SCIENCE ADVICE ON TIMING OF THE MANDATORY SLOW-DOWN ZONE FOR SHIPPING TRAFFIC IN THE GULF OF ST. LAWRENCE TO PROTECT THE NORTH ATLANTIC RIGHT WHALE

Context

In Canada, the North Atlantic Right Whale (NARW) is listed as Endangered under Schedule I of the *Species at Risk Act* (SARA), resulting in legal protection of the species and mandatory recovery planning. Under SARA, recovery actions associated with NARW are managed and/or administered by Fisheries and Oceans Canada (DFO). The SARA Recovery Strategy describe threats to the species, recovery objectives, and approaches for achieving them. Recovery objectives include reducing mortality and injury from vessel strikes and entanglements in fishing gear (DFO 2014). SARA Action Plans identify more specific measures to understand and reduce threats. The two most practical methods of decreasing the risk of NARW injury or mortality from vessel collisions are altering traffic routes and reducing vessel speeds (Vanderlaan et al. 2008). The two approaches to reduce entanglement injury and mortality outlined in the proposed Action Plan are the prevention/reduction of interaction with fishing gear and response to entanglement incidents (DFO 2016).

Since June 2017, 12 NARW have been found dead in the Gulf of St. Lawrence (GSL). Necropsies were conducted on 7 of these animals. In September 2017, the report from the first 6 necropsies confirmed 3 acute deaths from trauma consistent with vessel collisions, 1 mortality was the result of entanglement in fishing gear, and one carcass was very decomposed but did show signs of trauma (Daoust et al. 2017). In response to these mortalities, and prior to the release of the necropsy report, the Government of Canada implemented a voluntary speed restriction in the GSL for vessels greater than 20 m [65 feet] on 10 July 2017. On 11 August 2017, a mandatory slow-down zone (Figure 1; pink shaded area) was implemented. The zone, which requires all vessels greater than 20 m to reduce their speed to a maximum of 10 knots, is bounded by the following coordinates: 47° 10 N 62° 00 W; 47° 10 N 65 00 W; 50° 20 N 65 00 W; 50° 20 N 62 00 W (62,803 km^2 in total area).

On 2 November 2017, DFO Science was asked to provide immediate guidance to Transport Canada (TC) and DFO on the temporal adjustment of the slow-down zone in the GSL. Given the short timeline for a response, DFO's Science Response Process was used to deliver the advice. A more thorough advisory process will be needed to develop criteria for adjustments to mitigation measures (e.g., boundaries, speed and duration of speed restriction zones for NARW protection) going forward.

This Science Response addresses four questions:

1. When are North Atlantic Right Whales expected to leave the mandatory slow-down zone in 2017, and how will we know when they have moved?
2. When are North Atlantic Right Whales expected to leave the broader Gulf of St. Lawrence and Cabot Strait area in 2017, and how will we know that they have gone?
3. What is known about when North Atlantic Right Whales will return to the mandatory slow-down zone in the spring of 2018, and in what numbers?

4. What is known about when North Atlantic Right Whales will return to the broader Cabot Strait and Gulf of St. Lawrence area in the spring of 2018?

This Science Response Report results from the Science Response Process of 1 December 2017 on the Science Advice on Timing of the Mandatory Slow-Down Zone for Shipping Traffic in the Gulf of St. Lawrence to Protect North Atlantic Right Whale.

Background

Population Estimate

The NARW is considered one of the most critically endangered of large whales in the world. According to the latest population modelling, the NARW population increased from 270 individuals in 1990 to 482 individuals by 2010, but has since declined to an estimated 458 (95% Credible interval = 444-471) individuals in 2015 (Pace et al. 2017). Of particular concern is the divergent trend in male and female abundance within the population with males being more abundant (272 in 2015) than females (186 in 2015), resulting from a lower female survival rate after age 5 as compared to males (Pace et al. 2017). The recent decline in the population has resulted from a combination of increased mortality and decreased productivity (Meyer-Gutbrod and Green 2017; Pace et al. 2017). Some of these changes in productivity may be related to suspected changes in food availability, estimated from an index of abundance of *Calanus finmarchicus* in the Gulf of Maine (Meyer-Gutbrod and Greene 2017).

Population Range and Distribution

The NARW ranges from Florida to Iceland and Norway, although there is not one area within their range where all NARWs are present at one time (Davis et al. 2017; Brilliant et al. 2015; Mellinger et al. 2011; Jacobsen et al. 2004). Their regular seasonal use of some specific areas has resulted in the identification of Critical Habitats in both Canada and the United States, and has allowed for dedicated survey efforts and field studies to collect data on the population. However, it was recognized that several regions in Canada could benefit from increased search efforts to determine their use by NARWs, such as the GSL, most Scotian Shelf waters and north of Newfoundland (Pace et al. 2017; Brilliant et al. 2015, Knowlton et al. 2012).

