Fisheries and Oceans Canada
Pêches et Océans Canada

NORTH ATLANTIC RIGHT WHALE

A science based review of recovery actions for three at-risk whale populations

Canada

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Review of the Effectiveness of Recovery Activities for North Atlantic Right Whales

1. Context/Background

In November 2016, Canada's Oceans Protection Plan (OPP) was announced, which outlined several new initiatives aimed at addressing the threats to marine mammals in Canadian waters including the threats of contaminants, prey availability, and underwater noise. Under the OPP, the Government of Canada will take action to address the cumulative effects of shipping on marine mammals and work with partners to implement a real-time whale detection system to alert mariners of the presence of whales. As part of OPP, Fisheries and Oceans Canada (DFO) was tasked with launching a science-based review of the effectiveness of the current management and recovery actions for three at-risk whale species in Canada: the Southern Resident Killer Whale (*Orcinus orca*), the St. Lawrence Estuary Beluga (*Delphinapterus leucas*) and the North Atlantic right whale (*Eubalaena glacialis*). The review seeks to identify areas for immediate improvement in recovery efforts and priorities for new or enhanced actions. DFO adopted a phased approach for this review, and this document represents the first phase in that process and is focused on the recovery activities for North Atlantic right whale from a scientific perspective.

The North Atlantic right whale is considered one of the most endangered of all large whale species (Caswell et al. 1999, Kraus et al. 2005), and is federally protected under the Species at Risk Act (SARA) in Canada and the Endangered Species Act (ESA) in the United States of America (USA). Right whales throughout the Atlantic Ocean were considered a single species and first designated as endangered in 1980, and were re-assessed and confirmed as endangered in 1985 and again in 1990 (COSEWIC 2003). In 2003, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) recognised right whales in the North Atlantic as a separate wildlife species from those in the South Atlantic (Southern right whales; E. australis) and designated North Atlantic right whales as endangered (COSEWIC 2003). North Atlantic right whales were listed as an endangered species under the SARA in 2005 (COSEWIC 2013), and they are also listed as endangered under the International Union for Conservation of Nature's (IUCN) red list of threatened species (IUCN 2008). The species was re-evaluated by COSEWIC in 2013 and once again designated endangered (COSEWIC 2013).

Historically, intense whaling greatly diminished the number of North Atlantic right whales throughout their range (Aguilar 1986). Despite being internationally protected since 1935 (IWC 2001), the population has yet to increase to more than a few hundred individuals. This is in sharp contrast to southern right whales, whose numbers were also considerably reduced due to whaling, and have since exhibited an annual population growth rate estimated at 7% (Best 1990, Cooke et al. 2001) and are listed as "least concern" under the IUCN's red list of threatened species (IUCN 2008).

The population estimate for North Atlantic right whales was approximately 350 individuals in the mid-2000s (Kraus and Rolland, 2007). The population in 2015 was estimated to be 524 individuals based on the number of individually-identified photographed whales (Pettis and Hamilton 2016). The 'minimum number alive population index' (the minimum number of live whales in the population calculated from the individual sightings database) provides an estimated average population growth rate of 2.8% for the 1990-2011 period (Waring et al. 2016). However, due to a 40% decrease in the estimated calving rate since 2010 (Kraus et al. 2016), population growth rate in recent years (2012-2015) appears to be declining (Pace, 2016) and two out of the three population assessment methods demonstrate a decline in North Atlantic right whale abundance (Kraus et al. 2016 and references therein).

It has been hypothesized that the limited recovery of North Atlantic right whales may be due to decreased reproductive rates (Knowlton et al. 1994, Kraus et al. 2001), low genetic variability (Waldick et al. 2002), prey-field dynamics and reduced access to prey (Kenney 2001, Baumgartner et al. 2007, Michaud and Taggart 2007), and deleterious human activities such as vessel strikes and fishing-gear entanglement (Kraus 1990, Knowlton and Kraus 2001, Kraus et al. 2005, van der Hoop et al. 2013, Kraus et al. 2016). However, the only hypothesis that we can directly address is deleterious human activities to reduce mortalities and promote recovery.

2. Objective of this Review

This document provides a summary of recovery activities (measures) that have been developed and implemented to support the conservation and protection of North Atlantic right whales throughout their range (but with a focus on Canadian efforts) and aims to assess their overall effectiveness for achieving population recovery. Recovery activities are assessed from a scientific perspective only, and effectiveness of recovery activities are considered in terms of their ability to reduce threats that have been identified and associated with the endangered status of the population. This document also aims to identify how recovery objectives can be better achieved by accelerating implementation of recovery activities already identified but not underway, by identifying possible new measures, and by providing guidance on the relative priority of the measures intended to reduce risk of the identified threats to North Atlantic right whales.

3. Sources of Information

The Recovery Strategy for North Atlantic right whales in Atlantic Canadian Waters (hereafter referred to as the "Recovery Strategy") was published in 2009 (Brown et al. 2009) and amended in 2014 (DFO 2014). The Recovery Strategy outlines the interim recovery goal for the species, recovery objectives, and broad strategies that should be implemented to achieve recovery, and performance indicators for the recovery strategies. The proposed Action Plan for North Atlantic right whale in Canada: Fisheries Interactions ("hereafter referred to as the "Action Plan"; DFO 2016a) outlines specific recovery activities needed to

address the threat of fishing-gear interactions. The Report on the Progress of the Recovery Strategy Implemented for the North Atlantic right whale in Canadian Waters for the Period 2009-2014 (hereafter referred to as the "Progress Report"; DFO 2016b) describes recovery activities that have been completed or are underway. All three of these SARA recovery documents were consulted for the development of this review. The majority of the recovery activities presented here were obtained from the Action Plan and Progress Report. Other sources of information used include scientific primary literature, and reports from the National Oceanic and Atmospheric Administration (NOAA) and the International Maritime Organization (IMO).

4. Methods for Assessing Effectiveness of Recovery Activities

The interim recovery goal for North Atlantic right whales is:
"To achieve an increasing trend in population abundance over three generations" (DFO 2014).

In the context of this review, assessing the effectiveness of recovery activities is to be understood as examining the degree to which activities currently underway as well as those proposed in existing recovery documents have, or will, directly contribute to abating threats to North Atlantic right whales to reduce further population decline and help achieve the recovery goal for the population. Recovery activities already completed or underway since 2005 (the year of the SARA listing) will be considered; however, important activities prior to 2005 are also presented as historically significant actions contributing to the assessment of mitigation measures, and in some cases demonstrate previous actions that were ineffective for reducing the impact of threats on the North Atlantic right whale population.
North Atlantic right whale generation time is estimated to be approximately 20 years thus three generations spans approximately 60 years (DFO 2014). This review assesses if the recovery of North Atlantic right whales is on track to reach the interim recovery goal within this longer timeframe, in approximately 50 years.

The recovery objectives included in the recovery documents (DFO 2014, 2016a, 2016b) were developed at a time when the understanding of SARA was different than it is today and did not take into consideration the 2016 tri-departmental Proposed Policy on Survival and Recovery (Government of Canada 2016); therefore, neither does this review.

5. Review of Recovery Activities

5.1 Recovery Objectives

This review considers recovery activities to address each recovery objective outlined in the North Atlantic right whale Recovery Strategy (DFO 2014). The Recovery Strategy describes seven objectives to achieve recovery:

1. Reduce mortality and injury as a result of vessel strikes;
2. Reduce mortality and injury as a result of fishing-gear interactions (entanglement and entrapment);
3. Reduce injury and disturbance as a result of vessel presence or exposure to contaminants and other forms of habitat degradation;
4. Monitor population and threats;
5. Increase understanding of life history characteristics, low reproductive rate, habitat, and threats to recovery through research;
6. Support and promote collaboration for recovery between government agencies, academia, environmental non-government groups, Aboriginal groups, coastal communities, and international agencies and bodies; and,
7. Develop and implement education and stewardship activities that promote recovery.

Objectives 1-3 directly address reducing identified threats to North Atlantic right whales. Objectives 4-7 describe research and monitoring approaches that could further contribute to addressing threats, but only indirectly. As this review is focused on assessing effectiveness of recovery activities that directly reduce threats to North Atlantic right whales, only measures listed under Objectives 1-3 are evaluated (Section 6), while other relevant measures listed under Objectives 4-7 are considered separately (Section 7).

5.2 Threats

To review the effectiveness of recovery activities towards achieving the interim recovery goal, the efficacy of the measures towards reducing threats to the population was considered. The Recovery Strategy identifies three major threats to North Atlantic right whales: vessel strikes, fishing-gear entanglement, and disturbance and habitat degradation. The latter is further divided into four threats: contaminants, acoustic disturbance, vessel-presence disturbance, and changes in food supply (DFO 2014). Recovery activities to address these threats are considered in this review.

5.3 Review of Recovery activities

To address identified threats to North Atlantic right whales, several conservation initiatives and recovery activities have been implemented throughout Canada and the USA, and are presented in Table 1 and discussed in more detail in Section 6. In some cases, recovery activities implemented prior to 2005 are also discussed as they highlight important accomplishments or recovery activities that were unsuccessful in reducing threats.

Table 1 - Recovery activities since 2005 that have been or are currently being implemented within Canada (the main focus of this review) and in some cases the USA and internationally (in italics) to address North Atlantic right whale recovery objectives.

The broad strategies presented were obtained from the Recovery Strategy (DFO 2014). "Threat(s) Addressed" lists the relevant threats for each recovery activity; "indirectly" indicates that the listed threats are only indirectly addressed by the recovery activity. "Status" refers to the progress towards completion of each recovery activity, assigned as "Not yet initiated" (recovery activity has not yet begun). "Partially Completed" (some work has been done but further work is required), "Completed" (no further work is required), "Ongoing" (if the work is underway and continuous), or "Unknown" (at the time of this review there was no information available to assess the status of the recovery activities). The majority of the achievements are listed in the Progress Report (DFO 2016b). Note that several of the recovery activities could be listed under multiple objectives, but to reduce repetition are only listed once under the objective to which they are likely most relevant.

Broad strategy	Summarized recovery activity	Threat(s) addressed	Status	Achievements
Objective 1: Reduce mortality and injury as a result of vessel strikes				
Better understand the relationship between vessel activity and North Atlantic right whales by evaluating the risk of vessel collision based on analysis of all available data on seasonal and inter-annual distribution of North Atlantic right whales and vessel traffic in Canadian waters.	Research to estimate and reduce the risk of lethal vessel collisions	Vessel strikes (indirectly)	Partially completed	• Estimated relative risk of lethal vessel strikes in Roseway Basin and the Bay of Fundy (Vanderlaan et al. 2008) • Developed a method to measure the probability of encounter between North Atlantic right whales and vessels and to quantitatively assess vessel routing options to reduce risk of vessel strikes (Vanderlaan et al. 2009) • Developed a model to assess the probability of a lethal vessel strike (van der Hoop et. al. 2012) • Estimated relative risk of lethal vessel strikes in the Bay of Fundy (2015) and examined changes in risk associated with implementing speed restrictions and moving the TSS outside the Grand Manan Basin critical habitat (Vanderlaan and Brown, unpublished data)
Consider, evaluate, and implement management strategies that reduce the amount of overlap, in time and space, of vessel activity and North Atlantic right whales (advisories, routing, and speed reductions)	Implement Roseway Basin Area to be Avoided (ATBA)	Vessel strikes, acoustic disturbance, vessel-presence disturbance	Completed	• A recommendatory seasonal ATBA that seeks voluntary compliance to re-route vessels around Roseway Basin was adopted by the International Maritime Organization (IMO) and implemented by Canada (Vanderlaan et al. 2008 and references therein)

Broad strategy	Summarized recovery activity	Threat(s) addressed	Status	Achievements
Consider, evaluate, and implement management strategies that reduce the amount of overlap, in time and space, between vessel activity and North Atlantic right whales (advisories, routing, and speed reductions) - continued	Monitor compliance with the Roseway Basin ATBA	Vessel strikes, acoustic disturbance, vessel-presence disturbance (indirectly)	Ongoing	• Vessel Avoidance and Conservation Area Transit Experiment (VACATE) and Marine Stewardship Recognition Program initiated to evaluate compliance with the ATBA (Vanderlaan and Taggart 2009) • Monitor vessel compliance with the ATBA (Vanderlaan and Taggart 2009; Brown et al. unpublished[1]) • Improve compliance with the ATBA via direct communication with vessel operators navigating the region (Brown et al. unpublished[1])
	Amend Traffic Separation Schemes (TSS) to reduce the co-occurrence with areas frequented by North Atlantic right whales	Vessel strikes, acoustic disturbance, vessel-presence disturbance	Partially completed	• *Implemented a change to the Boston TSS to avoid large aggregations of whales; adopted by IMO and implemented by USA (IMO 2006a)* • *Evaluated the change in relative risk of lethal vessel strikes as a result of the shifted TSS to inform further refinement of TSS to reduce risk of vessel strikes (IMO 2006b, Merrick et. al. 2007[2])* • *Modified existing lanes to reduce the threat of vessel strike; adopted by IMO and implemented by USA (IMO 2008a)*
	Design and recommend voluntary ship traffic routes	Vessel strikes, acoustic disturbance, vessel-presence disturbance (indirectly)	Partially Completed	• *Implemented alternative voluntary seasonal ship traffic routes off the coasts of Georgia and Florida, and in Cape Cod Bay, to reduce vessel traffic in areas frequented by North Atlantic right whales (NOAA 2006)* • *Evaluated the change in relative risk of lethal vessel strike as a result of implementing the voluntary ship traffic routes off Georgia and Florida (Lagueux et. al. 2011)*

[1] Brown, M.W., Taggart, C.T., and Vanderlaan, A.S.M. unpublished manuscript. Mitigation of vessel strikes of North Atlantic right whales in Canadian waters: development, implementation, monitoring, and stewardship. In prep. for Marine Policy.

[2] The authors use a different definition of risk and do not incorporate the probability of a lethal injury in their risk calculations as in Vanderlaan et al. (2008) and Vanderlaan and Taggart (2009).

Broad strategy	Summarized recovery activity	Threat(s) addressed	Status	Achievements
	Implement the Great South Channel ATBA in the USA	Vessel strikes, acoustic disturbance, vessel-presence disturbance	Completed	• *A recommendatory seasonal ATBA that seeks voluntary compliance to re-route vessels away from critical habitat adopted by the IMO and implemented by the USA (IMO 2008a)* • *Evaluated the change in relative risk of lethal vessel strikes as a result of the ATBA implementation by the USA (Merrick et. al. 2007[2])*
Consider, evaluate, and implement management strategies that reduce the amount of overlap, in time and space, between vessel activity and North Atlantic right whales (advisories, routing, and speed reductions) - continued	Implement Seasonal Management Areas (SMAs) to restrict vessel speed in areas frequented by North Atlantic right whales	Vessel strikes, potentially acoustic disturbance	Partially completed	• *Implemented vessel speeds restrictions to no more than 10 knots in various areas off eastern USA to reduce the probability of a lethal injury in the event of a vessel striking a large whale (NOAA 2008a, NOAA 2013)*
	Measure compliance with the SMAs in the USA	Vessel strikes, potentially acoustic disturbance (indirectly)	Partially completed	• Evaluated *vessel compliance to the mandatory speed restrictions within the SMAs (Silber et. al. 2014)*
Collaborate with shipping interests and operators about ways in which they can, through measurable voluntary action, reduce the number/frequency of interactions between North Atlantic right whale and vessel operations	Promote awareness among mariners of high concentrations of whales and educate on mitigation measures	Vessel strikes, acoustic disturbance, vessel-presence disturbance (indirectly)	Ongoing	• Updated navigational charts used by mariners to include the coordinates of Grand Manan and Roseway Basin critical habitats, the amended TSS, and the ATBA • Updated Annual Notice to Mariners (NOTMAR) to include information on critical habitat and best practises for maneuvering vessels when whales are present (https://www.notmar.gc.ca/annual-annuel-en.php) • Produced a Mariner's Guide to Whales in the Northwest Atlantic (ROMM 2014)

