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Recovery Potential Assessment for the North Atlantic Right Whale (*Eubalaena glacialis*)

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Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

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ABSTRACT

The North Atlantic right whale (NARW; *Eubalaena glacialis*) was assessed as endangered by the Committee on the Status of Endangered Wildlife in Canada in 2003; a status which was re-confirmed in 2013. In 2005, the NARW was listed as Endangered on Schedule 1 of the *Species at Risk Act*. Given the substantial advancements in our knowledge of NARWs in Canadian waters since the last Recovery Potential Assessment in 2007, and the significant changes observed in the distribution and habitat use of NARWs in Canada since 2010, an updated assessment was requested. The main objective of this Recovery Potential Assessment was to provide up-to-date information, including the associated uncertainties, on the following elements: recent abundance trajectory; current distribution; contemporary life-history parameters; identification of important habitat; threats and limiting factors to the survival and recovery of NARWs; identification of activities likely to destroy important habitat; recovery targets for the abundance and distribution of the NARW; and, to evaluate the maximum human-induced mortality that the species can sustain without jeopardizing its survival or recovery. The NARW represents a single population with no distinguishable units and a population estimate of 372 (credible interval: 360 – 383 individuals) in 2023. The sharp decrease in population size observed from 2015 – 2020 appears to have slowed, though the trajectory of the abundance remains uncertain. Summary information for 23 threats to NARWs were presented and predation, prey availability, pathogens, diseases, genetics and inbreeding were considered limiting factors for the species. Identified important habitat comprises: the southern and northwestern Gulf of St. Lawrence; including the Jacques-Cartier Strait and entrance to Chaleur Bay; the Scotian Shelf, especially Emerald and Roseway Basins; the Bay of Fundy; and the Canadian portions of Georges Bank and the Gulf of Maine. The important habitat also includes corridors for migratory movements and habitat connectivity, namely, the Laurentian Channel, Honguedo Strait, the western portion of the Jacques Cartier Strait, Cabot Strait, and eastern Scotian Shelf. Distributional recovery targets for NARWs included maintaining the historical and contemporary distribution of NARWs in Canadian waters with unimpeded access to migratory corridors and aggregation areas, and maintaining unrestricted movement to identified potential feeding areas and the migratory corridors that connect these potential feeding areas to identified important habitat. A long-term recovery target could be to reach more than 1,000 mature individuals. Proximate recovery targets could be to achieve: sustained positive growth rate for one generation (35 year) or a doubling of the population in one generation. A range wide population viability analysis allowed for the presentation of relative risk reduction scenarios that would achieve the recovery targets based on decreases in fishing-gear entanglements, vessel strikes, and/or prey availability.

INTRODUCTION

The North Atlantic right whale (NARW, *Eubalaena glacialis*, Rosenbaum *et al*. 2000) and North Pacific right whale (*E. japonica*), were originally considered as a single species, the right whale, by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and other international organizations. In 2003, COSEWIC separated the right whale into two species, and assessed the NARW as Endangered, a status which was re-confirmed in 2013. In 2005, the NARW was listed as Endangered on Schedule 1 of the *Species at Risk Act* and afforded legal protection in Canada under the act. The species is also designated as endangered under the *Endangered Species Act* in the United States of America (USA), and is listed as Critically Endangered by the International Union for Conservation of Nature (IUCN; Cooke 2020).

After COSEWIC assesses an aquatic species as Threatened, Endangered or Extirpated, there are a number of actions and decisions to be taken by Fisheries and Oceans Canada (DFO) that require scientific knowledge on the current status of the species, threats to its survival and recovery, and the feasibility of recovery. This is typically delivered as scientific advice in a Recovery Potential Assessment (RPA) that is conducted shortly after the COSEWIC assessment. To support recovery planning the first RPA for NARWs was conducted in 2007 (DFO 2007). In DFO (2007) the recovery target was defined in terms of population abundance as "an increasing trend in population abundance over three generations (i.e., 60 years)" and the recovery target for population distribution was "maintenance of a broad distribution". A Recovery Strategy for the NARW was completed in 2009 (Brown *et al.* 2009) and amended in 2014 (DFO 2014a) and an Action Plan was published in 2021 (DFO 2021).

A RPA may be required for:

1. a species assessed as Threatened, Endangered, or Extirpated when there is substantial new scientific information to consider since the last assessment; and
2. a species listed under Schedule 1 for which the required recovery strategies and action plans need to be developed or updated.

As there have been significant changes observed in the distribution and habitat use of NARWs in Canada since 2010 and especially since 2015, as well as substantial advancements in our knowledge of NARWs in Canadian waters since the 2007 RPA, updates to the RPA and Recovery Strategy are needed. DFO Science was asked by the Species at Risk Program to undertake a new RPA process for the NARW based on the most recent Guidance for the Completion of a RPA for Aquatic Species at Risk (DFO 2014b).

The RPA guidance (DFO 2014b) describes 22 elements to be addressed that are categorized as information relevant to the: biology, abundance, distribution and life-history parameters (elements 1-3); habitat and residence requirements (elements 4-7); threats and limiting factors to survival and recovery (elements 8–11); recovery targets (elements 12–15); scenarios for mitigation of threats and alternatives to activities (elements 16-21); and, allowable harm assessment (element 22).

The objectives of this RPA process were to provide up-to-date data, with the associated uncertainties, to specifically address elements 2, 4-10, 12, 14, and 22 of the RPA guidance (DFO 2014b). As relevant information is already available within the existing scientific literature to address elements 1, 3, 11, 13, 15-17, and 19-20, only a brief description of the best available sources for this information is included in this document. Elements 18 (feasibility of restoring important habitat) and 21 (model parameter recommendations) are not required for NARW recovery planning and therefore are not addressed in this assessment. Thus, this RPA focuses on: abundance trajectories; contemporary distribution; life-history parameters; identification of important habitat; threats and limiting factors to the survival and recovery of NARWs; identification of activities likely to destroy important habitat; recovery targets for the abundance and distribution of the NARW; and, allowable harm or the maximum human-induced mortality that the species can sustain without jeopardizing its survival or recovery.

ASSESSMENT

ELEMENTS 1, 2, AND 3: BIOLOGY, POPULATION ABUNDANCE, DISTRIBUTION, AND LIFE-HISTORY PARAMETERS

NARWs have unique markings on their heads called callosities that can be used to identify individuals, along with other distinguishing characteristics such as ventral pigmentation and scarring (Kraus *et al*. 1986, Hamilton *et al*. 2007). These characteristics have been used to track NARW population size, as well as individual reproduction schedules, movements, and health. While basic information on species biology and ecology has been summarized in other recent sources (COSEWIC 2013, DFO 2014a, NOAA 2022, Pace *et al*. 2017, 2021, Runge *et al*. 2023), salient updates are provided in the sections below.

Abundance

A recent analysis combining data on contemporary genomics and demographic history confirms that the NARW represents a single population with no distinguishable units, and minimal to no population substructure (Crossman *et al*. 2023). Population size was estimated at 300 (±10%) in 1997 (IWC 2001). Further advancements in statistical modelling has led to population dynamics, abundance, and trends of NARWs being assessed using integrated population models fitted to sightings data, carcass recovery data, prey data, and multiple other sources of information spanning 30 to 40 years (see Pace *et al*. 2017, Pace 2021, Runge *et al*. 2023, Linden 2024, Linden *et al*. 2024, 2025). These models indicate that the population grew in size in the 1990's and 2000's to reach a maximum of approximately 484 individuals in 2011 (Figure 1), to then declined steadily to an estimated abundance of between 360 – 383 individuals in 2023 (95% credible interval, CI), with a point estimate of 372 individuals depending on specific models used (Linden 2024). The sharp decrease observed from 2015 – 2020 appears to have slowed, though the NARW population continues to experience annual mortalities above recovery thresholds (Linden *et al*. 2024).

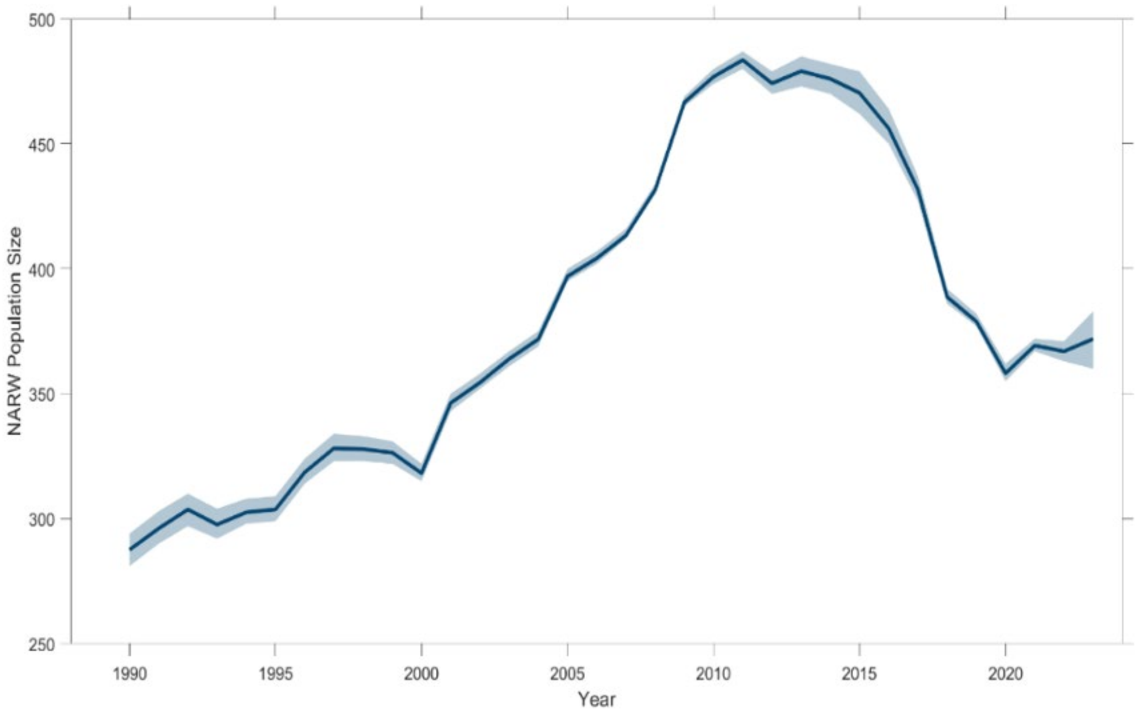

Figure 1: The estimated population size (blue solid line) for the North Atlantic right whale (NARW) and the associated 95% credible interval (blue shading) from 1990 through 2023. Data from Linden (2024).

Life History Parameters

Life history parameters for this species, including those that affect reproductive success, have been changing over time with linkages to decreasing overall health, fitness, and survival of individuals (e.g., Rolland *et al*. 2016, Schick *et al*. 2016). The calving interval, which is expected to be approximately three years in this species (Frasier *et al*. 2024), has been increasing over time, from 3.3 to 6.6 years in 2009 –2016, to 7.0 to 10.2 years since 2017 (Pettis and Hamilton 2024). Although females as young as five have been observed with calves (Hamilton *et al*. 1998), many females have shown a delay in age at first reproduction and have failed to produce calves despite being well beyond the presumed age of sexual maturity of approximately 10 years of age (Reed *et al*. 2022, 2024). There is a significant influence of age on male reproductive success for NARWs with most males not fathering a calf until they are approximately 15 years old and no males under the age of 10 years known to have fathered a calf (Frasier *et al*. 2007). The average annual probability of calving for a proven female (i.e., known to have had a calf before) decreased from 0.22 in 1990 – 2010 (95% CI: 0.16 – 0.28) to 0.15 (95% CI: 0.07 – 0.26) in 2011 – 2019 (Linden *et al*. 2025). These results are confirmed by a study indicating that the annual fecundity rate (proportion of calves born per reproductively available female per year) has been declining since 2011, with females born in or after 2000 being half as likely to transition to a reproductively available stage than the females born prior to 2000 (Reed *et al*. 2022).

Body size (length) has been shown to effect fecundity of NARWs, with shorter whales having longer inter-birth intervals and producing fewer calves per potential reproductive year (Stewart *et al*. 2022). Stewart *et al*. (2021) highlighted a decrease in body lengths of NARWs since the 1980’s, with the maximum expected length of a whale born in 2019 being approximately 1 m shorter than a whale born in 1981, corresponding to a 7.3% decline in maximum body length over the past four decades. Furthermore, entanglements in fishing gear were demonstrated to directly contribute to this stunted growth (Stewart *et al*. 2021), as non-lethal entanglements lead to increased energy expenditures (Rolland *et al*. 2016, Pettis *et al*. 2017, van der Hoop *et al*. 2017). The body condition of juvenile, adult, and lactating females in NARWs also scored lower than southern right whale (*E. australis*) populations (Christiansen *et al*. 2020).

Multi-event modeling of the true reproductive states of individual females estimated that there were only 72 breeding female NARWs alive at the beginning of 2018, and that by 2021, 49 sexually mature females (age range 10 to 34 years, where known) had never been observed with a calf (Reed *et al*. 2022; Bishop *et al*. 2022). A lower survival rate for females (5+ years, Pace *et al*. 2017) has contributed to a change in the male:female sex ratio within the population, changing from 1.24 males per female in 1990 to 1.42 males per female in 2022 (Linden 2023).

It is uncertain if NARWs reach reproductive senescence (Rolland *et al*. 2005) and the longest documented match for an individual NARW based on photographs was 60 years, suggesting a minimum age of 65 (Hamilton *et al*. 1998). The median lifespan for southern right whales was estimated at 74 years with more than 10% of the whales living past the age of 130 (Breed *et al*. 2024). NARWs have considerably shorter lifespans than southern right whales, with a median estimated age of only 22 years and only 10% of NARWs reaching an age of 48 (Breed *et al*. 2024).

