Managing Canada's Endangered: An Analysis of Canada's Efforts to Mitigate Shipping Impacts on North Atlantic Right Whales

By

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ABBREVIATIONS

ATBA – Area to be Avoided

CBD – Convention of Biological Diversity

COSEWIC – Committee on the Status of Endangered Wildlife in Canada

DFO – Department of Fisheries and Oceans

DOM – Dynamic Ocean Management

ECCC – Environment and Climate Change Canada

GoC – Government of Canada

IMO – International Maritime Organization

IUCN – International Union for Conservation of Nature

IWC – International Whaling Commission

MEPC – Marine Environment Protection Committee (IMO)

MPA – Marine Protected Area

NARW – North Atlantic Right Whale

NMCA – National Marine Conservation Area

NOAA – National Oceanic and Atmospheric Administration

SARA – Species at Risk Act

TSS – Traffic Separation Scheme

TC – Transport Canada

UNCLOS – United Nations Convention on the Law of the Sea

WC – Whale Coordinator

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ABSTRACT

North Atlantic Right Whales are vulnerable to anthropogenic impacts from commercial shipping and fishing practices. After the 2017 NARW season, that left 17 NARWs killed in Canadian and U.S waters, the U.S defined the situation as an "unusual mortality event". Necropsies confirmed that a large proportion of dead NARWs showed evidence of blunt force trauma, a trauma experienced through lethal vessel to whale encounters. In the past, management measures have been put in place to address ship-strikes and NARWs, however due to an unexpected presence of NARWs in the Gulf of St. Lawrence these management measures have been deemed ineffective. This research project involves the implementation of dynamic ocean management (DOM) in the Gulf of St. Lawrence in an attempt to mitigate ship-strikes on NARWs. This graduate project analyses the effectiveness of previous vessel measures, the challenges in implementing DOM and how the Government of Canada can protect NARWs in the years to come.

Keywords:
Dynamic ocean management, North Atlantic right whales, commercial shipping, shipping lanes, ship-strike, species management, adaptive management, marine mammal conservation, Government of Canada, policy analysis

CHAPTER ONE: INTRODUCTION

The marine environment provides some of the most complex and productive ecosystem services world-wide. In addition to providing natural resources for coastal communities, the ocean allows for ease of transport internationally. Shipments from across the world are brought into coastal and inland ports, unloaded and shipped cross country to ensure the needs of peoples and economies are met. Despite the importance of the ocean ecosystem, human activities can leave large footprints on the marine environment, with some activities negatively impacting marine life. This is particularly the case in the encounters between marine mammals, like large baleen whale species, and vessels, big and small, when navigation routes overlap with areas where species spend parts of their life cycles. As some marine mammals migrate along coastal waters over vast distances, the chances of encounters with marine industries are large. Marine mammals are at risk from bow and propeller strikes and the physical and acoustic displacement from constant vessel presence. This can lead to death, serious injury, wasted energy, abandoned critical habitats, decreased mating and socializing behaviours, and even interferences with hunting prey (Erbe, 2002).

In order to mitigate shipping impacts on marine mammals, a variety of management strategies and routeing measures have been used in Canadian and U.S waters. These include designation of conservation areas, mandatory ship-position reporting, re-routing of shipping lanes, mandatory vessel speed restrictions, recommended areas to be avoided and seasonal management areas (Vanderlaan and Taggart, 2009). Although marine protected areas (MPAs) are viewed as important for preserving marine ecosystems, for large pelagic species like marine mammals, which often are highly migratory species, the overall lack of effectiveness is heavily criticized in the literature (Agardy, Notarbartolo, Sciara and Christie, 2010). This is due to the dynamic nature of marine mammals, deeming small MPAs ineffective as marine mammals travel large distances for varying life-cycle purposes (Agardy et al, 2010).

The dynamic nature of marine mammals was illustrated during the summer of 2017 when seventeen North Atlantic Right Whales (NARW), *Eubalaena glacialis*, a large endangered baleen species, were found dead within the waters of Canada and the U.S (NOAA, 2017). The first carcass of a NARW, found on June 6th drifting in the Gulf of St. Lawrence, marked the beginning of the unusual mortality event of 2017. The carcasses of other NARWs continued to be found over the summer, twelve NARWS in Canadian waters and 5 in U.S waters (Daoust, Couture, Wimmer and Bourque, 2018). Across transboundary waters, a total of seventeen dead NARWs were found in the 2017 season (Daoust et al, 2018).

With the 2018 season now complete, NARWs returned to the Gulf of St. Lawrence in large aggregations. As measures to mitigate lethal vessel collisions in the Gulf of St. Lawrence were previously non-existent, a continuing concern is how to efficiently protect an endangered species that is seemingly changing traditional foraging and aggregation sites.

Through this graduate project and my internship placement at Transport Canada (TC), I have analyzed the management measures adopted in the past for NARW protection, what TC implemented in the 2017 season, the mitigation measures applied in the 2018 season, and possible gaps in order to address the following research questions and sub-questions:

1. How can Canada decrease the number of ship-strikes on the North Atlantic Right Whale in the face of uncertainty?
    a. *What role can dynamic management areas and particularly sensitive sea areas play in whale conservation?*

b. *What can Canada do to protect North Atlantic Right Whales in the next two to five years?*

The above research questions will aid in identifying considerations for the Government of Canada (GoC) going forward. Additionally, I will also conclude with a suite of recommendations, highlighting the creation of a one-stop shop web application for improved industry engagement with the federal government.

The identified research questions will be addressed in seven chapters. Chapter Two will introduce NARWs, their history, population, threats and the unusual mortality event of 2017. Chapter Three will analyze management measures used to minimize lethal vessel strikes of NARW in the past, and the mitigation measures put in place in response of the 2017 season. Chapter Four will introduce and describe the theory behind Dynamic Ocean Management (DOM) and its related framework. Chapter Five will analyze the 2018 NARW measures adopted by Transport Canada using the DOM framework and applying a Strengths, Weaknesses, Opportunities and Threats (S.W.O.T) analysis. Chapter Six will discuss the findings from Chapter Five's S.W.O.T analysis. Lastly, Chapter Seven provides recommendations for management going forward and concluding remarks.

Methodology

The methodology for this graduate project included the daily operational management and support of the dynamic shipping lanes in the Gulf of St. Lawrence, an in-depth literature review, shadowing government employees from Transport Canada and the Department of Fisheries and Oceans (DFO), utilizing the dynamic ocean management framework outlined in Hobday et al (2014), and conducting a S.W.O.T analysis.

Through my internship with Transport Canada, a large portion of my graduate research involved the day to day operational tasks of managing dynamic shipping sectors and communicating with various federal departments and industry groups. Through this designation I was able to conduct a thorough shadowing experience of the various layers necessary to implement dynamic ocean management into the Gulf of St. Lawrence, which fed the main component of this graduate project. This internship position was also used to identify the various challenges and accomplishments of the federal government for the 2018 NARW season from an insider view and allowed for a thorough S.W.O.T analysis. This information helped guide the recommendations touched on later in Chapter Seven. It also gave me access to the decision-making processes for the 2018 NARW season and the perspective of industry.

The in-depth literature review allowed me to analyze past management measures used for NARW protection in not only Canadian waters, but U.S waters as well. Utilizing papers from key researchers, I was able to apply what worked in the past to what could be considered for management measures in the future. It also gave me insight into the legal requirements for certain designations and allowed for more cohesive management recommendations in Chapter Seven.

The information gathered from the literature review and shadowing allowed for the proper utilization of the Hobday et al (2014) DOM framework, indicating if the current measurements in the Gulf of St. Lawrence are resilient in the years to come and where future resources may be needed. The utilization of a S.W.O.T analysis allows for a more thorough analysis of the 2018 NARW measures, aiding in the identification of TC's Strengths, Weaknesses, Opportunities and Threats to current measures for future improvements. A S.W.O.T analysis was chosen for this graduate project as it considers multiple measures for future management, ensuring the most feasible actions are identified through evidence informed decision-making.

CHAPTER TWO: THE MANAGEMENT PROBLEM

North Atlantic Right Whales

Worldwide, three species of right whales have been identified; the NARW, the north pacific right whale (*Eubalaena japonica*) and the southern right whale (*Eubalaena australis*). Deemed the 'right' baleen whale to hunt due to their size and large blubber content, these species were targeted heavily in the whaling era (Brown, Fenton, Merriman, Robichaud-Leblanc and Conway, 2008). To this day, two of these species, the NARW and the north pacific right whale, have yet to recover from the extensive whaling that occurred decades ago, with only the southern right whale seemingly beginning to recover (WWF, n.d). As suggested by their names, these right whales can be found in the Atlantic Ocean, Pacific Ocean and Southern Ocean, where they have long migratory routes. Despite genetic differences, the three right whale species can be identified by the same key features: dark colouring, white belly patches, rough callosities patches located on the head, unique v-shaped blow from their two blow holes behind their callosity's patches and no dorsal fin (Brown et al, 2008). Right whales exhibit active surface behaviour through forming large aggregations for mating, socializing behaviours, and feeding exclusively at the ocean subsurface. As members of the baleen family, right whales filter feed through their large, bristle-like baleen plates, filtering large volumes of water for small microscopic zooplankton species – like copepods (Brown et al, 2008).

Prior to the whaling era, NARWs could be found throughout the Atlantic Ocean, with evidence of previous appearances in the waters south of Greenland and Iceland, off the British Isles, and distributed along the Canadian and U.S eastern seaboard (Brown et al, 2008). Migrating north for feeding opportunities, NARWs are found within northern waters during the warmer months, with aggregations found within Cape Cod as early as May. Cape Cod is an identified habitat for the NARWs, where researchers have identified and tracked NARWs annually for decades (NOAA, 2018). The migration north occurs closer to the end of spring, with NARWs traditionally entering the Bay of Fundy region off the coast of Nova Scotia, Canada.

Copepods, the preferred prey for NARWs, historically gather in large abundances near the ocean surface in the Bay of Fundy – an area identified as critical habitat for NARW (Brown et al, 2014). NARWs demonstrate feeding behaviour and also surface social activity that researchers have related to a sort of courtship between females and potential mates. Breeding within the Bay of Fundy has not been documented, leaving this sort of courtship behaviour premature and unusual (WWF, n.d). Historically, fluctuations of copepods, as well as changes in oceanic conditions, have led the NARWs to migrate further to the Roseway Basin (Meyer-Gutbrod and Greene, 2018). Here, NARWs traditionally perform the same behaviours documented in the Bay of Fundy. NARWs leave Canadian waters as the temperature begins to drop, migrating south to warmer waters for calving purposes. Off the coast of Florida is an identified area for calving and female NARWs. Although seemingly all NARWs migrate south in the winter, females and juvenile males can be predominantly found within the calving grounds, where researchers are able to document the number of calves produced (Figure 1). While nursing in the southern waters, NARWs have not been documented to feed, relying solely on their fat storages within their blubber for nutrients for the winter months (Meyer-Gutbrod and Greene, 2018). Due to this, when in Canadian waters, pregnant females require higher levels of caloric intake, as they need to build up a reservoir of fat to survive the winter months and provide nutrients to their calves (Meyer-Gutbrod and Greene, 2018). Speculation has been given on where mature male NARWs are spotted, however an official habitat for the winter months has yet to be identified. The lack of consistent sightings of individual

NARWs, has led researchers to search for other key feeding and mating areas that may not be identified currently.

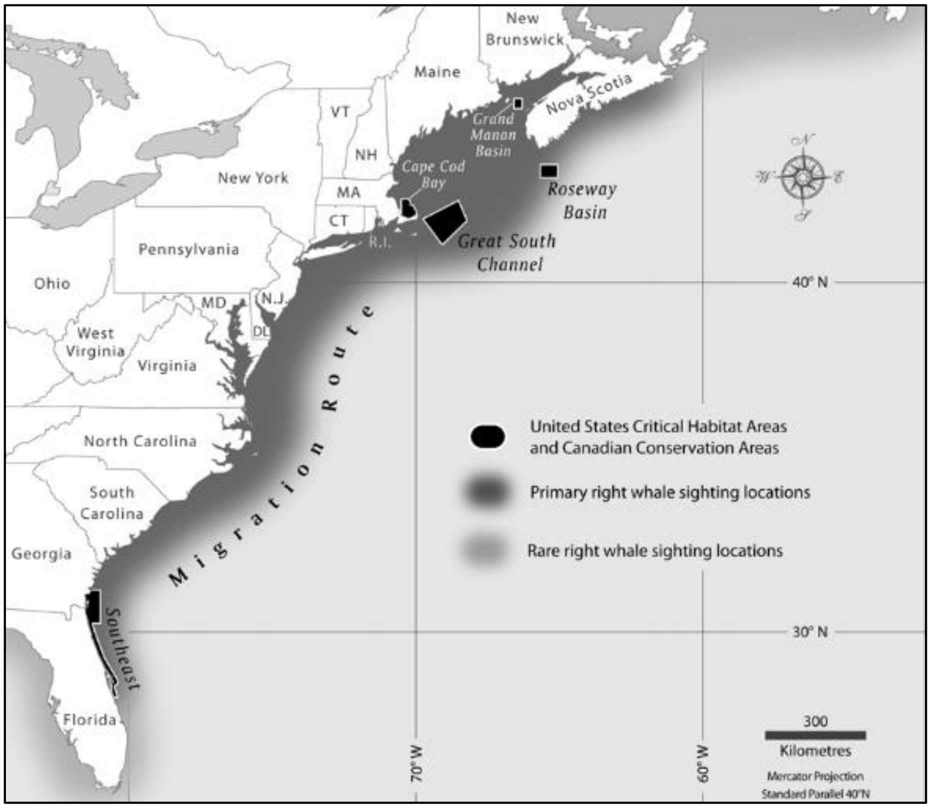

Figure 1. Designated critical habitat for NARW in U.S and Canadian waters. (DFO, 2009)

__Population__

At an estimated population of 450 individuals, NARWs are considered one of the most endangered marine mammals in Canadian waters (Brown et al, 2014). Identified as endangered by the committee on the status of endangered wildlife in Canada (COSEWIC) in 1980, the NARW populations have fluctuated greatly over the years. Fluctuations in population numbers have been correlated with fluctuations in prey availability, matching years of NARW successes and failures (Meyer-Gutbrod and Greene, 2018). This is especially evident in reproductive females, as calving success is linked to the overall health and condition of the mother (Meyer-Gutbrod and Greene, 2018). For instance, years of low birth rates are similarly years with low copepod abundances. Additionally, if there is not enough food available, and the environment is deemed stressful for NARWs, the length between calving intervals increases – a large threat to a population which is trying to regain its numbers (Fortune, Trites, Perryman, Moore, Pettis et al, 2012). For instance, in 1990 there was a documented decrease in copepods, followed by a decrease in NARW birth rates, leading to a historical low for NARWs in 1999 and 2000 (Meyer-Gutbrod and Greene, 2018).

Since 2010, the NARW has been steadily decreasing, with many expressing concerns for the species rebound potential and capabilities (Fortune et al, 2012). With approximately 100 breeding females remaining, long gestation periods of 12 months, and longer birthing intervals between calves, there are speculations that NARWs are functionally extinct (Meyer-Gutbrod and Greene, 2018).

Threats

In addition to environmental stressors, NARWs health is impacted severely from anthropogenic sources, such as noise pollution and lethal ship-strikes from large vessels and entanglement in fishing gear (Brown et al, 2014). In this section, noise pollution and lethal ship-strikes are identified as main threats from vessel activity.

Noise Pollution

Negative encounters between commercial shipping and large marine mammals occur due to shipping noise dominating the lower-frequency regions and contributing largely to the ocean's ambient noise (Hildebrand, 2008). Propulsion systems of commercial ships account for a large portion of commercial shipping noise, dominating the <200Hz frequencies for underwater noise and having high probability for long-range propagation of underwater noise (Hildebrand, 2008).

Due to this overlap, commercial shipping has the potential to diminish the success of whale calls, removing a whale's ability to communicate, locate prey and even locate potential mates through what is referred to as "masking" (Rolland et al, 2012). Masking is the process in which the sound within the environment overlaps or cancels out the calls propagated by marine mammals; limiting their ability to communicate effectively and leading to life threatening consequences (Weilgart, 2007). Additionally, commercial shipping may cause impacts on critical life-events through the abandonment of critical habitat, behaviour changes and vocalization alterations (Rolland et al, 2012). The increased energy levels required to avoid the physical and acoustic disturbance of shipping may be costly and could lead to impacts against a species ability for survival (Rolland et al, 2012).

For instance, baleen species have been studied to shift the frequency band or energy levels of their whale calls by either continuing calls for longer periods of time or waiting for the disturbance to pass (Rolland et al, 2012). The constant necessity to alter vocalization, either by frequency or amplitude, has potential physiological effects to marine species in terms of energy cost or additionally lost hunting and mating opportunities (Tyack, 2008). Cetacean researchers stress the importance of long-term population research to determine impacts of noise on cetaceans, with a large emphasis on cumulative impacts of numerous marine activities within critical habitat areas and the behavioural shifts associated with introduced activity (Weilgart, 2007). For instance, studies have documented the abandonment of critical habitat by gray whales in Baja California due to introduced dredging within the region (Tyack, 2008). The lagoon was a critical mating ground, and when dredging practices occurred the amount of mother and calf sightings decreased dramatically with gray whales only returning years after dredging had commenced (Tyack, 2008). An additional concern is the threat of hearing loss within cetaceans due to long-term exposure to anthropogenic noise; leading to a loss in their ability to pick up on navigational cues or the presence of predators (Weilgart, 2007).