Broad strategy	Summarized recovery activity	Threat(s) addressed	Status	Achievements
	Implement a near real-time alert system to inform mariners of the presence of a North Atlantic right whale	Vessel strikes, acoustic disturbance, vessel-presence disturbance	Partially completed	• A near real-time alert system "Whale Alert" was developed as a smart phone app to alert mariners to the acoustic detections of North Atlantic right whales in the Boston TSS. An updated version of the app included acoustic detections in other locations and the ability to report sightings, including dead or distressed whales, an expanded region including Canadian waters, and developed in both French and English (http://www.whalealert.org/) • A near real-time alert Canadian system is under development in eastern Canada to relay positions of visually or acoustically detected whales to mariners within the vicinity via Automated Identification System (AIS) messages (C. Taggart, personal communication)
Objective 2: Reduce mortality and injury as a result of fishing gear interactions (e.g., entanglement and entrapment)				
Evaluate, promote, and/or implement strategies that will reduce the potential for harmful interactions between fishing gear and North Atlantic right whales	Research to estimate and reduce the risk of lethal fishing gear entanglements	Fishing-gear entanglements (indirectly)	Partially completed	• Estimated the risk of lethal fishing gear entanglements in Grand Manan and Roseway Basin critical habitats and identified possible area-specific seasonal closures for some fisheries to reduce the threat and risk to whales without unduly compromising fishing interest (Vanderlaan et al. 2011) • Estimated the risk of lethal fishing gear entanglements in the Bay of Fundy, on the Scotian Shelf and in the southern Gulf of St. Lawrence and identified possible measures to reduce the likelihood of entanglement in fixed fishing gear through spatial and temporal closures (Brillant et al. 2017) • DFO is also estimating lethal entanglement risk to North Atlantic right whales in Atlantic Canada from fixed fishing gear fisheries

Broad strategy	Summarized recovery activity	Threat(s) addressed	Status	Achievements
	Conduct research on interactions between North Atlantic right whales and fishing gear	Fishing-gear entanglements (indirectly)	Partially completed	• Examined contemporary trap settings used by Bay of Fundy lobster fishery and concluded that existing trap-settings minimized slack in the lobster groundlines below a hypothesized entanglement threat elevation of 3m (Brillant and Trippel 2010) • *Examined the types of gear involved in North Atlantic right whale entanglements (Johnson et al. 2005)* • *Analysed 132 ropes retrieved from 70 whale entanglements in the USA and Atlantic Canadian waters and concluded that increased rope strength has contributed to increased severity of North Atlantic right whale entanglements; recommended ropes with reduced breaking strengths to be developed and tested in fixed gear fisheries (Knowlton et al. 2015)*
	Develop and implement voluntary standard practices and mitigation strategies to address interactions between North Atlantic right whales and fishing gear	Fishing-gear entanglements	Partially completed	• In LFAs 33 and 34, industry led an initiative to reduce the amount of slack rope in the water column and report whale sightings to fishing vessels • Voluntary standard practices have been developed in Lobster Fishing Areas (LFAs) 33, 34, 36, 37, 38, and 41 • Offshore lobster fishery on the Scotian Shelf developed voluntary standard practices to reduce the risk of entanglement as part of their Marine Stewardship Council (MSC) certification conditions • Grand Manan Fisherman's Association operating in LFAs 36, 37, and 38, in partnership with Fisheries and Oceans Canada (DFO), conducted aerial surveys at the beginning of lobster seasons; fishers reported sightings and were instructed not to deploy or haul gear in the presence of North Atlantic right whales • Fundy North Fisherman's Association began an ongoing project that started in 2011 to remove "ghost gear" from the Bay of Fundy • Scotia-Fundy Fixed Gear Groundfish Advisory Council developed Voluntary Standard practices • The Integrated Fisheries Management Plan (2013) for the snow crab fishery in the Maritimes Region acknowledges the

Broad strategy	Summarized recovery activity	Threat(s) addressed	Status	Achievements
				potential risk of interactions with North Atlantic right whales and fisheries observers are required to monitor and report on interactions with North Atlantic right whales
Evaluate, promote, and/or implement strategies that will reduce the potential for harmful interactions between fishing gear and North Atlantic right whales – continued	Amend and implement changes to the fishing area boundaries, season, gear modifications to reduce entanglement risk	Fishing gear entanglements	Partially completed	• DFO is developing an amendment to the Fisheries Act Regulations Section 27: Identification of Fishing Gear, which currently requires both ends of fixed gear to be marked; the amendment will permit the use of a single tag, float or buoy in approved fisheries • *Extends Atlantic Large Whale Take Reduction Plan (ALWTRP) gear modifications for all regulated areas along the east coast of the USA (Maine to Florida) to the eastern edge of the EEZ; requires weak links of appropriate breaking strength* • *Implement broad-based sinking groundline requirements for all trap/pot fisheries in all ALWTRP-regulated trap/pot waters. Broad-Based Sinking Groundline Requirement*

Broad strategy	Summarized recovery activity	Threat(s) addressed	Status	Achievements
Support emergency response and disentanglement programs	Respond to marine mammal emergencies	Fishing-gear entanglements and vessel strikes	Ongoing	• In Newfoundland and Labrador, the Whale Release and Strandings Group is authorized by DFO to disentangle cetaceans and sea turtles caught in fishing gear or stranded on the coastline • In Atlantic Canada and in Québec, several regional response networks, including Marine Animal Response Society (MARS), are in place to respond to marine mammals that are dead or in distress, coordinate multiple partners in response efforts, and conduct hands-on responses • In the Bay of Fundy, the Campobello Whale Rescue Team leads disentanglement efforts for North Atlantic right whales • DFO C&P Officers conduct patrols to verify sightings of dead and distressed North Atlantic right whales and respond to reports of entangled or stranded marine mammals • Transport Canada pollution patrol flights and the Department of National Defence offshore patrols provide visual coverage of offshore areas and have provided high-resolution imagery of dead North Atlantic right whales to try to ascertain cause of death, identity, and sex • *Several agencies in the USA also respond to marine mammal emergencies and attempt to disentangle North Atlantic right whales*
Support emergency response and disentanglement programs – continued	Maintain and increase capacity for disentanglement response	Fishing-gear entanglements	Ongoing	• DFO's national Marine Mammal Response Program (MMRP) continues to support and coordinate responses to incidents of marine mammals in distress such as entanglement or strandings • MMRP provides resources and equipment in support of incident response in Atlantic Canada • MMRP provided disentanglement training to DFO (C&P) Officers • Members of the MARS have taken disentanglement training to increase disentanglement capacity in the Maritimes • Grand Manan Whale and Seabird Research Station (GMWSRS) developed and prepared a manual detailing how to release entrapped whales from herring weirs

Broad strategy	Summarized recovery activity	Threat(s) addressed	Status	Achievements
Collaborate with fishers to enhance in which they can reduce the number/frequency of interactions between North Atlantic right whales and fishing operations	Develop and implement voluntary codes of practice and data logging to be promoted by whale-watching companies	Fishing-gear entanglements (indirectly)	Partially completed	• GMWSRS promoted the use of the Voluntary Fishing Code for people working around large whales in the Bay of Fundy and promoted the use of trip record for whale-watching companies to record species observed
	Perform awareness education and outreach to the fishing industry	Fishing-gear entanglements (indirectly)	Ongoing	• DFO presents educational materials and information regarding species at risk to several fishing industry advisory councils including the Scotia-Fundy Groundfish Advisory Council, the Scotia-Fundy Herring Advisory Council, the Hagfish Advisory Council, the Shrimp Advisory Council part of the North Atlantic right whale Fisheries Mitigation Working Group • DFO provides emergency contact information for marine mammal incidents (e.g., MARS contact information) to fishers • Quebec-Labrador Foundation prepared and distributed identification charts of marine species to fishers and professional fishery organizations in 2012
Evaluate and minimize the effects of all new and expanding fisheries on right whales	No specific activities identified		Unknown	• The exploratory whelk fishery was excluded from Roseway Basin as a condition of the 2014 fishery licence
Objective 3: Reduce injury and disturbance as a result of vessel presence or exposure to contaminants and other forms of habitat degradation				
Evaluate and reduce the harmful impacts of dangerous substances on North Atlantic right whale habitat including both natural and human-induced sources	Determine the presence of certain chemicals in North Atlantic right whales	Contaminants (indirectly)	Ongoing	• The occurrence of paralytic shellfish poisoning (PSP) toxins in North Atlantic right whales in the Bay of Fundy was measured from fecal samples and it was suggested that PSP toxin-producing *Alexandrium* pose a threat to the North Atlantic right whales (Doucette et al. 2006) • *It was demonstrated that organochlorine pesticides and various brominated flame retardants were present in North Atlantic right whales; further research is needed to monitor these substances (Montie et al. 2010)*

Broad strategy	Summarized recovery activity	Threat(s) addressed	Status	Achievements
Evaluate and reduce impacts from existing or future human induced noise in right whale habitats and reduce harmful levels of exposure	Conduct research on the potential impact of vessel noise on North Atlantic right whales	Acoustic disturbance (indirectly)	Partially completed	• Opportunistic study that evaluated stress hormones in right whales in relation to vessel noise demonstrated that vessel noise causes measurable stress in North Atlantic right whales (Rolland et al. 2012)
	Conduct research on the potential impact of seismic airgun noise on North Atlantic right whales	Acoustic disturbance (indirectly)	Partially completed	• Acoustic data was collected in Roseway Basin during Shell's 2013 western Scotian Shelf seismic survey; presence of right whale calls were analyzed; data could contribute to an assessment of ambient and anthropogenic noise levels within the North Atlantic right whale critical habitat during the seismic surveys once analyzed
	Develop guidelines to reduce vessel-noise emissions	Acoustic disturbance (indirectly)	Partially completed	• *IMO guidelines have been developed that provide some practical measures to reduce shipping noise, including noise generated by the propeller which is the main source of underwater noise associated with vessels (IMO 2014)*
	Ensure North Atlantic right whales have been considered for Environmental Assessments and Strategic Environmental Assessments	Acoustic disturbance (indirectly)	Ongoing	• Seven strategic environmental assessments have been completed for large areas of the Scotian Shelf and Slope which consider North Atlantic right whales • Two project specific environmental assessments were completed for seismic exploration programs on the Scotian Shelf and Slope that considered North Atlantic right whales and potential impacts on the Roseway Basin critical habitat • North Atlantic right whales were considered in environmental assessments completed for Bay of Fundy tidal turbine projects

Broad strategy	Summarized recovery activity	Threat(s) addressed	Status	Achievements
Evaluate and reduce impacts from existing or future human induced noise in right whale habitats and reduce harmful levels of exposure – continued	Develop guidelines to reduce noise impacts on right whales	Acoustic disturbance (indirectly)	Partially completed	• DFO conducted a science advisory process to review mitigation for seismic airgun noise and its impacts on at-risk whale species; identified sound exposure criteria, whether current practices were adequate for avoiding harm to whales and critical habitat, and additional mitigation and monitoring measures (DFO 2015) • *The National Marine Fisheries Service compile, interpreted, and synthesize the scientific literature to produce acoustic thresholds for onset of temporary and permanent threshold shifts (NFMS 2016)*
Evaluate and reduce disturbance associated with vessel presence	Amend the Marine Mammal Regulations to reduce the threat of vessel presence	Vessel-presence disturbance, acoustic disturbance	Partially Completed	• The Marine Mammal Regulations under the Fisheries Act are being considered for amendment to provide regulatory tools for effective management of non-harvest resource users and impacts (i.e., whale watching); the amendments include a general approach distance for vessels
	Monitor compliance with Marine Mammal Regulations	Vessel-presence disturbance, acoustic disturbance (indirectly)	Ongoing	• C&P Officers monitor whale-watching vessels to ensure the operators are not disturbing the marine mammals
	Promote awareness among mariners and whale-watching companies and educate on mitigation measures and voluntary best practices	Vessel-presence disturbance (indirectly)	Ongoing	• Marine Mammal Enforcement Advisory Committee was established in southwest New Brunswick and focuses on education of the whale-watching community to avoid harassment of North Atlantic right whales • Annual NOTMAR provides updates to include information on critical habitat and best practices for vessels when whales are present • GMWSRS worked with industry to keep the profile of North Atlantic right whales high and promote best practices for whale watching tour operators

Broad strategy	Summarized recovery activity	Threat(s) addressed	Status	Achievements
No broad strategies in Recovery Strategy identified	Study the impact of human activities on North Atlantic right whale food supply	Changes in food supply (indirectly)	Ongoing	• DFO researchers have developed habitat models for *Calanus* that can be used to predict effects of climate change in Atlantic Canadian waters and can support development of ecosystem-based advice (Albouy-Boyer et al. 2016)
Objective 4: Monitor population and threats				
Promote and conduct regular monitoring of North Atlantic right whales throughout Canadian waters and in particular in known habitat areas	Conduct visual and acoustic surveys and monitor the North Atlantic right whale population	All threats (indirectly)	Ongoing	• DFO conducted two large scale aerial surveys throughout eastern Canada; the Trans North Atlantic Sightings Survey in 2007 (Lawson and Gosselin 2009), and a North Atlantic International Survey for marine mammals in 2016; all whale sightings including North Atlantic right whales were recorded • DFO Quebec conducts three large-scale visual boat-based surveys each year in the Gulf of St. Lawrence since 2015, using DFO large research vessels as a platform of opportunity • North Atlantic right whale critical habitat in the Bay of Fundy was surveyed (vessel based) during DFO 'shoulder' season in October 2013 • Transport Canada pollution patrol flights and Department of National Defence offshore patrols provide visual coverage of offshore areas and have provided high-resolution imagery of living and dead whales • Canadian Whale Institute (CWI) conducts boat-based surveys in Roseway Basin and the southern Gulf of St. Lawrence • As part of various research projects, the Taggart Lab (Oceanography, Dalhousie University) has conducted both visual boat-based surveys for Roseway basin and acoustic surveys in various areas of eastern Canada using autonomous gliders • Passive acoustic monitoring using bottom-mounted acoustic recorders has been and is being used by various DFO researchers, Dalhousie University researchers, JASCO Applied Sciences, Eastern Charlotte Waterways and others to investigate distribution, seasonal occurrence and habitat use of North Atlantic right whales throughout Atlantic Canada

Broad strategy	Summarized recovery activity	Threat(s) addressed	Status	Achievements
				• Grand Manan Whale and Seabird Research Station (GMWSRS) contributed to long-term North Atlantic right whale population monitoring by collecting sighting data from whale-watching vessels • DFO maintains sightings databases to collect and archive whale sightings data including information on North Atlantic right whales • DFO initiated an outreach program to seek information from the public about sightings of North Atlantic right whales outside critical habitats, posters were also distributed on wharves, community bulletin boards, Coast Guard vessels, ferries, whale-watching companies, and DFO area offices in Atlantic Canada and Quebec • *The New England Aquarium (NEAq) continues leading its long term population study in Atlantic Canadian Waters* • *NEAq continues to maintain a long-term photo-identification program and continues to collect samples of skin, blubber, feces, and blow to be used in various research projects* • *NOAA conducts aerial surveys and research by vessel and aircraft* • *A study investigated call types of mother-calf pairs to be used in passive acoustic monitoring (Parks et al. 2014)* • The North Atlantic right whale Consortium manages access to North Atlantic right whale databases, including a sightings database, photo-identification database, genetics database, contaminants, health assessment, necropsy, blubber management and blubber archive
Promote and conduct regular monitoring of North Atlantic right whales throughout Canadian waters and in particular in known habitat areas - continued	Monitor presence and condition of North Atlantic right whale carcasses	All threats (indirectly)	Ongoing	• DFO is gathering marine mammal entanglement and mortality information from imagery collected during routine patrol flights by Transport Canada and DFO C&P officers

Broad strategy	Summarized recovery activity	Threat(s) addressed	Status	Achievements
	Investigate potential North Atlantic right whale mating grounds	All threats (indirectly)	Partially completed	• *A study suggesting that the central Gulf of Maine is the mating grounds for North Atlantic right whales was conducted (Cole et al. 2013)*
Promote and conduct regular monitoring of existing and emerging threats	Conduct research to describe the warming trends in the Bay of Fundy	Changes in food supply (indirectly)	Partially completed	• Warming trends in the Bay of Fundy were described based on pop-up satellite tags deployed on basking sharks (Koopman et al. 2014)
	Conduct research to estimate the annual number of vessel strikes	Vessel strikes (indirectly)	Partially completed	• Vanderlaan et al. (2009) estimated a 60% chance of observing at least one North Atlantic right whale death per year from vessel strikes prior to the implementation of recovery activities; when these estimates were adjusted for undetermined causes of death and unobserved deaths there was a 10-fold increase in the expected annual number of fatal vessel strikes
	Conduct research to estimate the effects of the Roseway Basin ATBA on the expected number of vessel strikes	Vessel strikes (indirectly)	Completed	• It was estimated that the Roseway Basin ATBA resulted in an 82% reduction in the per capita rate of lethal vessel strikes and vessel strike rates would decrease from one lethal vessel strike every 0.8-2 years (prior to implementation) to one every 41 years (van der Hoop et al. 2012)
	Assess the scarring rates due to fishing-gear entanglements	Fishing-gear entanglements (indirectly)	Ongoing	• *Photographs of North Atlantic right whales for the period 1980-2009 were used to determine scarring rates and to identify that juveniles were entangled at a higher rate than adults; 83% of the population had been entangled at least once (Knowlton et al. 2012)*

