the right body wall, where it is also associated with discrete areas of red discoloration of the overlying blubber. c) and d) A locally extensive area of hemorrhage (arrows) is in the epaxial muscle at this level.

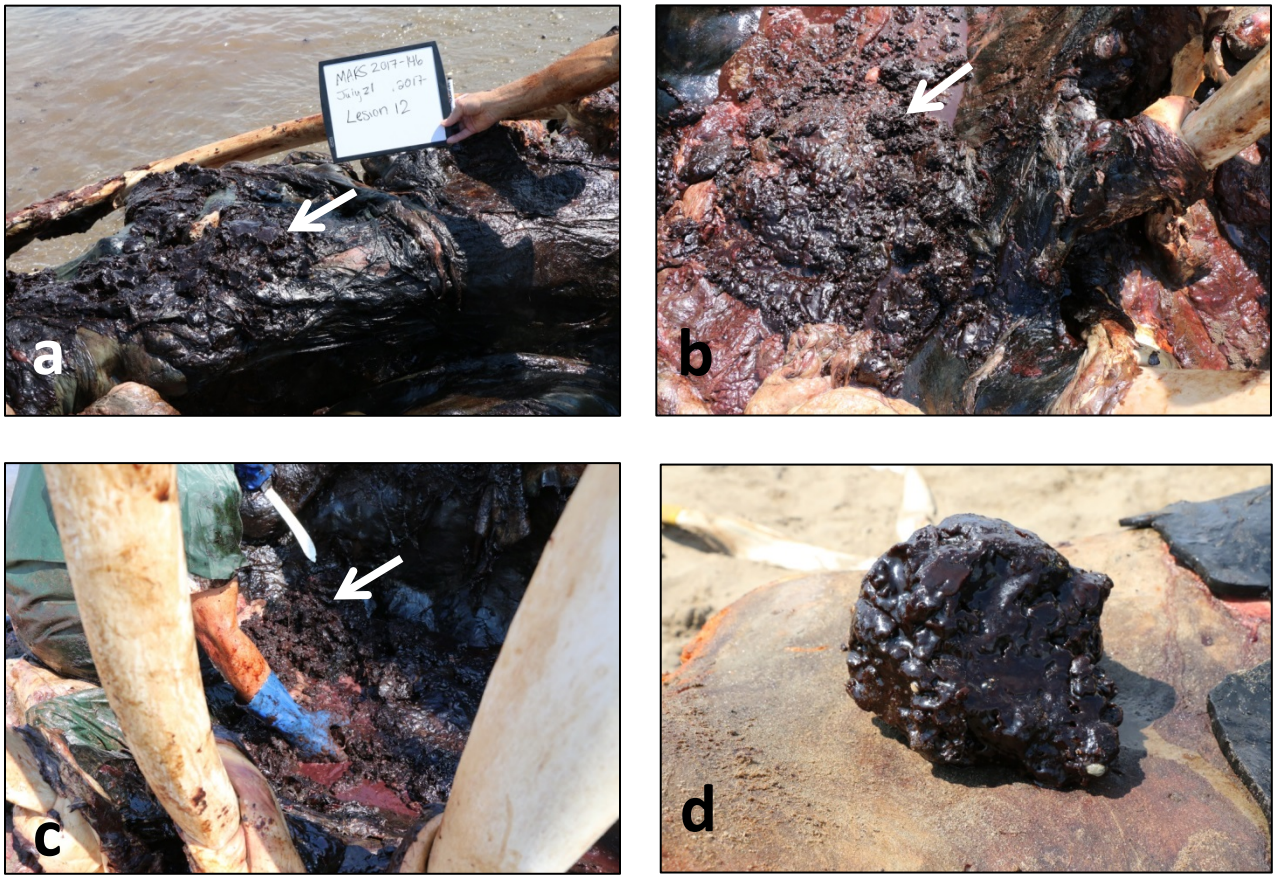


Figure 4. a) to c) Abundant amount of black putty-like material (arrows) in thoracic cavity. d) close-up of this material.