Ship-Strikes

Due to their urbanized migration routes, aggregations tendencies within high traffic shipping corridors for mating and feeding purposes and their endangered species at risk status in both Canada and the U.S, the NARW is the most at risk from the threat of vessel-strikes (Vanderlaan and Taggart, 2009). Typically, vessel-strikes occur due to the overlapping nature of critical habitat and major shipping lanes and may result in death, hemorrhaging, bone fractures or even injuries from propellers (Conn and Silber, 2013). Although an issue for all marine mammals, the risk of ship-strike is stronger in larger, baleen whale species, with the NARW being extremely vulnerable to negative vessel to whale encounters (Conn and Silber, 2013). The amount of lethal ship-strikes is only just an estimate, as the majority of dead whales are not detected and may sink to the bottom or be too far into the decomposition process for cause of death to be considered (Conn and Silber, 2013).

Additional research has found that ship-strike is particularly lethal when vessels are travelling at faster speeds, with greater injuries occurring from head on strikes from the bow of the vessels (Rolland, Parks, Hunt, Castellote, Corkeron et al, 2012). For a large whale species, it is thought vessels travelling at speeds between 8.6 to 15 knots increase the chance of ship and whale encounters leading to a lethal injury, with 15 knots having the chance of a strike being lethal by 79% (Vanderlaan and Taggart, 2007). The vulnerability to ship-strike increases during feeding, social aggregations and between mother-calf pairing (NOAA, 2004).

With a decreasing population, many have related that the future success of the NARW is heavily dependent on increased prey availability and decreased NARW mortality due to anthropogenic causes (Meyer-Gutbrod and Greene, 2018). As such, this indicates if NARWs experience low prey availability and an increase in lethal mortality events from human activities, the future of this species becomes even more uncertain. Unfortunately for the NARW, the 2017 NARW season brought on the highest NARW mortality event in decades, with the U.S declaring the 2017 season as an 'unusual mortality event' (NOAA, 2017).

Unusual Mortality Event of 2017

The dynamic nature of marine mammals was illustrated during the summer of 2017 when 17 NARWs were found dead within the waters of Canada and the U.S (NOAA, 2017). Large quantities of dead NARWs continued to be found over the summer, many with injuries from blunt force trauma and evidence of lethal entanglements in fishing gear (Daoust et al, 2018).

A population that was predicted to have reached replacement levels (Agardy, Notarbartolo, Sciara and Christie, 2010) has once again become on the verge of extinction, with the signs of blunt force trauma accounting for the majority of fatalities (Daoust et al, 2018). Aerial and vessel surveys have provided a reason for the recent increase in fatalities – the NARWs have been spotted more frequently within the waters of the Gulf of St. Lawrence, an area that was previously inept at providing protection for NARWs (Transport Canada, 2018). The reason for the shift in habitat is currently under speculation, but researchers believe that as whales begin to respond to environmental and/or biological changes, migratory routes and designated critical habitat areas may begin to be less predictable (Stokstad, 2017).

The large number of NARW deaths in the 2017 NARW season is linked to an increased presence within the Gulf of St. Lawrence, with few NARWs returning to designated critical habitat in the Bay of Fundy or Roseway Basin (Tracy Chatman, personal communication, July 26th, 2018). This shift to the Gulf of St. Lawrence was not an immediate movement, as over the last five years the presence of NARWs in the Gulf of St. Lawrence has been growing (Stokstad, 2017). What can be clear after the 2017 NARW season is the unprecedented presence of NARW in the Gulf requires further management intervention to better accommodate NARWs and decrease fatalities due to overlapping areas of interest. After the unusual mortality event was declared last summer, the attention on Canada and NARWs increased, with necropsies pointing to lethal vessel strikes as the suggested driver behind the majority of NARW fatalities (Daoust et al, 2018).

CHAPTER THREE: POLICY AND MANAGEMENT RESPONSES TO DATE

International Legislation

Due to the endangered status of NARWs, support from international legislation has been sought after. This has included listing NARWs as endangered in the International Union for the Conservation of Nature's (IUCN) Red book and Convention on International Trade in Endangered Species of Wild Fauna and Flora, and through Ship-Strikes Working Groups with the International Whaling Commission (IWC) and the Marine Environment Protection Committee (MEPC) (IMO, 2008). This designation allows for an international body to conduct research on further mitigation measures in order to address the threat of ship-strikes (IMO, 2008). In addition to the various working groups, the IWC is responsible for a global database of ship-strikes with whales in an attempt to develop informed mitigation measures. Through this data base, IWC is analyzing varying factors that may contribute to a higher risk of mortality between a vessel and whale encounter (IMO, 2016). This includes analyzing vessel types and speeds to determine proper mitigation measures and to provide future vessel specific measures (IMO, 2016).

U.S Federal Legislation

As the NARW critical habitat is within transboundary waters, the U.S federal government provides additional protection under their national legislation. NARWs are listed as an endangered species within the U.S's Endangered Species Act, where it is listed as illegal to "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, collect.. or import, export or transport and sell endangered species in interstate or foreign commerce" while in U.S jurisdiction (Endangered Species Act, 1973).

Under the ESA, the federal government of the U.S is responsible for designating critical habitat. This has been done for the NARW, however it does not mean appropriate habitat protection is in place. From designation, it is up to decision-makers to decide what appropriate habitat protection is needed to preserve NARW. This brings forth an issue as NARWs are highly mobile, with their habitat spread out over long distances and across transboundary waters. This factor makes it economically and culturally impossible to provide efficient coverage for all identified critical habitats, as it would involve the closure of multiple main shipping lanes (Mullen, Peterson and Todd, 2013).

Ship-Strike Rule

Additionally, the U.S has utilized ship-strike guidelines for NARW protection referred to as Ship-Strike Reduction Rules. These rules include seasonal and dynamic management areas for the protection of NARWs which require vessels larger than 65 feet to travel at a speed of 10 knots or less while transiting critical habitat and voluntary protected areas (Mullen, Peterson and Todd, 2013). The SMAs include: in Cape Cod Bay, Off Race Point, Great South Channel, Mid-Atlantic and Southeast U.S, which are activated in correlation with NARW migratory patterns (NOAA, 2018).

The initial effectiveness of these SMAs and DMAs after the ship-strike rules were introduced has been documented in literature as unsuccessful, with low compliance, lack of monitoring resources and inappropriately located as documented limitations (van der hoop, Vanderlaan, Cole, Henry, Hall, Mase-Guthrie, Wimmer and Moore, 2015). As rule awareness and enforcement began, compliance began to improve – with monetary fines a great incentive for vessels to comply. The overall success of these measures is unclear in the literature because while these management measures were being introduced other management measures were being implemented for NARW protection in the Bay of Fundy and Roseway Basin (van der hoop et al, 2015). It is appropriate to contribute any changes in NARW conservation to a mix of all these measures, with no sole measure as the only contributor to decreased ship-strike success.

Stellwagen Bank National Marine Sanctuary

The Stellwagen Bank National Marine Sanctuary (SBNMS) is a large MPA located in the southern Gulf of Main and regulated under federal legislation. SBNMS overlaps with critical habitat for NARW, experiencing large aggregations of NARW annually. Additionally, other large cetaceans are common in this area, similarly to the Bay of Fundy region. SBNMS has large vessel densities due to the port of Boston, and as such there have been increased risks of lethal ship-strikes of NARW within this area. Occupying 2181km^2, the SBNMS encompasses two of the five previously mentioned SMAs (Figure 2) (Lewison, Hobday, Maxwell, Hartog, Dunn, Brisecoe, Fossette, O'Keefe, Barnes, Abecassis, Bogard, Bethoney, Bailey, Wiley, Andrews and Crowder, 2015).

This includes the Off-Race Point SMA and Cape Cod Bay SMA (Lewison et al, 2015). The implementation of this sanctuary, although not solely for the protection of NARW, has allowed for more protection to NARW outside the ESA. Further protection for NARW was established through the shifting of the Boston TSS in 2007 (NOAA, 2006). Adopted by the International Maritime Organization (IMO) and based off over 25 years of NARW sighting data, the Boston TSS shift of 12-degrees northward decreased the risk percentage by 81% (NOAA, 2006). Although adding an additional 10-20 minutes onto shipping operations in the Boston harbour, there was a high compliance and cooperation from the shipping industry for this NOAA led initiative (NOAA, 2006).

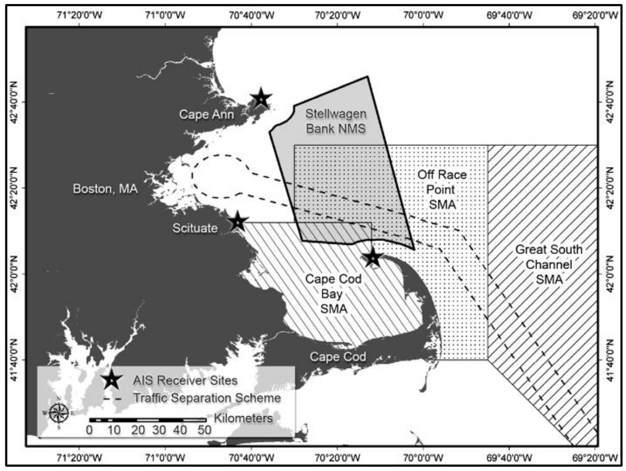

Figure 2. Map of Stellwagen Bank NMS and various U.S SMAs for NARW protection (Wiley, Thompson, Pace and Levenson, 2011).

Canadian Legal Framework

NARWs were designated as 'endangered' in 1980 by the COSEWIC, a committee of experts who classifies species as endangered, threatened or of special concern, and were adopted by the Species at Risk Act when it was passed by parliament in 2002 (Brown et al, 2014). This designation is used to protect species at a variety of at-risk status and allows for additional wildlife protection to be used in collaboration with already existing legislation. Under section 32 of SARA, "no person shall kill, harm, harass, capture or take an individual of a wildlife species that is listed as an extirpated species, an endangered species or a threatened species", while section 33 of SARA prohibits the destruction of the residence of "an endangered species or a threatened species, or that is listed as an extirpated species if a recovery strategy has recommended the reintroduction of the species into the wild in Canada" (Species at Risk Act, 2002).

The mentioned 'residence' is in reference to the critical habitat which is outlined within the SARA NARW recovery strategy and action plan (Figure 3). A habitat is deemed critical if the "habitat is deemed necessary for the survival or recovery of a listed wildlife species" (SARA, section 2, 2014). Additionally, fines and penalties for non-compliance with SARA are outlined in the recovery strategy, along with the definition for 'recovery' and what actions are necessary for the species to 'recover' are listed within the species action plan.

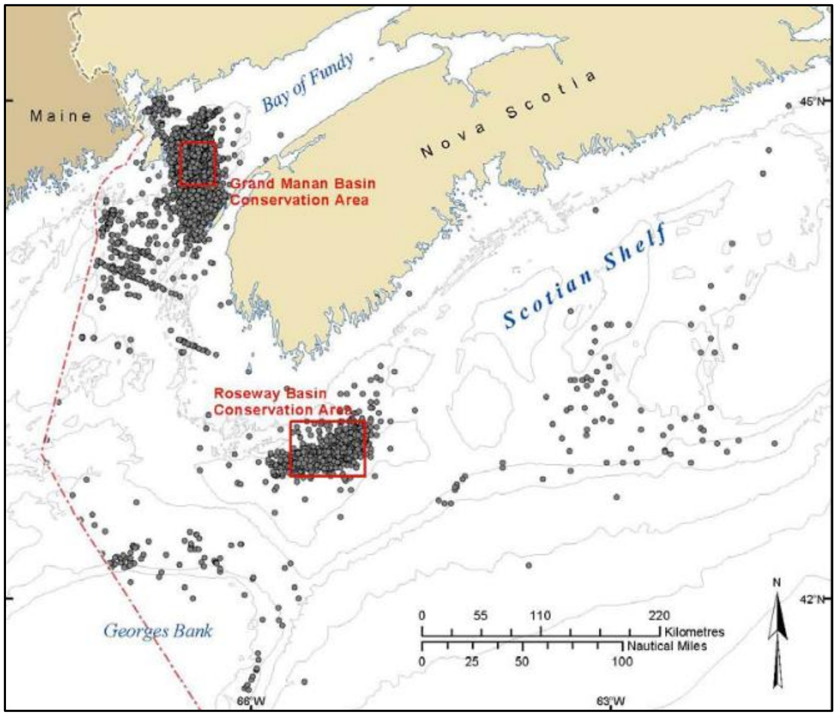

Figure 3. NARW conservation areas in Canadian waters outlined in red. Black dots represent NARW sighting data from 1951-2005 (DFO, 2008).

Additionally, NARWs are protected under the *Fisheries Act* (Fisheries Act, 1985) within their *Marine Mammal Regulations* (MMRs). MMRs protect NARW from any harm to itself, its habitat and from any disruption from human activities. Criticized in the past, new amendments for the MMRs have increased the protection for marine mammals, by increasing the approach distance of vessels to marine mammals. For all cetaceans, vessels must stay 100m away and for NARWs vessels are prohibited from approaching any closer than 200m. These amendments were created to decrease the amount of noise pollution from vessels to whales, and also attempt to reduce the amount of lethal encounters between vessels and whales. Prime Minister Trudeau has identified three key marine mammals within Canadian waters that need additional protection. These include NARWs, the St. Lawrence Beluga and the Southern Resident Killer Whales (DFO, 2017). With additional funding and legislative protection, one pillar of the Oceans Protection Plan is oriented toward providing better protection for all of Canada's marine mammals, with a heavy emphasis on species under category four in SARA.

Previous Management Measures

Measures to limit commercial shipping practices on marine mammals have been previously implemented under various statutes in Canadian and U.S waters. Measures that have been utilized for the protection of marine mammals include the designation of critical habitats, conservation areas, re-routing, speed restrictions, areas to be avoided and marine protected areas.

Critical Habitat

As part of the process of being enlisted within SARA, the identification of critical habitat is a vital component to providing proper protection of the species. Critical habitat includes areas that are traditionally utilized by an endangered species that aid in the performance of life activities, such as feeding, mating and/or calving. Critical habitat alone is not overly sufficient for protection of endangered species, as although the area is described and distributed, many human activities are free to exist within these regions, with vague restrictions. As this is typical for most species within SARA, the NARW is identified within category two.

Protection of critical habitat under SARA involves the prohibition of any destruction to such habitat. However, the act does not specify which activities may destroy critical habitat, or identify what classifies as destruction, thus creating no specific prohibitions to anthropogenic activities within identified critical habitat.

Defining critical habitat in Canadian waters has seemingly achieved very little in terms of NARW protection. With protection from critical habitat designation alone, NARWs continued to decrease in population numbers with more fatalities pointing to anthropogenic activities as the main drivers (Kraus, Brown, Caswell, Clark, Fujiwara et al, 2005). This must lead to further management intervention, as just defining the critical habitat of NARWs is deemed inefficient for increasing population numbers.

Protected Areas

Protected areas are "clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values" (IUCN, 2008). Protected areas for the marine environment still largely reflect terrestrial management practices with the intent of protecting areas of high biodiversity or of ecological/biological significance (Reimer, Gravel, Brown and Taggart, 2016). In Canada, there are three federal departments that create and implement protected areas. These include the Department of Fisheries and Oceans with marine protected areas (MPAs) (Oceans Act, 1996), Parks Canada Agency with national marine conservation areas (NMCA) (CNMCA Act, 2002), and Environment and Climate Change Canada with conservation areas (Canada Wildlife Act, 1985). Within these areas, the goal is to protect a marine ecosystem or species with a detailed management plan that provides indication on which activities are prohibited or allowed. The main criticism of MPAs is in relation to the activities that are allowed within an MPA. For instance, in the Laurentian Channel MPA, prohibitions are vague with regulations only prohibiting activities that are of no threat to ecological activity in the area. However, within this same MPA, oil and gas exploration are still permitted (Lake, 2018). Prohibitions for all MPAs in

Canada seemingly fall short when it comes to protection, with prohibitions vague or with various exemptions attached (Lake, 2018).

MPAs are not created solely for marine mammal protection but may benefit marine mammals by protecting the quality of their environment or food sources while they remain within the protected area. Successful stories of protecting marine mammals directly through protected areas has been documented through the protection of key life processes habitats, such as important feeding, mating or calving grounds. For instance, The Robson Bright Ecological Reserve was created to protect a key habitat used by the Northern Resident Killer Whales (NRKWs) in British Columbia (Ford, 2006). The reserve is closed to vessel traffic in order to protect the rubbing rocks frequented by the NRKWs (Ford, 2006).

The designation of the NARW Conservation Area in the Bay of Fundy and Roseway Basin was created for the protection of a key feeding area used seasonally by NARW (DFO, 2008). However, due to their long migratory route, NARWs remain at risk as they transit between identified conservation areas, leaving a large gap in efficient NARW protection (Mullen, Peterson and Todd, 2013).

Re-routing of Vessel Traffic

Re-routing measures can involve recommending adjustments to the navigation of a vessel or the actual changing of a routeing measure. The latter has been utilized to protect NARWs from lethal ship-strikes in the Bay of Fundy. Re-routing can involve shifting already existing traffic schemes, identifying areas to be avoided and may be augmented with vessel slow-downs.