Broad strategy	Summarized recovery activity	Threat(s) addressed	Status	Achievements
Promote and conduct regular monitoring of existing and emerging threats - continued	Assess the mitigation measures implemented to reduce anthropogenic effects to large whales	Vessel strikes, fishing-gear entanglements (indirectly)	Ongoing	• *A study concluded that the regulatory efforts implemented have not reduced the lethal effects of human activities on large whales (van der Hoop et al. 2013)*
	Assess the additional energy requirements due to fishing-gear entanglements	Fishing-gear entanglements (indirectly)	Partially completed	• *A method was established to predict drag forces due to entanglement to evaluate when to assist with disentanglement actions (van der Hoop et al. 2016)*
	Evaluate the effectiveness of gear modifications to reduce fishing-gear entanglements	Fishing-gear entanglements	Partially completed	• *The effectiveness of ALWTRP from 1999-2009 was evaluated and it was concluded that measures were generally ineffective in reducing North Atlantic right whale deaths attributable to fishing-gear entanglements (Pace et al. 2014)*
	Develop techniques to monitor the health of individuals	All threats (indirectly)	Ongoing	• A method to genetically identify individual North Atlantic right whales from samples of feces was developed and has increased the number of genetic profiles available for further research (Gillett et al. 2010) • North Atlantic right whale genetics database is maintained initially by Trent University and then by St. Mary's University
Support necropsies of dead animals in Canadian waters to help identify and evaluate the effects of human	Perform necropsies	All threats (indirectly)	Ongoing	• Since 2006 full necropsies were performed on three of the nine dead North Atlantic right whales found in Canadian waters

Broad strategy	Summarized recovery activity	Threat(s) addressed	Status	Achievements
activities	Develop protocols for responding strandings and beachings of marine mammals	All threats (indirectly)	Ongoing	• MARS developed set of detailed response protocols for live and dead cetacean strandings and produced resource material distributed with training • Regional marine mammal response networks and the Canadian Wildlife Federation formed a National Stranding Network Committee to maintain and improve the operations of regional emergency response networks, foster consistency in response standards, among all regions of Canada, and to encourage collaboration and knowledge sharing
Objective 5: Increase understanding of North Atlantic right whale life history characteristics, low reproductive rate, habitat and threats to recovery through research				
Promote and conduct research on North Atlantic right whale life history, historical abundance, habitat requirements, and distribution	Conduct research on North Atlantic right whale critical habitat and food resources within critical habitat	Changes in food supply (indirectly)	Ongoing	• Several studies have been conducted on North Atlantic right whale food in the Bay of Fundy critical habitat (Michaud and Taggart 2007, 2011) and in the Roseway Basin critical habitat (Davies et al. 2013, 2014, 2015a, 2015b) • DFO is modelling *Calanus* hotspots to aid prediction of potential North Atlantic Right Whale feeding grounds in the eastern Gulf of Maine, Scotian Shelf, and Gulf of St. Lawrence
	Conduct research on North Atlantic Right whale movements and distribution	All threats (indirectly)	Partially completed	• A movement model was used to estimate individual movement patterns and spatial probability distributions to produce monthly estimates of movement and distribution patterns in the Northwest Atlantic (Brillant et al. 2015)
	Identify ecologically and biologically significant areas (EBSAs) within the North Atlantic right whale range in Atlantic Canada	All threats (indirectly)	Partially completed	• North Atlantic right whale critical habitat has been identified as EBSAs and is being incorporated into Marine Protected Area (MPA) network planning. • DFO has identified several Areas of Interest for future designation of MPAs within the distributional range of North Atlantic right whales

Broad strategy	Summarized recovery activity	Threat(s) addressed	Status	Achievements
Promote and conduct research to further understand the factors limiting reproductive success	Conduct research on right whale health at various life stages	All threats (indirectly)	Ongoing	• *A state-space model that provides estimates of movement, health, and survival of North Atlantic right whales has been developed (Schick et al. 2013); this model was refined and used to examine the health of the population over the last 20 years (Rolland et al. 2016)* • *The energetic cost associated with fishing-gear entanglements was estimated (van der Hoop et al. 2016)*
Conduct research and analysis to further understand or refine critical habitat in Roseway Basin, and to evaluate the potential of identification of critical habitat in other areas	Conduct research to refine Roseway Basin critical habitat	All threats (indirectly)	Completed	• Davies et al. (2014) provided scientific support for expanding the critical habitat on Roseway Basin based on food availability and oceanographic conditions
	Conduct research on potential forging areas and potential suitable habitat for right whales	All threats (indirectly)	Ongoing	• DFO Maritime and Quebec regions are studying the variability of zooplankton presence in the Gulf of St. Lawrence and on the Scotian Shelf to identify potential habitat for right whales • DFO Maritimes and Newfoundland and Labrador regions are conducting research on suitable habitat for cetacean species, including North Atlantic right whales, through the use of species distribution models
Promote and conduct research of existing and emerging threats and effectiveness of mitigation measures	Activities identified under other objectives			• Achievements listed elsewhere in the table as recovery activities can address multiple objectives
Objective 6: Support and promote collaboration for recovery between government agencies, academia, environmental non-government groups, Aboriginal groups, coastal communities and international agencies and bodies				
Promote collaboration and coordination among decision makers and levels of government to foster joint conservation efforts and communications surrounding North Atlantic right whale conservation	Review and provide SARA permits as appropriate	All threats (indirectly)	Ongoing	• DFO evaluates research and other activities and if they determine if that they do not jeopardize the survival and recovery of North Atlantic right whales then they can receive a permit
Promote the involvement of Aboriginal peoples and perspective in recovery activities	Develop poster campaign to identify new North Atlantic right whale	All threats (indirectly)	Partially completed	• Maritime Aboriginal Peoples Council distributed the sighting posters with every logbook they shipped to fishery licence holders in the Scotia-Fundy and Gulf regions

Broad strategy	Summarized recovery activity	Threat(s) addressed	Status	Achievements
	aggregations			
Continue to collaborate with government agencies in the United States of America on transboundary North Atlantic right whale initiatives	Participate in International Meetings	All threats (indirectly)	Ongoing	• Continued and expanded representation from DFO at international meeting, workshops, and conference regarding North Atlantic right whales; recent meetings include the annual North Atlantic Right Whale Consortium meetings, Canada/USA Transboundary Resources Steering Committee Meetings, Canada-USA Species at Risk Working Group Meetings, Workshop on Trends and Threats to North Atlantic Right Whales, Marine Mammal Commission Meeting, and the ALWTRT Meeting, and annual DFO participation in the Atlantic Regional Scientific Review Group
Work with international bodies on North Atlantic right whale conservation issues of interest to Canada	Conduct field-work meetings to coordinate among research groups and share information on sightings	All threats (indirectly)	Ongoing	• DFO Maritimes hosts semi-annual meetings for groups conducting field work in Canadian waters to facilitate coordination of efforts among research groups; daily sightings are also sent out field teams in the summer and autumn
	Review the role of the IMO to implemented recovery activities	Vessel strikes (indirectly)	Completed	• *Silber et al. (2012) reviewed the role of the IMO to implement recovery activities to protect whales from vessel strikes and concluded to pursue large whale conservation objectives*

Broad strategy	Summarized recovery activity	Threat(s) addressed	Status	Achievements
Work with international bodies on North Atlantic right whale conservation issues of interest to Canada - continued	Gather and summarise information on international law, political frameworks, and outreach initiatives in relation to North Atlantic right whale	Vessel strikes, fishing-gear entanglements, and contaminants (indirectly)	Completed	• Duff et al. (2013) summarized information on the threats to North Atlantic right whales, international laws, international groups' roles in recovery, outreach initiatives, and recovery activities implemented
Support the maintenance of an ongoing multi-stakeholder advisory body in which to discuss right whale conservation and recovery issues	Establish and maintain the right whale recovery network	All threats (indirectly)	Ongoing	• Right whale recovery network was established to seek vital guidance for the development of the proposed Action Plan to address fisheries interactions • Right whale recovery network also conducted a workshop to address all other threats identified in the Recovery Strategy
Engage coastal communities and resource user groups in discussions and collaborations to foster right whale recovery and promote the gathering of knowledge of right whales from interested groups	Obtain information commercial-fishing industry about gear	Fishing-gear entanglements (indirectly)	Ongoing	• The North Atlantic right whale Fisheries Mitigation Working Group has developed and distributed questionnaires to gather information on the type of gear used in North Atlantic right whale habitat and migratory pathways
Objective 7: Develop and implement education and stewardship activities that promote recovery in Canada				
Continue to expand, refine, and update programs to educate mariners about the problems facing North Atlantic right whales, available shore-based resources, and how changes to vessel operations will help address those problems.	Develop and provide a cetacean identification training program	All threats (indirectly)	Ongoing	• DFO Maritimes region developed a cetacean identification training program and delivered training to commercial fishery observers, C&P Officers, Defense Research and Development Canada researchers and Canadian Wildlife Service (CWS) bird observers • DFO Newfoundland and Labrador region also offers a similar program for marine mammal observers aboard seismic vessels when requested • MARS offered cetacean training, as well as live and dead cetacean response training across the Maritimes • World Wildlife Fund provided live and dead cetacean identification training to at-sea observers in Nova Scotia and

Broad strategy	Summarized recovery activity	Threat(s) addressed	Status	Achievements
				Newfoundland
Develop programs to educate the general public about North Atlantic right whale conservation strategies and stewardship actions	Develop a Marine Species Identification Guide Common to the Bay of Fundy and Scotia Shelf Region	All threats (indirectly)	Completed	• DFO developed a marine animal identification key that was distributed to fishing industry, whale watching companies, C&P Officers, the Canadian Coast Guard, fisheries observers, and marine mammal observers (DFO 2013)

Develop programs to educate the general public about North Atlantic right whale conservation strategies and stewardship actions – continued	Develop websites with information about North Atlantic right whales	All threats (indirectly)	Ongoing	• There are several websites that contain information on North Atlantic right whales including but not limited to:
				  • DFO has websites about species at risk including North Atlantic right whales
				  • The Canadian Whale Institute has a website that describes research and recovery efforts in Canada
				  • The GMWSRS website has general information about North Atlantic right whales and whales observed in the Bay of Fundy each year
				  • The MARS website includes information to help identify marine mammals
				  • *The North Atlantic Right Whale Consortium website has a North Atlantic right whale information page*
				  • *NOAA's interactive North Atlantic right whale sightings map*
				  • *The New England Aquarium has a blog for communicating updates of their research activities including field work in Canadian waters*

	Provide information on North Atlantic right whales and participate in outreach events	All threats (indirectly)	Ongoing	• DFO Newfoundland and Labrador has a public outreach programme to collect sightings and distribute information about species at risk • DFO presents information on North Atlantic right whales to the public and participates in annual Oceans Day Events • GMWSRS hosted public lectures for tourists and produced "Right whale Stewards" booklet to middle schools and have also made presentations to university and high school students, whale camp groups, sea cadets, and student science

Broad strategy	Summarized recovery activity	Threat(s) addressed	Status	Achievements
				fairs
Expand and refine collaboration efforts with fishing industry that promote best practices to reduce the number and severity of whale/fishing gear interactions	Review gear configuration to determine methods for minimising entanglement risk	Fishing-gear entanglements (indirectly)	Ongoing	• DFO Newfoundland and Labrador has contract the Fish, Food, and Allied Workers Union (FFAW-Unifor) to review the development of trap mooring ropes with the goal of minimising entanglement risks for leatherback sea turtles and large whales
Promote a public reporting system for dead, stranded, injured, entangled, or entrapped right whales as part of the existing whale disentanglement program	Promote 24-hour hotlines	Vessel strikes and fishing-gear entanglements (indirectly)	Ongoing	• In Atlantic Canada and in Québec, several regional response networks, including the Marine Mammal Emergency Response Network, and MARS provide widely-advertised 24-hour hotlines

6. Effectiveness of Recovery Activities

In the following sections, for each identified threat (Objectives 1-3) recovery activities implemented to reduce the threat are described in detail and any information available on population demography to illustrate the effectiveness of the measures is presented. As it is difficult to assess the effectiveness of individual recovery activities and their associated impacts on the population, all recovery activities for a specific threat are considered collectively to evaluate whether a specific threat has been reduced.

While Objectives 4-7 in the Recovery Strategy do not directly reduce threats to North Atlantic right whales, they are important for informing threat-based mitigation measures. The effectiveness of recovery activities implemented to more directly reduce or mitigate threats often relies on information obtained under these non-threat-based objectives. Additionally, knowledge gained through completing measures under Objectives 4-7 can be used to inform the development of new recovery activities to reduce the impacts of threats. As these objectives are not threat-based, nor directly related to recovery, a measure of their effectiveness is not possible; however, their importance for assessing recovery is further discussed in Section 7.

6.1 Vessel Strikes

Vessel strikes impact several marine species including sea turtles (Hazel et al. 2008), manatees (Laist and Shaw 2006), sharks (Speed et al. 2008), and cetaceans (Laist et al. 2001). Vessel strikes contribute to mortality of all large whale species in the Northwest Atlantic (van der Hoop et al. 2013). 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. 2014). Substantial conservation measures have been suggested and implemented worldwide to protect marine species from vessel collisions, and this is especially true for endangered North Atlantic right whales (e.g. Kraus et al. 2005, Laist and Shaw 2006, Panigada et al. 2006, NOAA 2008a).

Several recovery activities have been implemented in Canada and the USA to protect North Atlantic right whales from vessel strikes, including vessel re-routing and speed restrictions (Table 1). Vanderlaan et al. (2008) argues that vessel re-routing and speed restrictions are the two simplest and most practical methods to reduce the risk to whales from vessels (see Appendix B for definition of risk). The precedent setting recovery activity of amending the Traffic Separation Scheme (TSS) in the Bay of Fundy to re-route the vessels around high use North Atlantic right whale habitat was proposed to IMO in 2002 by Transport Canada. The IMO amended the TSS in 2003, which was the first time the IMO adopted a change to their regulations to protect an endangered species. This TSS amendment reduced the probability of a vessel encountering North Atlantic right whales as the previous outbound lane of the

TSS required vessels to transit directly through the Grand Manan Basin North Atlantic right whale Conservation Area; an area that served to warn mariners of the presence of North Atlantic right whales. It was estimated that this change resulted in a reduction of the relative risk of a lethal vessel collision by 90% in the area where the TSS intersected the North Atlantic right whale Conservation Area and 62% throughout the entire study area (Vanderlaan et al. 2008). It was also estimated that detected mortalities attributable to vessel strikes would change from one every four years to one every 12 years in the Bay of Fundy (Vanderlaan et al. 2008).

Similar re-routing has since taken place in USA waters with two amendments to the Boston TSS (IMO 2006a, 2008a). The first amendment in 2006 rotated the TSS 12 degrees to the north to avoid large aggregations of whales. This shift was estimated to result in a 58%[3] reduction in risk of vessel strikes to North Atlantic right whales (IMO 2006b). The second amendment in 2008 (IMO 2008b) narrowed the lanes to further reduce to the relative risk of a vessel strike by 11%[2] (Merrick et al. 2007). Both amendments reduced the spatial co-occurrence between vessel activity and North Atlantic right whales.

In the North Atlantic right whale's southern calving ground off the coasts of Georgia and Florida, as well as in Cape Cod Bay, recommended voluntary, seasonal traffic routes have been advised to shift the traffic patterns away from areas frequented by North Atlantic right whales (NOAA 2006). Lagueux et al. (2011) estimated that the recommended routing in the southern calving ground would reduce the probability of a North Atlantic right whale mortality from a vessel by ~72% from the pre-implementation period and measured compliance with the recommended routes at 96% by the end of their study.