Taylor *et al.* (2007) estimated the generation time for NARWs to be 23.3 years for a population growing at an annual rate (r) of 0.05, and 35.7 years for a stable population (r = 0; Taylor *et al*. 2007). Based on the IUCN criteria of assessment over three generations or 100 years (whichever is less), Runge *et al*. (2023) assumed that generation time for NARWs under stable conditions was at least 33.3 years. In this assessment the recovery potential under various threat levels and environmental conditions was assessed either over one generation (35 years) or 100 years.

Over the period 1970 through 2024, approximately 86% (120 of 139) of NARW mortalities where the cause of death was determined, were attributable to anthropogenic impacts (van der Hoop *et al*. 2013, Sharp *et al*. 2019, NOAA 2025). There are very few documented cases of natural mortality of NARWs and the majority of these cases include perinatal deaths (Moore *et al*. 2004, Sharp *et al.* 2019). Sharp *et al*. (2019) present the age class and sexes of NARW mortalities (n=70) for the period 2003 through 2018, where 43% of the deaths were adults, 20%, were juveniles, 14% were calves, and in 22% of cases age was undetermined, while 44% of the deaths were female, 40% were male, and sex was undermined in 16% of cases.

Distribution

NARWs are primarily distributed in the lower temperate and subtropical waters of the western North Atlantic in winter and migrate northward into temperate waters in the summer (Gaskin 1987, 1991). The NARW's range extends from the southern calving grounds off South Carolina, Georgia, and northeastern Florida, to their more northern feedings grounds in the Bay of Fundy, Scotian Shelf, and the Gulf of St. Lawrence (Figure 2). Occasional sightings have also been reported in Bermuda and the Caribbean to the south, and in the coastal waters around Newfoundland and Labrador, the Davis Strait and Iceland to the north, as well as off Norway and the Azores (Knowlton *et al*. 1992, Martin and Walker 1997, Jacobsen *et al*. 2004, Mellinger *et al*. 2011, Silva *et al*. 2012, Hayes *et al*. 2023, Lawson *et al*. 2025). Given their large range across the northwestern Atlantic Ocean and their small population size, assessing the abundance and distribution of the NARW over its range is challenging (St-Pierre *et al*. 2024;

however, see Davis *et al*. 2017), especially considering there is no single area where all NARW are present at the same time (DFO 2020).

Winn *et al*. (1986) proposed a conceptual model to explain the north-south movements of NARWs in the western Atlantic prior to an observed distributional shift (see below) that began circa 2010 (Meyer-Gutbrod and Greene 2018, Record *et al.* 2019, Simard *et al.* 2019, Sorochan *et al.* 2019, Meyer-Gutbrod *et al.* 2021, 2023). Prior to the shift, most adult females gave birth in the coastal waters between Brunswick, Georgia, USA and Cape Canaveral, Florida, USA during winter (Kraus *et al*. 1986, Hamilton and Cooper 2010, Keller *et al*. 2012, Soldevilla *et al*. 2014). Pregnant females were often accompanied by juvenile NARWs and, occasionally, by non-reproductive females and adult males (Kraus *et al*.1986, Hamilton and Cooper 2010, Gowan *et al*. 2019). The northward migration for females and calves occurred in late winter and early spring and a few NARWs were observed from December in Cape Cod Bay, where maximum occurrence was in March and April (Watkins and Schevill 1976, Hamilton and Mayo 1990, Mayo and Marx 1990). In the late spring to early summer, typically April through June, NARWs were found in the Great South Channel with a maximum abundance in May (Winn *et al*. 1986, Kenney *et al*. 1995). In June and July NARWs migrated to two feeding habitats in Canadian waters: the Bay of Fundy and Roseway Basin, where they remained concentrated through to autumn (Winn *et al*. 1986, Gaskin, 1987, Murison and Gaskin 1989, Gaskin 1991). Typically in October, a steady southward migration occurred with some NARWs passing through the Gulf of Maine, including Jeffery's Ledge (offshore of New Hampshire; Weinrich *et al*. 2000), Jordan Basin (central Gulf of Maine; Cole *et al*. 2013), and Cape Cod Bay (Winn *et al*. 1986). The distribution and occurrence of NARWs were relatively well documented among these five habitats with approximately two-thirds of the known NARW population occupying them (Kraus and Rolland 2007). While there was interannual variability in regional occurrence of NARWs (Winn *et al*. 1986) among these habitats, this represented the general distributional pattern for approximately 40 years (1980s through 2009).

Prior to 2010, NARWs were primarily observed in Canadian waters from July through October Ratelle and Vanderlaan *et al*. 2025). Two known high-use habitats in Atlantic Canada have been designated as critical habitat for the population: Grand Manan Basin in the Bay of Fundy and Roseway Basin on the Scotia Shelf (Figure 2; DFO 2014a). Both areas are well documented late-summer and autumn feeding habitats (Winn *et al*. 1986, Kenney *et al*. 1995). However, a portion of the population using Canadian waters has consistently not been observed in either the Bay of Fundy or Roseway Basin during any given year (Kraus and Rolland 2007). NARW sightings also occurred on the northern (Canadian) portion of the Gulf of Maine and Georges Bank, the central Scotian Shelf especially in the Emerald Basin, with occasional sightings in the southern Gulf of St. Lawrence and the northwest Gulf of St. Lawrence (see Ratelle and Vanderlaan *et al*. 2025). Infrequent sightings have been reported in northern, eastern, and southern Newfoundland, Cabot Strait, and the St. Lawrence Estuary, and only occasional sightings on the eastern Scotian Shelf and off the shelf break (Lawson *et al*. 2025, Ratelle and Vanderlaan *et al*. 2025).

Starting in the 2010's, a shift in NARW distribution was noted, with fewer sightings in the Bay of Fundy, Gulf of Maine, and on the western Scotian Shelf, and more NARWs detected in the southern Gulf of St. Lawrence as a result of a change in the distribution of NARW prey (Figure 3 through Figure 14; Davis *et al*. 2017, Brennan *et al.* 2019, Davies *et al*. 2019, DFO 2019, Record *et al*. 2019, Simard *et al*. 2019, Sorochan *et al*. 2019, Crowe *et al*. 2021, Meyer-Gutbrod *et al*. 2021, 2023, St-Pierre *et al*. 2024). Since the distributional shift of NARWs, there have also been increased detections of NARWs in Cape Cod Bay, Massachusetts Bay, the Mid-Atlantic Bight, and south of Martha's Vineyard and Nantucket in the eastern portion of the southern New England Shelf (Ganley *et al*. 2019, Charif *et al*. 2020, Quintana-Rizzo *et al*. 2021, O'Brien *et al*.

2022). Although there have been fewer sightings in the Canadian designated critical habitats areas, passive acoustic monitoring (PAM) efforts from 2010 to 2022 indicate that NARWs have continued to use these areas during this period (Figure 3 through Figure 14; Moors-Murphy *et al*. 2025, Ratelle and Vanderlaan *et al*. 2025). Similar PAM efforts in several areas of the Gulf of St. Lawrence suggested an increase in use of the Gulf of St. Lawrence starting in 2015 (Simard *et al*. 2019), which was supported by the detection of large numbers of NARW during four aerial surveys that year (Cole *et al*. 2020, Crowe *et al*. 2021). In Canadian waters, NARWs are detected in the Bay of Fundy, Grand Manan Basin, and shallower waters around the Wolves Islands and the mouth the Passamaquoddy Bay (New Brunswick), in Roseway Basin and on the western and central Scotian Shelf, in the southern Gulf of St. Lawrence and northwest of Anticosti Island, in the Cabot Strait and occasionally in the waters surrounding Newfoundland (see Lawson *et al*. 2025, Ratelle and Vanderlaan *et al*. 2025).

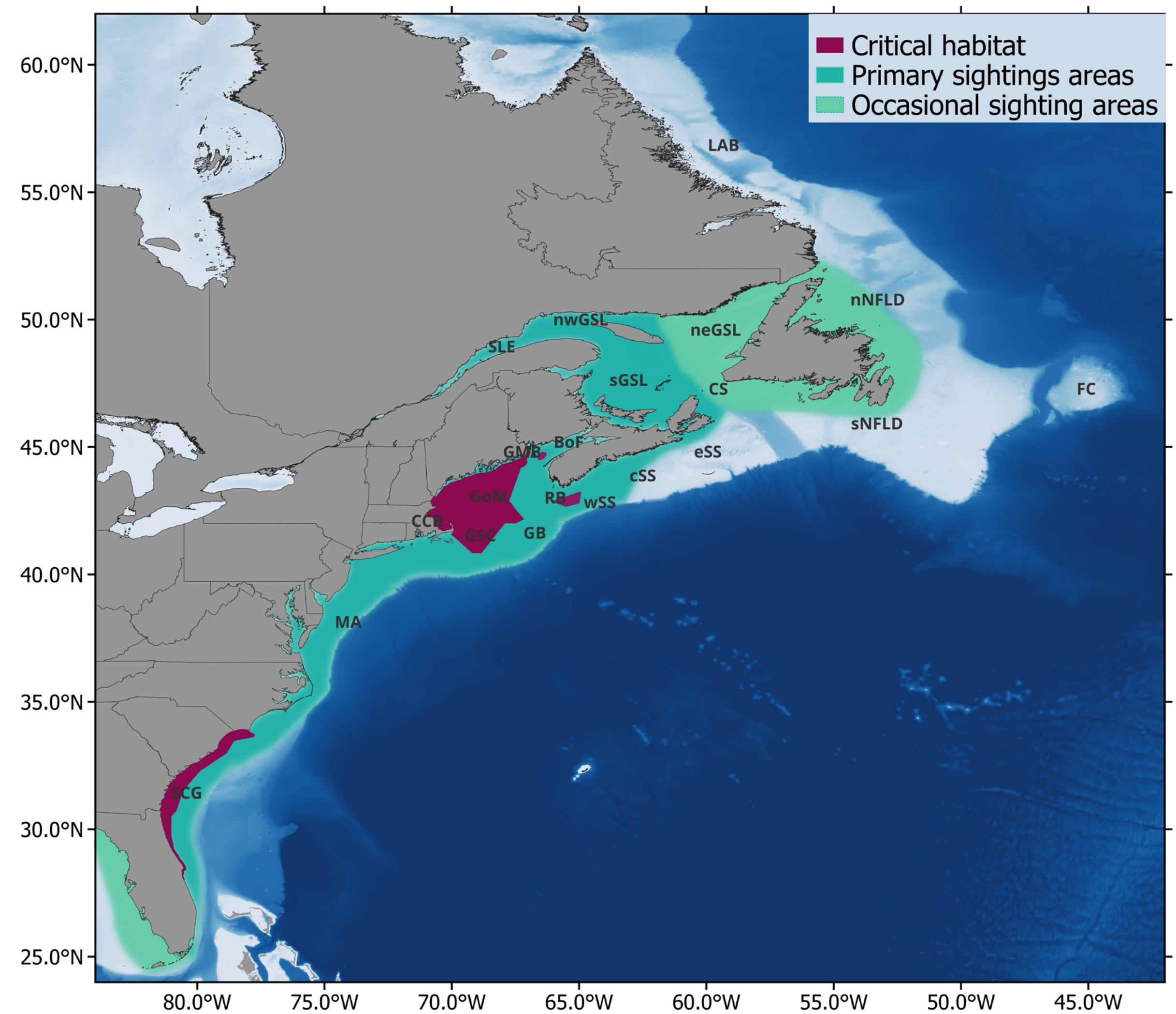

Figure 2: Distribution of North Atlantic right whales, showing primary sightings area (sea green polygon), occasional sightings areas (light green polygons), and critical habitats (maroon polygons). Location names include: Bay of Fundy (BoF), Cabot Strait (CS), Cape Cod Bay (CCB), central Scotian Shelf (cSS), eastern Scotian Shelf (eSS), Flemish Cap (FC), Georges Bank (GB), Grand Manan Basin (GMB), Great South Channel (GSC), Gulf of Maine (GoM), Labrador (LAB), Mid-Atlantic (MA), northeast Gulf of St. Lawrence (neGSL), northern Newfoundland (nNFLD), northwest Gulf of St. Lawrence (nwGSL), Roseway Basin (RB), Southern Calving Ground (SCG), southern Gulf of St. Lawrence (sGSL), southern Newfoundland (sNFLD), St. Lawrence Estuary (SLE), and western Scotian Shelf (wSS). Figure modified from Figure 1 in Hamilton et al. (2022).