The Bay of Fundy Traffic Separation Scheme (TSS) shift, a routeing measure that shifted lanes separating inbound and outbound vessels within the Bay of Fundy (Vanderlaan, Taggart, Serdynska, Kenney and Brown, 2008), was a joint effort between the federal Government of Canada, industry and marine scientists. The BoF TSS shift was achieved through collecting decades of NARW population data and vessel traffic patterns in order to identify areas with high probability of lethal vessel to whale encounters through relative probability estimates (Vanderlaan et al, 2008). Whale sighting data was collected through the use of varying survey platforms, mainly vessels and aircrafts, with every right whale location collected (Vanderlaan et al, 2008). Additionally, historical sighting data of right whales was obtained and included in this estimate to find areas historically and currently used by right whales (Vanderlaan et al, 2008). Vessel traffic within this area was collected through the Kongsberg Norcontrol IT Vessel Traffic Management and Information System log-files – which contain information regarding vessel identity, location, date, time and speed for vessels over 20m in length and 300 gross registered tonnage through the recording of radar data (Vanderlaan et al, 2008). These data allowed researchers to determine the vessel and speed within the study area within a 24-hour period. This study found that there was a 67% chance of spotting a right whale within the right whale conservation area in the Grand Manan Basin, with a smaller amount of right whale aggregation north and south of this identified area (Vanderlaan et al, 2008). Overlapping with the vessel data collected, it was determined the area with the highest probability for vessel to whale encounter was the North-East section of the conservation area, where it intersects with the outbound lane of the TSS – before amendments (Vanderlaan et al, 2008). It also identified vessels were travelling at 11-12 knots within the conservation area, with no indication of slowing down due to conservation area needs, despite the recommendations (Vanderlaan et al, 2008). A probability-of-lethal-injury-model was applied to estimate vessel speeds to the overlapped area, estimating a 64% chance of a strike being lethal within the original TSS lanes, with the probability increasing with vessel speed (Vanderlaan et al, 2008). This is shown in Figure 4. Through amendments to the original TSS there was a reduction of both vessel to whale encounter probability and the vessel risk to the whales by 90% (Vanderlaan et al, 2008). In this particular case, the re-routing of the TSS provided a better reduction of the risk of lethal vessel encounters than just imposing a speed restriction (Vanderlaan et al, 2008). This shows that cumulative conservation efforts were able to provide improved protection rates together, then individually, for NARWs in the Grand Manan region (Vanderlaan et al, 2008).

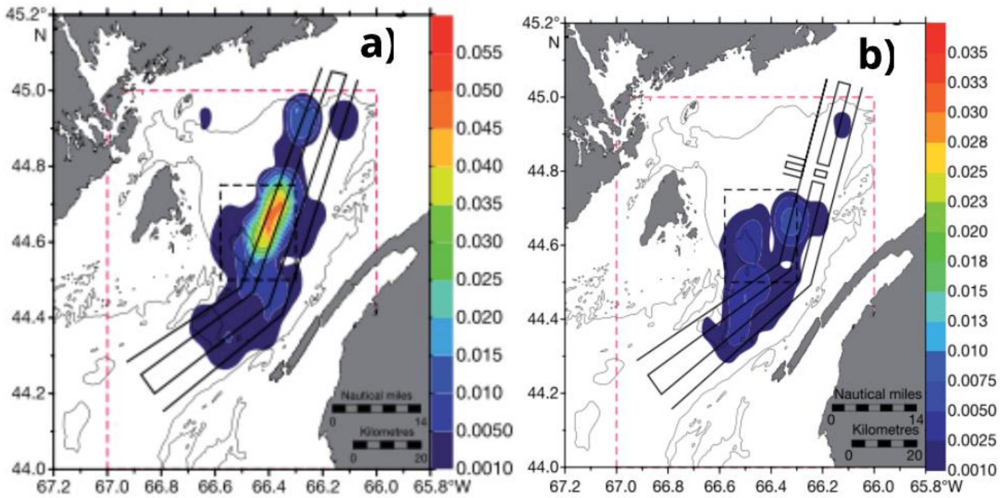

Figure 4. Bathymetric map of the Grand Manan Island region a) illustrates the original TSS route, with the red indicating a high probability of lethal whale to vessel encounter. b) illustrates the amended TSS route, with the blue and dark blue indicating the decreased probability of a lethal whale to vessel (Vanderlaan et al, 2008)

The adoption of this TSS shift was possible due to the adoption of this alteration by the IMO – an intergovernmental organization responsible for the regulation of international shipping by setting standards for maritime safety and protection of the environment from shipping impacts. The IMO has exclusive authority to designate international routeing measures and is responsible "for establishing and recommending measures on an international level concerning ship's routeing" (IMO, 1985).

Population and sightings data following the adoption of the Bay of Fundy TSS shift illustrate a population rebound for NARW, with the population experiencing a large jump in years directly after this mitigation measure (van der hoop et al, 2014). Due to the success of the Bay of Fundy TSS shift, both for the NARW but also with the minimal economic costs to industry, researchers began planning out how to best protect the identified NARW Conservation Area in the Roseway Basin.

Areas to be Avoided

Areas to be avoided (ATBAs) are another type of routeing measure and were created for the increased seasonal protection of the NARW from commercial shipping impacts (Vanderlaan and Taggart, 2009). As defined by the IMO, an ATBA is "a routeing measure comprising an area within defined limits in which either navigation is particularly hazardous, or it is exceptionally important to avoid casualties, and which should be avoided by all ships, or certain classes of ship" (IMO, 1985). With this in mind, these areas can be created on a season to season basis in areas associated with whale distribution, migratory routes, known critical habitat, historical sightings data and high traffic shipping lanes (Vanderlaan et al, 2008). In the case of Roseway Basin, the goal of this ATBA was to find the area where whale distribution and harmful human activities overlap and create a voluntary area to be avoided for the duration of the marine mammal's seasonal migration (Vanderlaan et al, 2008).

The Roseway Basin was the first ATBA designated solely for the protection of the NARW (Vanderlaan and Taggart, 2009). The similarities between the Roseway Basin ATBA and the amendments to the Grand Manan Island TSS involve the protection of NARWs and the methods used to determine key areas of NARW distribution and shipping practices (Vanderlaan et al, 2008). Through historical and current whale spotting data, the chances of spotting a right whale within the Roseway Basin is 86% (Vanderlaan et al, 2008). Within the Roseway Basin conservation area, the whale sightings data indicated the largest amount of right whale aggregation in the south-central region, with a smaller probability of viewing right whales east and west of this area (Vanderlaan et al, 2008). The implementation of the Roseway Basin ATBA (Figure 5) extends the existing conservation area, forming a polygon area that is based on the whale sightings data mentioned previously (Vanderlaan et al, 2008).

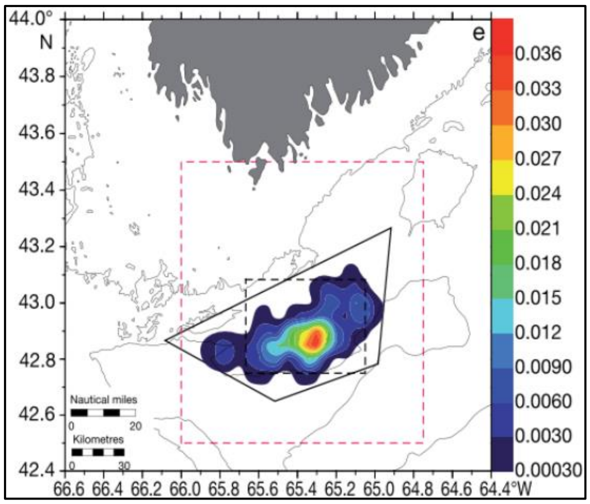

Figure 5. Roseway Basin ATBA. Red dotted line is the study area, the black dotted line is the Canadian Right Whale Conservation Area, and the solid black line is the Roseway Basin ATBA (Vanderlaan et al, 2008)

Differing slightly from the Grand Manan Basin TSS amendments, the vessel traffic data was obtained from the Eastern Canada Vessel Traffic Services Zone Regulations (ECAREG) database and the International Comprehensive Ocean-Atmosphere Data Set (ICOADS) (Vanderlaan et al, 2008). ECAREG is a mandatory reporting system for vessels over 500 GRT or for vessel which are carrying dangerous substances on board, while ICOADS is compiled from the fleet of Voluntary Observing Ships (Vanderlaan et al, 2008). Vessels that fit the criteria listed under ECAREG are required to report in advance their intent of entering the ECAREG region twenty-four hours, and two hours on departing within this zone (Vanderlaan et al, 2008). The ECAREG zone includes any Canadian waters south of 60 degrees north and south of the St. Lawrence River east of 66 degrees west (Vanderlaan et al, 2008). This data indicated that the highest aggregation of vessel traffic was just North of the conservation area; with a diagonal traffic route intersecting through the conservation area (Vanderlaan et al, 2008). The probability of whale to vessel encounters were again calculated by researchers, but this time for the Roseway Basin ATBA. This estimate indicated that the highest probability for whale to vessel encounter occurs where the probability of spotting a right whale is the highest – with the probability being 36 times higher within the conservation area than outside (Vanderlaan et al, 2008). This study also recorded average vessel speeds outside the conservation area at 11 knots, with vessels travelling at faster speeds of 13-15 knots within the diagonal traffic route through the conservation area (Vanderlaan et al, 2008). Similar to the Grand Manan Basin, there is no evidence to indicate that vessels reduce their speeds while travelling within the conservation area (Vanderlaan et al, 2008). Due to the lack of a TSS within the Roseway Basin, the use of a recommended and seasonal ATBA was implemented for the months of June-December (Vanderlaan et al, 2008). Through the recommended re-routing around the ATBA, instead of through, the Roseway Basin ATBA provides another way to provide protection for right whales without having major impacts to the shipping industry (Vanderlaan et al, 2008).

To determine compliance, researchers utilized Automatic Identification System (AIS) transponders, a system required by the IMO for commercial vessels larger than 300 gross tonnage on international voyages (Vanderlaan and Taggart, 2009). AIS data provides vessel identity, speed and location at near real-time, through one-minute intervals, and static data, through six-minute intervals (Vanderlaan and Taggart, 2009). This study, utilizing probability equations, found that after the IMO adopted the Roseway Basin ATBA, the majority of vessels travelling within the

Roseway Basin complied with the ATBA decreasing the risk of lethal vessel to whale encounters by 82%, with strikes occurring once every 89 years instead of once every 16 years (Vanderlaan and Taggart, 2009).

Gulf of St. Lawrence: Slowing Down to Save Whales

As the unusual mortality event regarding NARW became an international concern, the Government of Canada (GoC) implemented mitigation measures to prevent any further deaths of NARWs. From this, the idea of a mandatory large static speed restriction area was proposed and implemented in the Gulf (Figure 6) The slowdown was first voluntary, allowing vessels over 20m long to voluntarily slowdown their vessel below 10 knots, before it switched to a mandatory speed restriction (MacKinnon, 2017). The GoC was able to prescribe a mandatory measure because of Canada's sovereignty over those waters. As the Gulf of St. Lawrence is within the inland waters of Canada, and there is no international navigation right, the GoC had the legal authority to alter vessel traffic without needing the approval of the IMO. This differs from the Roseway Basin ATBA as due to the location of the proposed ATBA in the territorial sea, where there is an international right of innocent passage, Canada had no legal authority to impose mandatory measures which would have the effect of restricting international navigation. Therefore, for the Roseway Basin ATBA, the GoC was required to obtain this routeing measure through the IMO, as the competent international organization to designate such routeing measure, to ensure international shipping would be subject to an international standard and not be unnecessarily impeded while exercising the right of innocent passage under UNCLOS. Due to this, the static speed restriction area was able to be implemented quickly, allowing the measures to respond quickly to the NARW crisis.

Figure 6. 2017 Static speed restriction zone of 10-knots in the Gulf of St. Lawrence (Adapted from MacKinnon, 2017).

Within the speed restriction area in the Gulf of St Lawrence, vessels were forced to comply with a 10-knot speed limit or be subject to fines upwards of $25,000 under the Canada Shipping Act (Canada Shipping Act, 2001). This caused considerable economic strains on commercial shipping whose voyages were now slowed, causing delay, and resulting in penalties (demurrage) for loss of laytime (exceeding the time permitted to load or unload cargo) at ports of call, but also to coastal communities who were being subject to delayed deliveries (relying on just in time contracts), cancelled cruise ship calls, and threats of new marine protection surcharges from ocean carriers such as Oceanex (Oceanex, 2018). Similar to the measures put in place for the Roseway Basin ATBA, vessel compliance was tracked through the analysis of AIS data for vessels over 20m in length (Tracy Chatman, personal communication, July 26th, 2018). The static zone remained in place until January 2018 when DFO indicated that the probability of NARWs remaining in the area was low and the 10.0 knot slowdown began to threaten the safe navigation of vessels (Tracy Chatman, personal communication, July 26th, 2018).

With the unusual mortality event of 2017 looming over NARWs and international eyes on Canada and U.S, an emerging question arose – what mitigation measures can be put in place to protect a highly mobile and unpredictable endangered species in the face of uncertainty? As the previous measures put in place in the Bay of Fundy and Roseway Basin are seemingly ineffective if NARWs continue to visit the Gulf of St. Lawrence, the need for additional and more fluid management is necessary to remove NARWs from the path of extinction once again.

CHAPTER FOUR: TOWARD DYNAMIC OCEAN MANAGEMENT

What is Dynamic Ocean Management?

As typical marine management tools are based on terrestrial ecosystem management, traditional management techniques often lack flexibility and are static in nature (Lewison et al, 2015). While static management allows for effective resource management, it is typically applied in reducing threats to critical habitats, thus providing a benefit for marine mammals through the creation of a 'safe space' (Lewison et al, 2015). However, as seen with many MPAs within Canada, these areas are not always closed off from all activity, leaving the threat of negative encounters between humans and whales. As the ocean is highly dynamic, marine management needs to adapt to encompass a process that is fluid in both space and time to ensure there is not a mismatch between changes in the marine environment and management techniques (Lewison et al, 2015). Dynamic Management Areas (DMAs) or Dynamic Ocean Management (DOM) are defined as "management that changes rapidly in space and time in response to the shifting nature of the ocean and its users based on the integration of new biological, oceanographic, social and/or economic data in near real-time" (Lewison et al, 2015).

DOM may include re-routing measures, speed restrictions, delayed entry within the area or a combination of all of the above (Maxwell, Hazen, Lewison, Dunn, Bailey et al, 2015). Incorporating near real-time data allows marine managers to better align response time with the changing environment to ensure management strategies are effective in providing marine protection (Maxwell et al, 2015). DOM utilizes existing datasets, analytical processing and modeling techniques to predict species distribution or vessel routes, and near real-time sharing of data-sharing technologies between stakeholders (Maxwell et al, 2015) (Figure 7).

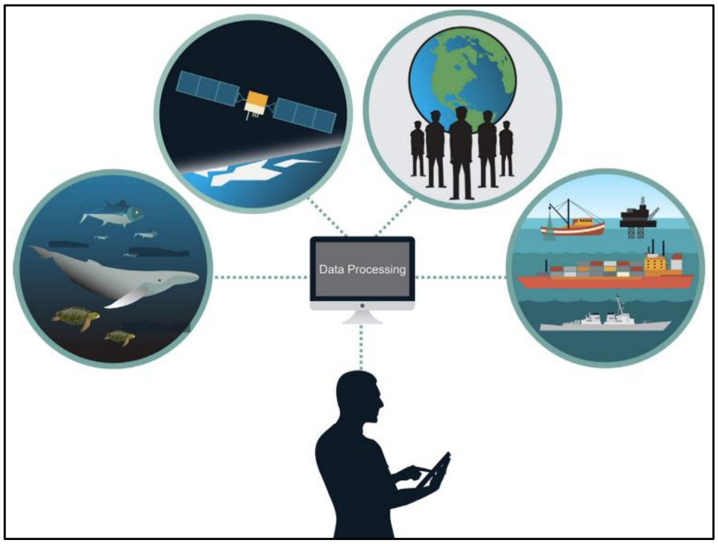

Figure 7. Visual representation of how DOM is used in near real-time between multiple stakeholders (Maxwell et al, 2015).

DOM can be combined with traditional management techniques such as seasonal areas to be avoided, adaptive management, remote sensing or animal tracking data in order to ensure minimal delays or impacts to the marine environment, species or users (Maxwell et al, 2015).

Due to the collaborative nature of adaptive management, "a structured, iterative framework supported by monitoring and assessment", the process of implementing new protection measures has been shown to be quite slow (Maxwell et al, 2015). However, as seen in Figure 8, adopting dynamic ocean management into the implementation phase of adaptive management can increase the pace of implementation due to near real-time data; removing the need to return to the decision-making phase and ensuring more flexible management of the marine environment (Maxwell et al, 2015).

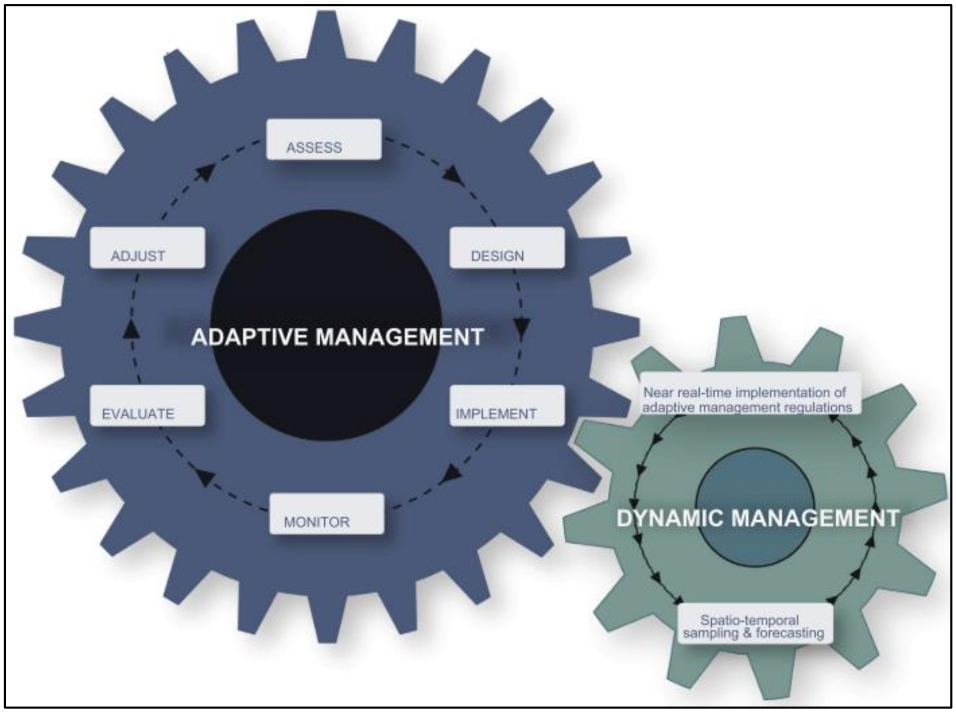

Figure 8. Image demonstrating how to effectively implement dynamic management into already existing adaptive management regimes (Maxwell et al, 2015).