NARW have been observed in the GSL for many years (Figure 1b). Their numbers in this area were previously considered to be low, but there has been limited dedicated effort during summer to locate NARW in Canadian waters outside of the Bay of Fundy and Roseway Basin. NARW were not detected in the GSL during large scale surveys of the GSL (Aug-Sep 1995 and July-Aug 1996, Kingsley and Reeves 1998; summer 2007, Lawson and Gosselin 2009; summer 2016, DFO unpublished data). These large-scale surveys in 2007 and 2016 also covered the coastal shelves and NARW were detected on the Scotian Shelf and in the Bay of Fundy in 2016 (DFO unpublished data). Prior to 2015, the Mingan Island Cetacean Study (MICS), the New England Aquarium (NEA), and the Canadian Whale Institute (CWI) carried out dedicated surveys for NARW in coastal waters around the Gaspé Peninsula and in the north-western GSL although effort around the Gaspé Peninsula was limited. However, there has been an increase in observations of NARW in the Gaspé-Magdalen Islands-Miscou area, since 2015. The increase in sightings from 2015 to 2017 is likely the result of both a change in the distribution of NARW and increased survey effort, particularly in the offshore area.

A relatively high NARW presence was documented in the GSL in 2017 (Figure 1a). Since June, multiple platform surveys have consistently detected NARWs in the southern GSL. The number of NARW identified in the GSL this season (as of 30 August 2017) was 117 individuals, or approximately 25% of the population (T. Cole, National Oceanographic and Atmospheric

Administration, *pers. comm.*). Although it is suspected that NARW presence in the GSL was higher in 2017 than in previous years, the fact that survey efforts to locate NARW this year far exceeded efforts conducted in the GSL in the past makes rigorous comparisons with previous years challenging.

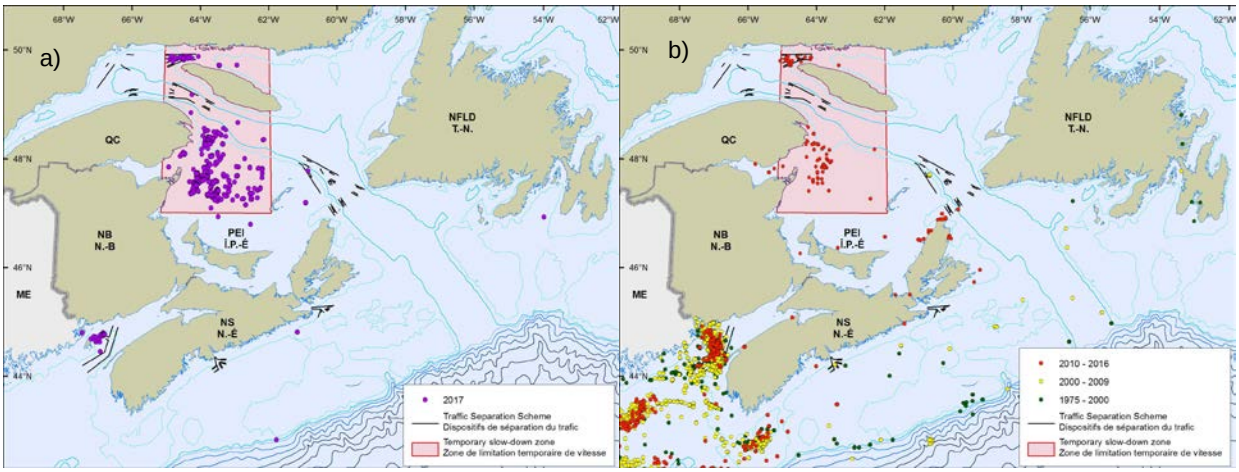

Figure 1. a) 2017 confirmed sightings of NARWs (left panel) and b) sightings of NARWs between 1975-2016 (right panel), with shipping slow-down zone indicated in shaded pink. Map includes sightings information from the DFO cetacean sightings database, which includes sightings from dedicated surveys and opportunistic sightings from DFO, NOAA, Canadian Whale Institute (CWI), New England Aquarium, Mingan Island Cetacean Study (MICS), whale watching companies and others. Disclaimer: this is a sightings map, not a distribution map and search effort is not presented. It is not known whether areas without sightings are due to whale absence or lack of search effort. (DFO Science, unpublished data; 2017 sightings updated to 5 December 2017).

Threats to the Population

The two main identified causes of NARW mortality throughout the species' range are vessel strikes and entanglement in fixed fishing gear (DFO 2014; Knowlton et al. 2012; van der Hoop et al. 2013; Kraus et al. 2016; Meyer-Gutbrod and Greene 2017). NARW are vulnerable to ship strikes due to their large body size, relatively slow swim speed, use of coastal habitat with high maritime traffic, feeding at or near the surface, and the fact that they must breathe at the surface (Wiley et al. 2016). Mating behaviour at the surface may also increase vulnerability to ship strikes.

While the total level of human-caused mortality and serious injury throughout the entire range of the NARW population is unknown, the reported human-caused mortality and serious injury in US and Canadian waters was estimated to be a minimum of 5.65 NARW/year from 2010 through 2014 (NOAA 2017). The estimated serious injury rate from fishing gear of NARWs in the Canadian Atlantic was 1.7 NARW/year between 2008 and 2014 (based on opportunistic sightings) (Themelis et al. 2016). Both aforementioned values exceed the Potential Biological Removal[1] (PBR) estimate of 1.0 for this species (NOAA 2017), while the 2017 reported mortalities are an order of magnitude above the PBR. Moreover, out of the 12 carcasses reported in eastern Canada in 2017, 4 were females, of which 2 were mature adults (9 years and older). The loss of females, combined with the small population size, means that any human-caused mortality can be considered to have significant population-level impacts.