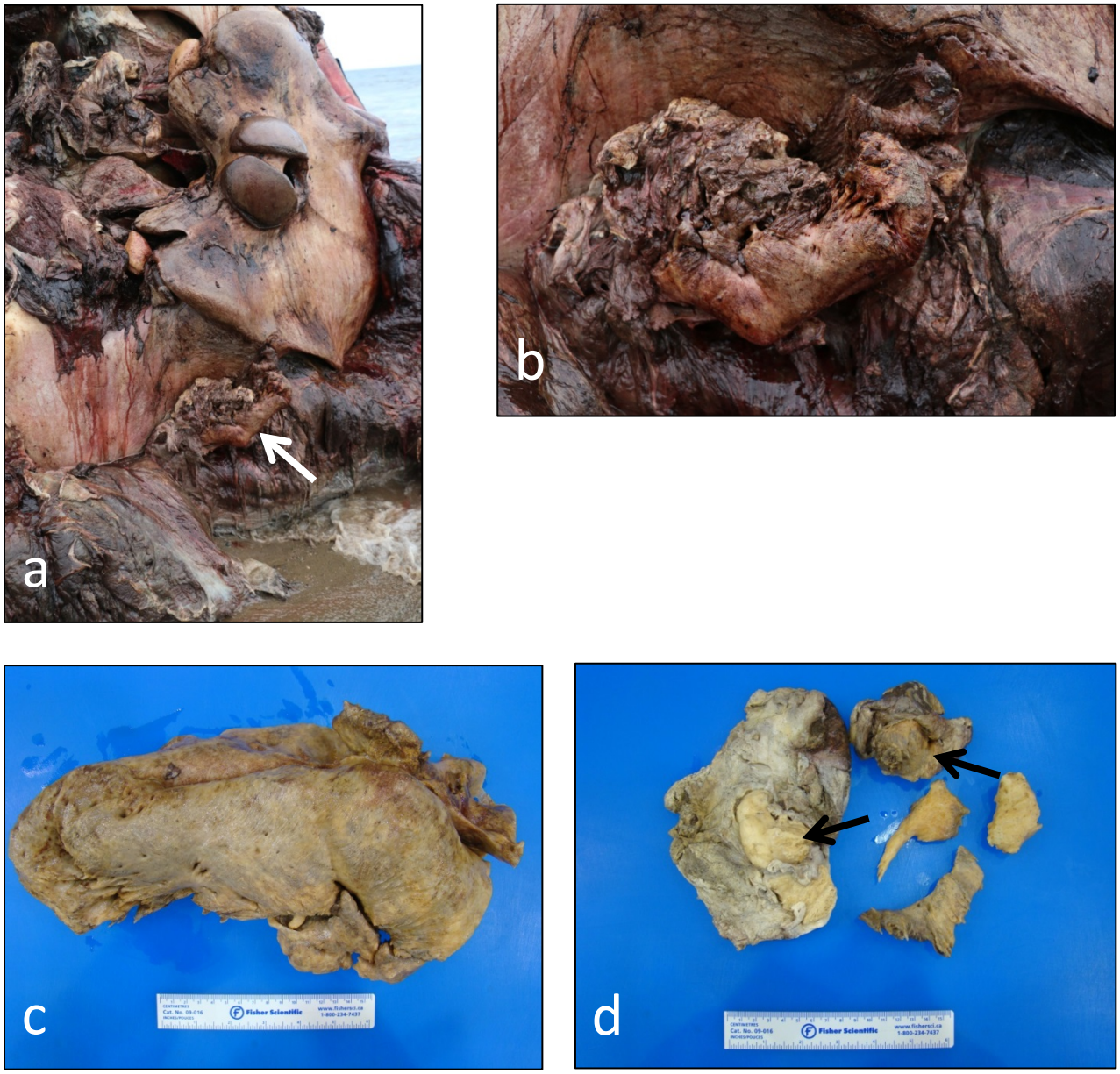


Figure 5. a) Large exostosis of very irregular shape firmly attached to the caudal surface of the skull, right of the occipital bone (squamosal bone?) (arrow). b) Close-up of the exostosis. c) Portion of the exostosis that was cut off with a handsaw and fleshed out. d) Immediately medial to the exostosis, and irregularly attached to it, was a mass of fibrous tissue within which were embedded several, relatively smooth, discrete, small pieces of bone of irregular shapes. The arrows point to two of these pieces that have been left within the fibrous mass; the other pieces could be easily shelled out.

Figure 6. Several small discrete pieces of bone free around the right tympano-periotic complex (middle-inner ear); in most of these pieces, one facet shows what appears to be a recent fracture (arrows).

Figure 7. Thin layer of brown putty-like material covering transverse processes of some thoracic vertebrae (arrow).

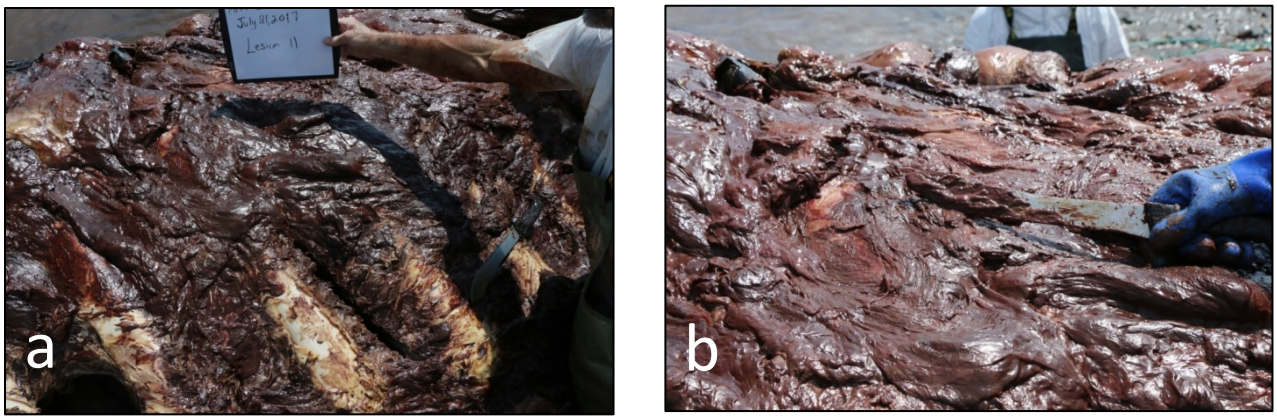
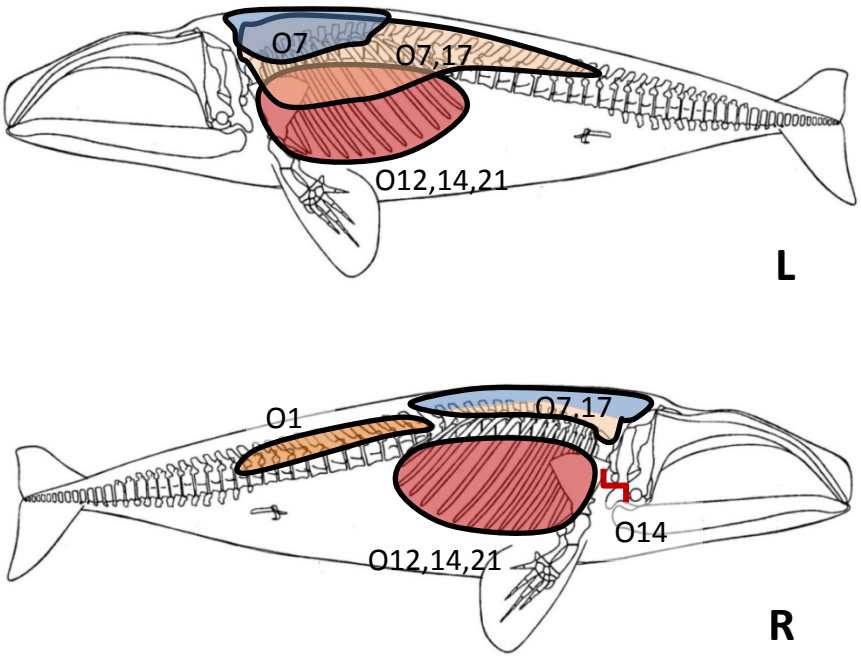


Figure 8. a) Thick, brown material mixed with hypaxial muscle tissue along the left ventral body wall was interpreted as liquefied/autolyzed muscle. This appeared very quickly after the muscle mass had been exposed to air (oxidative process?). b) This liquefied muscle tissue can be easily scooped up with a knife.