As traditional methods of ocean management lack the flexibility to make quick alterations or implementations, typically larger areas are regulated to accommodate highly migratory species (Maxwell et al, 2015). This increases the number of stakeholders impacted through the restrictions of human activities – potentially resulting in high opportunity losses and more conflict (Maxwell et al, 2015). As DMAs are implemented in response to a threat or change in the marine environment, the restrictions on regulated activities within the designated area are minimal due to their reduced spatio-temporal nature resulting in higher compliance and support levels from marine users (Maxwell et al, 2015).

How is Dynamic Ocean Management Applied?

To properly integrate DOM into traditional ocean management regimes, consideration is necessary on what type of DOM is needed for the particular management issue and what legal authorities are necessary for successful implementation. There are four types of DOM, all focusing on data input and data product (Lewison et al, 2015) (Figure 9). The differences between the types of DOM is in relation to the amount of resource requirements and intensity of the management situation. For instance, Type 1 and 2 focus on a simplistic DOM style, requiring data input and data product and the addition of statistical analysis for Type 2 (Lewison et al, 2015). However, Type 3 and 4 are increasingly complex, utilizing the combination of multiple data sources and incorporating dynamic modelling (Lewison et al, 2015). Consideration is necessary to determine which type is best suited for the management issue, as it is vital to consider the intensity of the situation and the amount of resources that may be involved.

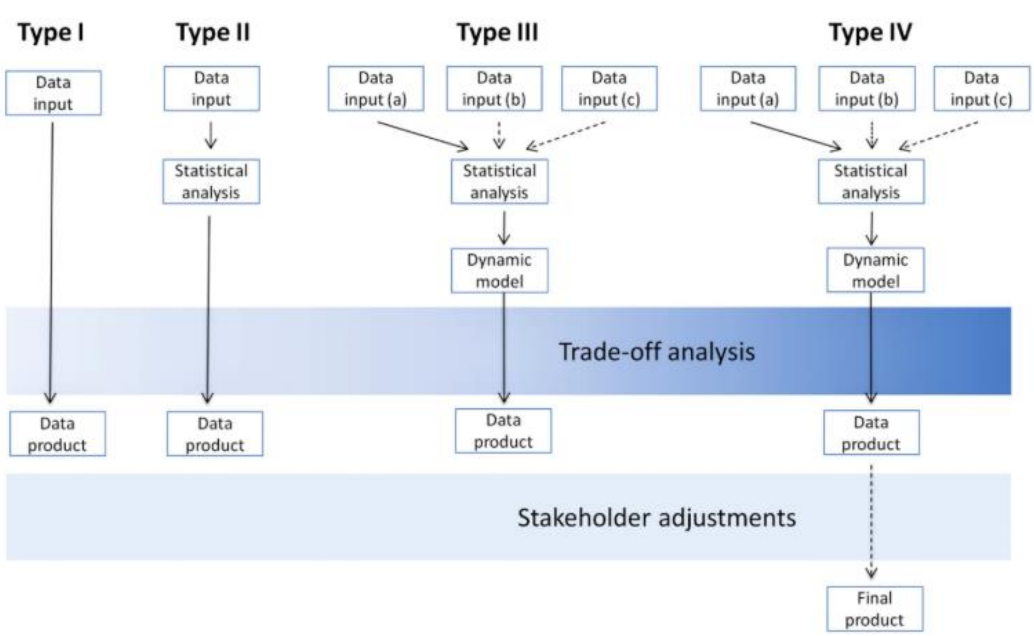

Figure 9. Image demonstrating the four types of DOM and their related outputs (Lewison et al, 2015).

To successfully encompass dynamic management, the management procedure must follow seven key DOM elements (Figure 10). These include data collection, data upload, data processing, data delivery, decision-making, implementation and enforcement, which all together create a continuous feedback loop (Hobday, Maxwell, Forgie, Mcdonald, Darby, Seto, Bailey, Bograd, Briscoe, Costa, Crowder, Dunn, Fossette, Halpin, Hartog, Hazen, Lascelles, Lewison, Poulos and Powers, 2014). These elements ensure that all considerations have been made on how data will be collected, decisions will be made and distributed and how it will be enforced. To have a long-term, resilient management regime focused in DOM theory and the precautionary principle, the seven elements must be considered.

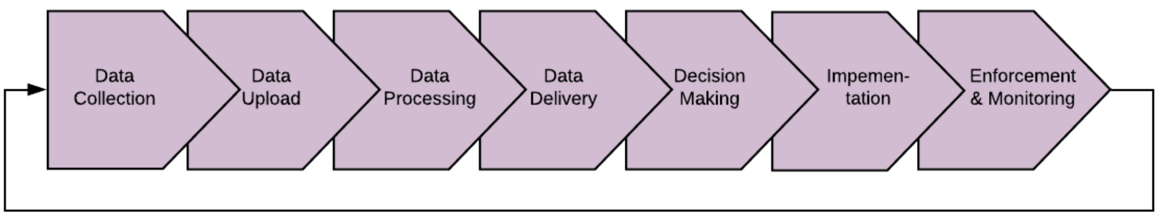

Figure 10. Seven key DOM elements adapted from Hobday et al, 2014.

Data Collection

Thorough data collection is necessary to ensure DOM is being applied effectively. This will also help decrease the amount of space necessary to provide sufficient protection, as it narrows down potential areas of concern and activities that may overlap. For instance, collecting data on whale sightings and vessel traffic will allow for areas of conflict to be identified and mitigated appropriately. For DOM to operate in near real-time, the data should be collected in real-time and have the ability to be adapted as conditions change. Data collection can derive from a variety of platforms including traditional visual observations and additionally tracking technology such as tagging, AIS, acoustic detections and satellite imaging. The importance lies in ensuring the data collection platform is properly certified and quality assured. This ensures resources are being utilized properly and economic losses for industries are minimized. For instance, if looking for a specific marine species, verified sources would include organizations or technologies that are deemed qualified for identifying the specific species accurately.

Data Upload and Processing

Consideration in data upload and processing is needed to ensure data is uploaded efficiently and in near real-time. For collected data to be used effectively, the data needs to be readily available and accessible to decision-makers for interpretation. In addition to data upload efficiency, there needs to be consideration for any additional processing data may need once uploaded as any processing required will increase the delay in data delivery.

For DOM Types 3 and 4, the need for data to be automatically processed is crucial, as multiple sources would be providing data at the same time. The use of real-time data for DOM is vital to managing a species of concern, as decision-makers would need to be informed efficiently if said species was seemingly changing its migratory route, or critical habitat. This sort of information requires decision-makers to act as soon as possible, shifting the boundaries of their existing Dynamic Management Area (DMA).

Data Delivery

To obtain data in real or near real-time, delivery options need to ensure decision-makers obtain information quickly in order to implement appropriate actions. Typical delivery options include email/mail, with some practices moving towards phone calls, interactive mapping tools and iCloud.

As highlighted by Hobday et al (2014), involved with data delivery are potential legal considerations for management. This is in relation to issues of "confidentiality, data sharing, ownership and intellectual property rights, use of autonomous marine vehicles and animal ethics" (Hobday et al, 2014). The constraints to DOM can be addressed through agreements and clarification on what is to be shared between departments and with the public before operations begin.

Decision-Making Processes

At the decision-making level, there must be consideration of what agency is responsible for implementation and what legal authority it has to implement DOM (Hobday et al, 2014). For instance, DMAs can be voluntary or mandatory, depending on what capabilities and legal instruments are available for utilization. At the government level, legislation and regulations can be utilized to ensure measures are mandatory and properly enforced under their legal authority. Key to determining the legal authority of a governmental entity involves the geographic location of the proposed measures. As mentioned previously, government can only make measures mandatory if the proposed area is within territorial waters. If it is outside territorial waters, government cannot make measures mandatory as it may restrict the international right of innocent passage under UNCLOS. As Canada is party to the International Convention for the Safety of Life at Sea (SOLAS), various routeing measures are adopted under SOLAS Chapter V, which places international routeing authority with IMO. At the same time, the government may willingly decide to make measures voluntary if the amount of scientific information needed is still missing or if voluntary measures are considered to have high compliance.

Additional consideration is needed to consider what would 'trigger' the dynamic management measures. For instance, in the U.S they have DOM for a seasonal management areas (SMAs), DMAs and ATBAs for vessels in order to minimize negative vessel to NARW encounters. The seasonal management area is implemented for specific months of the year, and the DMAs is activated once three or more NARWs are spotted in a 10x10 square nm with the option to 'refine' the trigger further if one NARW is feeding or if a mother and calf NARW are spotted within 15nm of a shipping lane (NOAA, 2004). Due to the geographic location for SMAs and DMAs in the Gulf of Marine, the U.S was required to obtain routeing measures from the IMO to increase international vessel awareness and compliance.

Implementation

To be successful, DOM utilizes multiple tools to ensure decision-makers are provided with the information necessary for daily operational purposes. Information provided for DOM operations needs to be readily available to decision-makers and be flexible enough to combine data from multiple sources (Hobday et al, 2014). For instance, if the government was considering using DOM for fisheries management, government officials would need to be provided data from endangered species sightings, fishing practices within the area and the type of threats that may arise if these two activities were to overlap.

In order for implementation to be effective, the measures need to be broadcasted widely and efficiently to industry members within the impacted region (Hobday et al, 2014). For instance, the use of traditional broadcasting methods for marine transportation industries in Canada may include official Notices to Shipping (NOTSHIPs) and Notices to Mariners (NOTMARs) which are broadcasted by CCG, reaching all vessels that enter a particular area of interest.

Enforcement and Compliance

If measures are voluntary, then compliance may not typically be measured. However, despite voluntary or mandatory, compliance can still provide a great indication if DOM is working successfully within an area. Compliance and enforcement can be tracked through a variety of tools, including satellite, on board observers, AIS or VMS (Hobday et al, 2014). Information is gathered through these devices, allowing for decision-makers to track vessels movements, speeds, and identification numbers. For instance, in the U.S, a voluntary speed restriction is put into place for the protection of NARWs when known aggregations are observed (NOAA, 2004). Information is provided through various tools, including an online mapping tool that shows last known locations for individual right whales. With this information, vessels have the option of slowing down in areas of known aggregations of right whales, in order to minimize their impact on crucial feeding grounds.

However, due to the voluntary nature of these measures, compliance has been found to be low with many choosing to opt out of slowing down due to the economic or operational implications (Hobday et al, 2014). If made mandatory, decision-makers have the option to issue penalties to non-compliant vessels, minimizing the chances of non-compliance and increasing protection for endangered species. The enforcement capabilities of a country are dependent on where the infringement occurs.

CHAPTER FIVE: APPLYING DYNAMIC OCEAN MANAGEMENT FOR NARW PROTECTION

Results: Shadowing

Creation

In 2017 and 2018, TC utilized section 7 of the Collision Regulations (c. 1416) of the Canada Shipping Act to enforce speed restrictions in the Gulf of St. Lawrence (Canada Shipping Act, 2001). Section 7 of the COLREGs allowed TC to require vessels to slow down in order to minimize the risk to vessel and crew if they were to hit a large baleen species (Tracy Chatman, personal communication, July 26th, 2018).

TC developed the 2018 measures in collaboration with federal departments, industry organizations and academic professionals (Tracy Chatman, personal communication, July 26th, 2018). From analyzing NARW sighting data from over the past 5 years, the GoC identified areas with NARW sightings and considered these areas with current vessel traffic data within the Gulf of St. Lawrence. In addition to vessel and NARW data, the GoC collaborated with industry through in person meetings, adapting an industry led proposal into the 2018 NARW considerations (Sonia Simard, personal communication, November 19th, 2018). In this section the original proposal from industry and TC's final 2018 measures will be discussed and compared. Additionally, as U.S measures had a great influence in the 2018 NARW measures, this section will also compare the differences between TC's measures and NOAA's.

Creation: Industry Proposal

Industry consultations for the 2018 NARW season were conducted via in person meetings with industry and the federal government in 2017. From this working group, the shipping industry was asked to provide suggestions for the upcoming season, thus resulting in the creation of an industry led proposal for management measures of the 2018 NARW season. This proposal was taken into consideration by TC and DFO and assisted in the creation and decision-making for what was found in the Gulf for the 2018 season. The main elements of the industry proposal can be seen below in Table 1, which was adapted from the proposal. The table is split into two management considerations, with the first regarding speculated "known" high-density NARW aggregation habitat, and with the second referring to areas outside of the two identified habitats where NARW may be spotted.

<table>
<tr><td colspan="2">Table 1: Industry Proposal Summary</td></tr>
<tr><th>For "Known" High-Density Right Whale Aggregation Areas</th><th>For areas where NARW could be unexpectedly present within the shipping corridors North and South of Anticosti</th></tr>
<tr><td>Risk management approach:
Establishment of static "seasonal" speed restrictions in the following proposed High-Density NARW Aggregation Areas

Proposed boundaries:
NARW Aggregation Area 1:
64 30 W 49 06 N; 62 12 W 48 25 N; 62 12 W 47 16 N; 64 30 W 47 16 N; 65 05 W 48 05 N;
NARW Aggregation Area 2:
50 20 n 40 64.00 W; 50 20 N 65.00 W; 49 50 N 64.00 W; 49 50 N 65 00 W

Seasonality:
The objective is to link the seasonality of the measure to the actual period of NARW occurrence for each of the NARW aggregation areas (based on the best available information).</td><td>Risk management approach:
Establishment of an operational navigational corridor (where vessels can transit at their efficient speed) and manage the lower probability of vessel-whale interaction through more dynamic mitigation measures that will focus of unexpected presence of NARW in the shipping lanes.</td></tr>
<tr><td>Elements of the proposal
<table><tr><th></th><th>Area 1</th><th>Area 2</th></tr><tr><td rowspan="2">Activation Date</td><td>May 15th*</td><td>July 15th*</td></tr><tr><td colspan="2">* Subject to change when trigger point to met</td></tr></table></td><td>Elements of the proposal:
Routing measures (applicable for the shipping lanes south of Anticosti):
Temporarily relocating shipping lanes closer to the south shore of Anticosti Island (during</td></tr>
</table>

<table>
<tr>
<td>
<table>
<tr><td>End Date</td><td>Based on DFO advice</td></tr>
<tr><td>Trigger Point</td><td>Based on trigger point in the U.S, 3+ NARW within a 75 square nautical mile area</td></tr>
<tr><td>Speed</td><td>10knots or less</td></tr>
</table>
</td>
<td>NARW season) to proactively reduce the risk of encounters between ships and whales.
AND
Temporary/Dynamic speed restriction zone:
Sighting of NARW trigger in shipping lanes, a zone would be created on a temporary basis around the aggregation where the 10 knots mandatory speed restriction rule would apply for a period of time.</td>
</tr>
</table>

Following the introduction of this proposal, the GoC continued to work with industry members adapting the original proposal further. Although the original proposal from industry was not completely adopted, industry successfully communicated to the GoC the need for DOM in order to address economic considerations while also providing NARW protection. The various industry proposals that were developed will allow for future considerations for TC and DFO, highlighting potential options in the next 2-4 years.

Creation: Transport Canada

From a GoC perspective, the two large shipping lanes south and north of Anticosti Island were of concern in relation to NARW deaths, as was the area around the Baie de Chaleaur (Tracy Chatman, personal communication, July 26th, 2018). Due to this the static closure section from the GoC's 2017 measures encompassed the entirety of the main shipping lanes, leaving no sections open to normal operational speed.

Through consultations with DFO and the Canadian Science Advisory Secretariat Science Response (CSAS), the best available information indicated that NARW sightings were lower in the shipping sectors, thus allowing for the creation of dynamic shipping sectors for the two main shipping lanes north and south of Anticosti island (Tracy Chatman, personal communication, July 26th, 2018). Additionally, 2018 measures within the Gulf included an altered mandatory static area from the 2017 season, which subjects' vessels over 20m in length to a 10.0 knot speed restriction (Transport Canada, 2018) (Figure 11).

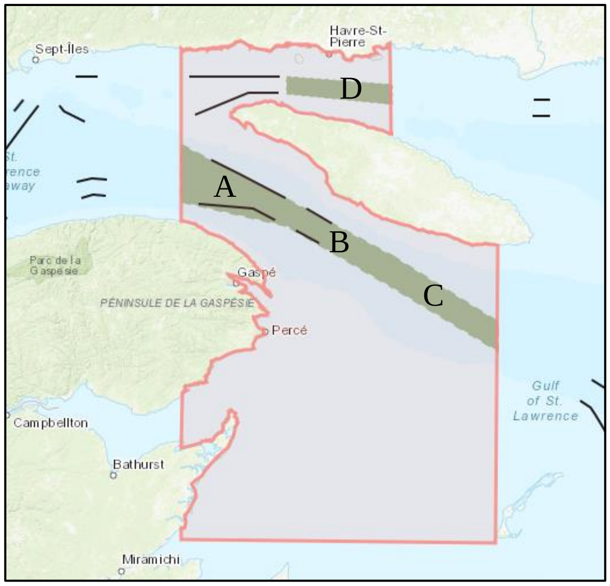

Figure 11. Transport Canada's 2018 NARW measures. Pink zone is the static speed restriction zone of 10-knots. Green sectors include the dynamic shipping sectors, A, B, C & D (Adapted from Transport Canada, 2018).