[1] Potential Biological Removal (PBR) Level is the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population.

In the GSL, the maritime industry consists of 15 major international ports and 50 regional ports, ferry services with various routes, and a growing cruise ship industry. In 2017, the southern GSL Snow Crab fishery had a 101% increase in the quota due to the high level of crab recruitment (DFO 2017). This resulted in greater fishing effort and an extension of the fishing season for 2017, relative to previous years. In response to 2017 NARW mortalities and entanglements, DFO closed the Snow Crab fishery and implemented restrictions in various fisheries while TC placed speed restrictions on vessels in the zone that included the areas of high NARW abundance. The high number of reported NARW mortalities in the GSL in 2017 could be a function of increased numbers of NARWs in the Gulf, overlap among NARWs and major shipping routes (Simard et al. 2014), and increased fishing effort in the southern GSL. It is also partly a result of the increased likelihood of detecting mortalities in the area due to enhanced monitoring efforts by NOAA, DFO, TC, New England Aquarium, Canadian Whale Institute, Mingan Island Cetacean Study and others, as well as increased public awareness.

Analysis and Response

NARWs have been detected using a variety of methods including visual observations from aircraft, ships and boats, as well as from passive acoustic monitoring (PAM), either in real-time via an underwater glider or in delayed-time from fixed station hydrophones. In 2017, visual observation surveillance and deployment of a passive acoustic glider resulted in greatly increased surveillance effort compared to previous years. Additional information from the fixed PAM data stations collected in 2017 remains to be recovered and analysed but historical data are analysed. The following section is based on the information currently available.

Sources of Data

Prior to 2017, most surveys occurred between June and September, so the limited survey effort outside of this period provides little information to assess the seasonal occurrence of NARW in the GSL. The information currently available on the presence, distribution, and abundance of NARW in the slow-down zone, the GSL, and Cabot Strait areas in 2017 came from different platforms, as outlined above. For this Science Response, the data have been restricted to sightings prior to 6 June (first reported mortality) and sightings from September to December 2017 to provide information on the seasonal extent of NARW occurrence in the GSL. Additional visual and acoustic effort occurred between June and August 2017, but these data do not help delineate the outermost seasonal extent of NARW occurrence in the GSL and, therefore, will not be discussed in detail (sightings shown in Figure 1a). The information available for this Science Response came from the following platforms:

1. Aerial surveys conducted by TC and Environment and Climate Change Canada's Atlantic Marine Aerial Reconnaissance Team (MART) Dash 8 survey (at least twice a week from 8 August and continuing currently) and DFO's Twin Otter survey (dedicated from 29 August – 14 November) (Figure 2).
2. Boat surveys carried out by the MICS (June – 4 October), and marine mammal observers aboard DFO research vessel surveys (29 May – 28 September 2017).
3. Opportunistic sightings from DFO Conservation and Protection (C&P; Gulf, Quebec, Maritimes, and Newfoundland and Labrador regions - multiple times weekly throughout the year), the shipping industry, cruise ship industry, ENGOs, and the general public.
4. A passive acoustic glider arranged through collaboration among Woods Hole Oceanographic Institute (WHOI), Dalhousie University (DAL), and CWI researchers. The Teledyne Webb Research Slocum glider was equipped with passive acoustic listening system (DMON/LFDCS) in the southern GSL (5 June – 19 September; 3 – 27 October).

5. Nine PAM stations have been deployed within the GSL and Cabot Strait since 2010 to detect the presence of NARW up-calls. However, these stations did not provide the data in real-time, and only the data from 2011 to 2016 from these stations will be used to evaluate the seasonality of the presence of NARW in the slow-down zone and the broader GSL and Cabot Strait area.

Methods

Visual Surveys

Aerial surveys provided coverage of wide areas, estimations of abundance, and the photographs required for the identification of individuals to estimate the number of individuals that visited the GSL in 2017 (Figure 2).

Flights of both the DFO Twin Otter and the TC Dash 8 were prioritized to conduct comprehensive aerial surveys for large cetaceans of the main shipping lanes, as well as other areas of interest based on fisheries areas and a model of potential foraging areas for NARW (S. Plourde et al. DFO unpublished data). Flights using the TC Dash 8 were initiated on 8 August 2017 and are continuing at the current time. Flights to search for NARW using the DFO Twin Otter began on 29 August 2017 and ended on 14 November 2017. Observations were also obtained from a NOAA Twin Otter that was flying in the southern GSL area to search for and complete photo-id flights to estimate NARW abundance. Since these flights were limited to summer (22 June – 30 July), observations are included in Figure 1 but are not discussed further.

At least two observers were present in the aircraft to visually detect NARWs. The Dash 8 was also equipped with a high resolution visual and thermal sensitive camera with a dedicated operator to facilitate the identification of detected targets at greater distances. The Dash 8 flew at 1500 ft altitude and the DFO twin Otter flew at 800 ft altitude. The aircraft can detect cetaceans at distances of approximately 2 km from the trackline. The Dash flies at approximately 120 knots, while the Twin Otter flies at approximately 110 knots.

Sightings and, in certain cases, NARW photos from boat surveys and other opportunistic platforms were provided to DFO for inclusion in the whale sightings database housed in the Maritime Region. They were also provided to the New England Aquarium so that they could be matched to known individuals to contribute to the estimate of the number of NARW individuals present in the GSL in 2017.