Transport Canada proposed the adoption of a recommendatory, seasonal Area to be Avoided (ATBA) in Roseway Basin to the IMO to further reduce the risk of vessel strikes through re-routing of traffic around another North Atlantic right whale high-use area (IMO 2007). On 01 May 2008, Canada implemented the ATBA seasonally (June through December). Although recommended by the IMO, this recovery activity is completely voluntary, similar to the Roseway Basin Right Whale Conservation Area (implemented in 1993) that was designed to promote awareness and education among mariners (Brown et al. 1995). The Conservation Area also advised vessels to either re-route around the area or reduce vessel speed, but there was no evidence of compliance with the voluntary recommendations (Vanderlaan et al. 2008). The Taggart Lab (Dalhousie Oceanography) implemented the Vessel and Conservation Area Transit Experiment (VACATE) to measure compliance with and efficacy of the voluntary ATBA. Within the first year of implementation compliance stabilized at 71%, resulting in a reduction of relative risk across the study area of 82% (Vanderlaan and Taggart 2009). Compliance estimation continues in the area, as does the Canadian Whale Institute's (CWI) Marine Stewardship Recognition Program (MSRP) designed to improve compliance with the ATBA through direction communication with vessel operators that transit

[3] The authors use a different definition of risk and do not incorporate the probability of a lethal injury in their risk calculations as in Vanderlaan et al. (2008) and Vanderlaan and Taggart (2009).

through the area. From 2008 through 2014, annual compliance averaged at 80% resulting in a reduction in risk to North Atlantic right whales of 92%[4] (Vanderlaan and Taggart, unpublished data).

An IMO-adopted ATBA in the Great South Channel was implemented in 2009 and annually in effect from the 01 April through 31 of July (IMO 2008a). Similarly to the Roseway Basin ATBA, the Great South Channel ATBA adopted by the IMO recommends that vessels re-route around the ATBA to avoid areas of North Atlantic right whale persistence. It was estimated that the ATBA would result in a 63%3 reduction in relative risk of a vessel striking a North Atlantic right whale (Merrick et al. 2007) though no estimate of compliance with the voluntary ATBA has been measured thus far.

Seasonal vessel speed restrictions in various North Atlantic right whale habitats and along their migratory pathway have also been implemented in the USA (NOAA 2008a). Speed restrictions were mandatory for all commercial vessels greater than 65 feet (~20m) long in ten spatially and temporally defined Seasonal Management Areas (SMAs, Table 2). These restrictions were implemented on the 09 December 2008 with a 5-year sunset clause that has since been removed (NOAA 2008a, 2013). Vessel speed is restricted to 10 knots (18.5 km/h) in each of the areas. Compliance with mandatory vessel speed restrictions has been low with only 24% of vessel transits within the SMAs slowing to the required 10 knots (Silber et al. 2014). However, within the first five years of implementation no vessel-struck North Atlantic right whales were found in or near (within 45 nautical miles or ~83 km) active SMAs (Laist et al. 2014).

Table 2 - Location of the Seasonal Management Areas and their active periods that are implemented annually, since 9 December 2009.

Seasonal Management Area (SMA)		Active Time Period
Southeastern USA	Coastal Florida and Georgia	15 November – 15 April
Mid-Atlantic Area USA	Brunswick, Georgia to Wilmington North Carolina	01 November – 30 April
	Ports of Morehead City and Beaufort, North Carolina	01 November – 30 April
	Entrance to Chesapeake Bay: ports of Hampton Roads, Virginia, and Baltimore, Maryland	01 November – 30 April
	Delaware Bay: Ports of Philadelphia, Pennsylvania, and Wilmington, Delaware	01 November – 30 April
	Ports of New York/New Jersey, New York	01 November – 30 April
Northeast USA	Block Island Sound, Rhode Island	01 November – 30 April
	Cape Cod Bay, Massachusetts	01 January – 15 May

[4] Brown, M.W., Taggart, C.T., and Vanderlaan, A.S.M. unpublished manuscript. Mitigation of vessel strikes of North Atlantic right whales in Canadian waters: development, implementation, monitoring, and stewardship. In prep. for Marine Policy.

Seasonal Management Area (SMA)		Active Time Period
	Race Point, Massachusetts	01 March – 30 April
	Great South Channel, Massachusetts	01 April – 31 July

As identified in Table 1, a number of other programs exist in Canada to alert mariners of the presence of North Atlantic right whales to reduce potential vessel strikes. A Mariner's Guide to Whales in the Northwest Atlantic was developed to promote awareness among mariners (http://www.shipfed.ca/data/News/2014-06-27EngMarinersWhaleGuide.pdf). Smart phone apps have been developed that focus on reducing lethal vessel strikes to whales and alerting mariners of the presence of North Atlantic right whales (e.g., Whale Alert; www.whalealert.org).

A near real-time whale alert system for eastern Canada is under development by researcher at Dalhousie University (http://meopar.ca/research/project/whale-whales-habitat-and-listening-experiment). Research has been conducted to determine the receptivity of the commercial fleet to information on whale locations as an early warning system (Reimer et al. 2016). Moving forward, this alert system will be based on the Automatic Identification System (AIS) that is required on all IMO vessels >300 gross tonnage and all passenger vessels. Whale sounds detected by passive acoustic packages on ocean gliders are transmitted by satellite to a ground station and then validated by an experienced analyst. Once the sounds have been confirmed as a North Atlantic right whale the associated locations are then broadcast as an AIS message in near real time from coastal AIS stations to all AIS vessels within VHF range. An operational trial on the coast of Nova Scotia is planned for summer 2017 (Christopher Taggart, Dalhousie University, personal communication).

Mandatory and voluntary conservation measures in Canada focus on re-routing vessels around high-use habitats to decrease the likelihood of a vessel strike, whereas in the USA the focus was on mandatory speed restrictions, to slow the vessels down to reduce lethality should a strike occur, and voluntary re-routing of vessels. Many of these measures are implemented in identified critical habitats (e.g., Grand Manan Basin, Roseway Basin, Great South Channel, and Cape Cod Bay) and as a result the spatial density of vessel-strike mortality to all large whales has shifted to outside the SMAs (van der Hoop et al 2014). Unlike other large whale species, over the long term the North Atlantic right whale's leading anthropogenic cause of death has been vessel strikes (44% of the human-induced mortalities from 1970-2009 compared with 35% for fishing-gear entanglements; van der Hoop et al. 2013). Seven North Atlantic right whale mortalities have been positively identified as vessel-strikes deaths in Atlantic Canada since 1970 (Knowlton and Kraus 2001; Moore et al. 2004, 2007; Campbell–Malone et al. 2008; Figure 1). However, no documented mortalities where the cause of death was conclusively determined to be attributable to vessel strikes have occurred in Canada since 2006 (van der Hoop et al. 2014; Pettis and Hamilton 2014, 2015, 2016). Furthermore, North Atlantic right whale vessel strike mortalities throughout Canada and the USA have significantly declined from 2.0 (2000-2006) to 0.33 per year (2007-2012; van der Hoop et al. 2014).

Overall, the recovery activities that have been implemented to reduce the risk of lethal vessel strikes to North Atlantic right whales appear to be effective in reducing observed mortalities. It is important to note; however, that changes in the reporting of vessel-strike mortalities over time are unknown. Observed increases in vessel strike mortality over the last 40 years could be a function of increased detection and reporting, although these increases also parallel increases in the number, speed, and size of vessels fleet-wide (Vanderlaan et al. 2009). Detection probabilities are spatially dependent, with offshore vessel strikes less likely to be observed compared to a whale killed closer to shore. Wherever the whales and vessels co-occur, there is the risk of lethal vessel strikes, and Canada has only implemented recovery activities to reduce risk of vessel strikes in identified critical habitat areas. As right whales travel to and from critical habitats and other areas in Atlantic Canada, they are unprotected from the threat of vessel strikes. Additional mitigation should be put in place, particularly as our understanding of North Atlantic right whale distribution and movement patterns increases and new high-use areas are identified.

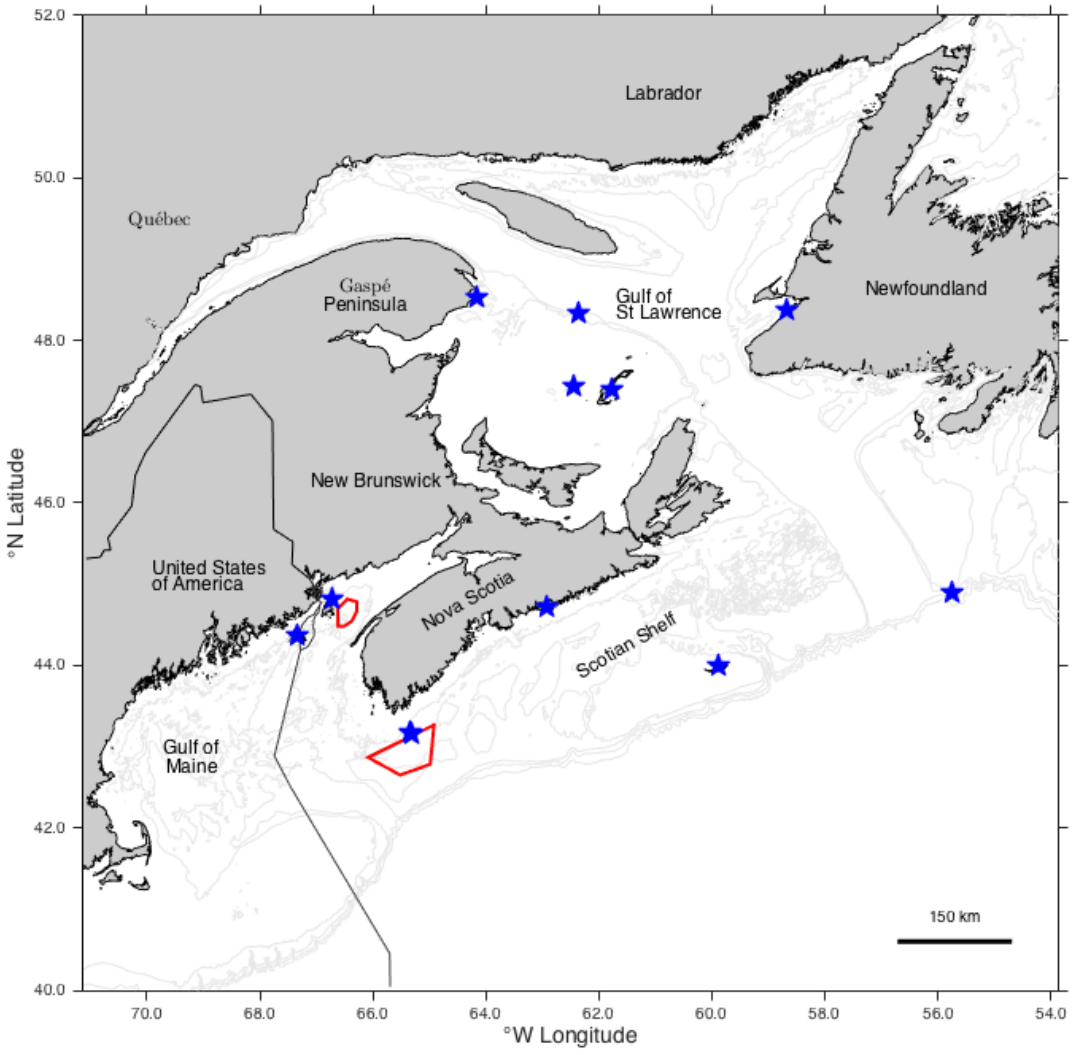

Figure 1: Bathymetric (100, 200, 500, and 1000 m isobaths) chart of Atlantic Canada illustrating the North Atlantic right whale critical habitats (larger red polygon = Roseway Basin; smaller red polygon = Grand Manan Basin), the known right whale mortalities in Canadian waters with blue stars depicting first observed locations of right whale carcasses discovered from 2005 through 2016, and the Canadian Exclusive Economic Zone boundary and "grey zone" polygon (dark grey line).

6.2 Fishing-Gear Entanglements

Any cetacean has the potential to become entangled in fishing gear and van der Hoop et al. (2013) identified entanglements as the primary cause of death among all large whale species with the exception of North Atlantic right whales during the period 1970 through 2009. Unlike small cetaceans that cannot escape entangling gear, entangled baleen whales are capable of dragging gear (Clapham et al. 1999), thus fishing-gear entanglements are not necessarily lethal for large whales. Many North Atlantic right whales appear to shed gear or self-disentangle (Johnson et al. 2007) and scarring analyses show approximately 82% of the North Atlantic right whale population have indications of at least one entanglement in fishing gear (Knowlton et al. 2012). Determining mitigation measures to decrease North Atlantic right whale entanglements is challenging (Knowlton et al. 2012) as North Atlantic right whale entanglement events are rarely directly observed (Weinrick 1999). The locations, in time and space, and the mechanics of fishing-gear entanglements remain largely unknown (Johnson et al. 2007). Unless gear can be attributable to a Canadian fisher, or the entanglement event is observed in Canadian waters, entanglement events cannot be assigned spatially, nor can the resulting statistics. Even if a whale is initially observed in Canadian waters with gear attached, it does not necessarily mean the whale was entangled in Canada, and vice versa for the USA. However, as USA fisheries continue to implement gear marking, it becomes easier to rule out entangling gear from the USA.

Recovery activities related to reducing entanglements include research to increase understanding of entanglement mechanisms, monitoring activities to identify when whales are present in areas and voluntary mitigation measures (Table 1). In the USA numerous mitigation measures have also been implemented both at the state and federal level (Table 3). The Canadian government, however, has yet to implement policies or regulations to reduce cetacean entanglements in fishing gear, including mitigation measures specifically for North Atlantic right whales.

The regulations that have been implemented in the USA to reduce large-whale interactions with commercial fisheries have aimed to reduce both lethal and non-lethal entanglements (Pace et al. 2014) mainly through gear modifications and select fishing closures (Table 3). Gear marking has also been implemented to gather information on the types and parts of gear involved in large-whale entanglements. Gear modifications include buoy line weak links, and net panel weak links with anchoring system, restriction of the number of buoy lines, and the implementation of broad-based sinking groundlines (Table 3). Weak links are hypothesized to increase the likelihood of self-disentanglement and sinking groundlines are hypothesized to reduce the probability of entanglement, but this has yet to be confirmed through quantitative analysis. Mandatory spatiotemporal closures have

also been implemented in the USA, both in critical habitats and dynamic areas around observed aggregations of North Atlantic right whales. These fishing closures may reduce the threat of North Atlantic right whale fishing-gear entanglements. However, it is difficult to assess the effectiveness of these closures due to a paucity of information regarding compliance.

Table 3 - Fishing-gear regulations that have been implemented in the United States of America to reduce entanglement of North Atlantic right whales.

Recovery Measure	Details	Date Implemented	Area	Ref.
Gear modifications	Requires buoy weak line links, net panel weak links with anchoring system and restricts the number of buoy lines	22 January 2001	Northern Inshore Lobster waters, Cape Cod Bay Restricted Area, Great South Channel Restricted Lobster Area, Northern Nearshore Lobster Areas, Southern Nearshore Lobster Areas, Offshore Lobster Areas	NOAA 2000
Dynamic Area Management (DAM) scheme implemented	Restricts use of lobster trap/pot and gillnet fishing gear to protect aggregations of North Atlantic right whales outside critical habitat	8 February 2002	USA waters North of 40°N. DAM zones: triggered by aggregations of 3 or more North Atlantic right whales outside previously established management areas or critical habitat zones, or within and outside these areas when seasonal management is not in effect.	NOAA 2002a
Gear modifications	Replaces existing gillnet Take Reduction Technology List with mandatory weak link requirements and allows the use of neutrally buoyant line in lobster fishing	11 February 2002	ALL Atlantic Large Whale Take Reduction Plan (ALWTRP) Regulated Lobster Waters and ALWTRP Regulated Gillnet Waters.	NOAA 2002b
Seasonal Area Management (SAM) scheme implemented	Prohibits use of floating groundlines; establishes the number, strength, location of weak links; limits to a single buoy line per net string	March 2002; SAM West: 1 March – 30 April SAM East: 1 May – 31 July	Massachusetts Coastal Waters	NOAA 2002c

Recovery Measure	Details	Date Implemented	Area	Ref.
Southeast USA (SEUS) gillnet prohibition	Prohibits straight set gillnets during nighttime hours	2002 15 November – 31 March	Coast waters of Georgia and east Coast of Florida	NOAA 2002
DAM gear modification	Allows use of specific anchored gillnet and lobster trap/pot modifications that reduce entanglement risk	25 September 2003	DAM zones, as above	NOAA 2003
Changes to the boundaries and season, gear modifications	Extends ALWTRP gear modifications for regulated areas to the eastern edge of the EEZ; requires weak links of appropriate breaking strength; replaced/eliminated SAM & DAM programs	5 April 2008 North of 40°N: year round Between 32°N and 40°N: 1 September – 31 May; Between 29°N and 32°N: 15 November – 15 April Between 27°15 N and 29°N: 01 December – 31 December	All ALWTRP-Regulated Trap/Pot Waters	NOAA 2007a
Broad-based sinking groundline requirement	Implement board-based sinking groundline requires for all trap/pot fisheries;	5 April 2009	All ALWTRP trap/pot waters	NOAA 2007a, NOAA 2007b NOAA 2008b
Vertical line rule	Minimum number of traps per trawl Increase the size and frequency of gear marking scheme	26 August 2014	All ALWTRP Northeast waters All ALWTRP waters	NOAA 2014
Marine Mammal Protection Act (MMPA) Rule	The MMPA rule aims to reduce marine mammal bycatch associated with international commercial fishing operations. The rule requires nations exporting fish and fish products to the USA to be held to the same standards as USA commercial fishing operations.	01 January 2017	All International waters	NOAA 2016a

There is one example of fishery exclusion in Canadian waters to reduce the entanglement risk of North Atlantic right whales. An exploratory whelk fishery was excluded from Roseway Basin to ensure trap gear did not entangle North Atlantic right whales in this critical habitat (DFO 2016b).