In addition to the static speed restriction area, TC also developed four dynamic shipping sectors, A, B, C, & D, with each sector open to safe operational speeds while subject simultaneously to closures if NARWs were spotted within the sectors, or within a 2.5 nautical mile of each sector. If a single NARW was spotted within these regions it triggered an automatic closure of 15 days, subjecting vessels transiting the sector to a speed restriction of 10.0 knots, with the sector opening only when two flights clear the sector(s) twice within the last 7 days of the 15-day period (Transport Canada, 2018). If another NARW was spotted within the same sector, it triggered another 15-day closure (Transport Canada, 2018). If no NARWs are spotted within the last 7 days, then the area is once again open to safe operational speeds (Transport Canada, 2018).

Dynamic shipping sectors were divided into sectors in response to industry's request for more flexibility to their operation schedule – in other words, the ability to keep some sectors open if no NARWs were present allowed for vessels to remain on schedule and minimize economic costs to industry members and Canadians (Tracy Chatman, personal communication, July 26th, 2018).

In addition to NARW sightings, sectors were also subject to close if two flights were unable to clear the sectors of NARW presence within a 7-day period (Tracy Chatman, personal communication, July 26th, 2018). As the policy was developed using the precautionary principle, even if NARWs haven't been spotted in the dynamic shipping sectors recently, decision-makers had to assume that NARW could be present if the proper surveillance requirements were not met. If an aerial flight was unable to clear each sector due to lack of resources or weather, the sector(s) in question were closed, subjecting vessels transiting the sector to a speed restriction of 10.0 knots. Sectors were only able to open to safe operational speed once an aerial flight was able to clear the sector(s) in question twice within a 7-day period.

The above measures were influenced from NOAAs use of dynamic management areas in the U.S. As seen in Table 2, although the two measures differ slightly, they both touch on the same aspect for DOM for NARW protection (NOAA, 2004).

<table>
<tr><th colspan="2">Table 2: U.S vs Canada Measures for Dynamic Management Areas</th></tr>
<tr><th>U.S</th><th>Canada</th></tr>
<tr><td><u>Trigger:</u>
1. NARW is "Resident": feeding NARW aggregations within shipping lanes
2. Mother/calf pairing within shipping lanes
3. Single NARW spotted in a port entrance/area</td><td><u>Trigger:</u>
1. 1 NARW within dynamic shipping sectors or within 2.5 nautical mile buffer</td></tr>
<tr><td><u>Buffer Zone/Geographic Extent of DMA:</u>
Buffer zone up to 15 nm from NARW spotting</td><td><u>Buffer Zone/Geographic Extent of DMA:</u>
Designated dynamic shipping sectors</td></tr>
</table>

Circle with a radius of 3nm per NARW	Buffer zone around dynamic shipping sectors of 2.5nm
Operation Restrictions of a DMA: 1. Temporary ATBA, SMAs and DMAs 2. Speed restrictions for vessels unable to avoid the area 3. Option to the mariner	**Operation Restrictions of a DMA:** 1. Speed restriction of 10-knots

Data Collection

By identifying areas with the highest amount of NARW and by comparing it to the main shipping lanes, the above management measures were possible. The start date was determined by the earliest NARW call from previous years – which happened to be April 28th, 2016 (DFO, 2018, B). As the GoC is acting on best scientific data and the precautionary principle, the start date was based off this data along with further measures as directed by CSAS (DFO, 2018, B).

Although the static and dynamic speed restrictions had an end date of November 15th, 2018, the need for continued NARW sighting data is necessary to properly implement dynamic management measures. This was a joint effort between TC and DFO, which required extensive collaboration and daily communication. NARW sightings data is reported through trusted sources to authorized departments that have been deemed as trustworthy in determining if a whale is a NARW or another species. Trusted sources included various non-governmental organizations, such as the New England Aquarium and MICS, who have been authorized to report NARW sightings. These sightings were reported to authorize departments, such as TC, DFO or NOAA. Additionally, these federal departments conducted aircraft and vessel surveillance with trained marine mammal observers on board.

Data Upload and Processing

If NARWs were spotted within the dynamic shipping sectors, the pilot would call into TC's Situation Centre (Sitcen), a 24/7 operational centre that responds to national crises, to report the coordinates associated with the sighting (Tracy Chatman, personal communication, July 26th, 2018). This is the same for any vessels that may spot NARW.

Coordinates were collected by employees at TC's Sitcen, who were responsible for correctly recording coordinates and NARW data and distributing this to TC and DFO distribution lists. The coordinates were plotted using Google Earth Pro, with the map showing where NARWs were spotted, how many NARWs and if possible, their current behaviour. An image is taken of the map with plotted NARW data, and it is sent to a second viewer for verification. Once verification is successfully completed, the Sitcen employee is responsible to getting the map distributed to senior management members for proper decision-making purposes. This process takes place in near real-time, with the only associated lag in relation to human errors with plotting data.

Data Delivery

If NARWs are spotted within a dynamic shipping sector, then appropriate management measures are necessary to efficiently restrict a sector to a speed of 10.0 knots or lower. This information is provided through Notices to Shipping (NOTSHIPs) and is distributed by the TC Whale Coordinator (WC) to the Canadian Coast Guard (CCG). CCG is responsible for broadcasting the NOTSHIP to vessels and shipping companies to ensure knowledge of the speed restriction is distributed. From the spotting of a NARW, the vessel typically has four hours to slow down. While speed restrictions were in place, CCG would monitor data from vessels AIS for compliance. If the vessels speed was over 10.0 knots, CCG would contact the vessel to enquire about the vessels speed and reconfirm the vessel was aware of the speed restriction (Tracy Chatman, personal communication, July 26th, 2018).

Flight tracks of successfully cleared sectors are found on Whale Map – an interactive map created by Hansen Johnson at Dalhousie University, which shows current NARW sightings, flight tracks from DFO and TC platforms and glider detections of NARW from the previous 24 hours. This tool is utilized heavily by industry, as they depend on this map for flight and NARW information (Tracy Chatman, personal communication, July 26th, 2018). This tool also holds GoC accountable for their surveillance efforts, tracking which days flights were attempted and which days there were no flights. From this, industry can check weather sites to see if the reason for no flights over an area is due to weather, or if there were other operational commitments that prevented flights.

Whale Map consists of all NARW sightings recorded by all GoC aircraft and vessels through a host server located at Dalhousie University (Hansen Johnson, personal communication, October 4th, 2018). GoC employees upload their raw data to a shared folder, typically Google Drive or Dropbox, where the host server is able to add the data to an existing database which is then uploaded onto Whale Map, updating every 5 minutes. To ensure data will always be in control of the agency who uploads it, Whale Map allows data users to be able to access their data in the folders– allowing them to erase, edit or add data at any time (Hansen Johnson, personal communication, October 4th, 2018). Any alterations to the data located in the shared file would be represented on Whale Map the next time it updates, thus allowing data users to control which data is accessible to the public and to ensure quality control on the data available. Currently, the Whale Map is not currently used for near real-time decision-making at the GoC level but could be utilized in the future for long-term policy decisions.

Decision-Making

Due to the nature of dynamic shipping sectors, daily flight operations are a necessity, with resources pooled into completing aerials surveillance flights and issuing NOTSHIPs when appropriate. On a day to day basis, multiple forms of data are collected by the WC in the form of NARW sightings data, aerial surveillance flight tracks and weather conditions of the Gulf of St. Lawrence. From the information collected, the WC is able to issue appropriate NOTSHIPs based on the best available scientific data. As seen in the diagram below (Figure 12), the WC has multiple procedures to choose from in order to accurately address the situation (Tracy Chatman, personal communication, July 26th, 2018). Tier II 1 procedure is implemented when NARW are spotted within the dynamic shipping sectors, with appropriate steps outlined in Figure 12. Tier II 2 procedure is implemented when there is inclement weather in the Gulf, creating a safety concern for vessels transiting the static speed restriction zone and the dynamic shipping sectors, as outlined in Figure 12. These procedure can be applied to remove all speed restrictions in the region, static and dynamic, or it can be used to lift any current speed restrictions in any of the dynamic shipping sectors.

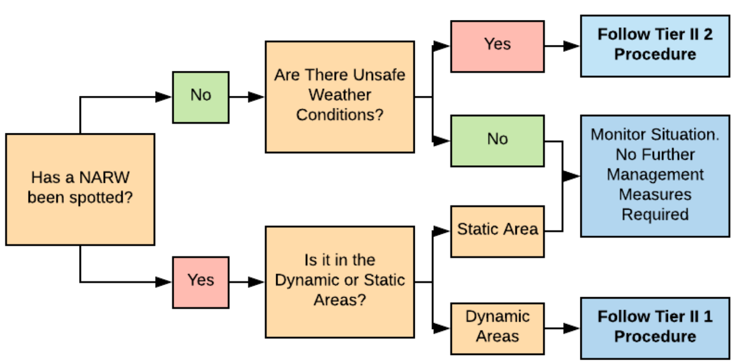

Figure 12. WC decision tree for when NARW were spotted in the Gulf of St. Lawrence.

Additional to speed restriction closures, daily operations include the distribution of ’72-hour warning’ emails to internal and external federal government and to industry distribution email lists. If any of the dynamic shipping sectors are at risk of closure due to weather restrictions, this warning email is issued 72 hours in advance in order to give industry advanced notice for their operational considerations. This was established at the request of industry representatives, who found the fluidity of dynamic measures negatively impacting operations. Within those 72 hours, TC will attempt to get the required aerial flights necessary to keep the shipping sector open. If the flights are successful, then the sector in question does not close.

Implementation

These measures were implemented April 28th, 2018 on the advice of DFO Science (Tracy Chatman, personal communication, July 26th, 2018). Implementing speed restrictions within the dynamic shipping sectors requires the cooperation between TC and CCG (Tracy Chatman, personal communication, July 26th, 2018). In order to successfully close sectors, a NOTSHIP is issued by CCGs Marine Communications and Traffic Services (MCTS), alerting vessels when they enter Canadian waters of the dire NARW situation, the designated static and dynamic slow down areas, and their related speed restrictions. This is updated based on current NARW sightings and aerial flights, with any changes to current NOTSHIPs being broadcasted to all vessels within the Gulf of St. Lawrence.

Weekly surveillances flights over the dynamic shipping sectors are completed by TC’s National Aircraft Services Program (NASP). Two flights are needed within a 7-day period for the sectors to remain open, with weeks operating on a ‘rolling week’ structure. This means that if a flight clears a sector on Monday, NASP has until the next Monday to get another flight up to clear the sector again, and keep it open to safe operational speeds. If this is not completed successfully, then the WC issues a NOTSHIP and closes the sector(s) in question.

NASP has utilized three surveillance equipment in support of the NARW initiative, including two manned aircrafts, Dash 7 and Dash 8, and a remotely piloted aircraft system, the SeaHunter (Tracy Chatman, personal communication, July 26th, 2018).

Enforcement and Compliance

As the dynamic and static shipping sectors are within Canada's territorial waters, the GoC has the legal authority to make these measures mandatory to all vessels transiting the region. As such, in order to determine compliance with these mandatory measures, TC utilizes AIS transponders, a system required on all international vessels larger than 20m by the IMO (Vanderlaan and Taggart, 2009). AIS data provides vessel identity, speed and location at near real-time, through one-minute intervals, and static data, through six-minute intervals (Vanderlaan and Taggart, 2009).

When a vessel goes over 10.0 knots when entering the static or dynamic speed restriction area, it is flagged and reported through AIS the CCG to the Safety and Security branch at TC where it is put under further review. If deemed as a violation of the 10.0 knot speed restriction, an Administrative Monetary Penalty (AMP) is issued ranging between $6,000 - $25,000.

Results: S.W.O.T Analysis

A S.W.O.T analysis was conducted to assess the 2018 NARW measures implemented by TC. Through my shadowing experience, I was able to analyze internal strengths and weaknesses of day to day operations, and the larger policy as a whole, while also experiencing the external opportunities and threats to the 2018 measures.

Strengths and weaknesses were determined through my four-month co-op placement where daily information on NARWs, compliance and enforcement statistics, dynamic shipping sector status, various industry perspectives and decision-making protocols were observed, collected and analyzed. The strengths highlighted in the table below (Table 3) are related to the 2018 NARW measures and does not imply they will be continued strengths going forward. These items are considered strengths as they were identified as aiding in the internal resiliency of the 2018 NARW measures and met the Hobday et al (2014) requirements for efficient DOM. Weaknesses were identified as areas where future efforts should be focused to ensure internal resiliency and continued successes as identified in strengths. These items are considered weaknesses as they did not fully encompass DOM as identified in the previous section. This included the decision-making protocols and surveillance capabilities of the 2018 measures.

Opportunities and threats are based on external factors that may help or hinder TC's NARW measures in the future. This can be based on the current political climate, international agreements or the resiliency of a species. In this case this includes the advancement of research capabilities in the academic world, the push for environmentally sustainable and adaptive management of our oceans and the adoption of future regulations. Threats that are external involve impacts outside the control of TC. This includes the standing endangered status of NARWs and the further implications for the population if future fatalities were to occur.

The items shown in Table 3 are further discussed in the following chapter.

Table 3: S.W.O.T North Atlantic Right Whales			
Strengths	**W**eaknesses	**O**pportunities	**T**hreats
High compliance rates. As of October 30th, 2018, 4612 vessels have transited the slow down area. Out of the 4612 vessels, only 3 vessels were given penalties	No political mechanism in place to assign tasks based on mandates	Advancing technology for increased surveillance efforts. (RPAs and gliders).	Pressure to implement large vessel/traffic alterations based on minimal NARW data
0 NARW deaths, with no NARWs spotted in dynamic shipping sectors	Big "P" policy and operational policy were in development at the same time measures were being implemented. Still no policy created.	Incoming regulations to better monitor vessels 20m and smaller	NARW outside the static and dynamic speed restriction zones
8 NOTSHIPs were issued to implement speed restriction in Dynamic Shipping Lanes	Large area subject to static speed restriction	Improved international reputation by adoption of IMO guidelines to Canadian legislation	NARW heavily endangered, we only saw 146 individually identified NARWs in the Gulf. Unknown habitats. 2 NARWs found dead in U.S waters in 2018.
Dynamic shipping sector 'A' closed for: 421.5 hours = 8.7% of season, sector 'B' closed for: 697.5 hours = 14.4% of season, sector "C" closed for: 673.5 hours = 13.9% of season and sector "D" closed for: 623.5 hours = 12.9% of season.	Aerial surveillance limited in over 15.0 knot winds		
Decreased economic impact, last year there was 3672 hours of speed restrictions	Vessels smaller than 20m without AIS are untraceable		
Measures based on best available scientific data			
Utilization of the precautionary principle			

CHAPTER SIX: DISCUSSION

This study identified the overall successes and weaknesses of TC's 2018 NARW measures – thus allowing for further consideration for future management measures for NARW protection in the Gulf of St. Lawrence. This section identifies areas of successes and weaknesses to the creation, implementation and operation of the 2018 NARW measures, as well as addressing some external opportunities and threats to future NARW measures for TC. This section will discuss the findings from analyzing the 2018 NARW measures through the Hobday et al (2014) DOM framework and through a S.W.O.T analysis.

Strengths

After the chaotic 2017 NARW season, the GoC enlisted a zero NARW death mentality for future management considerations (MacKinnon, 2017). Although NARW mortality was high in 2017, once the measures were mandatory the amount of NARW deaths seemingly slowed. This was highlighted in the 2018 NARW season, as the 2018 measures implemented in the Gulf was perceived as successful in preventing further deaths. From the analysis conducted, I identified the following areas as major strengths for the 2018 NARW season.

Decreased NARW Mortality

The main success of the 2018 NARW measures is in relation to the perceived decreased NARW mortalities. The 2017 NARW season showed a 4% decrease in the total NARW population, with studies suggesting a 2025 extinction rate for the NARW (Harvey-Clark, 2018). Preventing another unusual mortality event of NARW in the 2018 season was vital for the continuation of this species. This was achieved through the 2018 NARW measures as there has currently been no reported NARW mortalities in Canadian waters for 2018 (Fraser, 2018).

A large contributor to the success of these measures for NARW, is the use of scientific data to support management decisions. This includes the speed restrictions for vessels 20m and larger. By adopting the 10.0 knot speed limit, TC minimized the chance of a strike being lethal if a strike were to occur.

While these measures are a large success for Canada, there have been two NARW carcasses found in U.S waters for the 2018 NARW season. Although found in U.S waters, this does not indicate where the deaths occurred (Fraser, 2018). Currently, no necropsies have pointed to the source of the mortality, however there is evidence of previous entanglements in the form of rope scars on the NARW carcasses (Fraser, 2018).

The decreased mortality rate for the 2018 NARW season suggests that either vessels and shipping companies were more vigilant at avoiding NARWs this season, the static and dynamic speed restrictions of 2018 in the Gulf were successful at deterring vessels from striking NARW or potential fatalities were not documented due to the lack of carcass sightings. Additionally, this has the potential to change in future years as NARW continue to travel the Gulf.

Dynamic Shipping Sectors

Despite the 2018 NARW measures being the first time Canada had adopted dynamic ocean management into its suite of tools, the use of dynamic shipping lanes were a strength and success for TC. In the 2017 NARW season, the static speed restriction zone was in force for 3672 hours, restricting vessels longer than 20m to 10.0 knots.

Although TC implemented a similar static area for the 2018 measures, having the lanes with the most vessel traffic open to safe operational speeds severely decreased the amount of time and money spent transiting this area. As seen below (Figure 13) from the 2015 AIS vessel traffic data, TC implemented the dynamic shipping sectors in areas with the highest vessel traffic densities. Additionally, Figure 13 shows the 2017 NARW sightings primarily in the southern gulf, away from the dynamic shipping sector. Therefore, the ability to have dynamic shipping sectors within a static slow down area increased the chances of protecting NARW from lethal vessel strikes while simultaneously decreasing the impact on the daily operations of the shipping industry.