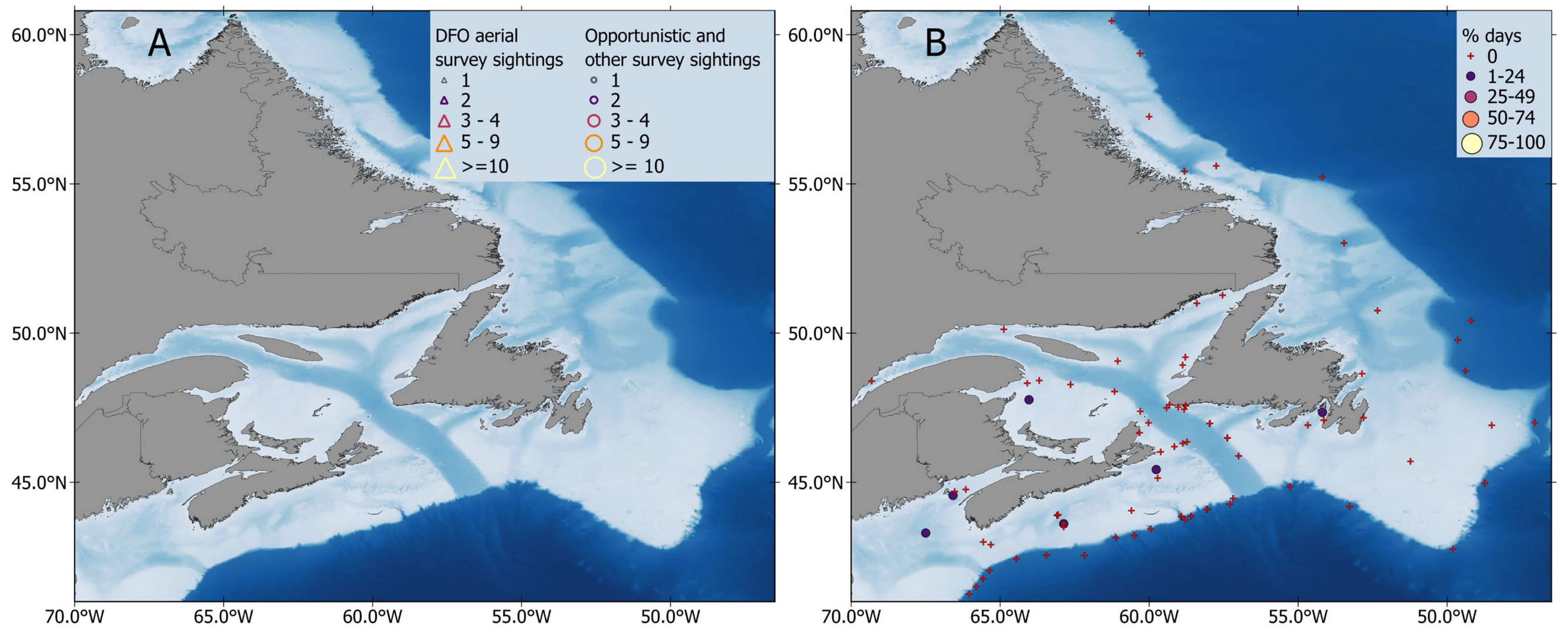

Figure 3: North Atlantic right whale (NARW) sightings locations in Canadian waters for January (A) for the period 2010-2023 where NARW group sizes are indicated by colour and symbol sizes. Sightings data are compiled from the North Atlantic Right Whale Consortium Individual Database, DFO ariel survey and regional sightings databases, Ocean Biodiversity Information System and various contributors to Whale Insight, and are not corrected for effort. Percent days with North Atlantic right whale upcall detections in Canadian waters for January (B) for the period 2010-2022. Red crosses represent recording where no NARW upcalls have been detected. Acoustic detections data were compiled from Davis et al. (2017), Simard et al. (2019, 2024), Durette-Morin et al. (2021), Lawson et al. (2025), and Moors-Murphy et al. (2025).

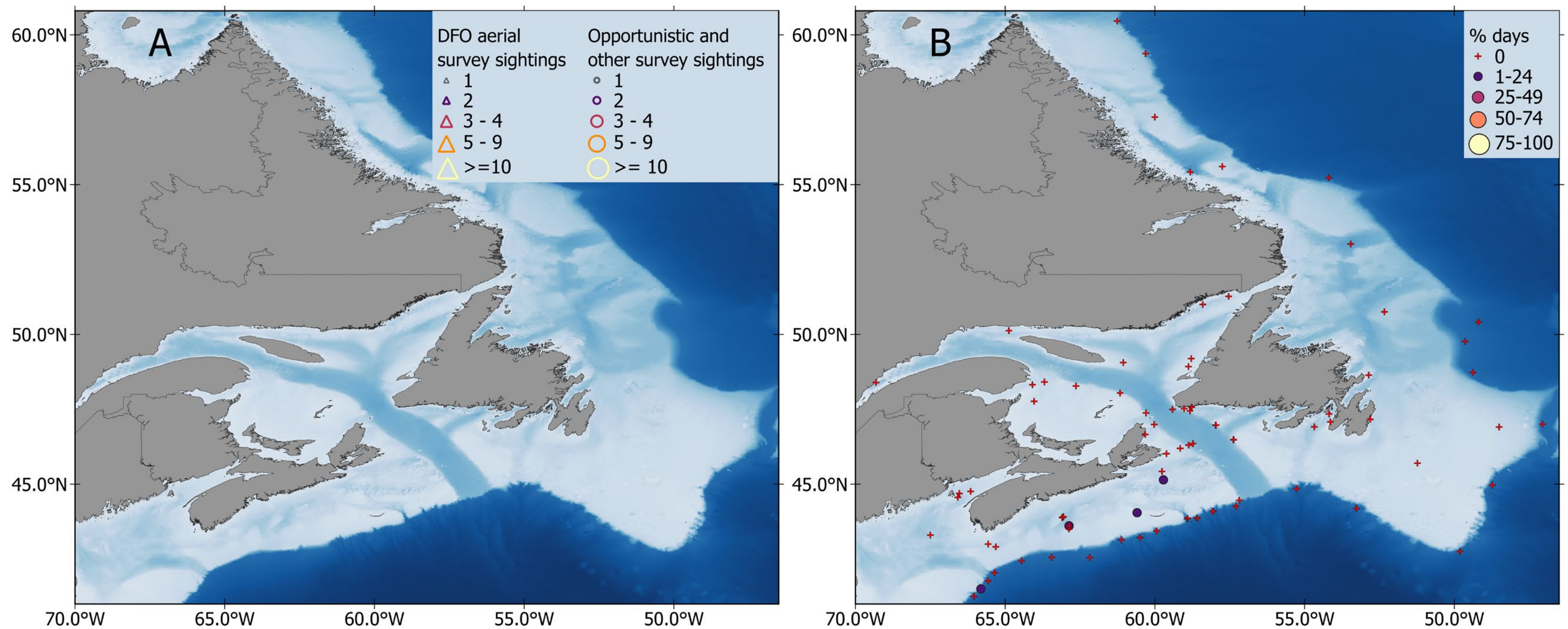

Figure 4: North Atlantic right whale (NARW) sightings locations in Canadian waters for February (A) for the period 2010-2023 where NARW group sizes are indicated by colour and symbol sizes. Sightings data are compiled from the North Atlantic Right Whale Consortium Individual Database, DFO ariel survey and regional databases, Ocean Biodiversity Information System and various contributors to Whale Insight, and are not corrected for effort. Percent days with North Atlantic right whale upcall detections in Canadian waters for February (B) for the period 2010-2022. Black circles with crosses represent recording where no NARW upcalls have been detected. Acoustic detections data were compiled from Davis et al. (2017), Simard et al. (2019, 2024), Durette-Morin et al. (2021), Lawson et al. (2025), and Moors-Murphy et al. (2025).

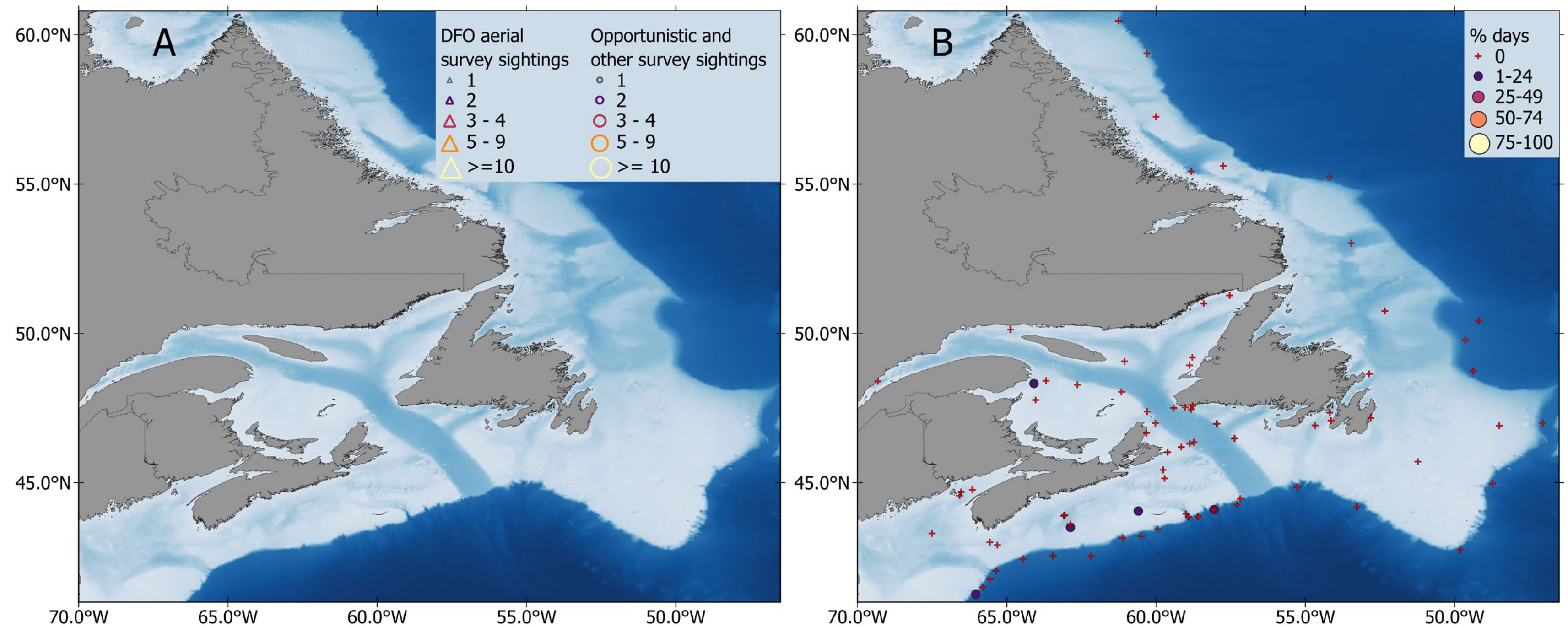

Figure 5: North Atlantic right whale (NARW) sightings locations in Canadian waters for March (A) for the period 2010-2023 where NARW group sizes are indicated by colour and symbol sizes. Sightings data are compiled from the North Atlantic Right Whale Consortium Individual Database, DFO ariel survey and regional databases, Ocean Biodiversity Information System and various contributors to Whale Insight, and are not corrected for effort. Percent days with North Atlantic right whale upcall detections in Canadian waters for March (B) for the period 2010-2022. Red crosses represent recording where no NARW upcalls have been detected. Acoustic detections data were compiled from Davis et al. (2017), Simard et al. (2019, 2024), Durette-Morin et al. (2021), Lawson et al. (2025), and Moors-Murphy et al. (2025).

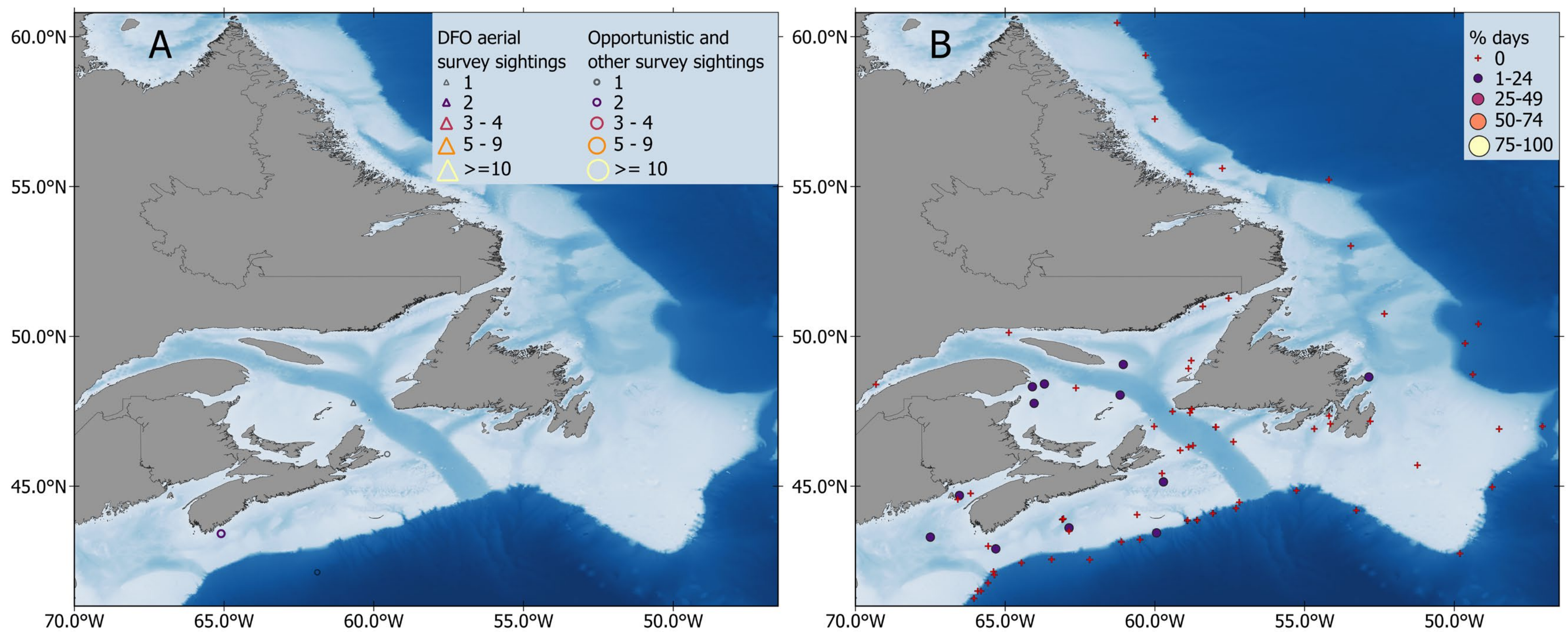

Figure 6: North Atlantic right whale (NARW) sightings locations in Canadian waters for April (A) for the period 2010-2023 where NARW group sizes are indicated by colour and symbol sizes. Sightings data are compiled from the North Atlantic Right Whale Consortium Individual Database, DFO ariel survey and regional databases, Ocean Biodiversity Information System and various contributors to Whale Insight, and are not corrected for effort. Percent days with North Atlantic right whale upcall detections in Canadian waters for April (B) for the period 2010-2022. Red crosses represent recording where no NARW upcalls have been detected. Acoustic detections data were compiled from Davis et al. (2017), Simard et al. (2019, 2024), Durette-Morin et al. (2021), Lawson et al. (2025), and Moors-Murphy et al. (2025).