In Canada, two studies have been undertaken to evaluate the risk to North Atlantic right whales from fishing gear entanglements (Vanderlaan et al. 2011, Brillant et al. 2017). Both studies identify possible spatiotemporal closure as an efficient measure to reduce the probability of North Atlantic right whale fishing-gear entanglements. Brillant et al. (2017) estimated that a 30% reduction in encounter probability between North Atlantic right whales and fishing gear would prevent the death of two North Atlantic right whales every three years and as many as 32 fewer entanglements annually. These studies have not yet been used to inform policy or to implement mitigation or recovery activities to reduce the risk of lethal fishing gear entanglements of North Atlantic right whales. A third study is underway to identify additional priority areas on which to focus efforts for reducing North Atlantic right whale entanglements. DFO will examine the potential risk of lethal entanglements to North Atlantic right whales on the Scotia Shelf using Species Distributions Models (Gomez et al. 2017) to predict North Atlantic right whale suitable habitat and areas of co-occurrence with fishing activities.

Brillant and Trippel (2010) examined contemporary trap settings used by lobster fishery in the Bay of Fundy and suggested that groundlines may not contribute to the entangling factor of the gear due to the groundlines remaining below three meters; which is the hypothesized elevation that could entangle North Atlantic right whales. Validation of these results is required to verify the hypothesized elevation for entanglement, and to ensure that groundline elevation is consistently low across fishers (only two captains were included in the study), the amount of gear deployed, location, and season.

Voluntary standard practices have been established for the Scotia-Fundy Fixed Gear groundfish fishery as well as the lobster fishery in Lobster Fishing Areas (LFAs) 33, 34 (southwest Nova Scotia) and 41 (offshore area). The standard practices provide guidelines for the maximum lengths of endlines, trail/ground lines, and gangions, the use of sinking or neutrally buoyant lines, as well as best operating practices, such as avoiding setting and retrieving gear when whales are present in the area and reporting protocols if an entangled whale is observed. Although these guidelines have been established, there is currently no measure of their effectiveness in reducing the risk of a fishing-gear entanglement. Furthermore, there is no measure of compliance with recommended procedures. It is therefore unknown if these voluntary standard practices are actually implemented or effective.

The Grand Manan Fisherman's Association that operates in the Bay of Fundy (LFAs 36, 37, and 38), in partnership with DFO, conducts aerial surveys at the beginning of the lobster season in early November and fishers are instructed not to deploy or haul gear in the presence of North Atlantic right whales. These surveys have been operational since 2006 and can result in the delay of the fishing season. These data have not been examined to assess whether North Atlantic right whale presence continues into the start of the lobster fishing season and warrants further mitigation.

The Grand Manan Whale and Seabird Research Station (GMWSRS) in collaboration with local fishers has developed a herring weir release manual to help weir operators release marine mammals, including

North Atlantic right whales, with minimal damage to both the gear and the mammals. This recovery activity would be effective in reducing injury and mortalities to right whales entrapped in fishing weirs.

In Atlantic Canada, Quebec, and in the USA, regional response networks are in place to respond to marine mammals that are dead or in distress. These networks provide 24-hour hotlines, coordinate response among multiple partners, and their contact information is widely distributed to fishers and coastal communities. DFO's national Marine Mammal Response Program (MMRP) supports responses to marine-mammal incidents, including North Atlantic right whales entangled in fishing gear. This program also provides training for Conservation and Protection (C&P) Officers and provides resources and equipment in support of incident response in Atlantic Canada. C&P officers also conduct aerial surveys to verify North Atlantic right whale sightings and respond to reports of entangled or stranded whales. The Campobello Whale Rescue Team, a group of volunteers, is on call to lead disentanglement efforts in Bay of Fundy and have responded to over 20 cases of whales in distress. The Marine Animal Response Society (MARS) is a charitable organisation dedicated to the conservation of marine animals and also responds to whales in distress throughout the Maritime Provinces. In Quebec, the Marine Mammal Emergency Response Network, which includes representatives from DFO, Parks Canada, and several non-government organizations, also responds to whales in distress throughout the Estuary and Gulf of St. Lawrence.

DFO and various non-government agencies, including World Wildlife Fund Canada (WWF), CWI, the Canadian Wildlife Federation (CWF), and GMWSRS continue to work with the fishing industry and coastal communities to educate people and provide information regarding species at risk, including the North Atlantic right whale, the threats they face and information on preventing fishing-gear entanglements as well as what to do if a whale is in distress or dead. However, marine education programs were deemed ineffective at reducing vessel strikes due to visibility constraints and the ability and/or willingness of mariners to follow precautionary advice (IMO 1999). It is difficult to assess the effectiveness of these indirect programs in reducing the threat of fishing gear.

There are two primary ways to directly reduce the risk and threat of fishing-gear entanglements to whales: 1) reduce the probability of a whale becoming entangled in the gear; and 2) reduce the probability of lethality, injury, or decreased fitness when an entanglement does occur. To reduce the probability of a whale becoming entangled in gear, i.e., preventing an entanglement, the amount of gear in the water at times and in areas where the whales are present must be decreased. This could be achieved through spatiotemporal-fishing closures, or ropeless fishing. To decrease the probability of lethality or injury, the breaking strength of ropes should be decreased to allow for whales to self-disentangle or for easier disentanglement by teams trying to free a whale from gear.

The North Atlantic right whale proposed Action Plan (DFO 2016a) focusses on fishery interactions; however, it does not "prescribe specific type of mitigation measures (voluntary or regulatory) needed to reduce the risk of entanglements". It does identify that specific future mitigation measures will rely on several other activities listed in the Action Plan, including conducting spatial analyses of entanglement risk associated with fishing gear. A total of 22 recovery activities are identified in the Action Plan, only three of which can directly reduce North Atlantic right whale entanglements (Table 4). Many of the

activities are essential for informing potential policies, and thus indirectly contribute to North Atlantic right whale recovery. As the recovery activities listed in the Action Plan are broad in scope and mainly make indirect contributions to recovery, it is not possible at this time to assess the effectiveness of the proposed recovery activities.

Table 4 - The recovery activities listed in the proposed Action Plan for North Atlantic right whales (DFO 2016a) and their potential to directly reduce the risk from fishing-gear entanglements.

Recovery activity	Direct reduction in risk or threat through		
	Rope reduction in the water column	**Gear modifications to reduce lethality**	**Increase survivorship through disentanglement**
Recovery Objective 2: Reduce mortality and injury as a result of fishing gear interactions			
Approach A: Prevention – reduce the risk to North Atlantic right whales of interaction with fishing gear			
Develop and implement mitigation measures to reduce risk	Possibly if closures are implemented	Possibly if effective gear modifications are implemented	No
Conduct Spatial analyses of Entanglement risk associated with fishing gear	No	No	No
Research interaction between gear and North Atlantic right whale	No	No	No
Continue and expand real-time entanglement prevention strategies	No	No	No
Link to Marine Protected Area planning	No	No	No
Review DFO commercial fishery policies in light of North Atlantic right whale recovery	No	No	No
Improve gear recovery and analysis procedures	No	No	No
Approach B: Entanglement and Entrapment Response			
Maintain and increase capacity for disentanglement response	No	No	Yes if disentanglement efforts are successful
Update joint entanglement response approaches with the USA	No	No	Possibly
Objective 4: Monitor population and threats			

Recovery activity	Direct reduction in risk or threat through		
	Rope reduction in the water column	**Gear modifications to reduce lethality**	**Increase survivorship through disentanglement**
Investigate use of At-Sea Observer Program	No	No	No
Conduct necropsies	No	No	No
Monitor North Atlantic right whale presence in areas outside critical habitat	No	No	No
Monitor scarring rates	No	No	No
Monitor impacts of entanglements on population recover	No	No	No
Objective 5: Increase understanding of life history characteristics, low reproductive rate, habitat and threats to recovery through research			
Investigate the role of “ghost gear”	No	No	No
Objective 6: Support and promote collaboration for recovery between government agencies, academia, environmental non-government groups, Aboriginal groups, coastal communities and I international agencies and bodies.			
Support North Atlantic right whale recovery network	No	No	No
Support and enhance networks of response organisation	No	No	No
Coordinate international and transboundary activities	No	No	No
Objective 7: Develop and implement education and stewardship activities that promote recovery			
Encourage, support and undertake stewardship opportunities	Possibly	Possibly	No
Inform mariners about threats to North Atlantic right whales and their responsibility	No	No	No
Review role of logbooks for reporting	No	No	No
Evaluate effectiveness of outreach efforts	No	No	No

Assessing the effectiveness of individual mitigation activities aimed at reducing the risk of entanglement to North Atlantic right whales from fishing gear is not possible. However, when examining the North

Atlantic right whale population and interactions with fishing gear, it becomes clear that the measures implemented thus far have been ineffective at reducing the number of North Atlantic right whale entanglements. Between 2009 and 2013 an annual average of 4.3 North Atlantic right whales were killed by human activities, in both Canada and the USA, a level much higher than the Potential Biological Removal (PBR)[5] level of one North Atlantic right whale (Waring et al. 2016). Of 24 records of mortality and serious injury from 2009 through 2013 (both from USA and Canada) 18 were attributable to fishing-gear entanglements (Waring et al. 2016). The average proportion of North Atlantic right whales with newly detected scars each year attributable to fishing gear has not significantly increased over the period of 1980 through 2009; however, a significant increase in the number of serious entanglements (deep wounds or whales carrying gear) over the same period was documented (Knowlton et al. 2012). Furthermore, there was a significant increase in the number of whales carrying gear that was attributed to an increasing difficulty for the whales to free themselves completely of gear (Knowlton et al. 2012). No reduction of serious or lethal entanglements of large whales, including the North Atlantic right whales, has been observed since North Atlantic right whales were listed as endangered in 2005 under SARA (Knowlton et al. 2012; van der Hoop et al. 2013; Pace et al. 2014).

Disentanglement response continues to be an option to reduce the risk of lethal fishing-gear entanglements until effective preventative measures are developed and implemented (Moore et al. 2013). However, several factors contribute to limiting the effectiveness of disentanglement in reducing serious injury and harm to entangled animals. The time between an entanglement occurring and the first observation of the entangled whale is typically unknown and further delays for disentanglement response may be caused by the location of the entangled whale, relaying the information to the proper authorities, and the disentanglement team finding the whale again. The location of the disentanglement team and the weather will also contribute to the amount of time a North Atlantic right whale is entangled. While entangled, a North Atlantic right whale has increased drag on its body because of the attached gear (van der Hoop et al. 2013) that will slowly reduce energy stores as they require ~2.2 $\times$1010 J more energy to swim and feed (van der Hoop et al. 2016). Furthermore, the most common point of attachment in North Atlantic right whales is the head region (Johnson et al. 2005), where the entangling rope often disrupts the baleen resulting in reduced feeding efficiency (Moore and van der Hoop 2012). The energy required to overcome the drag of the gear and the possibility for decreased feeding efficiency significantly contributes to the emaciation that is commonly seen with chronic entanglements (Cassoff et al. 2011). Lacerations and resulting infections are another cause of death in entangled whales as they can have severe tissue and bone damage (Moore and van der Hoop 2012). The length of the time whales are entangled can be years (Moore et al. 2013) and on average it can take six months for an entangled whale to die (Moore et al. 2006). Even if the disentanglement team locates the entangled whale and attempts disentanglement, there is a low probability of success. In a study of 53 North Atlantic right whale entanglements between 1995 and 2008 only 40% of the cases resulted in successful disentanglement (Robbins et al. 2015). Furthermore, sub-lethal entanglements can contribute

[5] The Potential Biological Removal (PBR) is defined as 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 (Wade 1998).

to declining health and reproductive failure long after the whale is disentangled (Rolland et al. 2016; van der Hoop et al. 2016, 2017). The effectiveness of disentanglement efforts for reducing the threat of entanglement is thus limited. To ensure a healthy population of North Atlantic right whales, entanglement events should be prevented rather than relying on reacting to observed entangled whales and attempting disentanglements as the primary means of reducing the threat. Prevention rather than reaction is required for North Atlantic right whale recovery.

6.3 Disturbance and Habitat Reduction or Degradation

Disturbance and habitat reduction and/or degradation have been identified as a threat to North Atlantic right whales in the Recovery Strategy (DFO 2014). Contaminants, acoustic disturbance, vessel presence, and changes in food supply, have been identified as the main contributors to disturbance and habitat reduction or degradation. The effects of various types of degradation could be instantaneous or cumulative, or both, and it is extremely difficult, and in some cases not possible, to document these effects using empirical data.

Mortalities due to human activities are well documented (e.g., Moore et al. 2004; Cassoff et al. 2011, van der Hoop et al. 2013); however, attributing sub-lethal effects of disturbance to anthropogenic activities is much more difficult (Rolland et al. 2016). It is also challenging to distinguish and quantify the relative impact of different factors, both natural and anthropogenic, on the health and vital rates of North Atlantic right whales (Kraus and Rolland 2007). As it is difficult to measure the response of the population or of individuals to the impacts of habitat loss, pollutants, acoustic disturbance, or climate change (Kraus and Rolland 2007), measuring the effectiveness of recovery activities addressing disturbance and habitat degradation (Sections 6.3.1-6.3.4) will be extremely difficult.

Contaminants, acoustic disturbance, vessel presence, and changes in food supply, are unlikely to result directly in the death of individuals although these threats have implications for the health of North Atlantic right whales. North Atlantic right whale health can be considered to assess the effectiveness of recovery activities that address these threats and indicate that the recovery activities listed below have not been effective, acknowledging that sub-lethal vessel strikes and fishing-gear entanglements will also affect the health of an individual. The annual average estimated health scores of all demographic groups in the population has declined over the period 1980 through 2008 (Rolland et al. 2016), although it was not determined if this observed decline was statistically significant.

6.3.1 Contaminants

Compared to all other wildlife worldwide, marine mammals are subject to the highest levels of environmental contaminants, some of which may suppress their immune function (Desforges et al. 2016). Contaminants and pollutants have been measured in North Atlantic right whales; however, the effects are generally unknown and causal links between health and reproduction have not been identified (Kraus and Rolland 2007). There have been a few studies on North Atlantic right whales and organochlorine and metal contaminants (Woodley et al. 1991; O'Shea et al. 1994; Montie et al. 2010). O'Shea et al. (1994) concluded that there was no definite basis for concluding that pollutants reviewed

affected baleen whale populations, and research and management priorities should focus on reducing anthropogenic mortalities. Prohibition and/or reductions of some contaminants have been implemented under programs unrelated to Species at Risk species including the Prohibition of Certain Toxic Substances Regulations, 2012 (Canada Gazette 2016), Products Containing Mercury Regulations (Canada Gazette 2014), and PCB Regulations, 2008. Further reductions in contaminants will be achieved as owners and operators of wastewater systems that are subject to the Wastewater Systems Effluent Regulations (which entered into force June 2012) comply with the effluent quality standards indicative of secondary wastewater treatment. Internationally, the Government of Canada has been working with other countries under the Stockholm Convention on Persistent Organic Pollutants and the Minamata Convention on Mercury to minimize exposure to contaminants from foreign sources.

North Atlantic right whales are also exposed to naturally occurring toxins such as paralytic shellfish poisoning (PSP) toxins. In the Bay of Fundy PSP toxins have been found in North Atlantic right whale feces and could have sub-lethal health effects on individuals (Doucette et al. 2006).

6.3.2 Acoustic Disturbance

Acoustic disturbance is generally attributable to two types of anthropogenic noise: impulsive sounds such as seismic airgun operations and military sonar (noise with high peak sound pressure, short duration, fast-rise time, and broad-frequency content); and non-impulsive (i.e., steady-state) noise, such as that produced during shipping activities (NMFS 2016). Both seismic operations and shipping activities produce sounds that have been shown to interfere with normal activities and movements of cetaceans (Richardson et al. 1995).