Fracture
O19: right petrotympanic complex

Putty-like material
O12,14,21: thoracic cavity

Red tinged gelatinous fluid
O7,17: left lateral wall, extending in dorso lateral portion of right body wall.

Hemorrhagic muscle
O17: right epaxial muscle, level of anus

Blubber contusion
O7: patchy discoloration, most obvious dorsally

Figure 9a. EG#8. Distribution of observations potentially associated with blunt trauma.

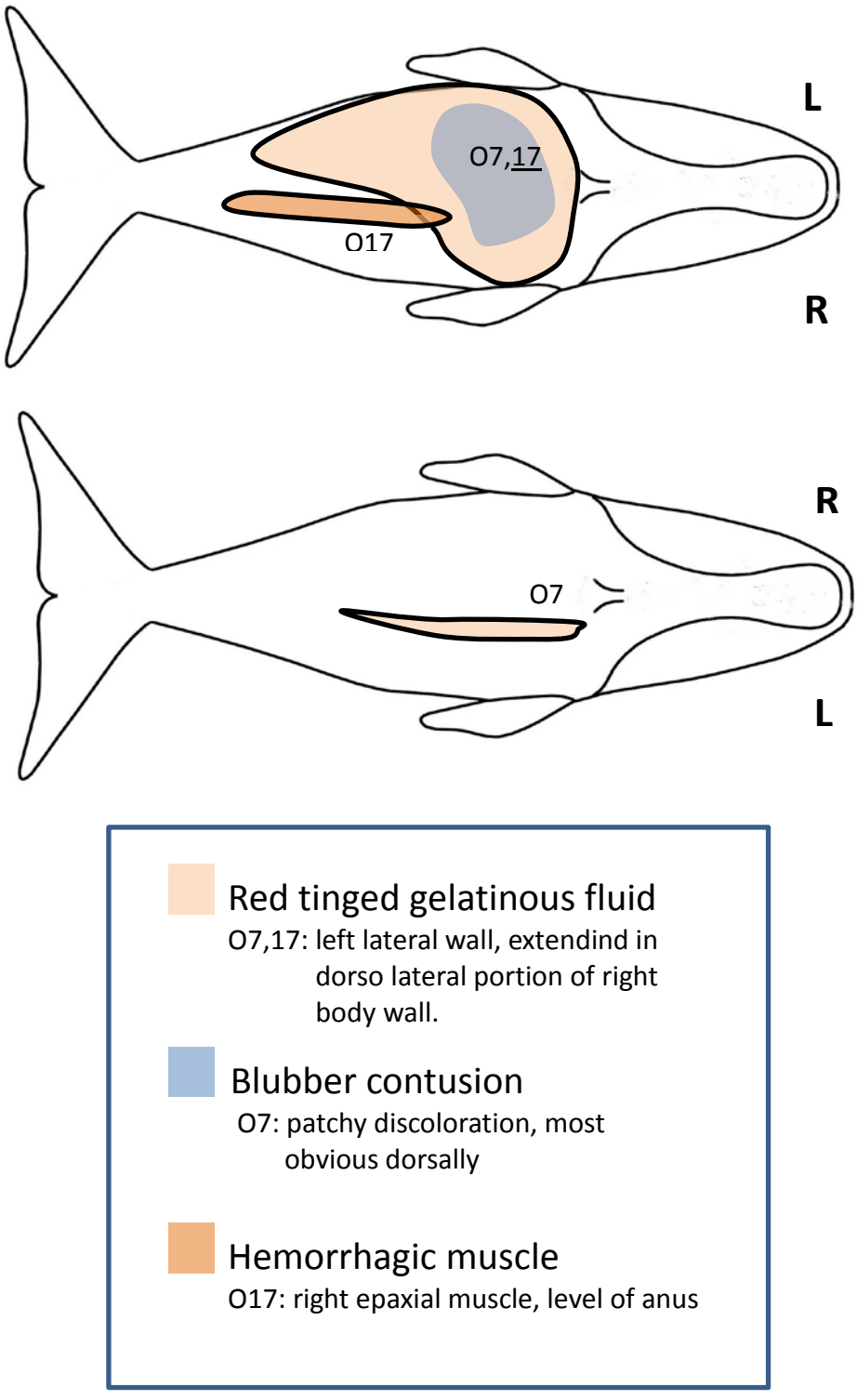


Figure 9b. EG#8. Distribution of observations potentially associated with blunt trauma.

Wildlife Diagnostic Report – EG#9

Necropsy#: EG#9; MARS2017-312; NEAq Catalog #4504 – 2 year old female

Incident Information

Species: North Atlantic Right Whale (*Eubalaena glacialis*)
Age: Juvenile (2 years)
Sex: Female
Necropsy date: 19 September
Location: Miscou Island, New Brunswick

Finder/Submitter Information

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

Information Provided with Specimen

This whale was found dead on September 15 in the Gulf of St. Lawrence, off the coast of New Brunswick. It was towed to shore at Miscou Island, NB, on September 18. A necropsy was done on September 19 by members of DFO, MARS and CWHC (Atlantic and Québec regions).

This whale was subsequently identified by NEAq. It was approximately 2 years old at the time of entanglement. It was last sighted in August 2015 in the Gulf of St. Lawrence as a new calf with its mother (known from NEAq; whale #1604).

Diagnosis and Interpretation

Final Diagnosis

Acute entanglement in fishing gear and subsequent drowning (probable)

Interpretation

The relatively small size of this whale and the large amount of gear, including a snow crab trap, in which it had become entangled suggested that it had not been able to drag this gear over a long distance and had presumably quickly died from drowning. There were several dermal linear indentations in the cranial region of the body and around both flippers, but all of them were either very acute or very superficial ante-mortem lesions or post-mortem changes from fishing lines rubbing against the surface of the carcass, since there was no good evidence of associated chronicity such as fibrosis (scar tissue). Moreover, the line could easily be disentangled from the carcass, except where it was solidly anchored

at the base of the left and right racks of baleen in their caudal half, having cut deeply into the gum between two baleen plates on the right side. A single long, raised, linear ridge of dermis on the ventral surface of the body at the level of insertion of the right flipper was very suggestive of scar from a previous entanglement.