Acoustic Data

A Slocum glider equipped with acoustic equipment was also deployed in the GSL in 2017. The glider moves up and down in the water column, at slow speeds (< 2 knots). The glider was already in the southern GSL prior to the first reported mortality; deployments occurred from 5 June – 19 September and 3 – 27 October 2017. The glider follows a course set by waypoints transferred during Iridium (satellite) communication sessions. Acoustic signals are received, recorded with the programmable digital acoustic monitoring (DMON) instrument and processed in near real-time using the onboard Low Frequency Detection and Classification System software (LFDCS; which calculates pitch tracks and runs the detectors through the raw audio data), and the processed data is communicated to a shore-side computer via an Iridium satellite link (Baumgartner et al. 2013). Whale detections have been confirmed by aerial/boat surveys for ranges up to 20 km from the glider (Baumgartner et al. 2013), although NARW are most accurately detected within 5 km (M. Baumgartner, Woods Hole Oceanographic Institute, *pers. comm.*). A protocol is in place to validate the detection data through examination of the pitch tracks.

PAM stations have been deployed within the GSL and Cabot Strait for multiple years. Efforts outside the mandatory slow-down zone include nine AURAL acoustic recorders in the broader GSL and Cabot Strait, including one off the north coast of Cape Breton and in the Strait of Belle Isle (Figure 3, red squares). The first recorder was deployed in late 2007; since then, the systems have been recording for various periods (Figure 4). Three hydrophones have also been deployed within the slow-down zone in the 50-100 m deep basin off the tip of the Gaspé Peninsula (Figure 3, blue squares) since mid-June 2011 by DFO-MLI and ISMER-UQAR. These PAM stations were deployed to determine the occurrence and residence of cetaceans based upon the occurrence of their specific calls, including NARWs contact calls (Parks and Tyack 2005; Parks et al. 2011), which are produced year-round (Davis et al. 2017). PAM deployments throughout the southern GSL are similar with the exception of cable length.

The three AURAL M2 autonomous recorders off the Gaspé (Figure 3, blue squares) were moored approximately 5 m above the bottom and sample the 16-dB pre-amplified signal with a 16-bit resolution at 8,192 or 32,768 Hz for 15 or 30 min every hour (Simard et al. 2016). The NARW up-calls were automatically detected based on spectrogram correlation with a 1-s synthetic upsweep call template from 100 to 200 Hz with a thickness of 20 Hz (Mouy et al. 2009). The recall index (i.e. percentage of detected true calls) of this algorithm is 49%, from manual examination of a subsample of the recordings at one station representing 109 true calls. The corresponding precision index (i.e., percentage of properly classified true detections) is 60%. All resulting detections were then manually checked and labelled as ‘true’ or ‘false’. Context was used to discriminate between NARW calls and other species. False detections were eliminated to produce a clean series of true detections used for the analysis. The median up-call detection radius at the central station was estimated following Simard et al. (2016). This radius was estimated to be approximately 40 km based on the probability distribution of the ambient noise in the NARW up-call band over one year, an up-call source level of 160 dB re 1 μPa rms at 1 m (Hatch et al. 2012; Mussoline et al. 2012; Parks and Tyack 2005), and parabolic equation (PE) propagation modelling in a radius of 200 km around the station (Aulanier et al. 2016). The metric used to report the NARW call occurrence is the number of hours in a day where contact calls were detected. It varies from 0, for days when no call was detected at any hour, to 24 for days when calls were detected at every hour of the day. This common PAM metric, therefore, does not report the calling density but the calling occurrence. It is, therefore, relatively robust to variable number of callers and changes in detection probability with range.

The recordings realized in the mandatory slow-down zone were made at 3 locations (Figure 3, blue squares). The Cap d’Espoir station was moved to Percé in June 2016, and the Shediac valley was monitored from June 2015 to October 2016 (Figure 4). For assessing the relative NARW occurrence from year to year in the mandatory slow-down zone, when 2 stations were recording at the same time, the highest of the 2 daily occurrences was used for the analysis.

Results

Visual Surveys

Generally, the aircraft were tasked to monitor the shipping lanes, potential foraging areas and/or where NARW had been detected earlier rather than focusing on the entire GSL. The Twin Otter flew almost 140 hours on effort between 29 August and 14 November, and the Dash 8 flew over 218 hours between 8 August – 5 December, resulting in over 45,000 km being flown by both aircraft and over 50 NARW sightings (Figure 2). The flights confirmed that NARW were present well into the fall, with an aggregation of more than 20 NARWs sighted in the southern Gulf on 13 November 2017, 5 confirmed sightings of NARW northwest of Anticosti Island (2 December 2017), and 6 NARW to the east of the Magdalen Islands (5 December 2017).