There has been little progress in directly addressing anthropogenic noise threats to North Atlantic right whales in Canadian waters. The changes in vessel traffic due to recovery activities focused on reducing vessel strikes in the Bay of Fundy and Roseway Basin regions may have reduced noise in North Atlantic right whale critical habitat, but this has not been studied or quantified. Some passive acoustic monitoring studies that measure baseline noise levels within the distributional range of North Atlantic right whales are currently underway. DFO, JASCO Applied Sciences, and other organizations are collecting data and characterising the soundscape, including natural and ambient noise levels, throughout Nova Scotia, Newfoundland and Labrador, and the St. Lawrence estuary and Gulf of St. Lawrence waters. Some, but relatively limited monitoring of noise levels in and around identified critical habitats has occurred.

The recovery activities outlined in the Progress Report related to acoustic disturbance focus on reviews of environmental assessments of oil and gas exploration and seismic exploration programs (DFO 2016b). DFO completed a review of the mitigation and monitoring measures used for seismic airgun activities in and near the habitat of cetacean species at risk, identifying enhanced and additional mitigation measures that should be implemented for Species at Risk (DFO 2014b).

The Recovery Strategy identified shipping noise as a threat to North Atlantic right whales; however, it does not propose mitigation measures from this disturbance. Rolland et al. (2012) demonstrated that a 6 dB reduction in background noise (50Hz – 20 kHz) in the Bay of Fundy was associated with a reduction

in the hormones associated with stress in North Atlantic right whales. Little effort has been made to monitor sound levels associated with shipping noise within North Atlantic right whale critical habitat even though the outbound lane of the Bay of Fundy TSS intersects the critical habitat (Figure 2). Not only are large vessels required to transit through the TSS, but transit at a higher speed compared to the inbound lane of the TSS (Vanderlaan et al. 2008) making the critical habitat for North Atlantic right whales a potentially noisy area. On Stellwagen Bank, an area also intersected by the Boston TSS, Hatch et al. (2012) estimated at 63-67% loss in North Atlantic right whale communication space due to vessel noise. Clark et al. (2009) postulated that North Atlantic right whales are particularly vulnerable to communication masking as a result of chronic noise from vessel traffic. Vessel noise could be increasing stress levels in North Atlantic right whales, masking their "contact calls", and decreasing their communication space.

On Roseway Basin the majority of vessels transit around North Atlantic right whale critical habitat, as the critical habitat has the same boundaries as the IMO-adopted ATBA. However, non-compliant vessels still transit through the critical habitat possibly leading to acoustic and vessel-presence disturbance. Vessel noise can travel great distances and even vessels transiting near but not within Grand Manan and Roseway Basins can potentially impact the acoustic environment within these critical habitat areas. In the Recovery Strategy, acoustic disturbance has been identified as having the potential to result in destruction of North Atlantic right whale critical habitat (DFO 2014) and it is not known if the level of noise generated by vessels transiting in or near the TSS or ATBA could be considered destruction of North Atlantic right whale critical habitat.

One study monitored noise levels in the Bay of Fundy to compare among other North Atlantic right whale critical habitats (Parks et al. 2009). Parks et al. (2009) determined that the Bay of Fundy was the loudest of the three areas studied that also included Cape Cod Bay and the southern calving ground off the coast of Georgia. This research has not continued, therefore it is not possible to determine if noise has changed in the Bay of Fundy critical habitat. Further studies are required to monitor this threat and determine if noise is increasing, decreasing, or remaining constant. One option to monitor noise, both contemporary levels and historic levels, could be to use vessel presence and the number and type vessels as a proxy for noise levels, ensuring to explicitly state the caveats and assumptions associated with using these data. Vessel data are available to monitor the number and type of vessels in coastal areas, some starting as early as 2007, through DFO's Canadian Coast Guard terrestrial network of AIS receivers and the Taggart Lab (Dalhousie Oceanography) AIS network.

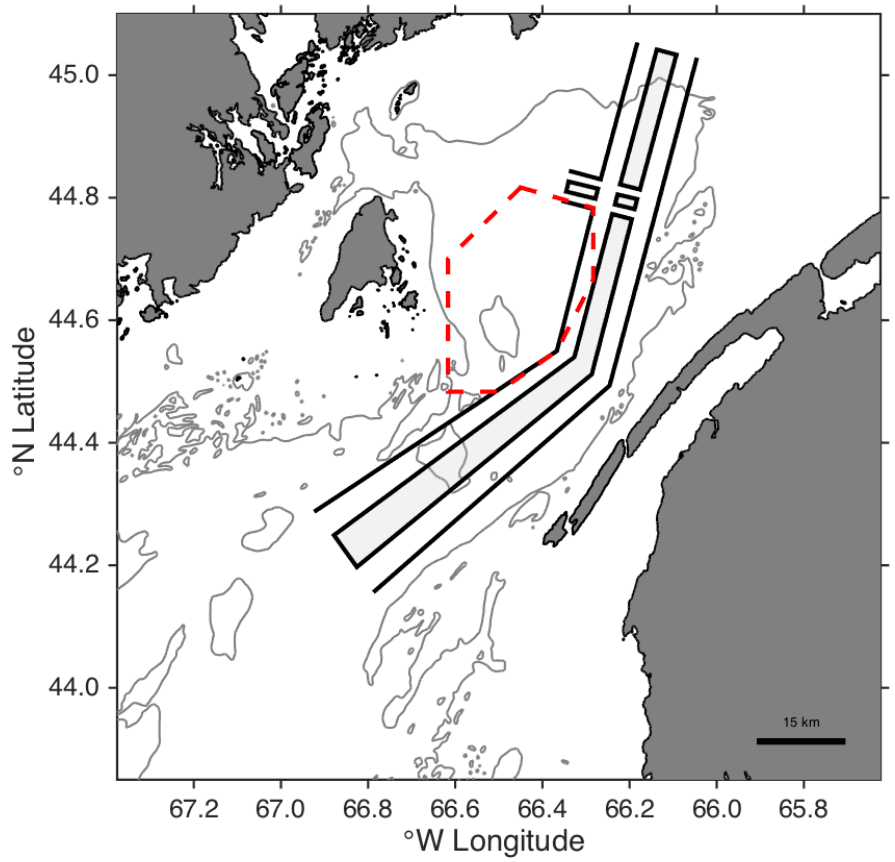

Figure 2. The spatial concurrence of the Traffic Separation Scheme (black lines and polygons) and North Atlantic right whale critical habitat (red dashed polygon) in the Bay of Fundy. The 100m and 200m isobaths (grey lines) are also depicted.

6.3.3 Vessel-presence Disturbance

Vessel-presence disturbance has been identified as a threat in the Recovery Strategy; however, there is no performance indicator associated with vessel-presence disturbance (Appendix C, Table C3). The potential harmful effects of vessel-presence disturbance are unknown and this threat represents a large knowledge gap. Further research is needed to determine the effects on the health and survival of North Atlantic right whales attributable to vessel-presence disturbance to inform the design of effective threat-based recovery activities. As no measures are in place to reduce the unknown effects of this threat, effectiveness of the Recovery Strategy relating to vessel-presence disturbance cannot be evaluated.

6.3.4 Changes in Food Supply

North Atlantic right whale occupancy in critical habitats has been linked to food supply (Patrican & Kenney 2010; Davies et al. 2015a). Adequate food resources are directly connected to fitness of

individuals and the viability of the North Atlantic right whale population (Schick et al. 2013; Rolland et al. 2016) and there is some evidence that nutritional stress may be limiting recovery (Greene and Pershing 2004; Fortune et al. 2013). Changes in food supply have been identified as a threat to North Atlantic right whales and prey removal from identified critical habitats has the potential to result in the destruction of critical habitat (DFO 2014). Changes in food supply that threaten North Atlantic right whales include decreases in food availability and condition (i.e., nutritional value) and shifts in distribution, especially shifts that move food supplies outside of critical habitats that offer some protection to North Atlantic right whales from other threats. Several studies are completed or underway to examine the factors affecting *Calanus* distribution (e.g., Michaud and Taggart 2007, 2011; Davies et al. 2015b; Albouy-Boyer et al. 2016). At this time, there is no fishery for *Calanus* and therefore no competition for this food resource other than other marine animals that also prey on copepods. As such, little is being done to address this threat other than research that examines the variation in distribution and abundance of *Calanus*.

As critical habitat for this species was originally defined as "areas that possess the environmental, oceanographic and bathymetric conditions that aggregate concentrations of right whale prey, especially stage-C5 *Calanus finmarchicus* copepodites, at interannually predictable locations" (Brown et al. 2009), activities around critical habitat are discussed here. Critical habitat has been defined in both Canada (DFO 2014) and the USA. USA recently identified the Gulf of Maine as critical habitat that includes the previously defined critical habitat in Cape Cod Bay and in the Great South Channel. The Southern calving ground was also expanded to include all coastal waters of Georgia, South Carolina, and part of North Carolina; increasing the identified critical habitat area by ~5-fold, from 1,611 nm^2 to 8429 nm^2 (NOAA 2016b). In the Recovery Strategy, the Roseway Basin critical habitat was identified as possibly requiring refinement of the geospatial boundaries pending further research and scientific review. Davies et al. (2014) proposed that the critical habitat should be expanded based on oceanographic and bathymetric conditions that support the aggregation of copepods at depth. Refinement of currently identified critical habitat, and identification of new critical habitat in areas being more frequently used by right whales, could provide further protection of North Atlantic right whales.

7. Indirect Recovery Activities: Monitoring and Stewardship

Through research and monitoring efforts many recovery activities under Objectives 4-7 are being addressed (Table 1). When counting the number of activities that have been completed or are underway listed in the Progress Report (DFO 2016b) that apply to each objective, it becomes evident that most activities thus far focus on Objectives 4-7, with each of these objectives having at least double the number of activities as compared with Objectives 1-3 (Appendix C, Table C1). Similarly, when examining the performance indicators in the Recovery Strategy, only the first nine performance indicators address Objectives 1-3, and these have a lower number of activities associated with them when compared to the other 11 performance indicators that address Objectives 4-7 (Appendix C, Table C2).

As previously discussed, this is a threat-based assessment of the effectiveness of recovery activities that have been implemented to directly reduce threats North Atlantic right whales. As Objectives 4-7 are not directly associated with identified threats, they will not be evaluated here for their effectiveness on

North Atlantic right whale recovery. However, it is important to recognize that many of the activities listed under Objectives 4-7 may indirectly affect the effectiveness of, and are important for informing, threat-based recovery activities. For example, without research and monitoring of the population to increase knowledge of their abundance, distribution, seasonal occurrence and habitat use (such as surveys undertaken by the New England Aquarium, NOAA, CWI, DFO, Dalhousie University, and others), it would be difficult to implement effective spatiotemporal threat-based recovery activities, such as the amendment to the Bay of Fundy TSS and the Roseway Basin ATBA. The science justification for many of these measures relied on data generated through activities that support Objectives 4-7. As well, some of the stewardship activities listed under Objectives 4-7 are needed to promote and encourage the continuing success of implemented recovery activities. Furthermore, many research and monitoring activities, particularly those related to monitoring population health, abundance and trends, are required to evaluate the effectiveness of any threat-based recovery activities implemented, as has been evidenced in the previous section of this review. It is imperative to better identify the high priority activities within Objectives 4-7 that have a direct impact on the implementation of management measures to ensure that they are supported.

8. Threat-Based Recommendations

The following sections present recommendations about the most effective (and thus high priority) recovery activities to reduce threats to North Atlantic right whales and reduce risks to the population, based on this review that was made under a limited time frame and a limited review process. These recommendations should therefore be considered with these caveats in mind, noting that it is possible that with a more extensive scientific review process, different recovery activities might be recommended.

There is considerable evidence that vessel strikes and fishing-gear entanglements are the primary and immediate concerns for North Atlantic right whale recovery as they are the leading cause of documented human-induced deaths (van der Hoop et al. 2013), are known to cause serious injury and harm, and consequently have resulted in population-level impacts as the PBR has been exceeded every year except one between 1995 through 2009 (van der Hoop 2013) There is less evidence of direct impacts on North Atlantic right whale recovery from disturbance and habitat degradation threats, largely due to the difficulty in assessing the likely sub-lethal impacts from these threats on individuals and populations. The extent and severity that the negative effects of threats related to disturbance and habitat degradation have on health and long-term survival represent a knowledge gap for cetaceans in general.

In most cases, the most effective recovery activity would be to remove the threat from areas where North Atlantic right whales are present - i.e., spatiotemporal avoidance (Table 4). To accomplish this we need to know (1) where the North Atlantic right whales are in space and time; (2) where the threat is in space and time; and (3) areas, in space and time, where the two intersect. Much of the work to assess the risk of vessel strikes and fisheries interactions within identified North Atlantic right whale critical habitat in Canadian waters has been completed, and has demonstrated that removing these activities from the critical habitats will reduce the risk of lethal vessel strikes and fisheries interactions

(Vanderlaan et al. 2008, Vanderlaan and Taggart 2009, Vanderlaan et al. 2011). Given that the identified critical habitat supports important life functions for North Atlantic right whales and represents areas where the majority of right-whale sightings in Canadian waters have occurred, little additional research is needed to support that implementing spatiotemporal-avoidance measures in these areas will reduce the risk to the population. Spatiotemporal-avoidance measures should also be considered for other North Atlantic right whale high-use areas (for example, potentially in the southern Gulf of St. Lawrence); however, further work is required to define these other areas. Considerable research is required to explain the variation in North Atlantic right whale movements and residency patterns, thus continued studies focusing on distribution and habitat use are a high priority to support implementation of effective spatiotemporal-avoidance measures.

The following sections provide a more detailed description of spatiotemporal-avoidance measures and other recovery activities that must be undertaken to reduce the threats of vessel strikes, fishing-gear entanglements, and disturbance and habitat destruction for North Atlantic right whales, as well as research and monitoring activities required for implementing the measures and assessing their effectiveness. Table 5 presents a summary of the recommended recovery activities, including anticipated effectiveness from implementing such measures towards reducing risk and the estimated timelines for conducting the scientific research required to support successful implementation of the measures.

Table 5 -Recommendations for broad strategies and potential recovery activities to reduce identified threats to North Atlantic right whales.

Impact describes whether the recovery activity will have a direct or indirect impact with respect to threat abatement. Scope is the degree to which the recovery activities will benefit the population and is categorized as "High" (reduces the risk of the threat and thus reduces mortalities and serious injuries), "Medium "(reduces potential impacts on health and/or reproduction), or "Low" (can be used to inform the development and implementation of recovery activities, including measuring the effectiveness of a recovery activity). The time for the supporting science available refers to the estimated time required to establish the supporting science for justification and implementation of a recovery activity. The anticipated time for benefits refers to the time required for the recovery activity to reduce the threat. The anticipated time for benefits does not necessarily reflect the amount of time required to observe measurable changes in the population. Both timing columns are categorized as "Immediate" (less than one year), "1-5 years", "5-10 years" or ">10 years". Rank was assessed either as '1' (impact is direct, the scope is high) or '2' (impact is direct or indirect and the scope is either low or medium). The same recovery activity, e.g., remove vessel traffic from critical habitats, could have different assigned rank when addressing different threats due to differences in scope.