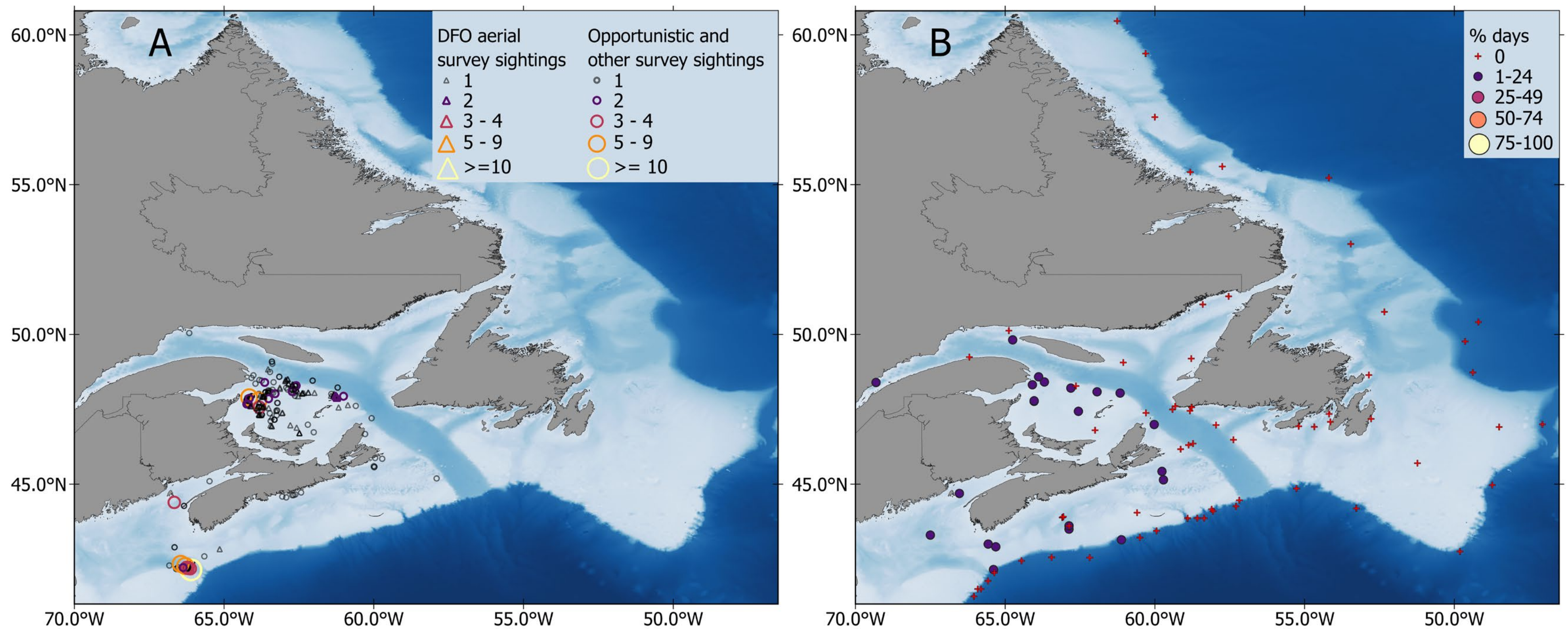

Figure 7: North Atlantic right whale (NARW) sightings locations in Canadian waters for May (A) for the period 2010-2023 where NARW group sizes are indicated by colour and symbol sizes. Sightings data are compiled from the North Atlantic Right Whale Consortium Individual Database, DFO ariel survey and regional databases, Ocean Biodiversity Information System and various contributors to Whale Insight, and are not corrected for effort. Percent days with North Atlantic right whale upcall detections in Canadian waters for May (B) for the period 2010-2022. Red crosses represent recording where no NARW upcalls have been detected. Acoustic detections data were compiled from Davis et al. (2017), Simard et al. (2019, 2024), Durette-Morin et al. (2021), Lawson et al. (2025), and Moors-Murphy et al. (2025).

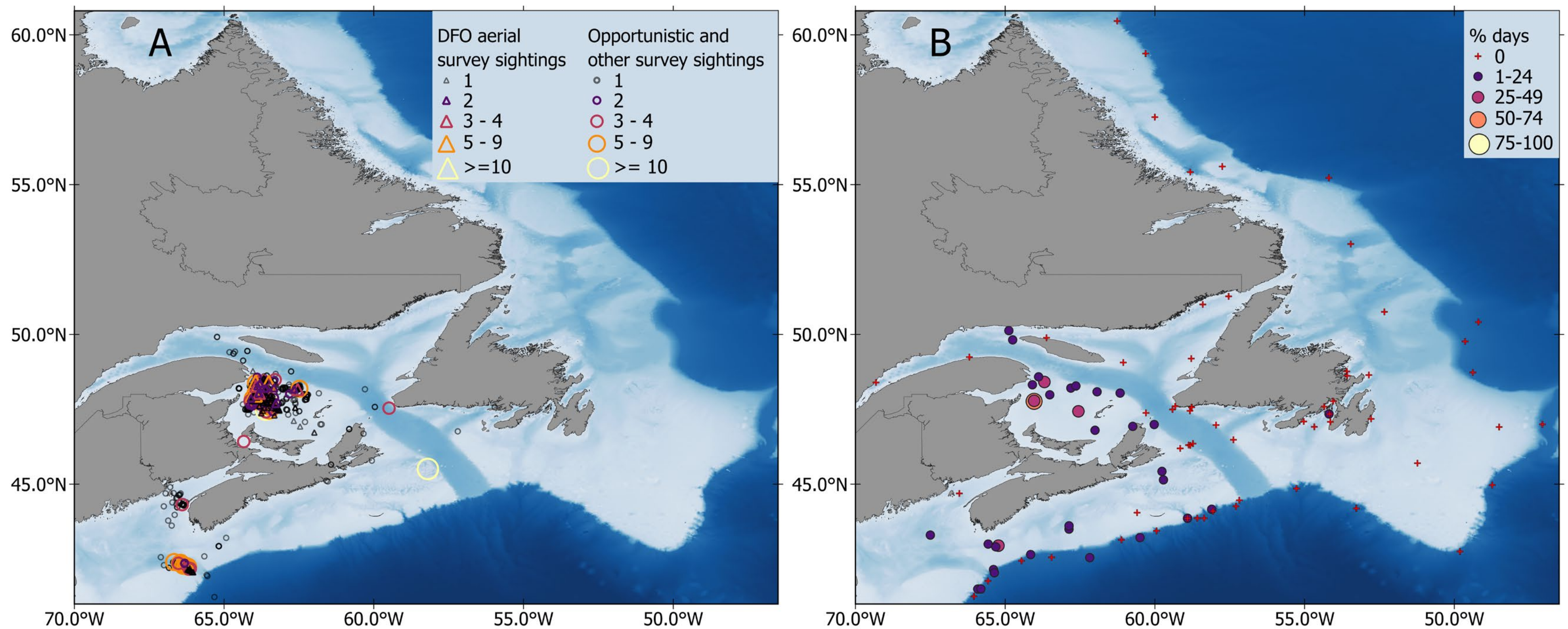

Figure 8: North Atlantic right whale (NARW) sightings locations in Canadian waters for June (A) for the period 2010-2023 where NARW group sizes are indicated by colour and symbol sizes. Sightings data are compiled from the North Atlantic Right Whale Consortium Individual Database, DFO ariel survey and regional databases, Ocean Biodiversity Information System and various contributors to Whale Insight, and are not corrected for effort. Percent days with North Atlantic right whale upcall detections in Canadian waters for June (B) for the period 2010-2022. Red crosses represent recording where no NARW upcalls have been detected. Acoustic detections data were compiled from Davis et al. (2017), Simard et al. (2019, 2024), Durette-Morin et al. (2021), Lawson et al. (2025), and Moors-Murphy et al. (2025).

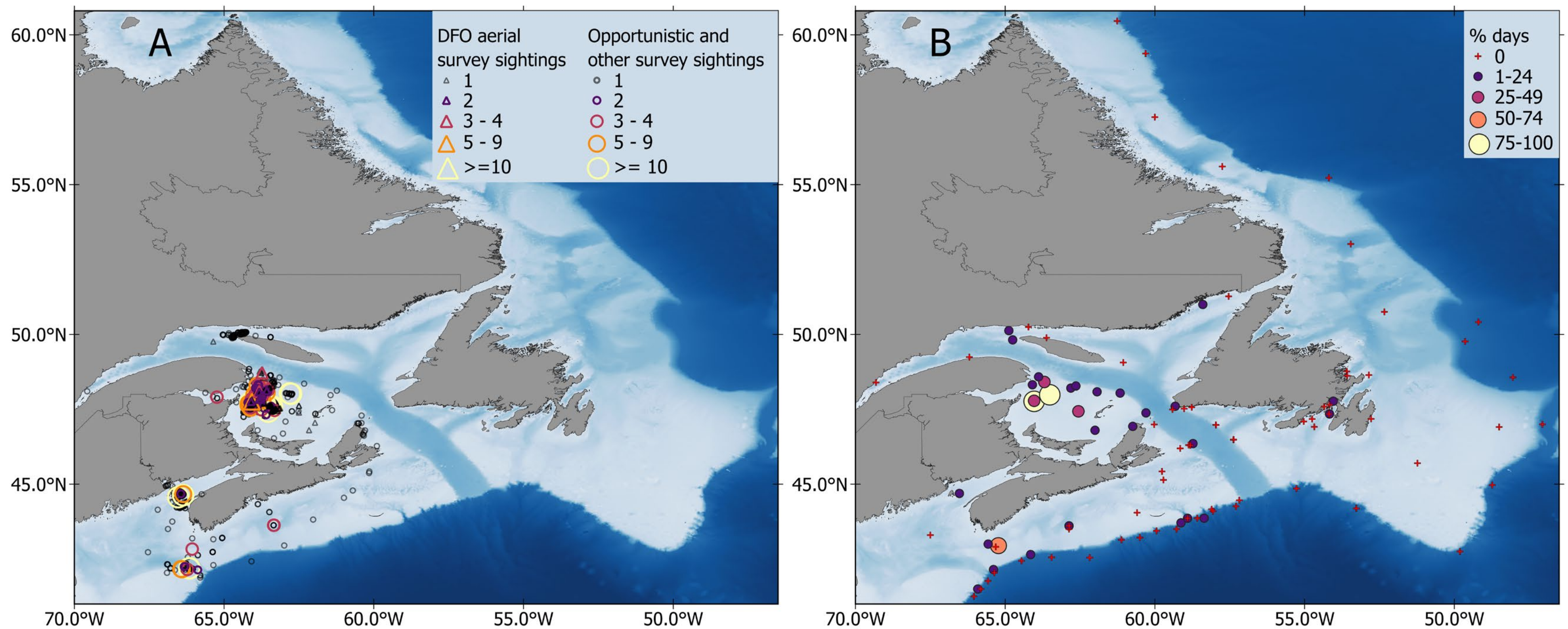

Figure 9: North Atlantic right whale (NARW) sightings locations in Canadian waters for July (A) for the period 2010-2023 where NARW group sizes are indicated by colour and symbol sizes. Sightings data are compiled from the North Atlantic Right Whale Consortium Individual Database, DFO ariel survey and regional databases, Ocean Biodiversity Information System and various contributors to Whale Insight, and are not corrected for effort. Percent days with North Atlantic right whale upcall detections in Canadian waters for July (B) for the period 2010-2022. Red crosses represent recording where no NARW upcalls have been detected. Acoustic detections data were compiled from Davis et al. (2017), Simard et al. (2019, 2024), Durette-Morin et al. (2021), Lawson et al. (2025), and Moors-Murphy et al. (2025).