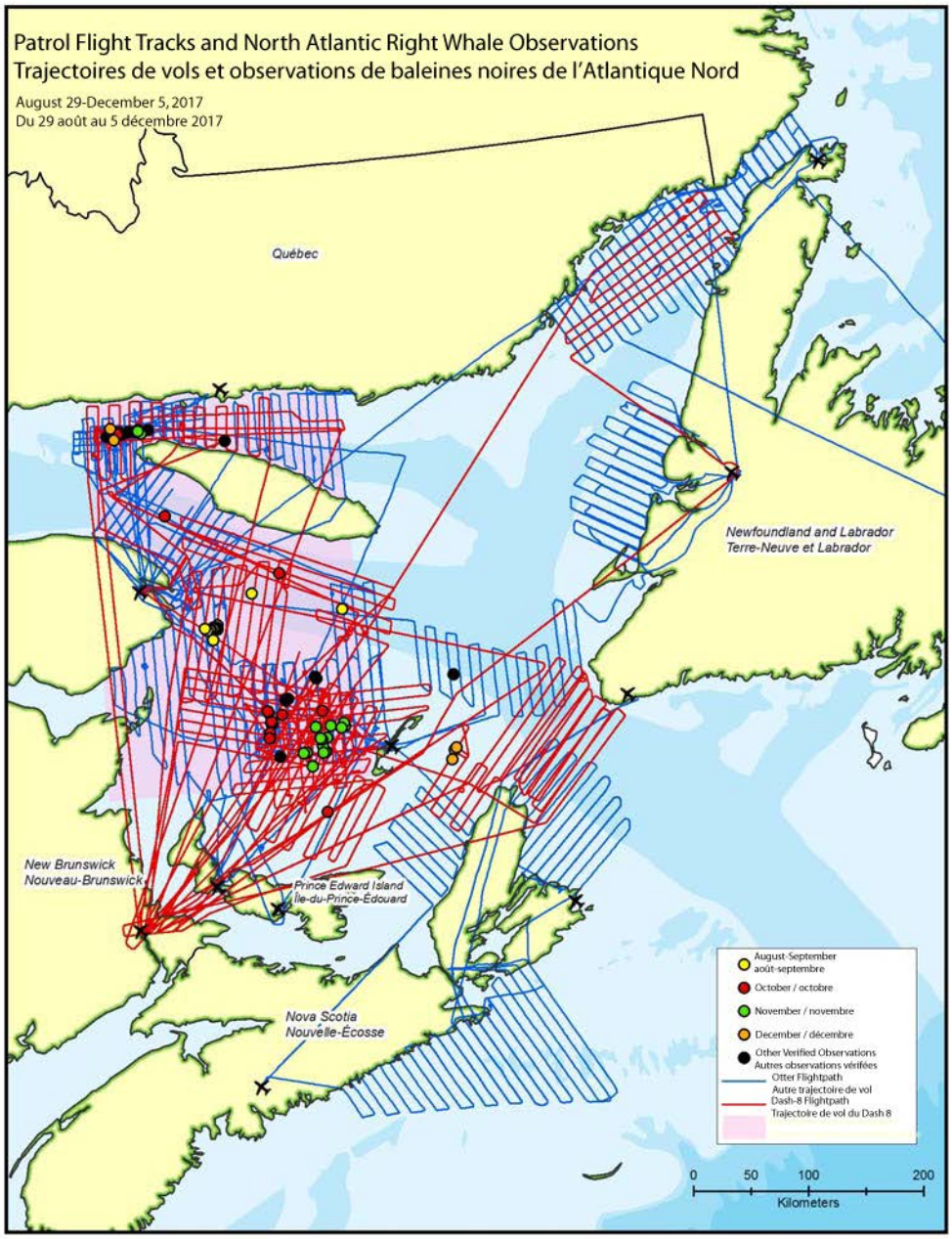

Figure 2. The DFO Twin Otter and TC Dash 8 flight coverage from 8 August to 5 December 2017 with the confirmed NARW observations (yellow, red, and green dots), as well as all other NARW observations reported by other platforms (black dots) within this restricted time frame. The mandatory slow-down zone is shaded in pink. (DFO Science, unpublished data; updated 5 December 2017).

Acoustic Data

The PAM glider operations were limited to the southern GSL. The PAM glider detected the presence of NARW fairly consistently throughout the first deployment and consistently up until mid-October in the second deployment.

The results presented below are partitioned by stations in the broader GSL and Cabot Strait (Figure 3; Other AURALS, red squares), and PAM stations off Gaspé Peninsula that are within the mandatory slow-down zone (Figure 3; PAM observatory, blue squares). The extent of the

data available from these PAM stations is presented in Figure 4. The Old Harry station, NE of Magdalen Islands, is the only station outside the mandatory slow-down zone where NARW up-calls were detected. The earliest detection of NARW by this hydrophone was 20 July in 2015; the latest date of detection was 2 January in 2013.