Threat	Broad strategy	Recovery activity	Anticipated effectiveness of the activity		Timing		Rank
			Impact	Scope	Supporting science available	Anticipated time for benefits	
Vessel Strike	Reduce vessel impacts in North Atlantic right whale high-use areas	Remove vessel traffic from Grand Manan Basin critical habitat by amending the Bay of Fundy Traffic Separation Scheme so that it no longer intersects the Grand Manan Basin critical habitat	Direct	High	Immediate	Immediate	1
		Remove vessel traffic from Roseway Basin critical habitat by promoting awareness through further Notices to Mariners and monitoring the Roseway Basin Area to be Avoided to ensure compliance	Indirect	Low	Immediate	Immediate	2
		Remove vessel traffic from other high-use areas by restricting vessel transit through other identified high-use areas (e.g., potentially the Gaspé region in the Gulf of St. Lawrence)	Direct	High	1-5 years	Immediate	1
	Reduce vessel impacts in North Atlantic right whale high-use areas	Implement vessel speed restrictions in the vicinity of critical habitat and other high-use areas when North Atlantic right whales are present	Direct	High	Immediate	Immediate	1

Threat	Broad strategy	Recovery activity	Anticipated effectiveness of the activity		Timing		Rank
			Impact	Scope	Supporting science available	Anticipated time for benefits	
	Conduct research and monitoring to evaluate the efficacy of implemented recovery activities	Required research and monitoring to determine effectiveness of these activities include: outreach efforts, monitoring traffic patterns, necropsies of all dead whales, monitoring population abundance and individual health, scarring rate studies, etc.	Indirect	Low	1-5 years	1-5 years	2
Fishing-Gear Entanglement	Implement preventative measures to reduce risk of interactions between fishing gear and North Atlantic right whales	Remove fishing gear from critical habitats by implementing spatiotemporal closures to fishing activities in critical habitats when North Atlantic right whales are present	Direct	High	Immediate	Immediate	1
		Remove fishing gear from other high-use areas by implementing spatiotemporal closures of fishing activities when North Atlantic right whales are present	Direct	High	1-5 years	Immediate	1
		Remove rope from the water column by implementing ropeless gear fisheries in areas where North Atlantic right whales occur thereby partially removing the threat	Direct	High	5-10 years	Immediate	1
	Maintain and increase capacity for disentanglement response	Continue to support, increase capacity and implement response to North Atlantic right whale entanglement events	Direct	High	Immediate	Immediate	1
	Implement gear marking and gear retrieval programs	Implement gear marking and gear retrieval programs to provide information allowing the identification of the source of the gear (i.e., the specific fishery) and the type of lines (e.g., endlines versus groundlines) involved in the entanglement.	Indirect	Low	Immediate	>10 years	2

Threat	Broad strategy	Recovery activity	Anticipated effectiveness of the activity		Timing		Rank
			Impact	Scope	Supporting science available	Anticipated time for benefits	
	Implement gear reporting	Implement gear reporting (including when, where, and how much gear is being set) as a requirement for industry	Indirect	Low	Immediate	>10 years	2
Fishing-Gear Entanglement -continued	Conduct research and monitoring to evaluate the efficacy of implemented recovery activities	Required research and monitoring to determine effectiveness of these activities include: outreach efforts, monitoring fishing activities, necropsies of all dead whales, monitoring population abundance and individual health, scarring rate studies, etc.	Indirect	Low	1-5 years	1-5 years	2
Acoustic disturbance	Implement preventative measures to reduce acoustic disturbance	Remove vessels from critical habitats to decrease the level of vessel noise to some degree in the critical habitat, thereby decreasing the threat acoustic disturbance (though the extent that noise levels will be decreased is not currently known, and the close proximity of major shipping traffic to the critical habitats even once vessels are removed from the area will still result in some level of vessel noise exposure)	Indirect	Medium	Immediate	Unknown[6]	2
	Implement preventative measures to reduce acoustic disturbance	Remove fishing activities from critical habitats to decrease to the level of vessel noise to some degree in the critical habitat, thereby decreasing the threat acoustic disturbance (though the extent that noise levels will be decreased is not currently known, and the close proximity of major shipping traffic to the critical habitats even once vessels are removed from the area will still result in some level of vessel noise exposure)	Indirect	Medium	Immediate	Unknown[5]	2

[6] Unknown due to the proximity of the critical habitats to major shipping traffic

Threat	Broad strategy	Recovery activity	Anticipated effectiveness of the activity		Timing		Rank
			Impact	Scope	Supporting science available	Anticipated time for benefits	
	Continued research and monitoring to quantify this threat and identify additional direct recovery activities	This threat represents a major knowledge gap and further research is required to determine the impacts on North Atlantic right whales both within and outside critical habitats, and to identify additional direct recovery activities and determine the effectiveness of any recovery activities implemented	Indirect	Low	5-10 years	5-10 years	2
Vessel-presence disturbance	Implement preventative measures to reduce vessel-presence disturbance	Remove vessels from critical habitats to decrease exposure to vessel presence, thereby decreasing the threat of vessel-presence disturbance	Direct	Medium	Immediate	Immediate	2
	Implement preventative measures to reduce vessel-presence disturbance	Remove fishing activities from critical habitats to decrease the threat vessel-presence disturbance	Direct	Medium	Immediate	Immediate	2
	Continued research and monitoring to quantify these threats and identify additional direct recovery activities	This threat represents a major knowledge gap and further research is required to determine the impacts on North Atlantic right whales, and to identify additional direct recovery activities and determine the effectiveness any recovery activities implemented	Indirect	Low	5-10 years	5-10 years	2
Contaminants	Continued research and monitoring to quantify these threats and identify additional direct recovery activities	This threat represents a major knowledge gap and further research is required to determine the impacts on North Atlantic right whales, and to identify direct recovery activities and determine the effectiveness of any recovery activities implemented	Indirect	Low	5-10 years	5-10 years	2

Threat	Broad strategy	Recovery activity	Anticipated effectiveness of the activity		Timing		Rank
			Impact	Scope	Supporting science available	Anticipated time for benefits	
Changes in food supply	Continued research and monitoring to quantify these threats and identify additional direct recovery activities	This threat represents a major knowledge gap and further research is required to determine the impacts on North Atlantic right whales, and to determine if recovery activities can be implemented to address spatiotemporal variability in North Atlantic right whale food	Indirect	Low	5-10 years	5-10 years	2

8.1 Vessel Strikes

Several successful recovery activities have been implemented to reduce the risk of vessel strikes to North Atlantic right whales in both Canada and the USA, and a significant decrease in number of observed deaths of North Atlantic right whales attributable to vessel strikes has been documented. However the risk of lethal vessel strikes to North Atlantic right whales has not been eradicated. This threat still exists and does cause mortalities and serious injuries. Further measures could be implemented in Canada to reduce the risk of lethal vessel strikes, especially in identified critical habitats as well as in new areas where aggregations of North Atlantic right whales are being observed (e.g., the Gulf of St. Lawrence).

Although the 2003 modification to the Bay of Fundy TSS has reduced the risk of lethal vessel strikes, the amended TSS still intersects North Atlantic right whale critical habitat and not only puts North Atlantic right whales at risk of lethal vessel strikes but also exposes them to acoustic and vessel-presence disturbance. This has the potential to destroy critical habitat (DFO 2014) which is prohibited under the SARA. The TSS could be amended to further remove vessel transits from the critical habitat, also reducing vessel-presence disturbances and potentially vessel noise levels in the critical habitat.

The Roseway Basin critical habitat has the same boundaries as the recommendatory ATBA that was implemented to reduce the risk of lethal vessel strikes. The ATBA is a voluntary measure and the compliance with this recovery activity must continue to ensure sustained effectiveness. Compliance appears to be decreasing in 2016 (Vanderlaan and Taggart, unpublished data), and this suggests that further outreach to mariners must be conducted to ensure awareness of the ATBA and the IMO recommendations.

Vessels should also be removed from other North Atlantic right whale high-use areas. These may include relatively newly described aggregation areas such as those observed off the coast of the Gaspé Peninsula in the Gulf of St. Lawrence. Again, reducing the number of vessels in North Atlantic right whale high-use areas also decreases potential vessel-presence and acoustic disturbances. This recovery activity would require further research to find and define other North Atlantic right whale high-use areas.

In addition to spatiotemporal-avoidance measures, speed restrictions in the vicinity of critical habitats, in areas between the two identified critical habitats, and high-use areas when whales are present would also reduce the risk of lethal vessel strikes. North Atlantic right whales are highly mobile and although they tend to aggregate in specific areas, individuals are constantly on the move. By implementing a speed restriction, if a vessel were to strike a whale the probability of killing the whale is decreased (Vanderlaan and Taggart, 2007). Speed restrictions could be implemented as SMAs, similar to the USA, or in response to real-time detections or observations during surveys.

8.2 Fishing-Gear Entanglements

Contrary to the observed relative success of reducing the threat of vessel strikes, the threat of fishing-gear entanglement continues to be an urgent concern for North Atlantic right whales. Thus far, Canada has had a reactionary approach to fishing-gear entanglements focusing on disentanglement effort performed by various non-government agencies. Few proposed recovery activities focus on

entanglement prevention (e.g., spatiotemporal closures) and mitigation (e.g., decreased breaking strength in rope). Many knowledge gaps remain about fishing-gear entanglements, such as the mechanisms of entanglement, the level of threat associated with each type of line in fixed fishing gear (e.g., groundlines versus endlines), and the threat level associated with different fisheries. Nonetheless removing fishing activities from the Grand Manan and Roseway Basin critical habitats when the whales are present (i.e., spatiotemporal closures) would reduce the risk of lethal fishing-gear entanglements as demonstrated in previous studies (Vanderlaan et al. 2011; Brillant et al. 2017). These studies are based on historical fishing data and Vanderlaan et al. (2011) aggregated the fishing data across several years to capture the spatiotemporal variation in fixed fishing gear deployments. Fishing gear should also be removed from other high-use areas; however, this does require research to define the boundaries of these areas. Reducing the spatiotemporal co-occurrence of North Atlantic right whales and fishing gear would reduce the probability of a whale encountering gear and becoming entangled. This recovery activity would prevent entanglements from occurring thus there are no associated reductions in health due to increased drag on the whale or injuries as a result of an entanglement. Spatiotemporal-fishing closures also may have the added benefit of reducing other threats to the population such as acoustic disturbance and vessel-presence disturbance.

The USA Atlantic Large Whale Take Reduction Plan (ALWTRP) began in 1997 and NOAA and the USA fishing industry has implemented approximately 20 years of gear modifications implemented with little testing and little success in reducing fishing-gear entanglements. The failure of gear modifications as a recovery activity for North Atlantic right whales stems from the inability to effectively test proposed solutions prior to their deployment (Moore 2014). Knowlton et al. (2015) recently recommended decreasing the breaking strength of ropes to ≤ 7.56 kiloNewtons (≤ 1700 pound-force) to reduce the number of life-threatening entanglements. This modification could be developed and tested to determine the feasibility of using such rope in Canadian fisheries. Alternatively (or additionally), removing gear, specifically lines, from the water column would also decrease the threat of entanglements. Development and testing of ropeless gear, and its feasibility for use in a variety of Canadian fisheries, should also be considered. However, until gear modifications are developed, tested, and put into place, the immediate focus should be on keeping gear and whales separate in time and space (Moore 2014).

Disentanglement does not prevent entanglement, rather it is reactionary. Its effectiveness is limited due to challenges associated with disentangling North Atlantic right whales. Furthermore, even if disentangled, a whale could still suffer from long-term health effects from the entanglement. Despite these limitations, with such a small population where the death of two females each year can jeopardize recovery of the species (Fujiwara and Caswell 2001), every effort should be made to reduce the effects of fishing-gear entanglements on individual whales when they occur. Thus when North Atlantic right whales become entangled in fishing gear, disentanglement efforts should be a priority. Gear retrieval and protocols for storing and examining gear should also be a priority as this provides further insights into the types of gear and the identity of fisheries causing entanglements.

Gear marking and gear reporting, though not preventative recovery activities, should be implemented to increase the probability of identifying the source of the gear involved in entanglements (e.g., endlines versus groundlines and specific fishery). Gear reporting (including when, where, and how much gear is being set) should be a requirement for industry as detailed location data allow for more accurate risk estimation and the development of recovery activities. Locational data are generally spatially aggregated for these types of analyses and unique identifiers are not used (Vanderlaan et al. 2011, Brillant et al. 2017). Data should be standardised across all regions within DFO and for appropriate analyses specific latitudes and longitudes are required rather than low resolution reporting polygons. Detailed information on vessel location and speed was necessary to mitigate the threat of vessel strikes in North Atlantic right whale critical habitats and mitigation would not have been possible without these data. Similarly, detailed information on fishing activities are required to develop effective mitigation to reduce risk of entanglement to North Atlantic right whales.

8.3 Disturbance and Habitat Reduction or Degradation

There is a lack of information that exists about the threats from disturbance and habitat reduction or degradation. While the direct effects of these threats on individual North Atlantic right whale health and population dynamics are generally unknown, recovery activities could be implemented to reduce potential impact on individuals and the population.

As previously noted, moving vessel traffic and fishing activities outside identified critical habitat and high-use areas would decrease vessel-presence disturbance and acoustic disturbance. Reducing vessel speed could also potentially reduce the noise from container ship (McKenna et al. 2013) and would also decrease the probability of a lethal injury if a vessel were to hit a whale (Vanderlaan and Taggart 2007). If speed restrictions were to be implemented to reduce acoustic disturbances, they would have to be balanced with the potential effects of increased disturbance due to prolonged vessel presence. Until more is known about which threat, acoustic disturbance or vessel-presence disturbance, is more harmful to North Atlantic right whales, it is challenging to design effective recovery activities to address these disturbances through speed restrictions.

Threat-based measures for directly reducing the impacts of contaminants cannot be recommended at this time due to existing knowledge gaps; therefore, research and monitoring are required to address this threat.

Changes in food supply could also be affecting the health of North Atlantic right whales and their distribution. Several studies are assessing variability in *Calanus* aggregations, distribution, condition, and have been trying to identify areas outside the critical habitat that could support North Atlantic right whale feeding aggregations. However, no threat-based measures for changes to food supply can be implemented at this time.

9. Required Research and Monitoring

For all of the recovery activities described above, population monitoring is required to determine if the measures have been effective in reducing the targeted threat. Population monitoring studies assess abundance, survivorship, and health of the animals. It is a high priority for such population monitoring studies to continue.

As well, monitoring scarring rates and injured or dead animals (necropsies) provides further insights into the causes of health declines and/or increases in mortalities. Documentation of all incidents involving North Atlantic right whales (and other cetacean species) should continue in support of tracking threats and learning more about how incidents occur. Data on marine mammal incidents are currently scattered throughout different organizations making comprehensive analysis difficult – data collection of incidents should be standardized nationally and made available for analyses (DFO 2016c). Necropsies should be performed on dead North Atlantic right whales whenever safe for the necropsy team. Necropsies provide crucial information on threats and are the only method that has a high probability to make a specific determination of the cause of death (Campbell-Malone et al. 2008); including ruling out some causes. Necropsies also provide valuable statistics to scientists and agencies responsible for North Atlantic right whale protection and recovery. Data collected from North Atlantic right whale carcasses are the primary source of information on human-induced mortalities and is therefore essential for tracking causes of serious harm and mortality. Such data can also inform the development of future recovery activities. For example Vanderlaan and Taggart's (2007) study estimating the probability of a lethal injury to a large whale as a function of vessel speed at the time of collision was based on published reports documenting vessel strikes (e.g., Laist et al. 2001; Jensen and Silber 2003). This study was used, in part, to justify the 10 knot speed restriction in the USA and would not have been possible if necropsies were not done to determine the cause of death, and if the data were not amalgamated into a centralized database.

Managing human activities that threaten North Atlantic right whales requires knowledge of times and locations where the whales and the threats co-occur. Survey effort has generally focused on known seasonal aggregations of the North Atlantic right whales and only covers a fraction of their distribution (Brillant et al. 2015). Their movement patterns have implications for conservation patterns (Schick et al. 2009), especially as recovery activities, proposed and implemented, focus on critical habitats. Further research is required to detect, survey, and study North Atlantic right whales outside their traditional areas of occurrence. This research could identify high-use area and migratory pathways where further recovery activities should be implemented.

Rate of interactions in Canadian waters is a performance indicator for the threat of vessel strikes and fishing-gear entanglements in the Recovery Strategy. The data available for measuring fisheries interactions with large whales are frequently too limited to support strong, statistically-significant conclusions about the efficacy of recovery activities (Pace et al. 2014). This is often true in conservation biology and van der Hoop et al. (2014) attributed their inability to detect significant interactions in space and time following the implementation of speed restrictions in the USA, to low compliance; insufficient time and/or monitoring to examine effectiveness; or the SMAs being too short in duration and/or too

small. A simulation study concluded that rates of detected mortalities attributable to fishing gear must be decreased by at least 50% to be able to detect a change within 10 years (Pace et al. 2014). Although the abatement of threat is listed as immediate in many of recovery activities proposed, it will take a much longer time period to be able to detect changes within the population.

Monitoring and evaluating compliance are a crucial component of any conservation initiative (Stem et al. 2005). Monitoring allows for an accurate evaluation of the effectiveness of recovery activities, including determination of reasons (such as lack of compliance with mandatory and voluntary measures) why implemented recovery activities may be ineffective. For any recovery activity implemented, it is imperative that a monitoring plan is developed and implemented to determine compliance and effectiveness of the measure.

10. Conclusions

Since the Recovery Strategy was first published in 2009, the observed serious injuries and mortalities of North Atlantic right whales from fishing-gear entanglements appear to be increasing and may be overwhelming recovery efforts (Kraus et al. 2016). Between 1995 and 2009 the average per cent that the PBR (average PBR/year 0.1±0.2 standard deviation) was exceeded by human-induced mortalities per year (3.1±0.5 standard deviation) was 650 (± 379 standard deviation; van der Hoop et al. 2013). Two out of the three population assessment methods used for North Atlantic right whales demonstrate a decline in North Atlantic right whale abundance (Kraus et al. 2016 and references therein), therefore threats to the species collectively have not been sufficiently reduced to allow for continued population growth and the interim recovery goal stated in the Recovery Strategy is not being achieved.