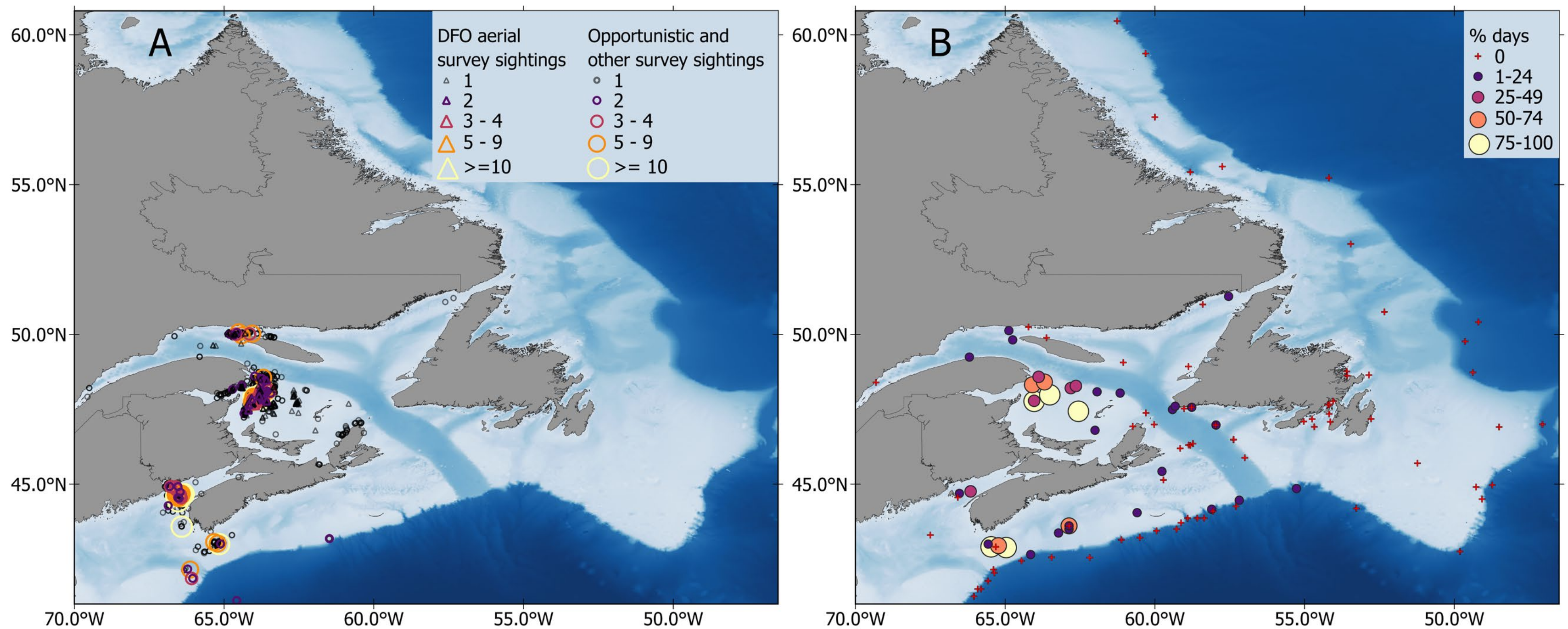

Figure 10: North Atlantic right whale (NARW) sightings locations in Canadian waters for August (A) for the period 2010-2023 where NARW group sizes are indicated by colour and symbol sizes. Sightings data are compiled from the North Atlantic Right Whale Consortium Individual Database, DFO ariel survey and regional databases, Ocean Biodiversity Information System and various contributors to Whale Insight, and are not corrected for effort. Percent days with North Atlantic right whale upcall detections in Canadian waters for August (B) for the period 2010-2022. Red crosses represent recording where no NARW upcalls have been detected. Acoustic detections data were compiled from Davis et al. (2017), Simard et al. (2019, 2024), Durette-Morin et al. (2021), Lawson et al. (2025), and Moors-Murphy et al. (2025).

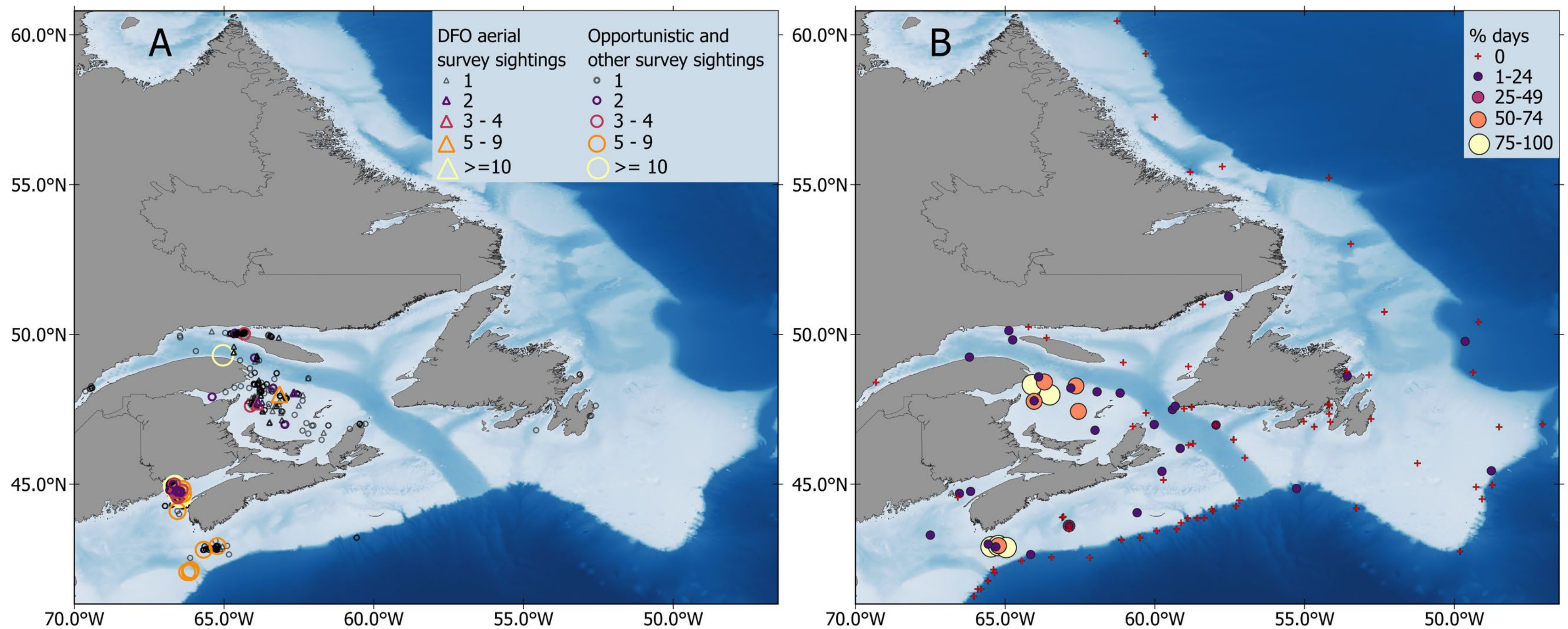

Figure 11: North Atlantic right whale (NARW) sightings locations in Canadian waters for September (A) for the period 2010-2023 where NARW group sizes are indicated by colour and symbol sizes. Sightings data are compiled from the North Atlantic Right Whale Consortium Individual Database, DFO ariel survey and regional databases, Ocean Biodiversity Information System and various contributors to Whale Insight, and are not corrected for effort. Percent days with North Atlantic right whale upcall detections in Canadian waters for September (B) for the period 2010-2022. Red crosses represent recording where no NARW upcalls have been detected. Acoustic detections data were compiled from Davis et al. (2017), Simard et al. (2019, 2024), Durette-Morin et al. (2021), Lawson et al. (2025), and Moors-Murphy et al. (2025).

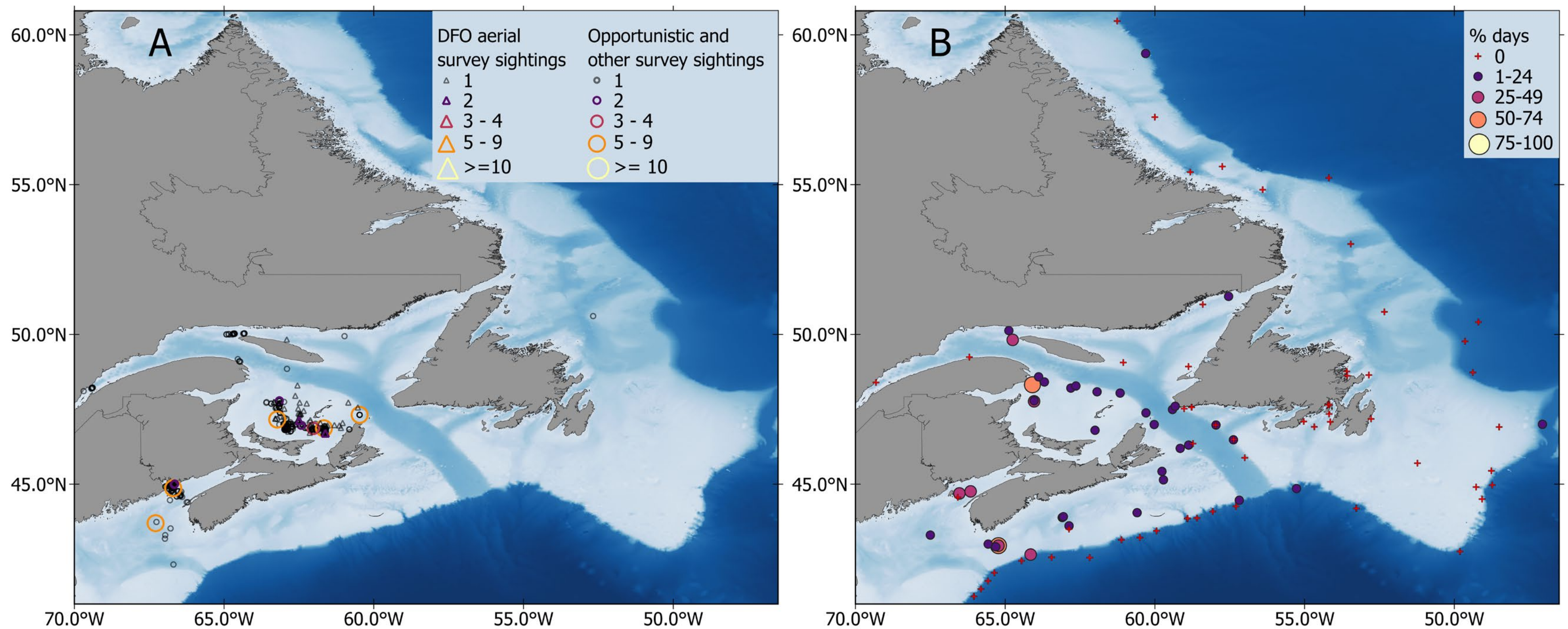

Figure 12: North Atlantic right whale (NARW) sightings locations in Canadian waters for October (A) for the period 2010-2023 where NARW group sizes are indicated by colour and symbol sizes. Sightings data are compiled from the North Atlantic Right Whale Consortium Individual Database, DFO ariel survey and regional databases, Ocean Biodiversity Information System and various contributors to Whale Insight, and are not corrected for effort. Percent days with North Atlantic right whale upcall detections in Canadian waters for October (B) for the period 2010-2022. Red crosses represent recording where no NARW upcalls have been detected. Acoustic detections data were compiled from Davis et al. (2017), Simard et al. (2019, 2024), Durette-Morin et al. (2021), Lawson et al. (2025), and Moors-Murphy et al. (2025).

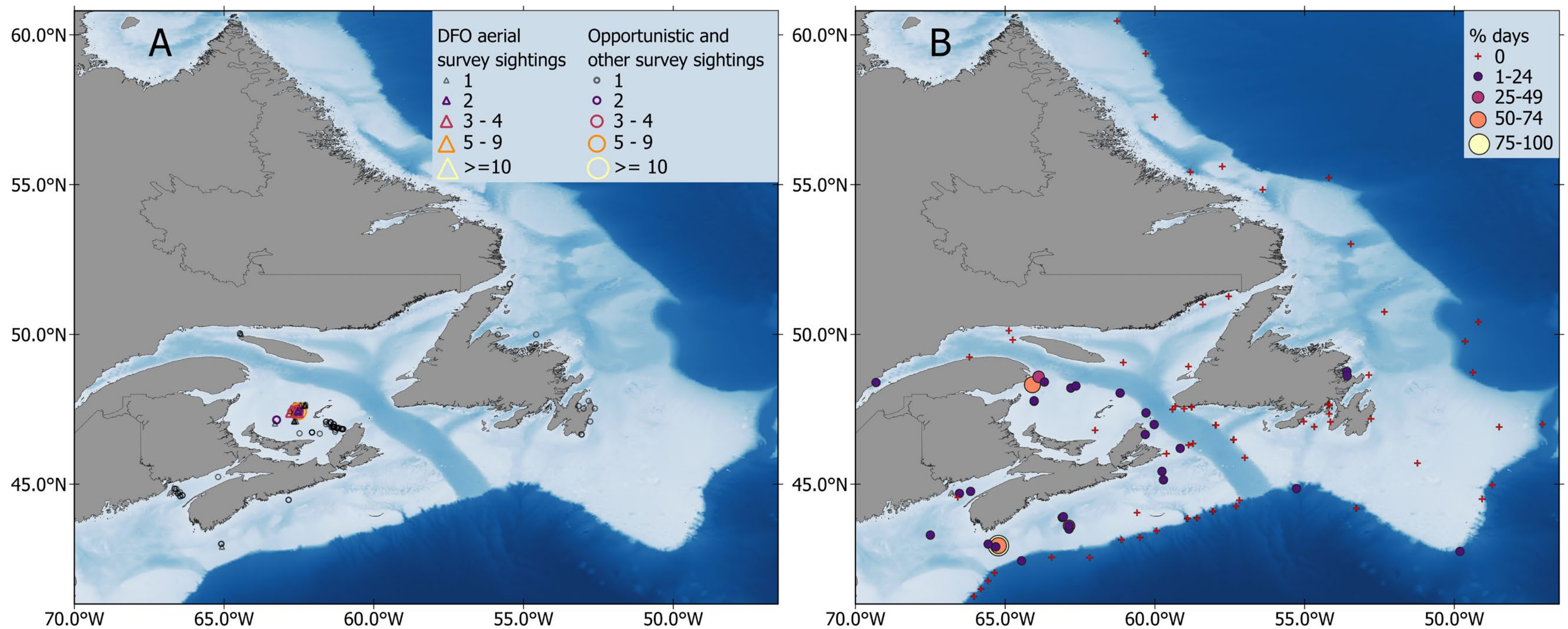

Figure 13: North Atlantic right whale (NARW) sightings locations in Canadian waters for November (A) for the period 2010-2023 where NARW group sizes are indicated by colour and symbol sizes. Sightings data are compiled from the North Atlantic Right Whale Consortium Individual Database, DFO ariel survey and regional databases, Ocean Biodiversity Information System and various contributors to Whale Insight, and are not corrected for effort. Percent days with North Atlantic right whale upcall detections in Canadian waters for November (B) for the period 2010-2022. Red crosses represent recording where no NARW upcalls have been detected. Acoustic detections data were compiled from Davis et al. (2017), Simard et al. (2019, 2024), Durette-Morin et al. (2021), Lawson et al. (2025), and Moors-Murphy et al. (2025).