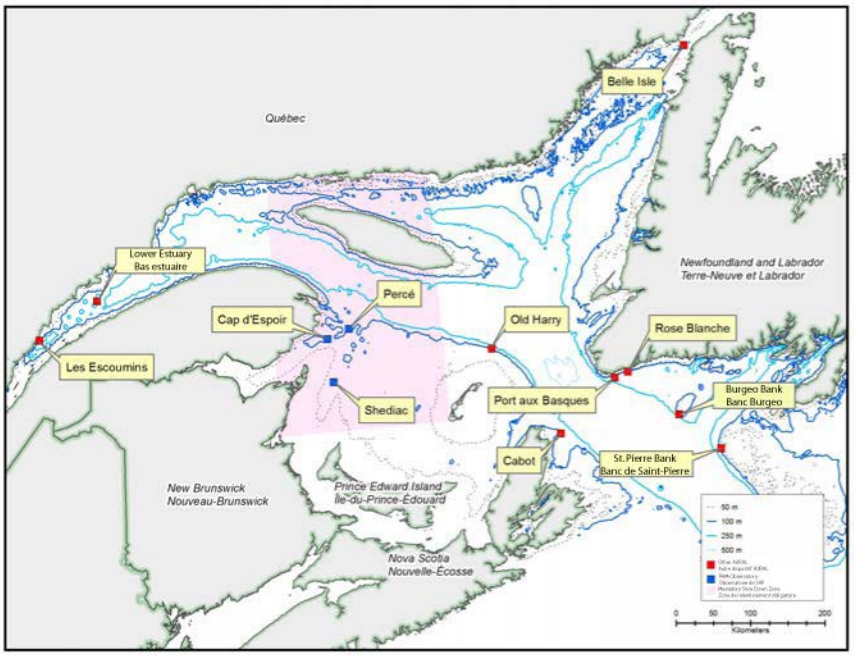

Figure 3. Location of the PAM stations (blue squares) off the Gaspé Peninsula, which are within the mandatory slow-down zone (shaded in pink) and other AURAL stations in the broader Gulf of St. Lawrence and Cabot Strait (red squares) The extent of the data available from these PAM stations is presented in Figure 4.

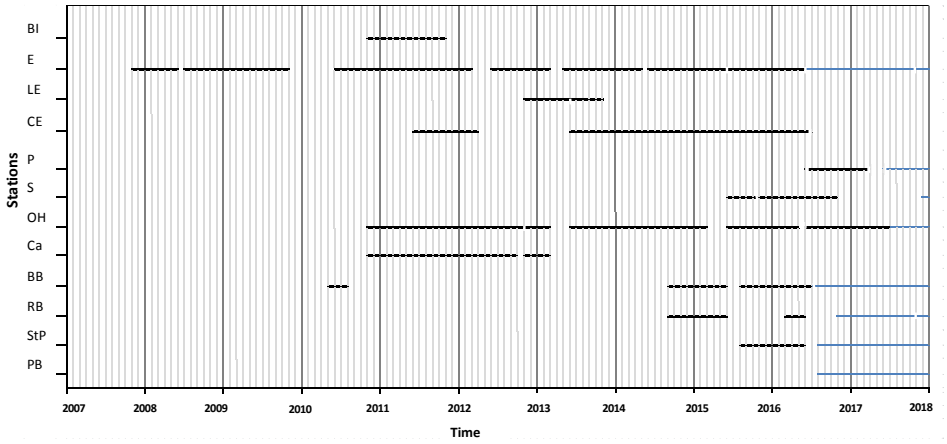

Figure 4. Archival operation timelines of the AURAL passive acoustic systems in and around the Gulf of St. Lawrence. The blue bars in the latter years show the systems which were recently retrieved or are still recording. Systems are downloaded once or twice a year for data retrieval and analysis. Each year is subdivided in 12 columns depicting the activity throughout the calendar year. (Legend: BI: Belle-Isle; E: Escoumins, LE: Lower Estuary; CE: Cap d'Espoir; P: Percé; S: Shediac; OH: Old Harry; Ca: Cabot; BB: Burgeo Bank; RB: Rose Blanche Bank; StP: St. Pierre Bank; and PB: Port aux Basques.

The PAM stations moored off Cap d'Espoir and Percé are close together, overlap in detection area, and provide the longest time-series of data within the slow-down zone (Figure 4). On average, NARW up-calls were detected from the beginning of June to the end of December, with occasional detections before June and into January (Table 1; Figure 5). Most detections (95%) occurred before mid-November, with the exception of 2015 where notable detections extended to December (Table 1).

In 2016, the earliest date that NARWs were detected at Cap-d'Espoir was 28 April followed by 25 May. At Shediac Valley, the earliest date of detection was 31 May followed by detections on 26 June (Table 1).

Table 1. Data from the Cap d'Espoir and Percé hydrophones showing progression (%) of hours with calls through the annual cycles, starting from 1 February (Note: in 2012, the recordings stopped on 12 April).

	Dates (mm-dd) of percentiles of total call detection hours						
Year	**>0%**	**5%**	**25%**	**50%**	**75%**	**95%**	**100%**
2011	07-22	07-22	08-05	08-18	08-21	11-20	11-20
2012	-	-	-	-	-	-	-
2013	06-19	07-14	08-06	08-15	09-13	11-22	01-02
2014	06-05	07-09	07-24	08-02	08-30	10-13	12-27
2015	06-02	06-29	07-31	08-21	09-25	12-08	01-15
2016	04-28	06-16	07-25	09-04	09-21	10-11	11-22
Mean	06-07	07-04	07-29	08-16	09-08	11-07	12-16