Test Results

Necropsy (19 September 2017)

Standard length: 11.1m[1]
Rostrum to angle of mouth: 2.66m
Rostrum to eye: 2.5m
Rostrum to ear: 2.8m
Rostrum to blowhole: 2.58m
Rostrum to flipper insertion: 2.94m
Rostrum to umbilicus: 5.98m
Rostrum to genital slit: 7.1m
Rostrum to anus: 7.7m
Anus to fluke notch: 3.5m

Flipper length at base: 0.72m
Flipper length (leading): 1.62m
Flipper length (trailing): 0.92m
Flipper width: 1.07m
Tail width: 3.49m
Left fluke width: 1.85m
Right fluke width: 1.9m
Notch to tail insertion: 0.88m
Fluke depth: 0.86m

[1] likely affected by multiple vertebral dislocations

(See Appendix 1)

Blubber thickness was measured at seven locations from mid dorsal to mid ventral at nine levels from cranial to caudal. Averages were taken of the seven locations at each level: nuchal crest, 12.6cm; axilla, 13.4cm; 1/3 axilla-umbilicus, 10.6cm; 2/3 axilla-umbilicus, 11.0cm; umbilicus, 11.8cm; 1/2 umbilicus-anus, 9.1cm; anus, 9.6cm; 1/2 anus-notch, 9.8cm; tail insertion, 8.5cm. (See Appendix 2)

Immature female (2 years old). The animal presented with thin blubber (9.2cm on the mid-dorsum, 11.3 on the mid-ventrum). However, this blubber thickness may have been distorted as the carcass was stretched from being pulled on the beach or may have been affected by the very advanced degree of decomposition of the carcass. Decomposition condition code 4. The thoracic and abdominal regions are markedly deflated (Figure 1). Most of the epidermis has sloughed off, although large sheets are still present in the rostral region of the mandible. All baleen plates are present, but the mouth had been partly closed when floating at sea because of the nature of the entanglement in fishing gear. Dislocation and multiple fractures of several vertebrae, particularly in cranial thoracic region (presumably post-mortem). Most or all of the vertebral epiphyses are un-fused, compatible with the animal's very young age. One kidney and multiple segments of the intestinal tract can be identified. A large proportion of the intestinal segments are in the thoracic cavity and pharyngeal region. An intestinal segment still located in the abdomen contains a few pale brown masses that have the distinct appearance of fecal material. No other organ can be located. A clitoris was identified, but no other portion of the reproductive tract was found. There is no evidence of dark brown putty-like material anywhere, except for a few small fragments among some muscle masses. Conspicuous observations at necropsy included:

- Entanglement of the head and both flippers, but particularly the left, by a yellow line with black bars, which is spliced to a tricolor line and entangled with a green line. End of tricolor line is attached to an old rusted snow crab trap.

- Although the line is wrapped around the rostrum and mandible and around the base of the left flipper, leaving several shallow indentations in the denuded dermis, none of these indentations, except possibly those around the left flipper (Figure 2) and dorsal surface of rostrum (Figure 3), leaves any evidence of chronicity such as fibrosis (scar tissue), and the line can be easily disentangled from these regions, including the base of the left flipper. It also appears that the line has slipped from some of its original locations during towing at sea and/or when the carcass was pulled ashore as some of the indentations do not match the location of the line (Figures 4-6).

- A length of the line is solidly anchored at the base of the left (Figure 7) and right racks of baleen in their caudal half, the line having cut deeply into the gum between two baleen plates on the right side.

- Long, raised, linear ridge of dermis, approximately 1 m long, on ventral surface of body at level of insertion of right flipper, very suggestive of scar from previous entanglement (Figure 8).

- Circular to elliptical lacerations, approximately 10-12 cm in diameter, along ventral surface of peduncle (Figure 9), caudal edge of right fluke, and distal region of right flipper, consistent with post-mortem scavenging by shark (possibly a Greenland shark [Dr. Chris Harvey-Clark, Dalhousie University, personal communication]).

- Dark red discoloration of inner half of blubber and relatively small amount of pale red gelatinous material between blubber and muscle layers in dorsal thoraco-lumbar region (Figure 10). This would be a post-mortem change (gravitational pooling of fluids) rather than evidence of ante-mortem bruising, considering the most likely cause of this animal's death.

- Relatively small amount of red gelatinous material around left scapulo-humeral joint (Figure 11a). The epiphysis of the left humeral head has separated from the diaphysis at the growth plate, revealing a very irregular surface (Figure 11b). This is presumably a post-mortem change since there is no indication of associated hemorrhage. (Microscopically, short columns of cartilaginous tissue similar to those in the right epiphysis can be recognized at the interface with the diaphysis.)

See Appendix 3 for detailed description of observations made in the carcass.

Entanglement (as described by Tonya Wimmer, MARS)

The gear remaining on the whale at the time of the necropsy consisted of ~152.09 m of three kinds of rope that were spliced into one length of rope and one snow crab trap. The snow crab trap attached to the tricolour rope was removed at the beach to facilitate bringing the animal ashore. The three lines involved were: 1) ~54.81 m of 3/4 in diameter 3-strand tricolor (red, white and blue) rope, 2) ~62.32 m of 7/8 in diameter 3-strand yellow rope, and 3) ~34.96 m of 3/24 in diameter 3-strand green rope. A 6-8' older style trap was attached to the end of the tricolour rope (Figure 12). Upon examination at the beach, it was determined that only the yellow rope (the middle segment) was involved in the wraps observed around the various parts of the animal (both flippers, the rostrum and the body). The tricolour

and green ropes were spliced to the yellow rope, but neither was found to be wrapped around the animal.

One trailing end of the rope configuration exited the animal's mouth. Following that piece of rope back to map out the entanglement, the rope entered the mouth and exited the baleen approximately midway along the jaw and midway along the length of the baleen. Once exiting the mouth, it ran between the baleen and the lower mandible, along the corner of the mouth, beneath the eye and then around the leading edge of the right flipper. The rope looped around underneath the flipper to the trailing edge and then across the animals back where it wrapped around its left flipper from the trailing edge to the leading edge. The line then ran across the head from the left to the right side of the whale, behind the whale's blowholes. At this stage in the rope, there was a loop (tied with a small piece of twine). This loop draped across the head of the animal, extending around to the ventral surface, forward of the flippers. The loose end of the loop wrapped around the upper rostrum of the animal once and tightly through the baleen on both sides along the lower mandible. After this, the loose end was threaded through the loop already mentioned and then extended across the ventral surface of the animal, trailing out the back of the animal with the snow crab trap attached. Given the size of the trap, it is likely that this line threaded through the man-made loop was the configuration before the animal encountered the gear (i.e., it is unlikely that the trap could have fitted through the loop in the rope).