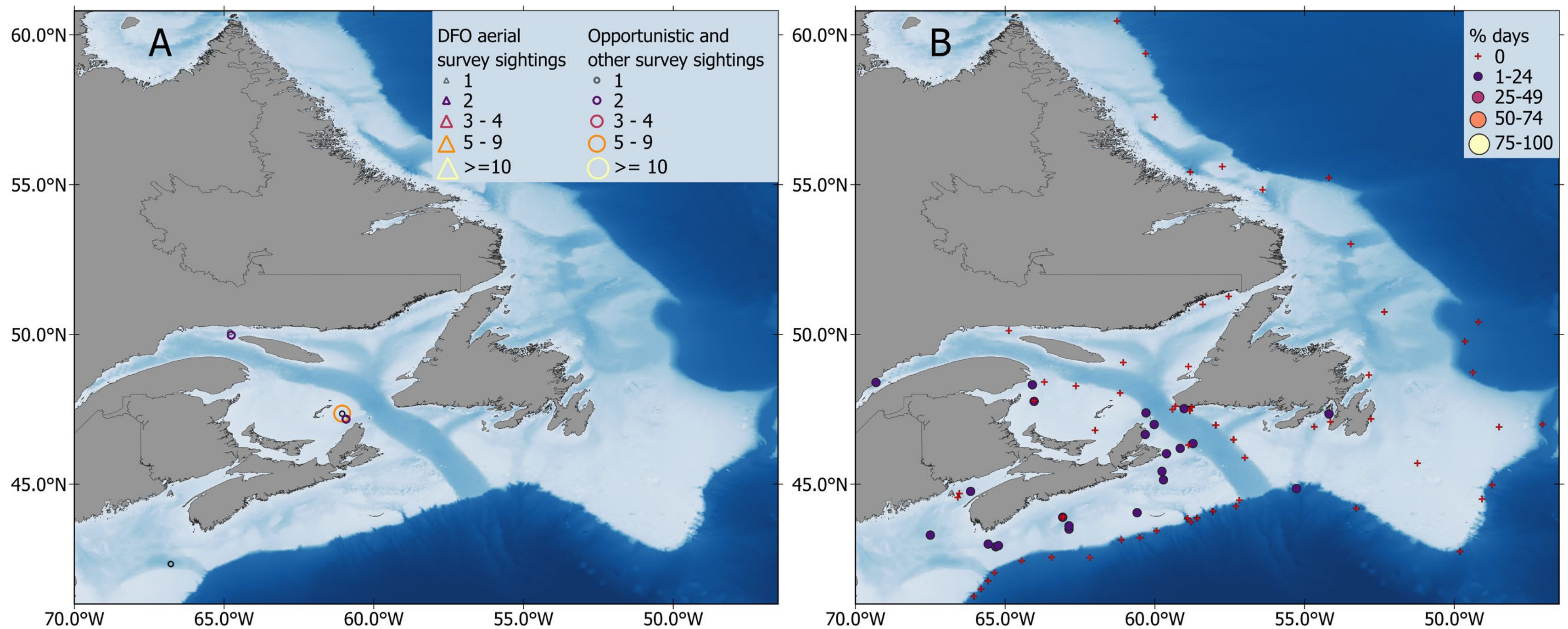

Figure 14: North Atlantic right whale (NARW) sightings locations in Canadian waters for December (A) for the period 2010-2023 where NARW group sizes are indicated by colour and symbol sizes. Sightings data are compiled from the North Atlantic Right Whale Consortium Individual Database, DFO ariel survey and regional databases, Ocean Biodiversity Information System and various contributors to Whale Insight, and are not corrected for effort. Percent days with North Atlantic right whale upcall detections in Canadian waters for December (B) for the period 2010-2022. Red crosses represent recording where no NARW upcalls have been detected. Acoustic detections data were compiled from Davis et al. (2017), Simard et al. (2019, 2024), Durette-Morin et al. (2021), Lawson et al. (2025), and Moors-Murphy et al. (2025).

ELEMENTS 4 THROUGH 7: HABITAT AND RESIDENCE REQUIREMENTS

Ratelle and Vanderlaan *et al.* (2025) have identified important habitat in eastern Canadian waters that is necessary for the survival and recovery of NARWs. The important habitat encompasses major NARW functional behaviours including foraging, feeding, reproduction, calf rearing, socializing and socialization, migration, as well as habitat connectivity. The identified important habitat includes: the southern and northwestern Gulf of St. Lawrence, including the Jacques-Cartier Strait and entrance to Chaleur Bay; the Scotian Shelf, especially Emerald and Roseway Basins; the Bay of Fundy; and the Canadian portions of Georges Bank and the Gulf of Maine (Figure 15). The important habitat also includes the corridors for migratory movements and habitat connectivity, namely, the Laurentian Channel, Honguedo Strait, Cabot Strait, and the eastern Scotian Shelf. Areas to the east of Newfoundland, the southern and eastern edges of the Grand Banks, the Flemish Cap, and north east portion of the Jacques Cartier Strait were all identified as potential feeding habitats with relatively high prey densities, though few NARWs have been detected in these areas (Figure 16). The functions, features, and main attributes of these areas are summarized in Table 1. Features and attributes for specific areas can be found in Ratelle and Vanderlaan *et al.* (2025).

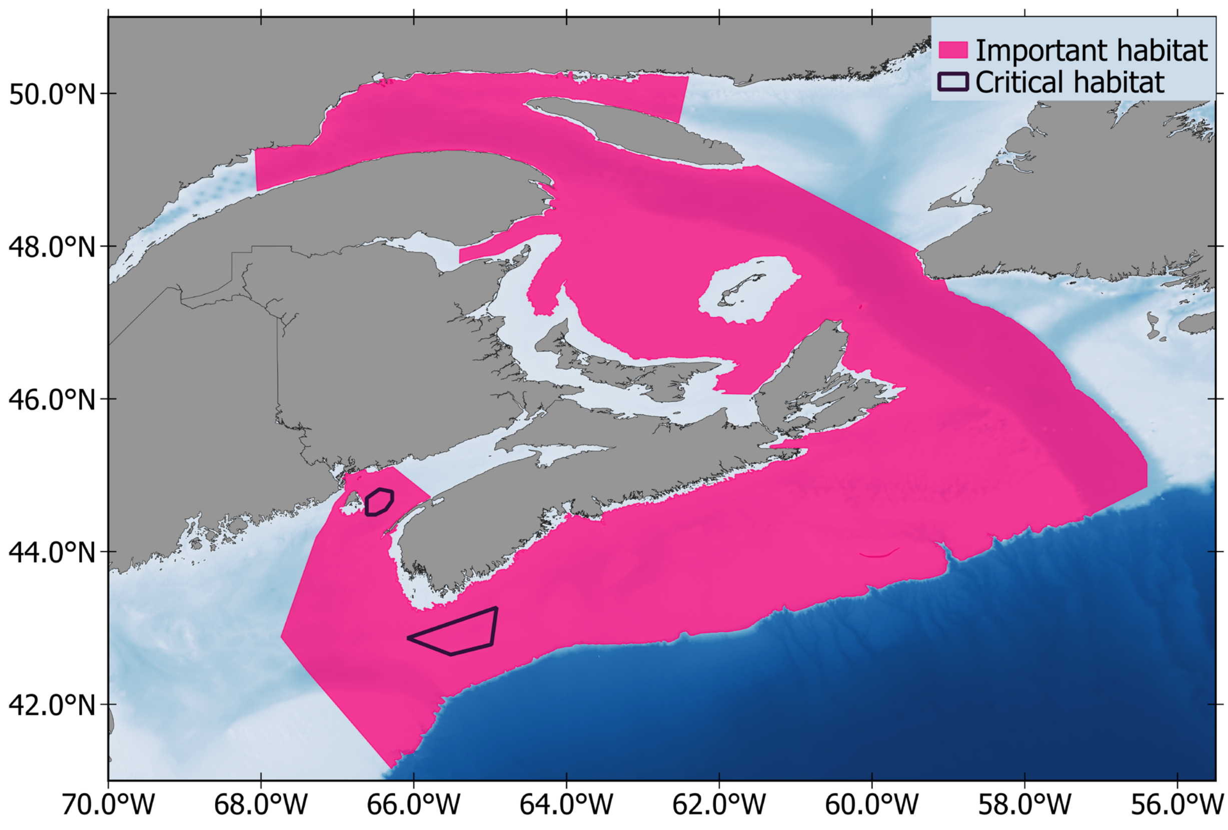

Figure 15: North Atlantic right whale (NARW) important habitat polygon categorized by the synthesis of NARW data considered within this analysis (pink polygon). The coastal margins of the polygon are defined by the 40 m isobath and does not extend to shore, while the outer boundary follows the 350 metre isobath and the southern boundary follows the exclusive economic zone of Canada. The black polygons depict the NARW designated critical habitat in Grand Manan Basin and Roseway Basin identified in the NARW recovery strategy (Brown et al. 2009, DFO 2014a).

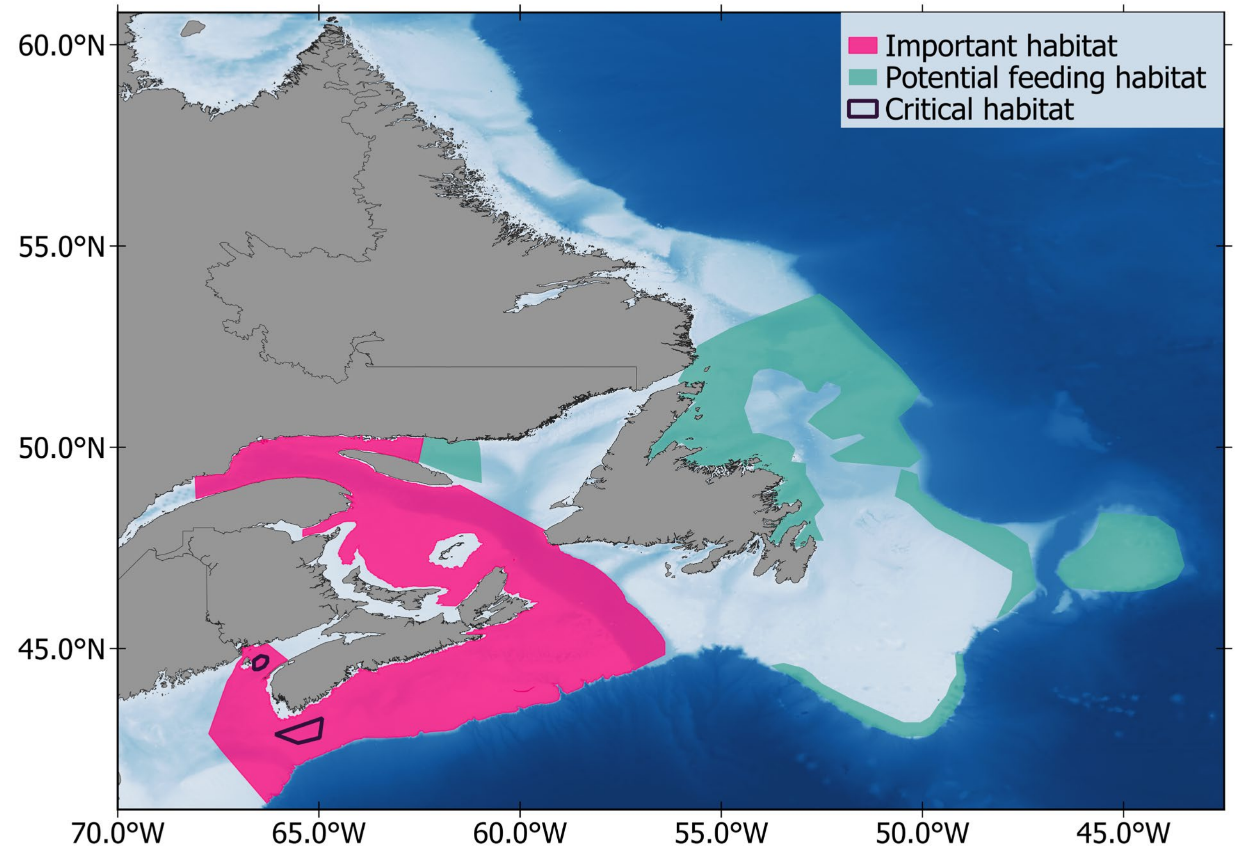

Figure 16: North Atlantic right whale (NARW) important habitat polygon (pink) identified by Ratelle and Vanderlaan et al. (2025) and the NARW designated critical habitat (black polygon) in Grand Manan Basin and Roseway Basin identified in NARW recovery strategy (Brown et al. 2009, DFO 2014a). NARW potential foraging habitats based on prey availability predictions are identified in green. Coastal margins of the important habitat polygon are defined by the 40 m isobath and do not extend to shore.