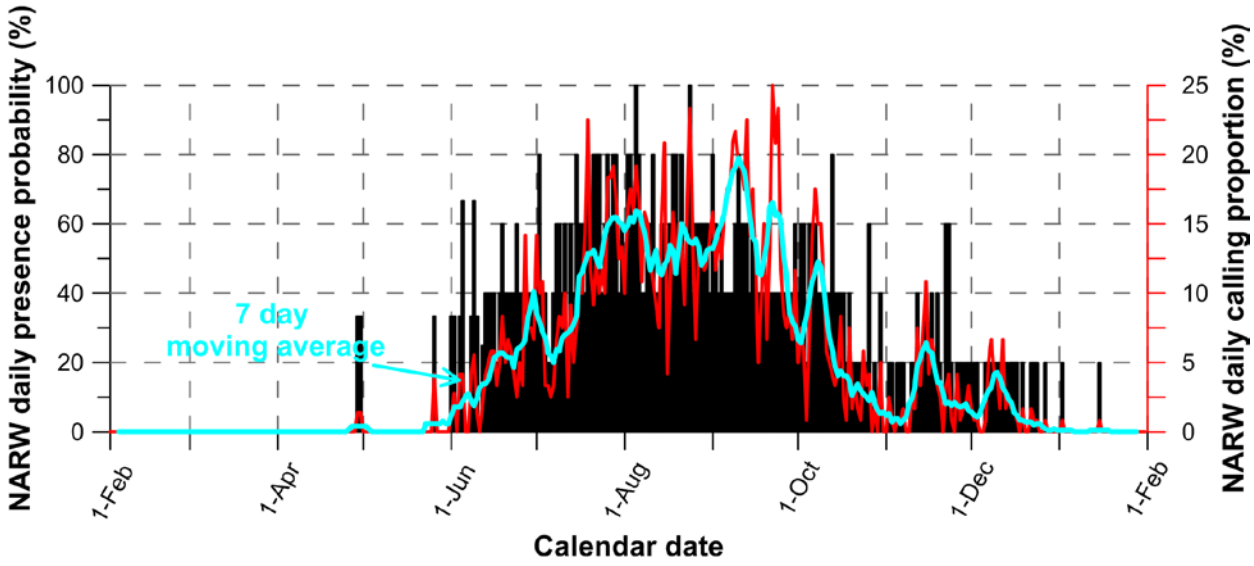

Figure 5. Probability of NARW presence within the Gaspé Peninsula through the annual cycle from 2011 to 2016 in the up-call detection time-series. Black bars: probability of detecting NARW on any given day. Red line: probability of detecting NARW in a given hour (cyan line = smoothed over 1 week).

Sources of Uncertainty

Several factors will affect the ability of both visual surveys (aerial or vessel) and PAM to detect NARW presence in the study area.

Sighting conditions, poor weather conditions (e.g., high winds-high waves, glare), observer experience, flying speed, altitude and size of the animal all contribute to our ability to detect whales at the surface (referred to as perception bias). However, whales are also missed

because they spend considerable proportion of time diving below the surface, meaning that they are not available to be seen (referred to as availability bias). In the fall and winter, poor weather conditions limit the number of flights resulting in infrequent coverage of the area as experienced in 2017. However, aerial surveys have the advantage of being able to cover large areas during short time windows of favourable weather conditions; they can provide information on the identification of individuals, abundance and precise location. Ships provide an alternative platform to aircraft, but these platforms are also weather-limited and their slow speed which is a positive feature to detect whales that re-surface, limits the amount of area they can cover in a day.

PAM provides valuable information either through fixed moorings or remotely-operated acoustic gliders. Acoustic measures, since they record data below the surface, are not subject to the same surface constraints as aircraft and vessels, i.e. detections are not affected by surface wave conditions. However, acoustic methods are also limited by detection and availability bias. Fixed moorings can provide continuous monitoring of the acoustic environment for the presence of marine mammals throughout the year, but they must be serviced to recover the data. The detection and localization spatial coverage is dependent on the call source level, ambient noise, and the 3D localization of the hydrophones in the basin (Simard et al. 2008). However, like gliders, their ability to detect whales is also affected by a combination of detectability and availability effects. Differences in bathymetry, water mass, bottom geo-acoustics, ambient noise, receiver depth and specifications, and signal processing algorithm will affect distances that PAM is able to detect the presence of NARW. In addition, whales need to vocalise for their presence to be detected (analogous to the diving whale problem for the aerial observer). NARW are considered to be relatively quiet animals (compared to humpback, blue and fin whales), although they are known to be more vocal when in surface active groups (SAG) (Parks et al. 2011). Finally, acoustic methods provide information on presence but do not easily provide an index of absolute abundance (but see Marques et al. 2009). Fixed acoustic arrays currently incorporate more sensitive hydrophones and provide larger spatial and temporal coverage than gliders, but fixed-station PAM must be recovered to download data although real time data transfer via cables to the coast (e.g., Canada West Coast ONC, OceanSonics Obs.) or via surface links and telecommunication have been identified (Simard et al. 2006).

PAM glider platforms slowly drift through the ocean and are capable of providing quasi real-time presence/absence information of whale vocalisations when the instrument surfaces, but currently their detection ranges are limited, they have limited operational range, and are unable to travel in certain areas, notably when currents are strong and would have a higher risk of being damaged or lost in high shipping traffic areas.

The factors that resulted in an apparent shift of NARW away from the Bay of Fundy and the movement of whales into the GSL are not currently understood. Additional information is needed on the availability and distribution of food resources, and the influence of other physical factors such as the presence of ice in the Gulf of St Lawrence, on the presence of NARW in the GSL.