Histology (AVC X22834-17)

Total of 9 tissues embedded in paraffin blocks and examined;

Slide 1 (observation 18): Dense collagen and some superficial pigmented epidermis, but otherwise no recognizable feature.

Slide 2 (observation 19): Good long section (from surface inward), but no pathological process identified.

Slide 3 (observation 20, left epiphysis): Short columns of cartilaginous tissue lined by thin layers of osseous tissue can be recognized at the interface with the diaphysis.

Slide 4 (observation 20, right epiphysis): A well-defined growth plate can be identified.

Slides 5,6 (observation 2): Good section from surface (dermal papillae still present?) inward; no pathological process identified; only dense collagen present.

Slides 7,8 (observations 5a, 5b): Finally, a discrete microscopic lesion, matching its discrete macroscopic appearance; bundles of collagens that are densely more compacted than those in the surrounding tissue.

Slide 9 (observation 8): Good section, composed only of collagen; no pathological process identified.

Other Tests

Fecal samples: Baseline levels of fecal glucocorticoids, used as potential indicator of chronic stress (more than 2 days, based on gastro-intestinal transit time in this species), were found in this whale, suggesting

that it died before an elevated response to stress by the adrenal glands could be reflected in a rise in fecal glucocorticoids (Endocrine Laboratory, New England Aquarium).

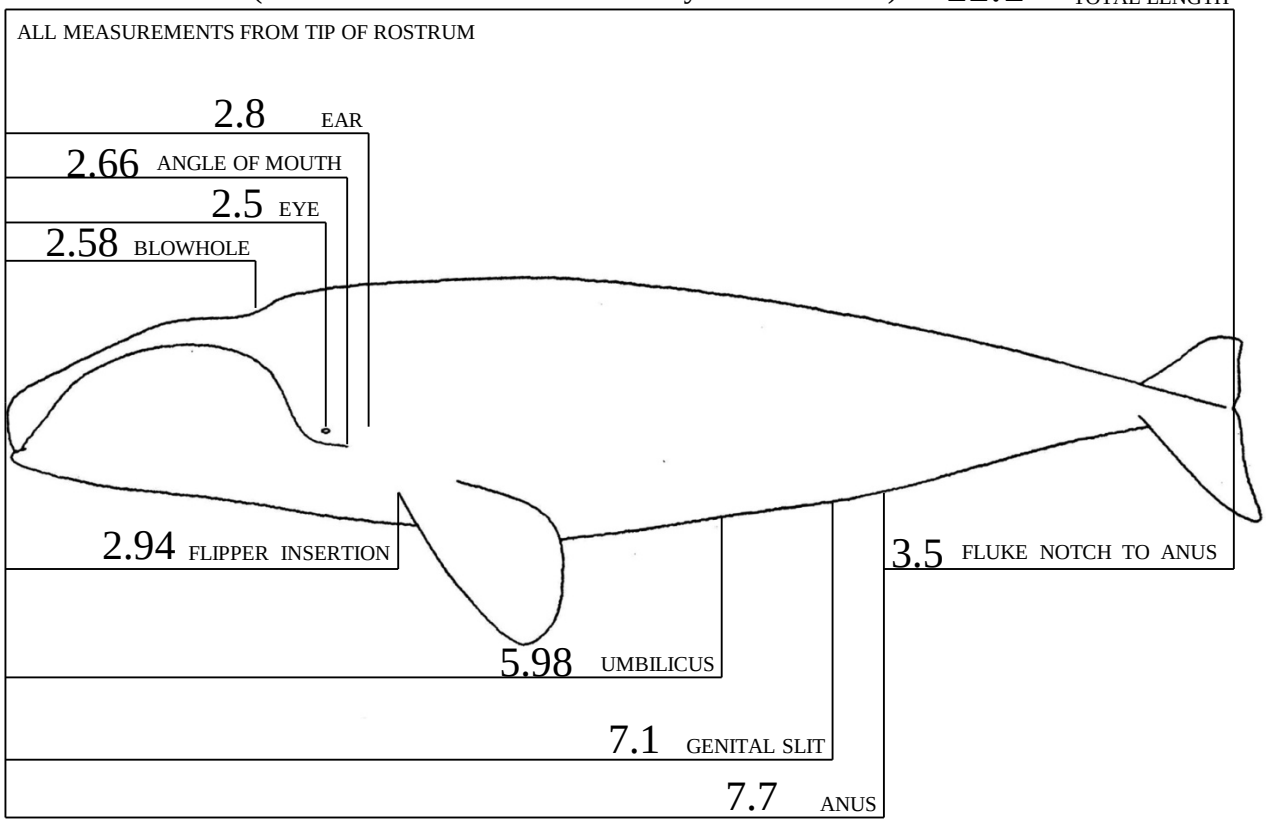
Inventory of Frozen Samples

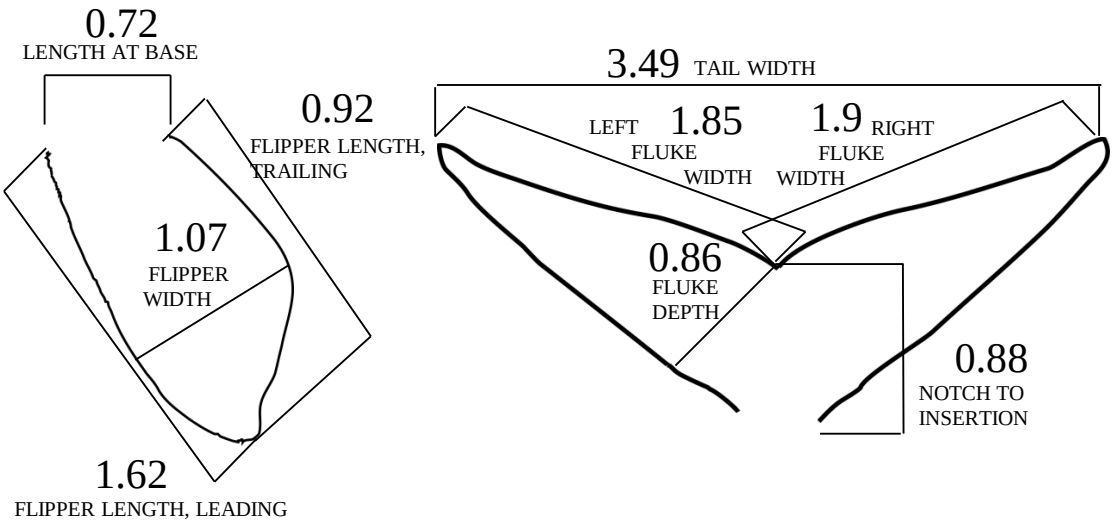
- Clitoris (for Dara Orbach, Dalhousie U.)
- Kidney
- Intestinal content
- Distal rectum content
- Feces
- Left ear