Table 1: General description of the biophysical features and associated attributes supporting identified life-cycle functions of the North Atlantic right whale (NARW) in eastern Canadian waters. 'All' life stages include: Adult females and males, juveniles and calves. Additional habitat details relevant to NARWs at specific time periods and locations identified in previously published literature can be found in Ratelle and Vanderlaan et al. (2025; Appendix 3).

Life Stage	Function(s)	Feature(s)	Attributes
All	Foraging/ Feeding Gestation/ Growth Rearing/ Nursing Social/ Reproduction Movement/ Migration	Prey supply	Prey availability at depths shallower than maximum NARW foraging depth. Abundant, sufficiently large and energy-rich prey with limited avoidance capabilities to meet NARW biological requirements. A minimum zooplankton energy density threshold for NARWs to feed. Persistent patches of prey that meet daily energy requirements of all life stages of NARWs, such as adult males and resting females (~1500-1900 MJ d^{-1}), pregnant females (~1855-2090 MJ d^{-1}), and including the most energy demanding life stages—lactating females (~4120-4233 MJ d^{-1}) and developing juveniles. Dominance of large lipid rich copepods, especially *Calanus* spp. Other zooplankton prey include smaller copepods with less caloric value per individual (e.g., *Pseudocalanus* spp., *Centropages* spp.) and potentially euphausiids.
All	Foraging/ Feeding Gestation/ Growth Rearing/ Nursing/ Socialization Social/ Reproduction Movement/ Migration	Marine environment	Presence of a local or proximate source of prey. Environmental, oceanographic, and bathymetric conditions to supply, support, and aggregate high concentrations of prey at depths shallower than maximum NARW foraging depth: upwelling or downwelling zones and localized interactions of ocean currents with coastline or bathymetric features. Environmental, oceanographic, and bathymetric cues for movement and migration.
Male and female	Rearing/ Nursing/ Socialization	Marine environment	Limited presence or total absence of potential predators including killer whales and white sharks.

Life Stage	Function(s)	Feature(s)	Attributes
juveniles and calves			
All	Foraging/ Feeding Gestation/ Growth Rearing/ Nursing/ Socialization Movement/ Migration	Bathymetric features i.e., bank, basin, canyon, continental shelf, continental slope/ ledge, seamount	Bathymetric features to retain and aggregate prey species at depths shallower than maximum NARW foraging depth: localized interactions of ocean currents with coastline or bathymetric features and prey-retaining basins or valleys providing habitat stability. Bathymetric features providing migratory cues (e.g., continental shelf break).
All	Foraging/ Feeding Gestation/ Growth Rearing/ Nursing/ Socialization Social/ Reproduction Movement/ Migration	Water column	Chemical, physical, and biological characteristics of the water column to supply, support, and aggregate high concentrations of prey and not result in loss of function. Prey availability at depths shallower than maximum NARW foraging depth. Water depth < 350 m to include recorded maximum NARW dive depth (i.e., 306 m).
All	Foraging/ Feeding Gestation/ Growth Rearing/ Nursing/ Socialization Social/ Reproduction Movement/ Migration	Physical space and Corridor	Physical space, including the vertical and horizontal planes of the water column, to allow animals to move freely and unimpeded by physical obstructions and not alter behavioural functions at and below the surface. Habitat connectivity to successfully immigrate, emigrate, and facilitate seasonal movements in and out of known habitats.
All	Foraging/ Feeding	Acoustic environment	Ambient sound levels ensuring integrity of acoustic space within the 20 Hz - 22 kHz frequency band.

Life Stage	Function(s)	Feature(s)	Attributes
	Rearing/ Nursing/ Socialization Social/ Reproduction Movement/ Migration		Ambient sound levels that allow efficient acoustic social communication and do not impede use of habitat for behavioural functions.
All	Foraging/ Feeding Gestation/ Growth Rearing/ Nursing/ Socialization Social/ Reproduction Movement/ Migration	Water quality and Air quality	Suitable chemical, physical, and biological water quality characteristics to sustain prey species. Water and air quality to not cause adverse health effects or result in loss of function.

Section 2(1) of the Species at Risk Act defines a residence as "a dwelling-place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating" (Species at Risk Act (S.C. 2002, c. 29))). While the RPA guidelines require residence requirements to be identified, these definitions generally do not apply to cetaceans (e.g., Gavrilchuk and Doniol-Valcroze 2021), including NARWs.

ELEMENTS 8 THROUGH 11: THREATS AND LIMITING FACTORS TO SURVIVAL AND RECOVERY

Threats

Vanderlaan *et al*. 2025 presented a comprehensive qualitative threat assessment for the NARW that addressed threats at both the population and individual level. The assessment considered the *Population Level of Impact* and associated *Threat Risk* (Table 2) of each threat for two regions: a Canadian Assessment Area that includes the waters of the Gulf of St. Lawrence bioregion, the Scotian Shelf bioregion, and a portion of the Newfoundland-Labrador Shelves bioregion (DFO 2009); and a Northwest Atlantic Assessment Area that includes a southward expansion of the Canadian Assessment Area to waters along the eastern shore of the USA out to the boundary of the exclusive economic zone. The *Threat Risk* was assigned to categories of *Unknown*, *Low*, *Medium*, or *High*, based on the product of the *Population Level of Impact* and the *Likelihood of Occurrence*. For the majority of evaluated threats, the *Population Level of Impact,* and *Threat Risk* thereof, were assessed as *Unknown* due to the paucity of information available at the population level. Pace *et al.* (2021) estimated that the majority of NARW mortalities (~64% between 1990 – 2017) were unobserved, and there is also a notable portion of observed mortalities (23% between 2003-2018) where the cause of death was undetermined (Sharp *et al*. 2019). This contributes to uncertainty in assessing population-level impacts. Some of the unobserved mortalities or observed deaths with unknown or undetermined causes could be due to threats whose potential impact cannot be elevated due to an absence of information.

NARWs face a large number of threats (Table 2), including *Historical*, *Current*, and *Anticipatory* threats, the majority of which occur continuously and extensively throughout their core habitats and migratory corridors. Overall, fishing-gear entanglements and vessel strikes were assessed as a *High Threat Risk* and are considered two of the highest threats to NARWs, as both threats have lethal and sublethal effects on the species (Moore *et al*. 2021), and ranked as *Extreme* for the *Individual Level of Impacts*. Vessel strikes were assessed as having *High Population Level of Impacts*, while entanglements in fishing gear were ranked as *Extreme*. Furthermore, a survival rate analysis (Linden *et al*. 2024) estimated that the average injury hazard rate from entanglement for an individual was 0.028, approximately twice the value for severe injury from vessel strike (0.012; Linden *et al*. 2024). The estimated survival rate for an animal that had received a severe injury was, however, higher for entanglement injury (0.42) than for vessel strike injury (0.08). There was evidence that mortality rates from both entanglement and vessel strike increased substantially during the period 2013-2019. Reed *et al*. (2024) estimated that female NARWs with minor injuries due to entanglements had the lowest probability of transitioning to the breeding cohort, indicating that effects on reproduction are not limited to individuals with severe injuries.

Petroleum spills and climate change were also assessed as a *High Threat Risk* to NARW. Petroleum spills are considered a significant concern due to documented substantial mortalities in other cetacean populations following large oil spills. Climate change presents a *High Threat Risk* given the NARW's vulnerability to shifting ocean conditions and prey availability, factors that are inextricably linked to climate change (Vanderlaan *et al*. 2025 and references therein).

The detailed methodology and results of the threat assessment for NARWs can be found in Vanderlaan *et al*. 2025.

Table 2: Summary of threat assessment for North Atlantic right whales (NARWs) in the Northwest Atlantic Assessment Areas and the Canadian Assessment Area. Definitions for each of the threat evaluation criteria (from DFO 2014b) and the methods applied to assign categories to each of these criteria are provided in the sections above. It is important to recognize that a level of impact assessment of "Unknown" does not mean effects on individuals or the population of NARWs are inconsequential.

Threat Category	**Threat**	**Assessment Area(s)**	***Likelihood of Occurrence***	***Individual Level of Impact (Causal Certainty)***	***Population Level of Impact (Causal Certainty)***	***Threat Risk*****	***Timing of Occurrence***	***Threat Frequency***	***Geographic Extent of Threat***
Incidental Catch & Fishing-Gear Interactions	Fishing-Gear Entanglement - Fixed Gear	Canadian, Northwest Atlantic	*Known*	*Extreme (Very High)*	*Extreme (Very High)*	*High*	*Historical, Current, Anticipatory*	*Continuous*	*Extensive*
Incidental Catch & Fishing-Gear Interactions	Fishing-Gear Entanglement - Pot/Trap Fisheries	Canadian, Northwest Atlantic	*Known*	*Extreme (Very High)*	*Extreme (Very High)*	*High*	*Historical, Current, Anticipatory*	*Continuous*	*Extensive*
Incidental Catch & Fishing-Gear Interactions	Fishing-Gear Entanglement - Gillnet	Northwest Atlantic	*Known*	*Extreme (Very High)*	*Extreme (Very High)*	*High*	*Historical, Current, Anticipatory*	*Continuous*	*Broad*
Incidental Catch & Fishing-Gear Interactions	Fishing-Gear Entanglement - Gillnet	Canadian	*Known*	*Extreme (Very High)*	*Extreme (Very High)*	*High*	*Historical, Current, Anticipatory*	*Continuous*	*Extensive*
Incidental Catch & Fishing-Gear Interactions	Fishing-Gear Entanglement - Hook and Line/Longline	Canadian	*Known*	*Extreme (Very High)*	*Extreme (Very High)*	*High*	*Historical, Current, Anticipatory*	*Continuous*	*Extensive*

Threat Category	**Threat**	**Assessment Area(s)**	***Likelihood of Occurrence***	***Individual Level of Impact*** ***(Causal Certainty)***	***Population Level of Impact*** ***(Causal Certainty)***	***Threat Risk*****	***Timing of Occurrence***	***Threat Frequency***	***Geographic Extent of Threat***
Incidental Catch & Fishing-Gear Interactions	Entrapment – Weirs	Canadian, Northwest Atlantic	*Known*	*Low (Very High)*	*Unknown (Very High)*	*Unknown*	*Historical, Current, Anticipatory*	*Recurrent*	*Restricted*
Incidental Catch & Fishing-Gear Interactions	Fishing-Gear entanglement (Aquaculture)	Canadian	*Known*	*Extreme (Medium)*	*Unknown (Unknown)*	*Unknown*	*Historical, Current, Anticipatory*	*Continuous*	*Restricted*
Incidental Catch & Fishing-Gear Interactions	Fishing-Gear Entanglement in Abandoned, Lost, or Otherwise Discarded Fishing Gear	Canadian, Northwest Atlantic	*Known*	*Extreme (Very High)*	*Extreme (Very High)*	*High*	*Historical, Current, Anticipatory*	*Continuous*	*Broad*
Vessel Traffic	Vessel Strike	Canadian, Northwest Atlantic	*Known*	*Extreme (Very High)*	*High (Very High)*	*High*	*Historical, Current, Anticipatory*	*Continuous*	*Extensive*

Threat Category	**Threat**	**Assessment Area(s)**	***Likelihood of Occurrence***	***Individual Level of Impact*** ***(Causal Certainty)***	***Population Level of Impact*** ***(Causal Certainty)***	***Threat Risk*****	***Timing of Occurrence***	***Threat Frequency***	***Geographic Extent of Threat***
Vessel Traffic	Vessel Presence & Vessel Noise Pollution	Canadian, Northwest Atlantic	*Known*	*Low (High)*	*Unknown (Unknown)*	*Unknown*	*Historical, Current, Anticipatory*	*Continuous*	*Extensive*
Pollution Subcategory: Noise Pollution	Seismic Surveys (Airguns)	Canadian, Northwest Atlantic	*Known*	*Medium (Medium)*	*Unknown (Unknown)*	*Unknown*	*Historical, Current, Anticipatory*	*Recurrent*	*Extensive*
Pollution Subcategory: Noise Pollution	Active Acoustic Technology Operation	Canadian, Northwest Atlantic	*Known*	*Low (Medium)*	*Unknown (Unknown)*	*Unknown*	*Historical, Current, Anticipatory*	*Recurrent*	*Broad*
Pollution Subcategory: Noise Pollution	Mid-frequency Military Active Sonar Operation	Canadian, Northwest Atlantic	*Known*	*High (Medium)*	*Unknown (Unknown)*	*Unknown*	*Historical, Current, Anticipatory*	*Recurrent*	*Narrow*
Pollution Subcategory: Chemical Contaminants	Persistent Organic Pollutants Pollution	Canadian, Northwest Atlantic	*Known*	*Unknown (Unknown)*	*Unknown (Unknown)*	*Unknown*	*Historical, Current, Anticipatory*	*Continuous*	*Broad*

Threat Category	**Threat**	**Assessment Area(s)**	***Likelihood of Occurrence***	***Individual Level of Impact (Causal Certainty)***	***Population Level of Impact (Causal Certainty)***	***Threat Risk****	***Timing of Occurrence***	***Threat Frequency***	***Geographic Extent of Threat***
Pollution Subcategory: Chemical Contaminants	Plastics and Marine Debris Pollution	Canadian, Northwest Atlantic	*Known*	*High (High)*	*Low (High)*	*Low*	*Historical, Current, Anticipatory*	*Continuous*	*Broad*
Pollution Subcategory: Chemical Contaminants	Petroleum Spills	Canadian, Northwest Atlantic	*Known*	*Extreme (Medium)*	*High (Medium)*	*High*	*Historical, Current, Anticipatory*	*Recurrent*	*Restricted*
Pollution Subcategory: Chemical Contaminants	Heavy Metals Pollution	Canadian, Northwest Atlantic	*Known*	*Unknown (Unknown)*	*Unknown (Unknown)*	*Unknown*	*Historical, Current, Anticipatory*	*Continuous*	*Broad*
Subcategory: Energy Development and Production	Coastal and Marine Offshore Development	Canadian, Northwest Atlantic	*Known*	*High (Medium)*	*Unknown (Unknown)*	*Unknown*	*Historical, Current, Anticipatory*	*Recurrent*	*Narrow*
Subcategory: Energy Development and Production	Drilling Operations	Canadian, Northwest Atlantic	*Known*	*Low (Unknown)*	*Unknown (Unknown)*	*Unknown*	*Historical, Current, Anticipatory*	*Recurrent*	*Restricted*