Conclusions

There has been limited effort from aerial surveys and acoustic monitoring to evaluate the occurrence of NARW in the slow-down zone and the broader GSL. Most of the aerial surveillance has been limited to the summer months (July-August) so there is no data from these platforms on when NARW arrive in the GSL in the spring. Surveillance in 2017 is the only year for which there is visual information on NARW distribution and abundance in the GSL during the fall. As a result, this Science Response relies primarily on the PAM results for which

there is data with continuous seasonal coverage of parts of the slow-down zone and the GSL from recent years.

Both the aerial surveys and the passive acoustic monitoring have limitations, but used in combination these techniques provide complementary information needed to detect NARW in the GSL. Improvements to aerial surveillance and acoustic coverage, as well as development of real-time monitoring systems, would improve our ability to provide advice on seasonal occurrence of NARW in the GSL in the future.

When are North Atlantic Right Whales expected to leave the mandatory slow-down zone in 2017, and how will we know when they have moved?

Historical PAM data (2011-2016), with supporting evidence from recent aerial surveillance information, can both be used to address the question of when NARW are expected to leave the mandatory slow-down zone in 2017. Within the mandatory slow-down zone, most of the PAM detections (95%) generally occurred before mid-November; however, NARW detections extended into January in 2013 and 2015.

Observations from aerial surveys in 2017 indicated that at least 20 NARW were still present in the mandatory slow-down zone in mid-November, and 5 NARW were sighted at the beginning of December (to the northwest of Anticosti Island). Based on these data, a conservative approach would be to assume that NARWs may be present in the slow-down zone until late-December and possibly to mid-January.

Visual observations will be the primary source of direct information on when NARW have moved from the slow-down zone in 2017, as there is no ability to monitor PAM detection in real-time this year. For the remainder of 2017 and early 2018, the only platform currently available for real-time observations within the slow-down zone remains the TC (MART) Dash 8 aircraft. However, winter weather conditions, will limit how often this platform will be able to fly to determine in NARW are still present in the GSL and so direct observations may not be available to determine when whales have left.

When are North Atlantic Right Whales expected to leave the broader Gulf of St. Lawrence and Cabot Strait area in 2017, and how will we know that they have gone?

Except for the Old Harry station, most of the PAM stations outside the slow-down zone have not detected NARW calls in the past. This could be an indication of the absence of NARWs or related to the lack of vocalizing outside of the Gaspé area during the fall and winter periods. At the Old Harry station, they were detected as late as 2 January in 2013. Given the presence of NARW in the slow-down zone and at the Old Harry station until late December or into January in some years, NARW can be present in the GSL until at least this time. It is unknown how quickly they would leave the Gulf once they move eastward.

As of mid-November and weather dependent, the only avenue for real-time detection remains the TC (MART) Dash 8 aircraft. This aircraft will be available for large whale searches with DFO marine mammal observers aboard. Search areas will not be restricted to the slow-down zone and are designed to cover areas of high interest (based on predicted foraging potential), areas of NARW known presence, and shipping lanes. However, given the weather conditions and limited coverage, visual surveys cannot be used as a definitive indicator of when whales leave the GSL. Aerial searches detected a feeding aggregation of NARWs in the southern Gulf (13 November 2017), 5 NARW northwest of Anticosti Island (2 December 2017), and 6 NARW to the east of the Magdalen Islands (5 December 2017).

NARW are not expected to be present in the GSL when pack ice is present. Historically, much of the southern Gulf is ice covered by January. However, while there is a 40-year time series of

information available on historical ice cover, changing climate conditions with a recent warming trend suggests that these data would not be a good predictor of future conditions.

Based on these data, and as for the previous question, a conservative approach would be to assume that NARWs may be present in the broader Gulf of St. Lawrence and Cabot Strait until late-December and possibly to mid-January.

What is known about when North Atlantic Right Whales will return to the mandatory slow-down zone in the spring of 2018, and in what numbers?

The only information available on NARW presence in the slow-down zone in spring comes from historical PAM results and one sighting with photographic evidence in 2017. Return of NARW to this area could be affected by ice break-up and the timing of the spring plankton bloom.

Within the mandatory slow-down zone, NARW calls were primarily detected by PAM in June; however, NARW calls were detected on 28 April in 2016 and in early to mid-May in 2013, 2014, and 2015. In 2017, the earliest reported NARW sighting within the slow-down zone was on 13 May (47^{o} 39.95'N 063^{o} 17.56'W). Based on these data, a conservative approach would be to assume that NARWs may return to the area of the mandatory slow-down zone in early-May, and possibly late-April in 2018.

It is not possible to estimate the number of whales that might be in this area at this time based on the historic acoustic records. Also, given the variability in the numbers of whales observed in the Gulf historically, it is not possible to predict how many whales may be present in the Gulf of St. Lawrence in 2018.

What is known about when North Atlantic Right Whales will return to the broader Cabot Strait and Gulf of St Lawrence area in the spring of 2018?

PAM studies have detected NARW as early as 28 April in the GSL and the first NARW sighting was reported on 13 May 2017. The sighting was within the slow-down zone; therefore, NARWs were in the broader GSL for an unknown amount of time prior to this date. There were no visual surveys from aircraft or vessels during this time, and no other opportunistic sightings were reported.

Based on the PAM data, NARW could return to the Gulf/Cabot Strait as early as April. A cautionary approach would be to commence NARW surveillance programmes in April 2018, once ice leaves, and managers from both DFO and TC will need to be prepared to implement conservation measures at this time.

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