Appendix 1. Right Whale EG#9 External Morphometrics

WRITE MORPHOMETRICS ON LINES

(several dislocated vertebrae – may not be reliable) 11.1 TOTAL LENGTH

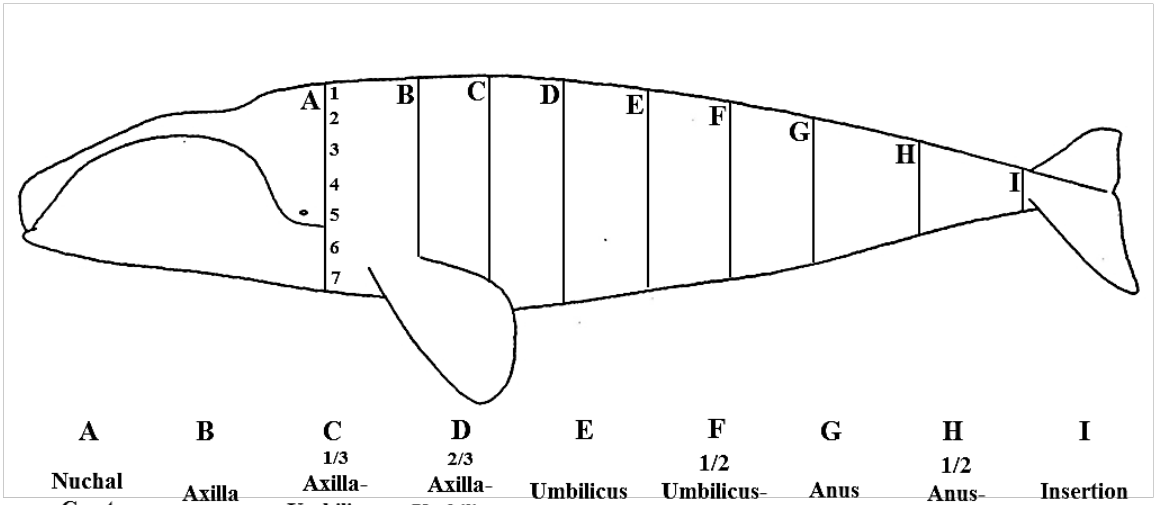




*measures in meters

Appendix 2. Right Whale EG#9 Blubber Thickness

Field # MARS2017-312 **Side Examined** ____ **Observer** _____ **Date** 19 September 2017



	A	B	C	D	E	F	G	H	I
	Nuchal Crest	Axilla	1/3 Axilla-Umbilicus	2/3 Axilla-Umbilicus	Umbilicus	1/2 Umbilicus-Anus	Anus	1/2 Anus-Notch	Insertion
Dorsal									
1	12.2	n/a	8.1	8.9	7.6	9.2	11.5	8.0	10.1
2	11.8	13.2	10.9	9.8	10.1	7.5	12.5	9.2	6.5
3									
4	12.0	11.6	10.5	9.7	9.0	9.2	8.3	10.7	7.6
5	11.3	16.0	10.4	9.8	10.7	7.2	9.5	9.6	6.8
6	15.8	14.8	11.5	11.1	11.0	8.9	8.4	9.2	7.6
7	n/a	11.2	10.2	13.5	20.4	11.3	8.0	11.7	10.6
Ventral									
	12.6	13.4	10.6	11.0	11.8	9.1	9.6	9.8	8.5

Note: all measurements are in cm

APPENDIX 3: External and internal observations by number

(Asterisks indicate observations of potential clinical significance)

Observation number	Physical location	Description	Photos taken (Y/N)	Histology taken (Y/N)
1	Dermis of left mandible	Linear area of erosion / indentation approximately 1.2m long by 4cm wide. Extends from ventral midline (cranial to the level of the eye) to ventral surface of mid-region of left mandible. No associated lesion on cut surface. Large sheet of epidermis covers this indentation, indicating that the latter is a post-mortem change.	Y	N
2	Body wall cranial to left flipper	Linear dermal erosion / indentation, oblique cranial to left flipper, bordered by a white zone 2cm wide. No associated lesion on cut surface. Two segments of the lesion separated by 4cm of unaffected dermis. Each about 0.3m long and range 4cm to 8cm wide.	Y	Y
3	Ventral body surface, at level of flippers	Two linear areas of dermal indentation beginning on either side of the right flipper, extending across ventrum and meeting at leading edge of left flipper. Linear areas consist of 2-3 parallel lines (1-2cm wide). No associated lesion on cut surface.	Y	N
4	Rostral region of left mandible	Linear area of erosion, 12cm long by 2.5cm wide; also thought to be post-mortem	Y	N
5a*	Ventrum, at level of right flipper insertion	Raised linear ridge of dermis surrounded by a faint white zone, extending caudally. Approx. 1m long by 2cm high. On cut surface of this ridge, well-demarcated white circular area.	Y	Y
5b	Caudal to lesion #5	Linear area of depigmentation caudal and perpendicular to lesion #5a, approx. 0.4m long. Does not extend on cut surface.		
6	Ventral surface, level of sternum	Several irregular areas of dermal depression with black pigmentation. Do not extend on cut surface. Range from 0.3 to 0.7m long.	Y	N
7a	Ventral peduncle	Circular to elliptical lacerations, approx. 10-12cm in diameter, consistent with post-mortem scavenging by shark. One portion of flesh has been removed, creating a crater		