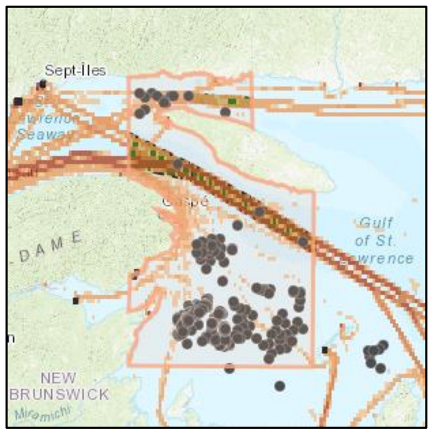

Figure 13. AIS vessel traffic data from 2015 shown in red. Black dots NARW summaries data from 2017. Pink zone is static speed restriction zone from 2018. Green areas are the dynamic shipping sectors, illustrating DOM was implemented with the highest vessel traffic density.

As seen in Appendix A, TC enforced the 2018 NARW measures for a longer period of time, beginning April 28th, 2018, and continuing to November 15th, 2018. TC increased the duration of the 2018 measures in relation to the speculation that NARW were expected to return to the Gulf after the 2017 season (CSAS, 2017). This was different in 2017, as the GoC was only made aware of an increased NARW presence in the Gulf once NARW carcasses began to be found in large quantities (CSAS, 2017). Despite the longer duration, the dynamic shipping sectors are considered a major strength, with the dynamic sectors closed for only an average of ~12.48% of the total NARW season.

Individually, the amount of time the shipping sectors were closed was not uniform. Due to varying weather conditions, some dynamic shipping sectors were closed more frequently than others. This is seen particularly with dynamic shipping sector “D”, which is located North of Anticosti island. Individually, dynamic shipping sector “A” was closed for 421.5 hours, sector “B” closed for 697.5 hours, sector “C” closed for 673.5 hours and sector “D” closed for 623.5 hours of the total 2018 season. This is a vast improvement from the 2017 season, leading to decreased economic implications to industry members travelling in the Southern Gulf.

High Compliance from Industry

TC’s ability to implement mandatory measures increased the amount of compliance from the shipping industry, resulting in only 3 AMPs being distributed in 2018 (Transport Canada, 2018).

Industry Engagement

As shown in the creation of the 2018 NARW measures, industry and stakeholders were consulted for the NARW measures going forward. Implementing a suite of measures for NARW protection in 2018, the GoC incorporated some of these ideas as seen in Table 2. The consultation and communication between stakeholders and TC have continued throughout the 2018 winter season, and through the roll out of the measures for the 2018 NARW season through the use of TC-hosted biweekly calls.

Industry was able to use the Whale Map to see all aerial surveillance tracks attempted by TC and DFO and be able to ask questions regarding the information provided by the map and GoC senior management. This was a great strength for the 2018 NARW measures, as both the GoC and industry showed their capacity to cooperate and communicate in a relatively transparent manner. This positive experience allows for continued collaboration leading into the 2019 NARW season.

Weaknesses

Due to the urgent manner of the 2017 NARW season, TC needed to implement efficient measures as soon as possible in order to prevent further NARW deaths. However, for the 2018 NARW season government and industry sought to develop proper policies and protocols to improve from the 2017 measures. Although the 2018 NARW measures were an improvement from the 2017 measures, there are still some areas of weaknesses that need to be considered for future management of NARWs in the Gulf.

No Policy Mechanism

Typically for mechanisms to be properly adopted into the federal government there is a standard developmental timeline. In this case, while both strategic and operational policy were being developed, regulations were being utilized and enforced in order to respond to the NARW crisis (Tracy Chatman, personal communication, July 26th, 2018). Future problems may stem from the lack of proper delegation of responsibilities and tasks within the GoC. Given the mandates and priorities of the departments involved, governance around the issue required clarification. In order to avoid overlap and complications, a leading entity should have been created to ensure departments knew their appropriate roles. This has yet to be addressed in 2018, with an all-encompassing policy for NARW procedures still missing.

As TC is currently using section 7 of the Collision Regulations (c. 1416) under the *Canada Shipping Act, 2001*, the GoC is at risk of having their authority challenged as the COLREGS are meant to protect the safety of the vessel and crew, not marine mammals (Tracy Chatman, personal communication, July 26th, 2018). In order to protect the marine environment, including marine mammals, from the impact of shipping, amendments to current legislation or regulations is necessary.

Surveillance Limitations

Although dependent on multiple platforms for NARW sighting efforts, there is a large limitation to aerial surveillance in the Gulf of St. Lawrence. Currently, TC has utilized the use of a manned aircraft, the Dash 7 and Dash 8, equipped with DFO's Marine Mammal Observers (MMOs) for surveillance of the dynamic shipping sectors for the 2018 NARW season. Additionally, they also attempted a Remotely Piloted Aircraft (RPAs) trial in the Gulf for the month of August (Tracy Chatman, personal communication, July 26^{th}, 2018).

A significant issue with current surveillance methods from a manned aircraft is in relation to limited wind speeds for optimal and confident clearance of shipping sectors of NARW. For instance, wind speeds over 15.0 knots limit the capabilities of the manned aircraft, as choppier water conditions make it harder for MMOs to confidently clear the area of NARWs.

Weather conditions in the Gulf were poor at the start of the 2018 season, causing the need to issue NOTSHIPs for speed restrictions in the dynamic shipping sectors – even if no NARWs were spotted. For the 2018 NARW season, all 9 NOTSHIPs restricting traffic speed to 10.0 knots that were issued were due to inclement weather conditions in the Southern Gulf, not due to NARW sightings. This caused great concern with industry members, who expressed frustration at the speed restrictions when no NARWs were spotted. Due to the adoption of the precautionary principle, TC had to close areas whenever two flights were unable to clear the sectors in a 7-day period. Possible solutions could involve enforcing measures once the first NARW is spotted in Canadian waters, similarly to U.S seasonal and dynamic protection measures for NARWs (NOAA, 2004).

Enforcement Concerning Vessels <20M

A large gap in TC's 2018 NARW measures involves vessels under 20m in length. As vessels under 20m in length are not required to carry AIS on their vessels, the ability to monitor their compliance with speed restrictions is not currently feasible. Although TC detected no NARWs within the dynamic shipping sectors, NARW were still detected heavily in the static speed restriction area – an area open to safe operational speeds for vessels less than 20m in length.

Given the AIS monitoring limitations, vessels less than 20m in length, including whale-watching and fishing vessels, are permitted to operate at normal operational speed. Vessels under 20m are still a huge risk to NARW populations – especially with the large numbers found around key fishing areas. This could increase the chance of vessel-strikes due to the limited restrictions and the higher quantity of vessels and NARWs in the same space.

New marine mammal regulations have been implemented this summer, issuing a mandatory 200m buffer from vessels to NARW (DFO, 2018). However, whale-watching and pleasure craft still pose a threat to NARW as they are exempt from the 10.0 knot speed restriction and are difficult to track. As NARW tend to be just at the subsurface, spotting NARW from a distance can be challenging and increases the chances of ship-strike – especially if the vessel is under 20m in length and is not following the 10.0 knot speed restriction.

The need for TC to increase enforcement capabilities for smaller vessels is vital to the success of minimizing NARW deaths due to ship-strikes in the future. Despite the absence of reported NARW deaths for 2018 in Canadian waters, Dalhousie's University Director of Animal Care, Dr. Chris Harvey-Clark has shown that from the 2017 necropsies NARWs showed signs of multiple cases of fractures from blunt force trauma that had healed sometime in the past (Harvey-Clark, 2018).

This suggests that vessel strikes are very common in NARW, even if they do not always lead to the death of the NARW, thus increasing the estimated amount of unreported ship-strikes of NARW.

Large Static Speed Restriction Zone

Although the size of TC's static speed restrictions has decreased in 2018, there is still a significantly large speed restriction zone inhabiting and restricting the Gulf of St. Lawrence. Although the main shipping lanes are more flexible this season, there is still a large cost for industry who transit within the static zone. For instance, industry members have expressed concerns for passenger and supply vessels that transit north of Anticosti island, who are constantly operating in the static speed restriction zone. This has large implications to their operations, increasing the amount of travel time for their trips, decreasing port times and delaying the delivery of resources to remote coastal communities (Master Mariner's Whale Symposium, Unpublished Proceedings, 2018).

This increase in transit time and associated repercussions has been a concern of industry in the past, who have requested reduction of the size of this area (Master Mariner's Whale Symposium, Unpublished Proceedings, 2018). Moving forward with NARW protection, decision-makers may need to consider the economic costs of a large static area and work to minimize this space as more NARW data is available.

Opportunities

Through this research, I have identified opportunities that could aid in TC's success in NARW protection in the Gulf of St. Lawrence. The identified opportunities have yet to be pursued by the GoC and could potentially be utilized in the future by TC.

Technological Improvements

As shown in the above analysis, a large weakness in the 2018 NARW measures employed to date is in relation to TC's surveillance limitations. Currently, the identification of NARW in high wind conditions is restricted for both manned and unmanned aircraft. An additional concern is the availability of the aircraft in current use, given that the aircraft in use is divided between two tasks; pollution prevention and NARW monitoring. An additional manned aircraft from TC is being implemented for the 2019 NARW season for the sole purpose of whale monitoring which should address this.

Along with manned aircraft, advancing surveillance technology is a large opportunity for the GoC to improve surveillance capabilities. For instance, although the GoC has yet to utilize gliders in the Gulf, Dalhousie University has been using autonomous gliders in the southern Gulf for detecting NARW calls, while simultaneously collecting environmental data (Hansen Johnson, personal communication, October 4th, 2018). Currently, the gliders are only operating in the southern Gulf, where DFO implemented fisheries measures and where TC's static speed restriction zone is implemented. There is an opportunity to program gliders to monitor the dynamic shipping sectors North and South of Anticosti island through a trial basis.

Equipped with hydrophones, gliders are able to detect NARW through the identifying of NARW upcalls through an attached algorithm. This algorithm is able to determine the approximate area a call was recorded, and which species this call belongs to (Hansen Johnson, personal communication, October 4th, 2018). Utilizing glider technology allows for detection of NARW in the dynamic shipping sectors when weather conditions may not be optimal for aerial surveillance. This could in turn prompt a speed restriction in a sector where NARW are detected or trigger increased surveillance of the related sectors by manned aircraft to confirm NARW sightings before closing any sectors to 10.0 knots.

TC's dependence of aerial surveillance may be limiting the capabilities available from advanced technology. That being said, the introduction of a RPAS trial for the 2018 NARW season proved that the GoC is looking into more cost and resource efficient forms of technology for NARW detection. This shows that introducing a suite of monitoring tools, in addition to the manned aircraft, is not a far-fetched idea for the GoC, and could increase the opportunities of including detection technology, such as gliders, to form a 'cocktail' surveillance plan. Supported by industry, this 'cocktail' has been suggested through the use of hydrophones and glider technology in consultations (Sonia Simard, personal communication, November 19th, 2018). There are many challenges associated with using unmanned surveillance technology, but this technology has the potential to improve as more trials are completed and may be a viable solution for increased surveillance in support of manned aircraft in the future.

Prospective AIS Regulations

Future regulatory changes to AIS requirements within TC legislation present an opportunity to conduct enforcement with respect to vessels 20m and lower. With new AIS regulations expected to be introduced in 2019, it will allow for better enforcement of smaller vessels in the Gulf, increasing the ability to track vessel speeds in areas with NARW aggregations. If in force for the 2019 season, this will allow for increased protection for NARWs, as TC's policy can now encompass smaller vessels within the static speed restriction area.

In addition, once the GoC has the ability to collect data on smaller vessel transits in the Gulf, the GoC will be better aided to develop and enforce future measures in the future – such as an area to be avoided where NARW aggregations negatively interact with vessels smaller and larger than 20m in length. By increasing the requirements for vessels, small and large, TC has the opportunity for improved management within the entire Gulf – which could lead to less of a static speed restriction zone and perhaps move towards a more flexible, cost-effective dynamic management plan once the proper data is collected.

Improved International Standing

Enhancing Canada's reputation at the international level is a spin-off benefit of TC's 2018 NARW measures. In relation to marine and environmental protection, Canada has ratified numerous agreements, including the Convention on Biological Diversity (CBD) and the United Nations Convention on the Law of the Sea (UNCLOS) (Government of Canada, 2017). Additionally, Canada has adopted various international standards, including standards from the IMO (Government of Canada, 2017). From the listed international commitments above, the implementation of the 2018 NARW measures has demonstrated Canada's commitment to promote the spirit of those instruments by the operationalization of concrete management measures.

As part of the CBD, Canada has agreed to a list of "strategic goals" and "the Aichi biodiversity targets", with the vision of "Living in Harmony with Nature" by 2050 (CBD, n.d, A). Most relevant to the 2018 NARW measures includes Aichi target 12, which states that "by 2020 the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained" (CBD, n.d, B). Due to the success of the 2018 NARW measures, Canada has responded effectively by implementing the preventative measures necessary to prevent an endangered species from further decline. As with most international agreements, all parities under the CBD are required to report on their progress every four years. Due to the 2018 NARW measures, Canada can report that they have "enhanced protection for species at risk, adopted the ecosystem approach and emphasized on the precautionary approach", criteria that is emphasized under the CBD (Government of Canada, 2017, B).

In addition to the CBD, Canada is party to UNCLOS, also known as the "constitution of the oceans" (Government of Canada, 2017, C). UNCLOS is a legal framework that governs wide ranging maritime affairs, including navigational safety, scientific research and the rights of countries to 200 nautical miles (Government of Canada, 2017. C). Most relevant to the 2018 NARW measures includes the emphasis of UNCLOS on rights of countries within their territorial waters and the emphasis on "comprehensive rules for the protection and preservation of the marine environment" (Article 192 of the Convention, 1982). As demonstrated previously, TC has utilized Canada's territorial waters to ensure mandatory measures were put in place for NARW conservation in order to protect and preserve the marine environment and the species that inhibit it, thus discharging its UNCLOS duty to protect and conserve the marine environment.

Canada has pursued the goals of the "2030 Agenda for Sustainable Development" in 2015, which outlines 17 Sustainable Development Goals (SDG) to lead to sustainable world development by 2030 (UN General Assembly, 2015). This includes SDG 14, which in relation to the 2018 NARW measures, emphasizes the need to protect marine life from the disruption from underwater noise and strikes between vessels and marine mammals (UN General Assembly, 2015). As part of this agreement, Canada has an improved international reputation by creating efficient mitigation measures from lethal vessel strikes and NARW.

Threats

External threats were identified from the current TC weaknesses outlined above. Despite being external, the 2018 NARW measures impact and are impacted by the current NARW situation. The threats listed below were considered the major threats to the success of future NARW measures, the NARW population and the marine environment.

Marine Mammals Outside the Gulf

As mentioned previously in the weakness section, TC has yet to develop a NARW policy for sightings outside the Gulf. This is not only a weakness of internal operations, but also an external threat to the overall resiliency of TC's NARW management in the future. With a NARW policy that is yet to be completed, there is a gap in procedures for current NARW protection when unforeseen circumstances occur. For instance, NARWs found outside designated speed restriction areas are at a large risk to vessel strikes, as vessels tend to speed up once outside speed restriction areas to make up for lost time to their schedules (Master Mariner's Whale Symposium, Unpublished Proceedings, 2018). This creates a threat to not only NARW outside the designated areas, but also to the decision-makers at TC as they may not be fully equipped to handle unforeseen appearances of NARW.

From a NARW conservation perspective, the lack of policy for protection outside the speed restriction areas increase the chances of being struck by a vessel. Although TC has done an efficient job at protecting known feeding areas in the Gulf, NARW movements within the gulf is still widely unknown – with hardly any sighting data showing NARW travelling to and from NARW aggregations. For instance, NARW were spotted sporadically North of Anticosti Island, with no sighting data of any NARW transiting from the southern gulf known aggregations to this location. Although the southern gulf is considered a prime location for NARW aggregations, how NARW use the rest of gulf is still uncertain.

Industry has raised this concern, especially as DFO has implemented the same management measures from the Gulf when NARW were spotted in the Bay of Fundy. As one federal department had utilized Gulf measures outside the Gulf, industry began to question if TC would follow suite. As only 146 individual NARW have been identified this season so far, researchers have yet to identify the location of remaining NARW (Tracy Chatman, personal communication, July 26th, 2018). To tackle this confusion, further efforts are necessary to properly communicate with industry and public members why further measures are not being pursued, perhaps highlighting the effectiveness of previous measures already currently implemented in the Bay of Fundy and Roseway Basin for preventing NARW mortalities.

Endangered Status of North Atlantic Right Whales

As this project has shown, the current status of NARW is of great concern. Management measures implemented today will either help or hinder the recovery of NARW numbers, who with only ~100 breeding females left, and an estimated extinction date of 2025, NARWs do not have time for the mismanagement of harmful anthropogenic activities. Although dynamic ocean management can be resource intensive it also allows for real-time protection, adapting to NARW movement and usage of the Gulf. The use of DOM allows decision-makers to address the uncertainty surrounding NARW migratory routes while simultaneously collecting vital NARW data.

The unpredictability of NARW in the Gulf illustrates the threat of moving from dynamic management to static traditional methods prematurely. Although the GoC and non-governmental organizations are currently collecting data on NARW usage of the Gulf, removing the flexibility of current measures could unintentionally put NARW at more risk as they continue to inhabit the Gulf, as it may lead to less protection in some areas. As years continue and more data is collected on NARW known areas in the Gulf, static measures may be a viable option. However, with today's changing ocean and the critical status of NARW, implementing more permanent measures could do more damage than good. For instance, the TSS shift in the Bay of Fundy happened after decades of NARW data determined their use of the area effectively.