In the Recovery Strategy (DFO 2014), Objectives 1-3 address mortalities, serious injuries, and the health of individual North Atlantic right whales in the population through directly addressing identified threats to the population (Table 1). While important and informative, Objectives 4-7 do not directly reduce threats to individuals in the population, rather they describe approaches that are needed to address the identified threats and thus support the first three objectives. The Progress Report (DFO 2016b) highlights that, to date, the majority of the effort on North Atlantic right whale recovery focuses on Objectives 4-7 rather than direct threat based measures of Objectives 1-3. This highlights the need to refocus recovery efforts to reducing the identified threats to North Atlantic right whales.

The proposed Action Plan is timely and focuses exclusively on fishing-gear entanglements as the majority of recent mortalities and serious injuries have been attributed to this threat. However, this Action Plan does not recommend recovery activities that would remove gear for entanglement prevention and thus reduce the risk of a lethal entanglement. To ensure a healthy population of North Atlantic right whales, the focus should be on preventing entanglement events rather than relying on gear modification and disentanglement efforts. The simplest, most direct and practical means of reducing risk to the North Atlantic right whales would be to remove fishing activities within critical habitats (i.e., spatiotemporal closures; Table 5, Vanderlaan et al. 2011, Brillant et al. 2017). Furthermore, the Action Plan only address one of the identified threats to North Atlantic right whales and further action plans should be developed to address the remaining and any new emerging threats.

Twice members of the scientific community have published reports declaring there is an urgent need for immediate management intervention to reduce human-induced mortalities of North Atlantic right whales (Kraus et al. 2005, 2016). Kraus et al. (2005) address threats from vessel strike and fishing gear, while Kraus et al. (2016) address the threat of fishing gear (Kraus et al. 2016). With only limited recovery of the population over the past several decades and recent declines observed in population health and growth (Kraus et. al. 2016; Rolland et al. 2016; Pace 2016), implementation of recovery activities that will reduce threats to North Atlantic right whales in the short-term is imperative for the long-term survival of this endangered species.

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Appendix A: Acronyms

The following is a list of acronyms used throughout this document:

ATBA – Area to be Avoided

ALWTRP - Atlantic Large Whale Take Reduction Plan

COSEWIC - Committee on the Status of Endangered Wildlife in Canada

CWF – Canadian Wildlife Federation

CWI – Canadian Whale Institute

CWRT - Campobello Whale Rescue Team

C&P - Conservation and Protection

DFO – Fisheries and Oceans Canada

ESA - Endangered Species Act

GMWSTS - Grand Manan Whale and Seabird Research Station

IMO - International Maritime Organization

IUCN – International Union for Conservation of Nature

Marine Animal Response Society – MARS

NOAA - National Oceanic and Atmospheric Administration

OPP- Oceans Protection Plan

PBR – Potential Biological Removal

SARA - Species at Risk Act

SMA – Seasonal Management Areas

TSS - Traffic Separation Scheme

USA - United States of America

WWF – World Wildlife Fund

Appendix B: Defining Risk

The terms “risk” and “risk assessment” have been widely used in conservation biology (Harwood 1999) and various definitions exist throughout the published literature. Specifically within the North Atlantic right whale literature, various definitions of risk are used, even when quantifying the risk from a specific threat. For example, Fonnesbeck et al. (2008) defined risk as the co-occurrence (in time and space) of whales and vessels. Similarly, Williams and O’Hare (2010) estimate risk by multiplying their predicted whale density estimate by a measure of shipping intensity. Vanderlaan et al. (2008) defined relative risk of a lethal collision as the relative probability that a vessel will encounter a whale (in time and space) multiplied by probability of a lethal collision given an encounter, which was estimated as a function of vessel speed (Vanderlaan and Taggart 2007). Wiley et al. (2011) estimate the risk of lethal collisions as the probability of lethality associated with specific speeds using Pace and Silber’s (2005) lethality model. In this report, unless specifically stated otherwise, a specific definition of risk, proposed initially by Kaplan and Gerricks (1981) is used. Kaplan and Gerricks (1981) definition of risk answers three questions or the “set of triplets”:

1. What can happen or what can go wrong?
2. How likely is it that it will happen?
3. If it does happen, what are the consequences?

The answer to the first question, what can go wrong, is often referred to as an event. In the context of North Atlantic right whales and the threats that they face, a North Atlantic right whale can be struck by a vessel, or entangled in fishing gear, or can be injured or disturbed from vessel presence, anthropogenic noise, or contaminants. The third question addresses the consequence and in many risk analyses in other disciplines the consequence is usually a monetary value. In this case it can be thought of from the perspective of the whale, i.e., the probability that the whale will die or have decreased health as a result of an event. Therefore, to reduce the risk to North Atlantic right whales from specific threats, the probability of an event must decrease, and/or the probability of death or injury must decrease. In the case of vessel strikes, to reduce the risk to North Atlantic right whales, vessels can be re-routed around the areas occupied predictably by whales to decrease the probability of a vessel striking a whale, and/or decrease the vessel speed thereby decreasing the probability of a lethal injury given that a vessel struck a whale.

Appendix C: Summaries of Recovery Activities

Table C1 - Recovery activities listed in the report on the progress of Recovery Strategy Implementation (DFO 2016b) and the corresponding recovery objectives addressed by the activity.

Recovery Activity	Recovery Objective						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Long-term population survey and monitoring				1	1	1	
Development of molecular techniques to identify individual North Atlantic right whale from free-floating feces				1	1		
DFO 'shoulder season' survey of North Atlantic right whale critical habitat in the Bay of Fundy in October 2013				1	1		
Discovery of evidence for North Atlantic right whale mating ground				1	1	1	
Oceanographic research to understand ocean warming trends in the Bay of Fundy					1	1	
Investigation of potential contribution of groundlines in the Bay of Fundy lobster fishery to North Atlantic right whale entanglement risk		1		1			
Acoustic research into North Atlantic right whale distribution and habitat use outside of the known critical habitat areas: Scotia Shelf				1	1	1	
North Atlantic right whale passive acoustic and habitat survey in Roseway Basin					1	1	
Research on the behaviour of North Atlantic right whale mother-calf pairs in the Bay of Fundy	1				1	1	
research to understand and reduce the risk of vessel collisions with North Atlantic right whales	1				1		
Analysis of entanglement risk from fixed -gear fisheries		1		1	1	1	1
Assessment of ambient and anthropogenic noise levels with identified critical habitat during seismic surveys in summer 2013			1	1	1	1	
Demonstration that vessel traffic noise causes measurable stress in North Atlantic right whales			1		1	1	

Recovery Activity	Recovery Objective						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Evaluations of historical and present policy initiatives for North Atlantic right whale conservation in Canada, and transborder between Canada and the USA	1	1	1	1	1	1	1
Increase understanding of North Atlantic right whale critical habitat in Roseway Basin					1	1	
North Atlantic right whale and plankton research in Roseway Basin					1	1	
Research into North Atlantic right whale distribution and habitat use outside of known critical habitat areas including identification of unknown North Atlantic right whale foraging habitat			1	1	1		
increased knowledge about human impact on North Atlantic right whales' food supply			1	1	1		
Investigation of North Atlantic right whale movement patterns within and among				1	1	1	
Total	3	3	5	12	18	13	2
Management Activity							
amendments to the Recovery Strategy for the North Atlantic right whale							
Development of the critical habitat order for Grand Manan Basin and Roseway Basin							
Development of an Action Plan for the North Atlantic right whale		1	1	1	1	1	1
SARA permitting processes						1	
Identification of Ecological and biologically significant area with the North Atlantic right whale's range in Atlantic Canada					1		
DFO C&P officer patrols and monitoring	1	1		1		1	1
Voluntary standard practices and mitigation strategies concerning interactions between North Atlantic right whales and fishing gear		1				1	1

Recovery Activity	Recovery Objective						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Consideration of North Atlantic right whale-fishing gear interactions in integrate fisheries management plans		1					1
Updates to navigational documents and charts	1		1				1
Production of the Mariner's Guide to Marine Mammals	1						1
Amendment of Marine Mammal regulations to include whale-watching guidance to reduce disturbance to marine mammals	1		1				
Completion and review of strategic environmental assessments for offshore oil and gas exploration and development activities on the Scotian Shelf	1		1				
Completion and review of environmental assessments for seismic programs on the Scotian Shelf	1		1				
Review of mitigation and monitoring measures for seismic survey activities in and near the habitat of cetacean species at risk			1			1	
Total	6	4	6	2	2	5	6
Emergency Response							
Marine Mammal Response Program		1		1			
Regional marine mammal response networks respond to report of dead or distressed marine animals including North Atlantic right whales		1		1		1	1
Development of National Stranding Network Committee		1		1	1	1	1
Monitoring presence and conditions of North Atlantic right whale carcasses					1	1	
Right-whale necropsies				1	1	1	
Total	0	3	0	4	3	4	2

Recovery Activity	Recovery Objective						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Education and Outreach Activities							
Poster campaign to identify new North Atlantic right whale aggregation areas				1	1	1	1
Outreach to fishing industry about identification and protection of North Atlantic right whales							1
Development of a herring weir release manual for large species including North Atlantic right whale		1				1	1
Voluntary codes of practise and record keeping tools promoted for use by Bay of Fundy industries			1	1			1
Cetacean identification training for at-sea observers and fisheries offices				1			1
Development of "Marine Species Identification Guide Common to the Bay of Fundy and Scotian Shelf Region"				1			1
Websites with information about North Atlantic right whales							1
Education and outreach activities for schools, local residents, and visitors to Grand Manan Island							1
Total	0	1	1	4	1	2	8
Grand Total	9	11	12	22	24	24	18

Table C2 - Recovery activities listed in the Report on the Progress of Recovery Strategy Implementation (DFO 2016b) and the corresponding performance indicators addressed by the activity.

Recovery Activity	Performance Indicator																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Long-term population survey and monitoring										1	1		1	1						
Development of molecular techniques to identify individual North Atlantic right whale from free-floating feces										1			1							
DFO 'shoulder season' survey of North Atlantic right whale critical habitat in the Bay of Fundy in October 2013														1	1					
Discovery of evidence for North Atlantic right whale mating ground													1							
Oceanographic research to understand ocean warming trends in the Bay of Fundy													1				1			
Investigation of potential contribution of groundlines in the Bay of Fundy lobster fishery to North Atlantic right whale entanglement risk			1																	
Acoustic research into North Atlantic right whale distribution and habitat use outside of the known critical habitat areas: Scotia Shelf																				
North Atlantic right whale passive acoustic and habitat survey in Roseway Basin															1		1			
Research on the behaviour of North Atlantic right whale mother-calf pairs in the Bay of Fundy		1											1	1			1			
research to understand and reduce the risk of vessel collisions with North Atlantic right whales	1				1															
Analysis of entanglement risk from fixed -gear fisheries				1						1			1				1	1	1	
Assessment of ambient and anthropogenic noise levels with identified critical habitat during seismic surveys in summer 2013								1							1		1			
Demonstration that vessel traffic noise causes measurable stress in North Atlantic right whales								1					1				1			
Evaluations of historical and present policy initiatives for North Atlantic right whale conservation in Canada, and transborder between Canada and the USA													1							

Recovery Activity	Performance Indicator																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Increase understanding of North Atlantic right whale critical habitat in Roseway Basin										1			1		1		1			
North Atlantic right whale and plankton research in Roseway Basin										1			1		1		1			
Research into North Atlantic right whale distribution and habitat use outside of known critical habitat areas including identification of unknown North Atlantic right whale foraging habitat									1				1		1					
increased knowledge about human impact on North Atlantic right whales' food supply									1	1			1							
Investigation of North Atlantic right whale movement patterns within and among										1			1				1			
Total	1	1	1	1	1	0	0	2	2	7	1	0	13	3	6	0	9	1	1	0
Management Activity																				
amendments to the Recovery Strategy for the North Atlantic right whale															1					
Development of the critical habitat order for Grand Manan Basin and Roseway Basin															1					
Development of an Action Plan for the North Atlantic right whale			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
SARA permitting processes																1	1			
Identification of Ecological and biologically significant area with the North Atlantic right whale's range in Atlantic Canada															1					
DFO C&P officer patrols and monitoring			1			1										1		1	1	
Voluntary standard practices and mitigation strategies concerning interactions between North Atlantic right whales and fishing gear					1	1										1			1	
Consideration of North Atlantic right whale-fishing gear interactions in integrate fisheries management plans			1		1	1														1
Updates to navigational documents and charts	1																	1	1	1
Production of the Mariner's Guide to Marine Mammals	1																	1	1	

Recovery Activity	Performance Indicator																			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Amendment of Marine Mammal regulations to include whale-watching guidance to reduce disturbance to marine mammals	1							1												
Completion and review of strategic environmental assessments for offshore oil and gas exploration and development activities on the Scotian Shelf	1							1											1	
Completion and review of environmental assessments for seismic programs on the Scotian Shelf	1							1											1	
Review of mitigation and monitoring measures for seismic survey activities in and near the habitat of cetacean species at risk								1								1	1			
Total	5	0	3	1	3	4	1	5	1	1	1	1	1	1	4	5	3	4	6	2
Emergency Response																				
Marine Mammal Response Program						1						1								
Regional marine mammal response networks respond to report of dead or distressed marine animals including North Atlantic right whales						1						1					1			1
Development of National Stranding Network Committee						1				1	1	1				1		1		1
Monitoring presence and conditions of North Atlantic right whale carcasses										1		1				1				
Total	0	0	0	0	0	3	0	0	0	2	1	4	0	0	0	2	1	1	0	2
Education and Outreach Activities																				
Poster campaign to identify new North Atlantic right whale aggregation areas										1					1	1		1	1	1
Outreach to fishing industry about identification and protection of North Atlantic right whales																		1	1	1
Development of a herring weir release manual for large species including North Atlantic right whale					1	1										1		1	1	1
Voluntary codes of practise and record keeping tools promoted for use by Bay of Fundy industries																		1	1	1

Recovery Activity	Performance Indicator																			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Cetacean identification training for at-sea observers and fisheries offices																		1	1	1
Development of "Marine Species Identification Guide Common to the Bay of Fundy and Scotian Shelf Region"														1	1	1		1		
Websites with information about North Atlantic right whales																				1
Education and outreach activities for schools, local residents, and visitors to Grand Manan Island																		1		
Total	0	0	0	0	1	1	0	0	0	1	0	0	0	1	2	3	0	7	5	6
Grand Total	6	1	4	2	5	8	1	7	3	11	3	5	14	5	12	10	13	13	12	10

Table C3 - Recovery objectives sand the corresponding performance indicators for the North Atlantic right whale, reproduced from the Recovery Strategy (DFO 2014).

Recover Objective	Performance Indicator
Objective 1: Reduce Mortality and injury as a result of vessel strikes	1. Rate of interactions in Canadian waters declines 2. Regular analysis of vessel/North Atlantic right whale risk and mitigation measures is conducted
Objective 2: Reduce mortality and injury as a result of fishing gear interactions (e.g. entanglement and entrapment)	3. Rate of interactions in Canadian waters declines 4. Regular analysis of gear/North Atlantic right whale risk and mitigation measure is conducted 5. Increased involvement in mitigation effort by fisheries associated with higher risk gear 6. Possible disentanglement efforts are conducted
Objective 3: Reduce injury and disturbance as a result of vessel presence or exposure to contaminants and other forms of habitat degradation	7. Assessment of impacts of contaminants on North Atlantic right whales are completed 8. Harmful levels of noise in North Atlantic right whale habitat is taken place at acceptable levels and durations 9. Human-induced impact on food supply are understood and reduced where possible
Objective 4: Monitor population and threats	10. Information collected in monitoring programs in disseminated 11. Regular forums to discuss monitoring results are held 12. Necropsies are conducted when possible
Objective 5: Increase understanding of life history characteristics, low reproductive rate, habitat and threats to recovery through research	13. Research is published 14. Regular forums to discuss research results and threat mitigations are held. 15. Critical habitat in Canadian waters is identified and protected
Objective 6: Support and promote collaboration for recovery between international agencies and bodies and between government agencies, academia, environmental non-government groups, Aboriginal peoples and coast communities in Canada	16. Successful implementation of North Atlantic right whale conservation activities increases 17. Cooperative bilateral or multilateral arrangement to advance North Atlantic right whale research and conservation
Objective 7: Develop and implement education and stewardship activities that promote recovery	18. Measured increase in awareness and support for recovery activities 19. Key user groups work to develop and implement best practices (stewardship) 20. North Atlantic right whale emergencies are reported in a timely fashion