	in the shape of a half-sphere.			
7b	Caudal edge of right fluke	Circular to elliptical lacerations, approx. 10-12cm in diameter, consistent with post-mortem scavenging by shark.	Y	N
7c	Ventral surface of leading edge of most distal region of right flipper	Circular to elliptical lacerations, approx. 10 to 12cm diameter, consistent with post-mortem scavenging by shark.		
8	Ventral peduncle	Linear areas of black pigmentation, cranial to and overlapping observation #7a, and extending slightly on right side. Barely extend on cut surface.	Y	Y
9	Ventral surface of insertion of right fluke	Linear area of deep erosion / indentation, approx. 0.5m long by 5cm wide, presumed to be post-mortem.	Y	N
10	Dorsal thoraco-lumbar region	Relatively small amount of pale red gelatinous material between blubber and muscle layers, beginning at level of right flipper's leading edge. Extends from right side about 1m dorsally to flipper insertion.	Y	N
11	Lateral body wall, caudal to right flipper	Linear area of dermal indentation (2cm wide).	Y	N
12	Leading edge of insertion of right flipper	Dermal indentation, 7cm wide and extending ventrally. Does not extend on cut surface.	Y	N
13*	Right axilla	Active entanglement of right flipper extending its width by yellow/black line, leaving an indentation that slightly extends by 1cm into dermis on cut surface.	Y	N
14*	Ventral surface of insertion of left flipper	Prominent network of (congested) blood vessels in dermis.	Y	N
15a	Cervical vertebral region	Multiple irregular bone fragments, thought to be transverse processes, 4-10cm long and 4cm thick.	Y	N
15b	Vertebral column, approx. 0.7m from foramen magnum	Marked dislocation and multiple fractures of vertebral bodies, thought to be cranial thoracic vertebrae.	Y	N
16	Dorsal body wall, lumbar region	Faint parallel lines of pigmentation, approx. 30cm long by 2cm wide; do not extend on cut surface.	Y	N
17	Dorsal thoraco-lumbar region	Dark red discoloration of inner half of blubber.	Y	N

18*	Dorsal surface of rostrum, midway between rostral tip and blowhole	Linear indentation, slightly thickened on cut surface.	Y	Y
19*	Left axilla	Active entanglement by yellow/black line, leaving a slight tear and indentation. On cut surface, extends slightly into dermis by 1cm. Dermis slightly firmer on palpation	Y	Y
20 ***??**	Left scapulo-humeral joint	Relatively small amount of red gelatinous material around the joint. Irregularly red joint surfaces, and presence of stringy friable material on both surfaces, more prominent on humeral surface. Epiphyseal plate of humeral head separated, revealing a very irregular surface as compared to that of the right humeral head which is firmly attached to the diaphysis and is regular and firm and of an opaque whitish color. The irregular surface of the left epiphyseal plate is covered with red material with a mucoid texture	Y	Y
No number*	Left and right racks of baleen	Length of the line solidly anchored at the base of the left and right racks of baleen in their caudal half, the line having cut deeply into the gum between two baleen plates on the right side.	N	N

Figures (78 other photos available)

Figure 1. Very advanced stage of post-mortem decomposition of the carcass. The thoracic and abdominal regions are markedly deflated. Most of the epidermis has sloughed off.