<u>CHAPTER SEVEN: CONCLUSIONS & RECOMMENDATIONS</u>

The adoption of management measures for NARW protection has been an international effort, with countries drawing on international and national legislation to mitigate anthropogenic impacts on NARWs. Canada specifically has drawn on numerous international connections, such as the IMO adoption of the Bay of Fundy TSS shift or the Roseway Basin ATBA, whilst simultaneously depending on national legislation, such as the *Canada Shipping Act*, to allow for the creation of innovative management options. The protective measures utilized in the past for NARWs in Canadian waters have provided great successes in mitigating anthropogenic impacts on NARW. However, as illustrated by this research, in a changing environment the use of these tools is only useful in the areas they're implemented in. As the ocean is highly dynamic, the GoC needs to incorporate flexible management tools to properly match the uncertainties related to ocean management (Reimer et al, 2016). As shown, DOM is a viable tool to incorporate into existing management techniques, providing managers the capabilities to address ocean issues in near real-time.

This research illustrated how DOM can successfully be implemented to compliment already existing management tools in order to provide efficient protection for an endangered, dynamic marine mammal. TC utilized DOM through the creation of dynamic shipping sectors in contribution to typical management tools – such as static speed restriction zones. This shows the adaptability of DOM into already existing management regimes and the minimized impact DOM allows through flexible restrictions.

From the analysis conducted in this project, a suite of concluding recommendations has been formulated for consideration in the years to come. I have recommended the implementation of an efficient federal Whale Management Committee, an Interactive Mapping Tool for industry and public engagement and potential management measures that may be pursued in the next two-five years.

Whale Management Committee

As identified above, a large gap in current 2018 NARW measures is the lack of strategic policy development and the mismatched mandate of TC. Without a proper written policy in place, protocols for 2018 NARW measures are not easily available or known. The completion of the NARW policy can address multiple weaknesses of the 2018 NARW measures, including the proper protocol for when NARW are found outside the Gulf and the responsibilities of TC teams. Completion of the NARW policy is urgently needed for the resiliency of TC's NARW measures going forward.

The delay of the written policy is primarily due to the chaotic events of the 2017 NARW season, where TC and DFO were pressured to produce feasible and efficient mitigation measures to prevent more NARW deaths (Tracy Chatman, personal communication, July 26th, 2018). As multiple teams within TC were independently tasked with providing NARW mitigation measures, my research illustrated the vast overlap between internal TC whale teams' objectives. With internal TC teams working on similar items, the efficiency of developing procedures and policies was negatively impacted, leading to the development of strategic policy while at the same time implementing operational policy.

To combat this weakness and ensure efficiency in future NARW protection, I recommend the formation of an executive Whale Management Committee within TC, that encompasses multiple leaders from the implicated internal teams to ensure items are properly tasked and information shared. As TC partakes in numerous NARW related meetings with external and internal stakeholders, the addition of an executive whale committee meeting within TC would not be a challenging recommendation to adopt. By including leaders from each team, responses to crises or assignment of tasks can be achieved more efficiently, improving the lack of communication within the TC. By meeting regularly this ensures no items are missed or miss-tasked, and responses or reviews of documents is easily communicated and completed on time. This would eliminate the tasking of items last minute, or quickly trying to get another teams approval within short deadlines.

Interactive Mapping Tool

Another significant weakness of the 2018 NARW measures is the communication and interactions between TC, industry and the general public. To address these concerns an interactive tool can be created to illustrate policy rationales and to increase transparency with stakeholders. As seen with the success of the Whale Map, industry engagement increased dramatically and relationships between stakeholders and the GoC improved as this tool allowed for increased data sharing and transparency. This project recommends a similar interactive mapping tool be created, either independently from Whale Map or as an added feature, to allow for efficient stakeholder engagement.

As such, I have developed a teaser web application using ArcGIS to increase awareness of TC's measures for NARW, to provide the rationale for the 2018 measures and to communicate to industry members the current status of the dynamic shipping sectors. As seen in Appendix B, the first part of the mapping tool allows for layers to be clicked for NARW sightings in 2017, and the measures that were implemented to address these concerns. This explains to stakeholders the reason why decision-makers implemented such a large static area, and the relation to where NARW were spotted. Added to this could be approved text from TC that better communicates policy decisions. This can be done again through clicking the 2018 measures and the vessel AIS data that shows the dynamic shipping sectors were chosen in the area with the highest density vessel traffic and the lowest NARW sightings from 2017.

Lastly, as seen in Appendix C, an added function could involve the creation of a 'status for dynamic shipping lanes', which would illustrate TC's current 72-hour notice through a green light, yellow light, red light process. Currently TC provides this 72-hour notice via email distribution lists whenever a dynamic shipping sector may be "at risk" of closure. By creating this mapping tool, industry and the public can be shown the status of any of the shipping sectors at any time. The challenges of this recommendation involve industry relying on the website for navigational purposes instead of abiding by NOTSHIPs. However, as utilized by DFO's Whale Map, a large disclaimer and caution text can address this issue, reinforcing the important role of abiding by NOTSHIPs – which are the legal documents for vessels to abide by.

Another concern for this mapping tool is the resources needed to ensure the map is maintained up to date. This concern can be met by using the same uploading system currently utilized by the Whale Map, which automatically uploads new information every 15 minutes from selected shared files. The WC of TC could simply upload data into the shared file, and the Whale Map would show the status every 15 minutes. Here, the status of shipping sectors will be known through: green as open to safe operational speeds, yellow as at risk of closure in the next 72 hours, and red as closed to the 10.0 knot speed restriction.

Future Management Measures

Management Tools

The success of the 2018 NARW season indicates that DOM has properly addressed the NARW crisis of 2017. Based on the S.W.O.T analysis in the previous section, it is recommended TC continue utilizing DOM in the Gulf to ensure continued protection for NARW. Utilizing DOM in the next 2-3 years will allow for more NARW data to be collected while ensuring flexibility while researchers try to understand how NARW are occupying and using the Gulf. In the face of uncertainty, DOM allows for fast and efficient NARW protection based on near real-time data and detection capabilities. There is a threat of moving toward more static and permanent management options before the proper data is collected.

Taking into the critical status of NARW, I would recommend TC continue with management measures similar to the 2018 season for the 2019+ seasons, to avoid any further mortality events. Reduction of the size of the static speed restriction zone at this stage would be a large risk to NARW and to the GoC's reputation. Although a large area, the majority of shipping is addressed through the dynamic lanes, and the static area is still providing protection for other marine species outside NARW. Taking away the static area increases the risk to not only NARW, but to other species that may be transiting the area who have no additional protective measures in the Gulf.

Technology Advancement

Building on the success of 2018 NARW measures for 2019+ provides a great opportunity for TC to research and test additional surveillance methods that could be used in future NARW management. The 2018 season brought the first trial of RPAs into the Gulf for NARW research.

The continued research into RPAs technology for additional surveillance should be pursued in the years to come.

In addition to advancing RPAs trials in the Gulf, I also recommend the investigation of autonomous gliders within the dynamic shipping sectors. As previously mentioned, gliders are currently being used to collect NARW and environmental data in the southern Gulf by Dalhousie University (Hansen Johnson, personal communication, October 4th, 2018). Like most technology, there are limitations for autonomous gliders. For instance, although the glider will pick up on a NARW call, the area where it picks up on the call does not necessarily mean the NARW is located at that location (Hansen Johnson, personal communication, October 4th, 2018). As sound travels further in water than on land, the actual location of the NARW would not be known. However, due to the vastness of the dynamic shipping lane, the identification of a NARW call could trigger more surveillance methods – such as the manned aircraft. For instance, if a NARW call was detected within one of the dynamic sectors, this could trigger the departure of a manned aircraft to determine if the NARW detected is within the dynamic sector, or within the static restriction area nearby. The benefits of using gliders within the dynamic sectors is a great opportunity for advancing surveillance capabilities within the federal government, and it has been requested from industry to ensure surveillance limitations can be properly addressed (Sonia Simard, personal communication, November 19th, 2018). Further consideration is needed to assess related risks of lost or damaged gliders and how detection will be impacted from constant vessel noise within the shipping lanes.

The development of advanced technological surveillance methods is highly recommended in the years to come. This will provide support to the manned air craft while simultaneously collecting the environmental data necessary to implement more seasonal or permanent management zones in the future.

Future Management Considerations

As for future pursuit of DOM, the development of static or seasonal management techniques in addition to DOM areas would be a logical response to NARW management in the Gulf. As mentioned in previous sections, this step would not be recommended until the NARW usage of the Gulf is better understood and the appropriate data requirements is reached. These seasonal management areas can still be used in combination with DOM, but would lead to less resource intensive surveillance efforts, saving money and man power.

I recommend looking into similar techniques as used in the Roseway Basin ATBA for future management of shipping in the Gulf, as this tool has been efficiently used to detect overlapping areas between vessels and NARW. Based off NARW sighting data from 2017-2018, Figure 14 illustrates the potential use of seasonal ATBAs in addition to DOM.

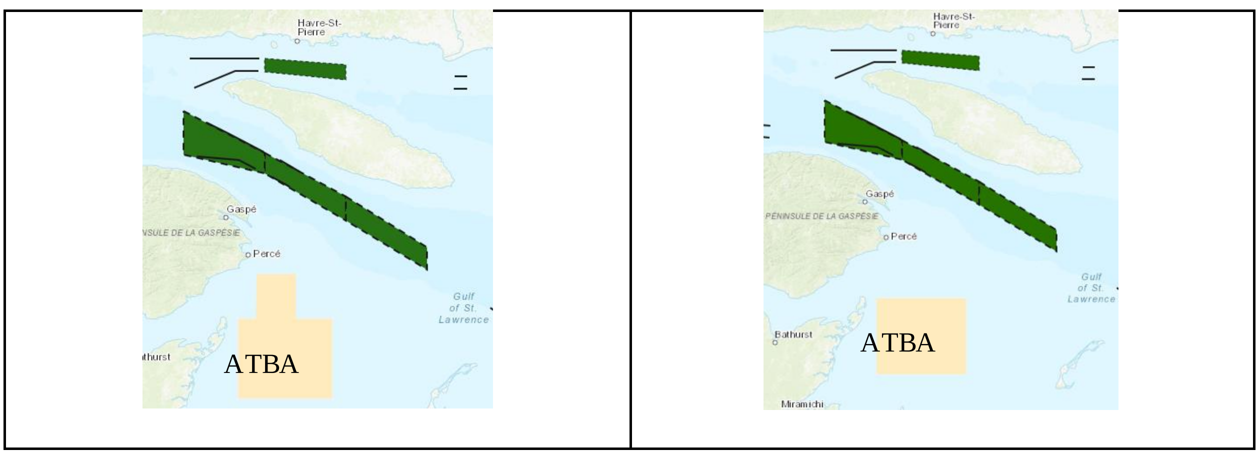

Figure 14. A) Potential ATBA with dynamic shipping lanes, based off of 2018 NARW data. B) Potential ATBA with dynamic shipping lanes, including DFO static fisheries management zone as ATBA.

The use of a mandatory ATBA is recommended as it would restrict vessels from entering the area where the most NARW aggregations have been detected. Although speed restrictions have shown increased protection to NARW, the avoidance of vessel to whale encounters would provide additional protection. As further NARW data is collected and analyzed, the introduction of a seasonal ATBA could be implemented. The difference between the Roseway Basin ATBA and the potential ATBA in the gulf, is in regard to territorial waters. As the potential ATBA in the gulf is within territorial waters, then the measure can be enforced as mandatory. Additionally, as a particularly sensitive sea area (PSSA), TC should submit any PSSAs implemented in the Gulf to the IMO for adoption to further international protection. A PSSA designation may allow for more strict regulations within the PSSA including; ATBAs, re-routing and strict environmental rules (IMO, 2016).

The next coming years will be critical in determining the fate of NARWs. Canada has proven its willingness to utilize management measures that can provide protection for NARWs, while simultaneously investigating advanced technology for surveillance needs (Elvin and Taggart, 2008). To continue protecting NARW in the Gulf of St. Lawrence, collaboration with other federal departments and stakeholders from the shipping industry is highly recommended, with the continued use of DOM being the key to the success of minimizing NARW deaths in the years to come. Combined with traditional management tools, DOM provides a complimentary tool to NARW conservation efforts within the federal government of Canada.

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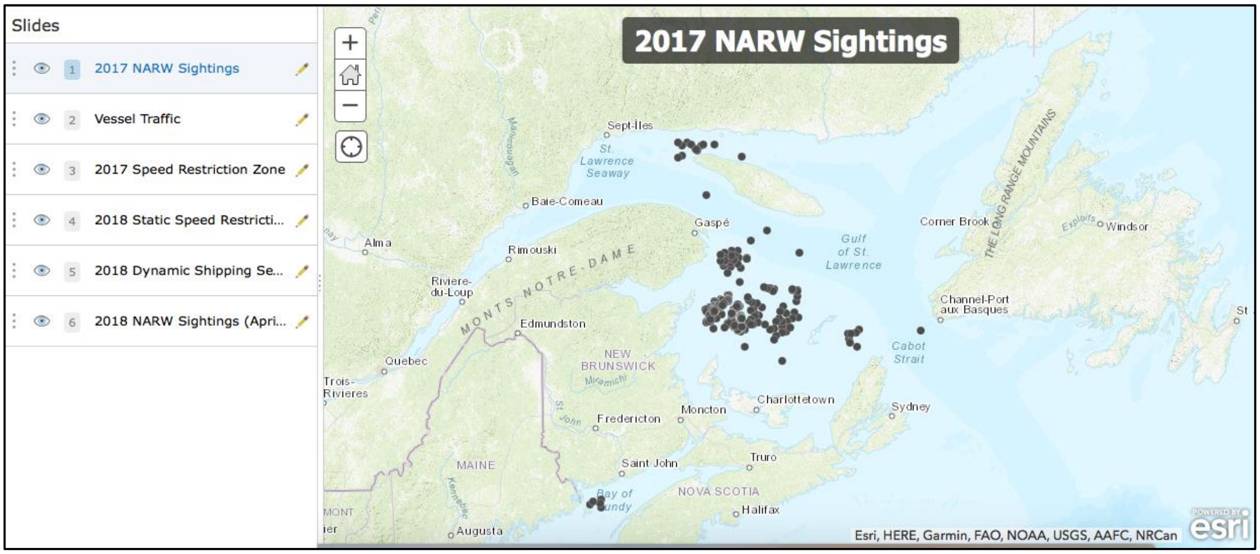
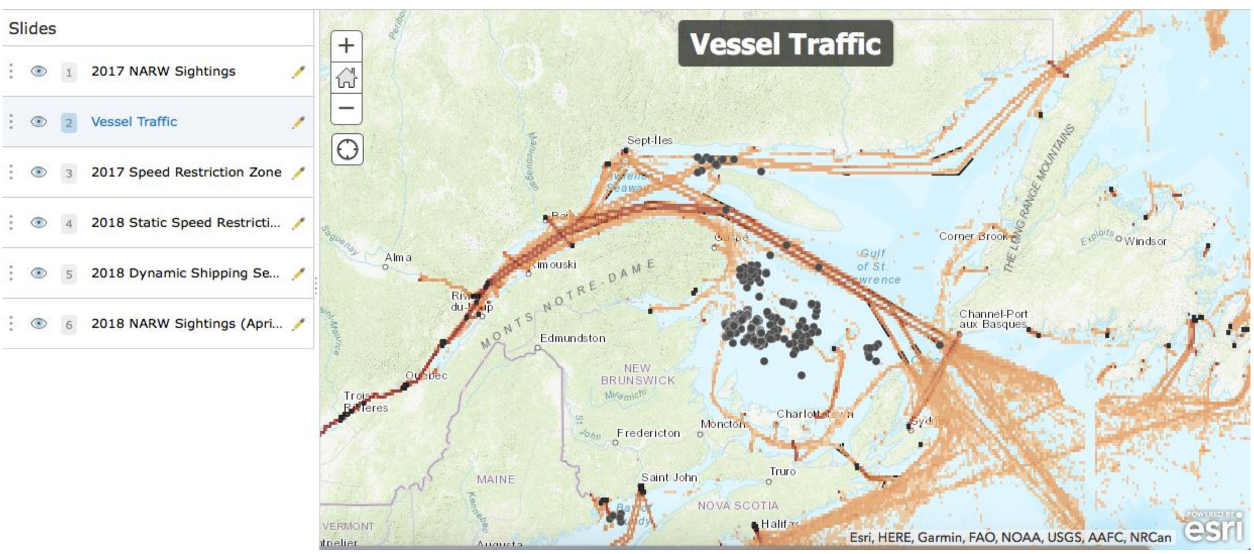
APPENDIX A: SPEED RESTRICTIONS

2017 NARW Season: August 11th 2017 – January 11th, 2018: 3672 hours							
2018 NARW Season April 28th 2018 - November 15th 2018: 4824 hours							
Date Issued	Time	Date cancelled	Time	A	B	C	D
2018-05-08	21:00	2018-05-11	1:20	X	X	X	X
2018-05-12	17:00	2018-05-15	22:00	X	X	X	X
2018-05-15	22:00	2018-05-24	19:00		X	X	
2018-06-15	4:00	2018-06-22	17:10	X	X	X	X
2018-07-27	4:00	2018-07-28	4:00		X		X
2018-07-28	4:00	2018-08-01	19:00		X	X	X
2018-08-09	4:00	2018-08-12	4:00				X
2018-08-12	4:00	2018-08-13	19:00		X	X	X
2018-09-24	4:00	2018-09-28	19:00	X			
2018-10-03	4:00	2018-10-05	23:00				X
			TOTAL:	421.5	697.5	673.5	623.5