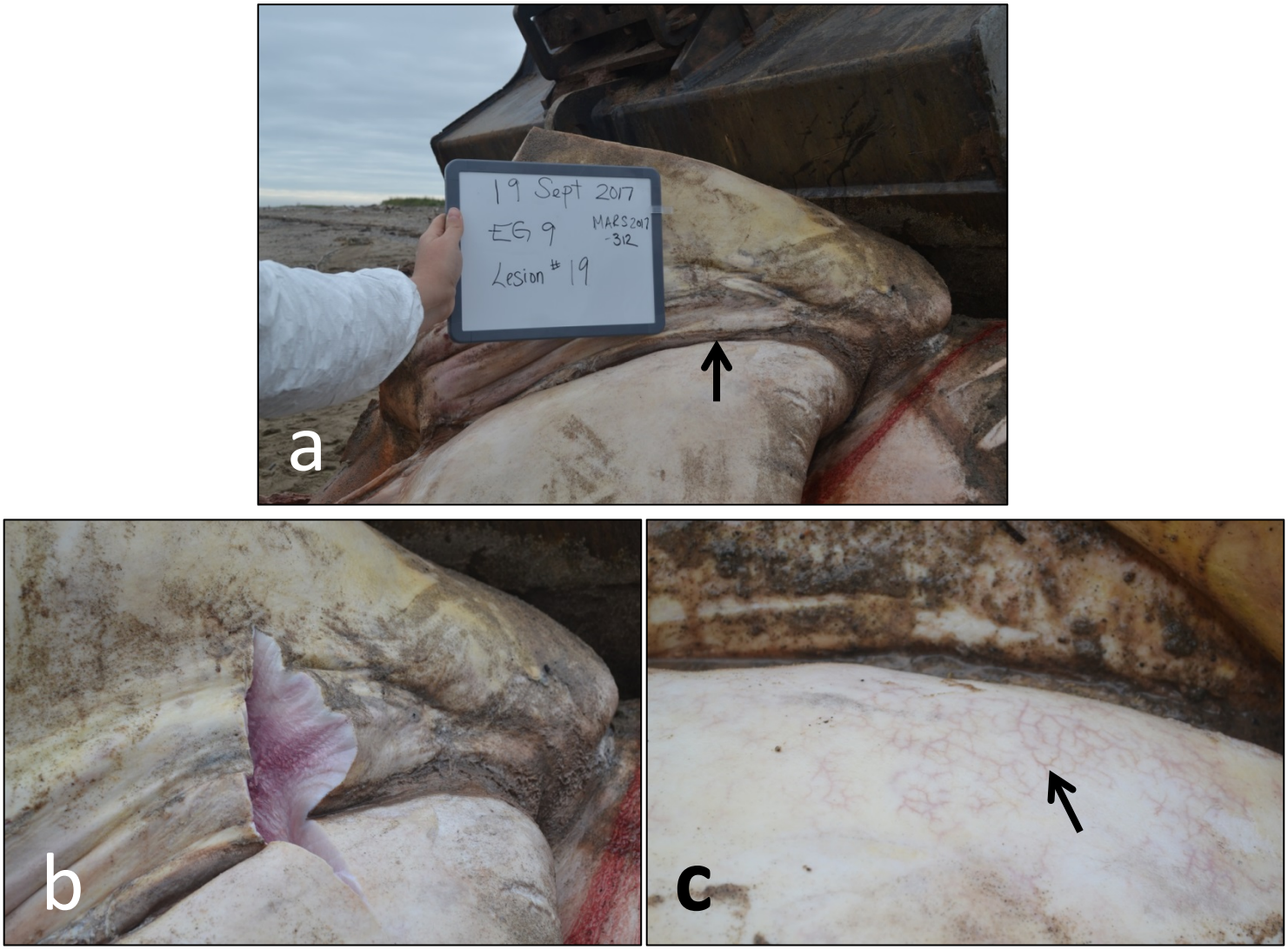


Figure 2. a) Slight dermal tear and indentation in axilla (arrow), presumably antemortem, left by line entanglement. b) On section, the dermis is slightly firmer on palpation. c) Prominent network of (congested) blood vessels in dermis (arrow), caused by restriction of return of blood flow due to pressure from the line?

Figure 3. Linear indentation on dorsal surface of rostrum, midway between rostral tip and blowhole, slightly thickened on cut surface (insert).

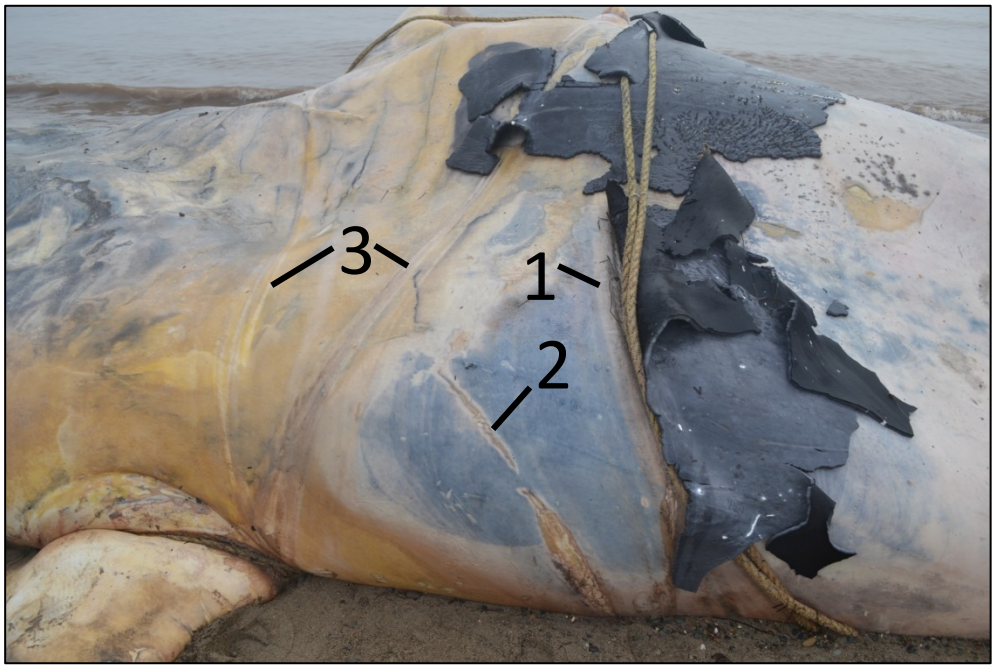


Figure 4. Several linear areas of dermal erosion / indentation on ventral surface of head. There was no associated lesion such as scar tissue formation on cut surface of these areas. One of them was associated with a rope, but both dermis and rope were covered by a sheet of normal epidermis. Therefore, all these linear areas may have been caused by ropes after the animal's death.

Figure 5. Linear area of dermal indentation caudal to right flipper (arrow). The line indicated by an arrowhead is shown in more details in Figure 6.

Figure 6. Line indicated by an arrowhead in Figure 5.

a) The line passes ventrally to the right eye and extends cranially underneath the right lip.

b) The line extends caudally along the right axilla, leaving an indentation into the dermis.

Figure 7. A length of the line is solidly anchored at the base of the left rack of baleen in its caudal half (arrow).

Figure 8. Linear ridge of dermis (arrow), approximately 1 m long, on ventral surface of body at level of insertion of right flipper. Inset: A section of this ridge reveals a well-demarcated white circular area (arrow).

Figure 9. Circular to elliptical lacerations, approximately 10-12 cm in diameter, along ventral surface of peduncle, consistent with post-mortem scavenging by shark (possibly a Greenland shark). One portion of flesh has been removed, creating a crater in the shape of a half-sphere (arrow).

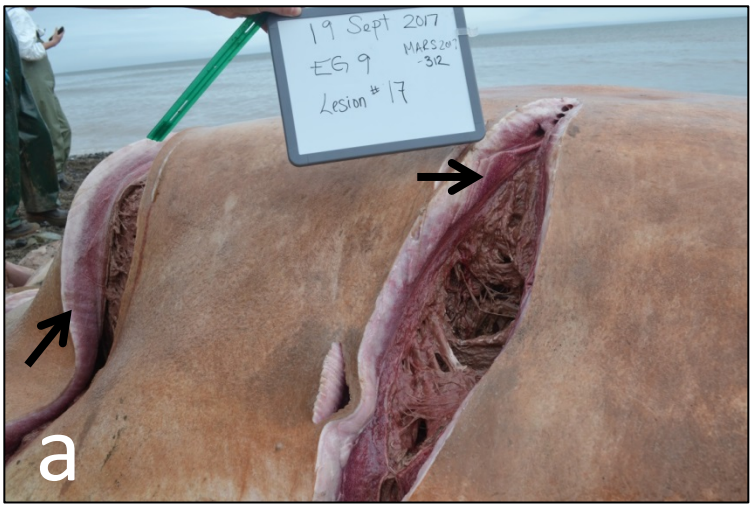


Figure 10. Dorsal thoraco-lumbar region.

a) Dark red discoloration of inner half of blubber (arrows).

b) Relatively small amount of pale red gelatinous material between blubber and muscle layers.

Figure 11. Left scapulo-humeral joint. a) A relatively small amount of red gelatinous material surrounds the joint. b) The epiphysis of the humeral head has separated from the diaphysis at the growth plate, revealing a very irregular surface.