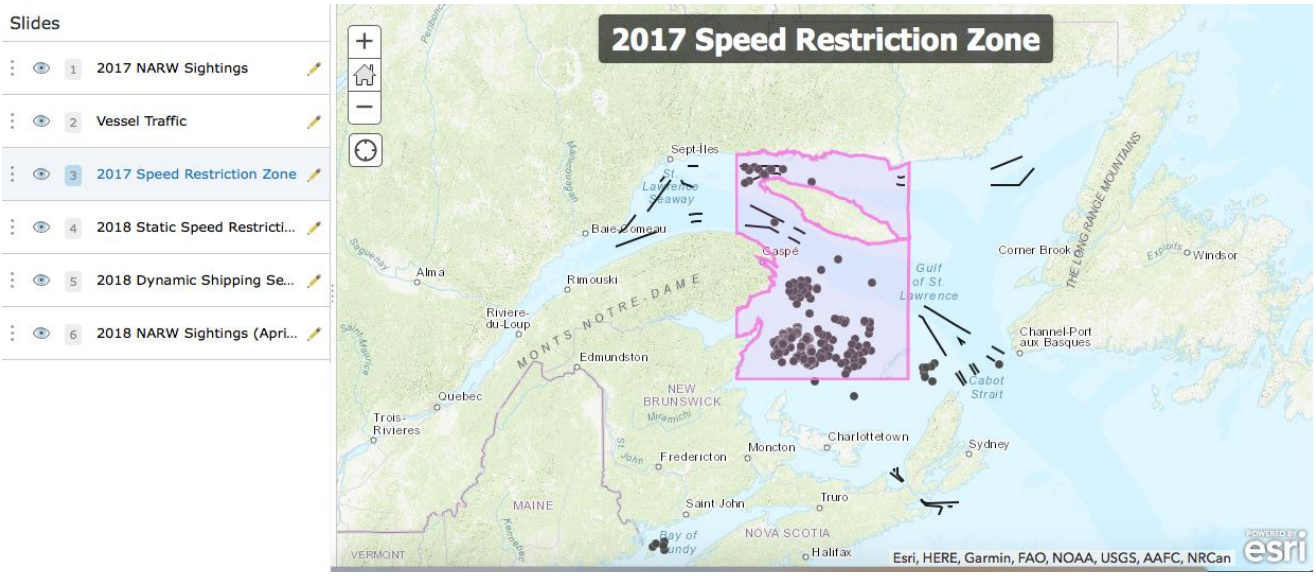
APPENDIX B: 2019 PROPOSED INTERACTIVE TOOL



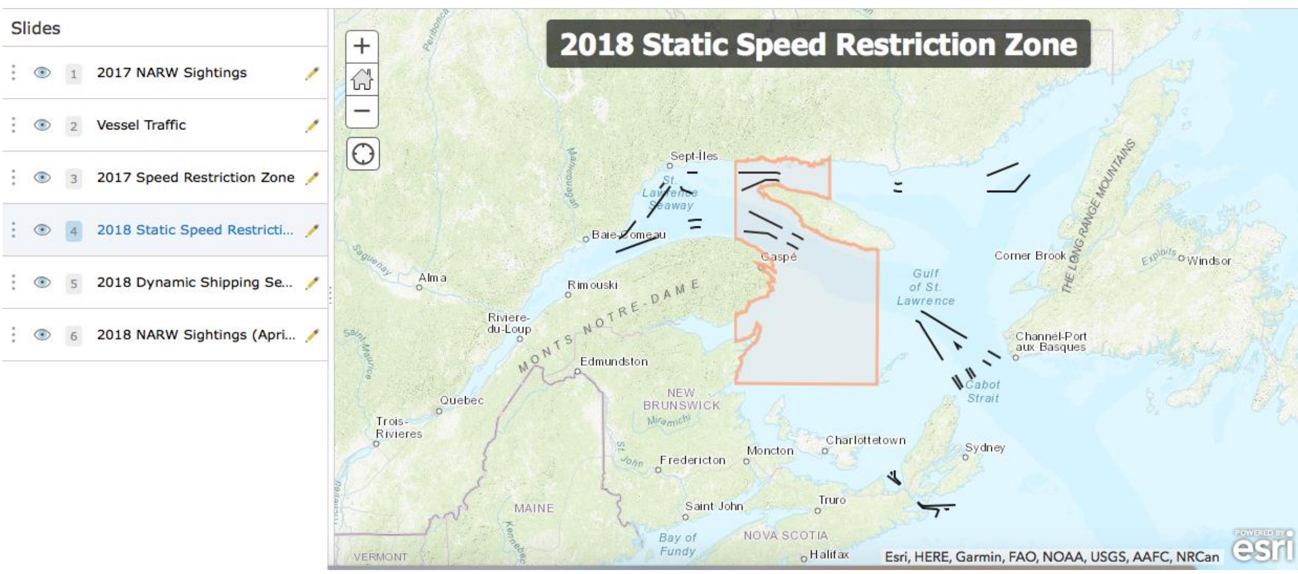
Appendix B.1: Interactive map clicked to show the 2017 NARW sighting data.



Appendix B.2: Interactive map clicked to show 2015 vessel traffic in relation to the 2017 NARW sighting data.

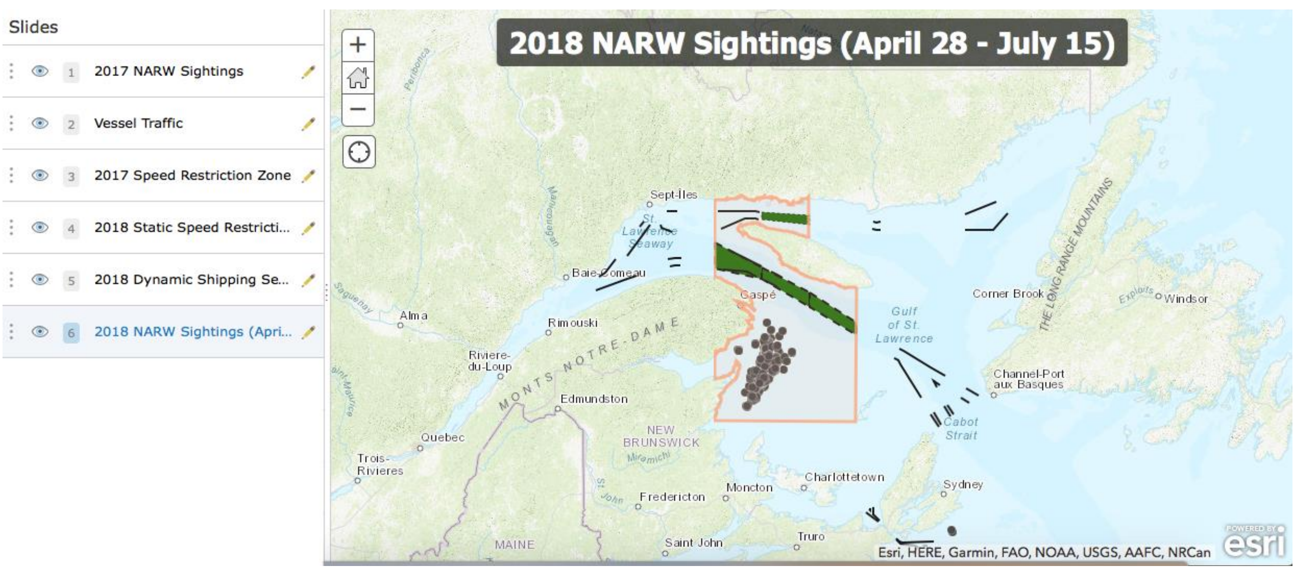


Appendix B.3: Interactive map clicked to show the 2017 speed restriction zone due to 2017 NARW sighting data and 2015 vessel traffic data.



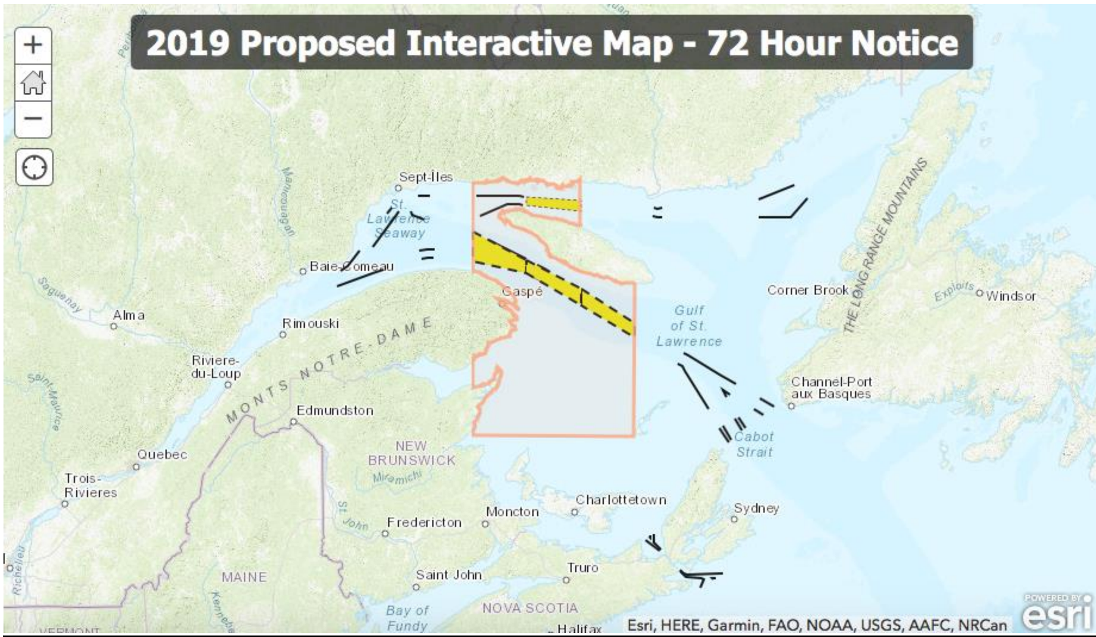
Appendix B.4: Interactive map clicked to show the adapted 2018 speed restriction zone.

Appendix B.5: Interactive map clicked to show the adapted 2018 dynamic and static management measures. This is based off of vessel data from 2015 and 2017 NARW sightings data.

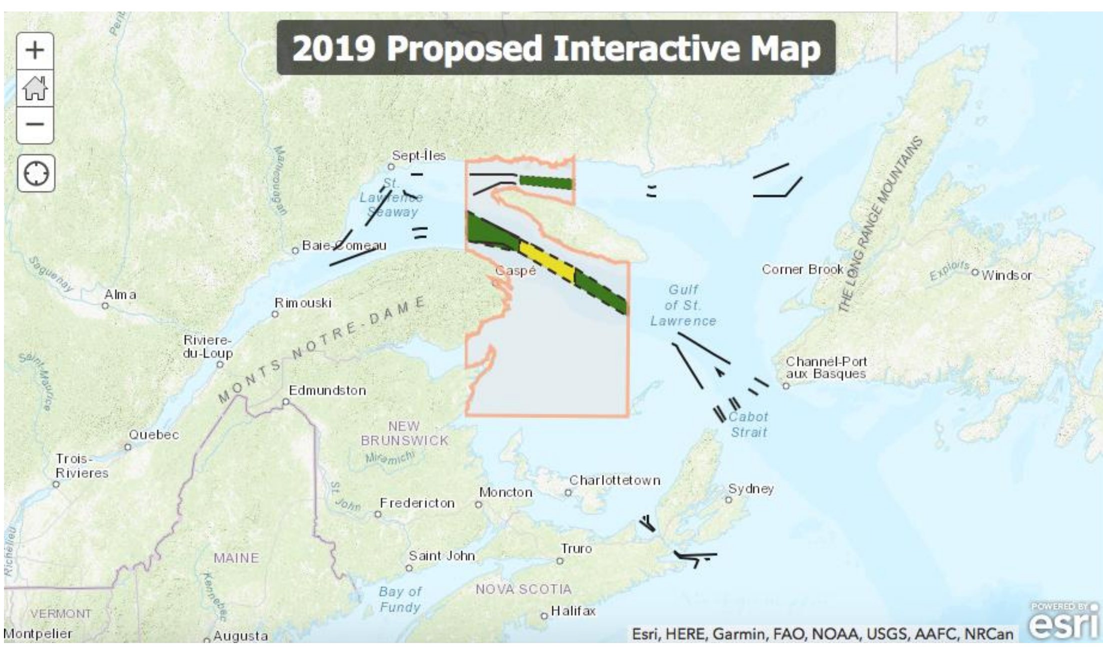


Appendix B.6: Interactive map clicked to show the 2018 NARW measures and the 2018 NARW sighting data up until July 15th, 2018.

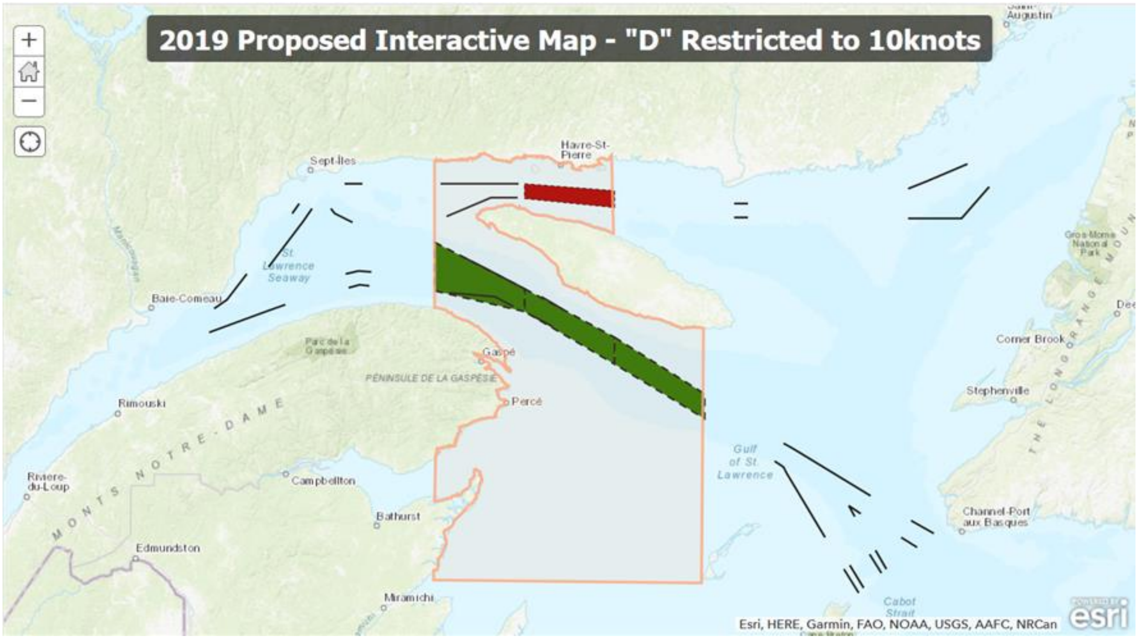
APPENDIX C: 2019 PROPOSED INTERACTIVE TOOL



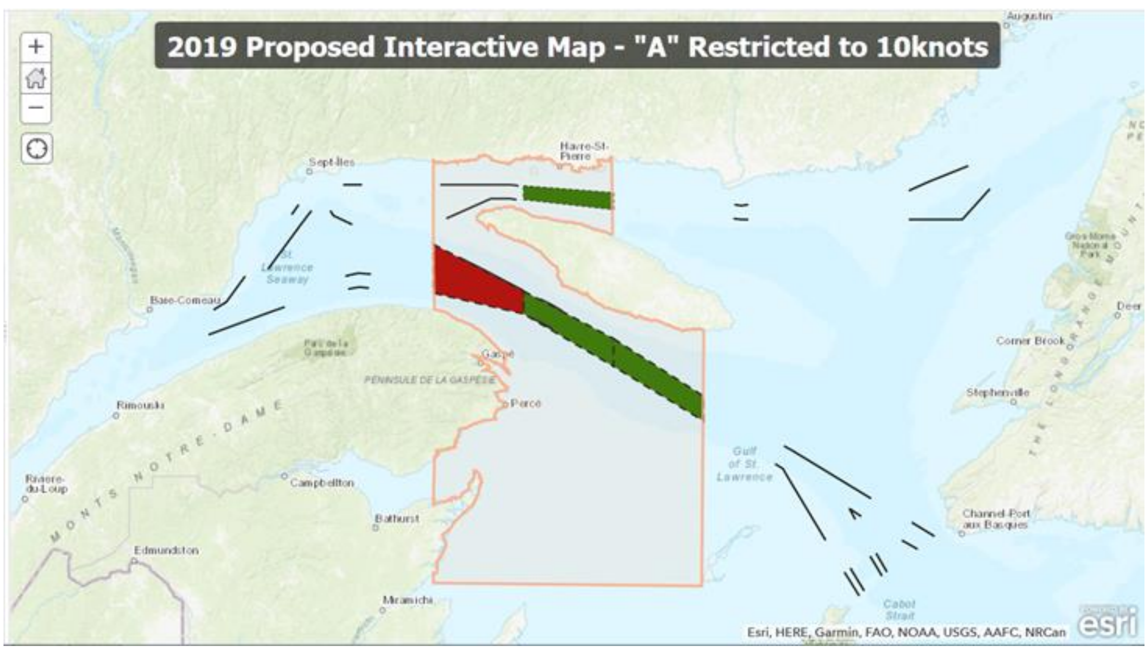
Appendix C.1: 2019 proposed interactive map. Dynamic shipping sectors appear yellow to communicate to industry that sectors A-D are at risk of closing to 10-knots within 72 hours. Here, all four zones are at risk of closure.



Appendix C.2: 2019 proposed interactive map. Dynamic shipping sectors appear yellow to communicate to industry that sector B is at risk of closing to 10-knots within 72 hours. Here, only sector B is at risk of closure.



Appendix C.3: 2019 proposed interactive map. Dynamic shipping sectors appear red to communicate to industry that which sectors are restricted to 10-knots. Here, sector D is currently restricted to 10knots.



Appendix C.4: 2019 proposed interactive map. Dynamic shipping sectors appear red to communicate to industry that which sectors are restricted to 10-knots. Here, sector A is currently restricted to 10knots.