Threat Category	**Threat**	**Assessment Area(s)**	***Likelihood of Occurrence***	***Individual Level of Impact (Causal Certainty)***	***Population Level of Impact (Causal Certainty)***	***Threat Risk*****	***Timing of Occurrence***	***Threat Frequency***	***Geographic Extent of Threat***
Subcategory: Energy Development and Production	Wind Energy Production	Canadian	*Known*	*Unknown+ (Unknown)*	*Unknown (Unknown)*	*Unknown*	*Anticipatory*	*Continuous*	*Narrow*
Subcategory: Energy Development and Production	Wind Energy Production	Northwest Atlantic	*Known*	*Unknown+ (Unknown)*	*Unknown (Unknown)*	*Unknown*	*Current, Anticipatory*	*Continuous*	*Narrow*
Ocean-Physics Alteration	Climate Change	Canadian, Northwest Atlantic	*Known*	*Unknown (Unknown)*	*High (Very High)*	*High*	*Historical, Current, Anticipatory*	*Continuous*	*Extensive*
Scientific Activities	Scientific Activities	Canadian, Northwest Atlantic	*Known*	*Low (High)*	*Low (High)*	*Low*	*Historical, Current, Anticipatory*	*Recurrent*	*Broad*
Direct Harvesting	Whaling (Harvest or Hunt)	Canadian, Northwest Atlantic	*Remote*	*Extreme (Very High)*	*Low* (Very High)*	*Low*	*Historical, Anticipatory*	*Not applicable*	*Narrow*
Resource Depletion	Food Supply Reduction (Directed	Canadian, Northwest Atlantic	*Remote*	*Unknown (Unknown)*	*Unknown (Unknown)*	*Unknown*	*Anticipatory*	*Not applicable*	*Unknown*

Threat Category	**Threat**	**Assessment Area(s)**	***Likelihood of Occurrence***	***Individual Level of Impact*** ***(Causal Certainty)***	***Population Level of Impact*** ***(Causal Certainty)***	***Threat Risk*****	***Timing of Occurrence***	***Threat Frequency***	***Geographic Extent of Threat***
	Fishing – Copepods)								

[*] This remains true only if the precautionary approach is applied if/when future hunting occurs.

[+] For the noise pollution aspect specifically of the threat of wind energy production the *Individual Level of Impact* is expected to be *Low*.

** The *Threat Risk* is a product of *Population Level of Impact* and *Likelihood of Occurrence*.

Limiting Factors

Anthropogenic threats (see Vanderlaan *et al.* 2025) are substantially impacting the NARW; however, there are other natural factors that could be contributing to a decline in health and reproductive rates, as well as mortalities, thus limiting the survival and recovery of the species.

The previous RPA (DFO 2007) stated that there was "no evidence suggesting the amount of available critical habitat was limiting NARW from reaching the identified recovery targets". With the broad geographical range of the NARW and the ability to adapt to limited prey availability by shifting distributions, habitat removal does not appear to be a limiting factor in the recovery of NARWs.

There are very few documented cases of natural mortality that exist for NARWs (Moore *et al.* 2004, Sharp *et al.* 2019), however, predation, reduced prey availability, pathogens, diseases, low genetic diversity, and inbreeding could also be limiting the survival and recovery of the NARW and are considered limiting factors for this species.

Predation

Natural predators of NARWs are limited but can include killer whales (*Orcinus orca*) and macropredatory sharks (Kraus 1990, Taylor *et al*. 2013). NARW scarring patterns have been consistent with killer whales attacks (Kraus 1990) and there have been documented cases of shark predation on NARW calves by white sharks (*Carcharodon carcharias*) and other species (Taylor *et al*. 2013). Although not always fatal, there is one case where a NARW calf's death was attributable to exsanguination due to premortem shark predation, and another where blood loss from the peduncle as the result of a shark bite was likely the immediate cause of death of an entangled two-year-old juvenile NARW (Taylor *et al*. 2013). There has also been a documented case of white sharks attacking a live 7-m humpback whale (*Megaptera novaeangliae*; Dines and Gennari 2020). Although not common, predation on NARWs is a limiting factor for this species.

Prey Availability

The availability of adequate prey is considered a limiting factor for the survival and recovery of NARW. There is evidence that climate change has already contributed to shifts in the distribution of NARW prey (e.g., Record *et al*. 2019, Pershing and Stamieszkin 2020, Meyer-Gutbrod *et al*. 2021). This shift was considered and evaluated in the threat assessment (see Vanderlaan *et al*. 2025). Potential reductions in food supply due to anticipatory directed fisheries of copepods were also assessed in the threat assessment. Thus, here we focus on natural variation in abundance and/or distribution of prey for NARW as a limiting factor.

Prior to the large NARW distributional shift associated with climate change, NARW presence in the Canadian designated critical habitats had been linked to food availability within these areas (Murison and Gaskin 1989, Baumgartner *et al.* 2003, Patrician and Kenney 2010, Davies *et al.* 2015). NARWs are highly mobile species and capable of adapting to variability in the distribution of prey on regional scales (Baumgartner *et al*. 2007) and changes in NARW distribution have been linked to prey variability (e.g. Pendleton *et al.* 2012, Record *et al.* 2019, Meyer-Gutbrod *et al.* 2023). Further changes in the abundance of *Calanus* species are expected in the western North Atlantic with the overall abundance predicted to decline toward the end of the century in Canadian waters south of Newfoundland (Lehoux *et al*. 2024). Assuming no drastic changes occur in global ocean circulation during the 21st century, the long-term projections suggest that NARW foraging habitat will continue to decline at a greater rate in the Bay of Fundy, northeast Gulf of Maine, and on the western Scotian Shelf than in the shelf waters off Newfoundland and Labrador (Lehoux *et al*. 2024). This may result in further distributional changes of NARWs.

In the 2010s, the population level of late copepodite stages of *Calanus finmarchicus* and overall zooplankton biomass was generally lower than the 2000s in the southern Gulf of St. Lawrence and western Scotian Shelf where NARW are known to feed (Sorochan *et al*. 2019, Bernier *et al*. 2023). In a population viability analyses Runge *et al.* (2023) examined the effects of returning NARW prey abundance to levels observed prior to 2010 to estimate the changes in the probability of quasi-extinction of NARW. Increasing prey availability, while holding the effects of fishing-gear entanglements and vessel strikes threats constant, reduced the probability of quasi-extinction for the NARW by 6% (Runge *et al.* 2023).

Information on NARW prey species in Canadian waters has been provided by Johnson *et al.* (2024) and Plourde *et al.* (2024) while Sorochan *et al.* (2021) provides a comprehensive summary of NARW prey in their feeding habitats. If there are further changes to abundance and distribution of the primary prey of the NARW, another possible response is for NARWs to shift to feeding on other prey species. Southern right whales feed on euphausiids (i.e., krill -*Euphausia superba*; Seyboth *et al*. 2016 and reference therein) and NARWs have been observed feeding on layers of juvenile krill in Cape Cod Bay (Watkins and Schevill 1976, Mayo and Marx 1990). It may be possible for NARWs to shift their diets to incorporate larger zooplankton if the availability of calanoid copepods is limited, especially given that NARWs have been observed feeding on one of the life stages of krill and other larger zooplankton species (Watkins and Schevill 1976, Murison and Gaskin 1989, Mayo and Marx 1990). However, the ability of other large zooplankton to support NARW energy requirements is unknown. Contemporary estimates of biomass and energy contributions from other abundant zooplankton species, such as *T. longicornis*, *Pseudocalanus* spp., and euphausiids, appear to be minimal when compared to *Calanus* spp. in the Gulf of St. Lawrence (Lehoux *et al*. 2020). It is difficult to assess the abundance of some large zooplankton, like krill, using traditional sampling methods since they can avoid nets by swimming. It is believed that other abundant zooplankton provide minimal biomass and energy contributions to NARW diets when compared to *Calanus* species (Johnson *et al*. 2024). Further food limitations and changes in prey availability, whether driven by natural variability or climate-change, will affect NARW distribution and reproduction. Nonetheless, NARWs have demonstrated that they can respond to changing prey distributions and food limitations. The speed at which NARWs shift their distributions as a result of changes in prey availability is uncertain (Runge *et al*. 2023). Further shifts in prey distribution and thus NARW distribution could also increase the likelihood of exposure to the other threats NARWs encounter (Record *et al*. 2019, Meyer-Gutbrod *et al*. 2021, Pershing and Pendleton 2021).

Pathogens - Biotoxins/Algae Bloom

Toxins produced by certain species of phytoplankton can accumulate in the ocean during harmful algal blooms and subsequently concentrate in the marine food web. Although a natural phenomenon, harmful algal blooms are increasing in frequency, and of the four explanations of these increases, three of them involve anthropogenic activities (Hallegraeff 2003). Nutrient pollution is a common source of exogenous nutrients that can stimulate harmful algal blooms (Glibert and Burkholder 2018). Marine mammals can become exposed to toxins produced by phytoplankton through consumption of prey, and harmful algal blooms have been increasingly linked to their mortality and morbidity (Fire *et al.* 2021).

Paralytic shellfish toxins have been detected in seemingly healthy NARWs, and lethal doses of these toxins for mysticetes, including NARWs, are unknown (Doucette *et al.* 2006). Saxitoxins and domoic acid or amnesic shellfish poison have also been detected in mysticetes and odontocetes in North America, resulting in mortalities as well as sublethal exposure with unknown effects (Doucette *et al.* 2006, Torres de la Riva *et al.* 2009, Fire *et al.* 2021). Both of these toxins have been measured in NARW fecal samples from Roseway Basin and Bay of Fundy and NARWs are repeatedly exposed on an annual basis in multiple habitats (Doucette *et al.* 2012). While there is uncertainty in the impact of toxins produced during harmful algal on NARWs, their impact could be severe. Paralytic shellfish toxins, of which there are many types, are associated with harmful algal blooms and hypothesized to be the probable cause of death for a significant mortality event involving 28 adult (22 females) and 3 juvenile southern right whales in Golfo Nuevo, Argentina (Uhart *et al*. 2023). There have also been two other cetacean mass mortality events attributed to paralytic shellfish toxins: one involving humpback whales in Cape Cod Bay, USA (Geraci *et al.* 1989); and another in southern Chile where over 340 sei whales (*Balaenoptera borealis*) died (Häussermann *et al.* 2017). The Cape Cod Bay event is especially alarming given this is a designated critical habitat under the USA *Endangered Species Act* for the NARW (e.g., Costa *et al.* 2006, Clark *et al.* 2010, Federal Register (USA) 2016, Hudak *et al.* 2023). Harmful algal blooms that are intense and broadly spread often resulting in mortalities of numerous marine animals (Torres de la Riva *et al.* 2009) and, if extensive blooms occurred in NARW habitats, they could have the potential to devastate the population.

Diseases

It has been hypothesized that a number of diseases could be affecting reproduction in NARW (Kraus *et al*. 2007). Diseases known to cause abortions and reproductive dysfunction in domestic animals have also been found in free ranging cetaceans (Kraus *et al*. 2007 and references therein). McAloose *et al*. (2016) reviewed infectious diseases in necropsied southern right whales between 2003 and 2012 and found that infectious diseases were not a significant factor in the cause of death. However, marine mammals are susceptible to diseases, especially in combination with exposure to stressors and threats including fishing-gear entanglements, disturbance from underwater noise, and prey limitations (Harcourt *et al*. 2019). Investigating the impacts of diseases on NARW is extremely challenging (Kraus and Rolland 2007) and there is generally a paucity of information regarding diseases for NARWs.

Genetics and Inbreeding

One of the hypothesized drivers of recovery limitation for NARWs is reduced genetic variability (Waldick *et al*. 2002). Low genetic diversity for this population is observed at both functional and non-functional nuclear and mitochondrial markers (Malik *et al.* 2000, Schaeff *et al.* 1991, 1997, Waldick *et al.* 2002, Gillett *et al.* 2014) and predates commercial whaling activities (McLeod *et al.* 2010, Waldick *et al*. 2002). NARWs have one of the lowest levels of genetic diversity reported for a wildlife species (Frasier *et al.* 2007), and inbreeding is evident in the population (Crossman *et al.* 2023, Orton *et al.* 2024). When compared to southern right whales, NARWs have lower levels of genetic diversity, higher inbreeding coefficients, and lower effective population sizes that may be affecting the resiliency and recovery of this population compared to the southern species (Crossman *et al.* 2023). Low genetic diversity may be a factor affecting reproductive success (Crossman *et al*. 2024), and it has been observed that NARW calves had higher levels of heterozygosity than expected by chance as a result of postcopulatory selection in fertilizations or pregnancies between genetically dissimilar gametes (Frasier *et al.* 2013). The results from Frasier *et al.* (2013) indicate that heterozygosity in calves born into the population has gradually increased, indicating a natural mechanism by which the genetically limited NARW population could enhance its genetic diversity over time. Additionally, Orton *et al.* (2024) provide evidence that genetic purging has reduced the frequency of highly deleterious alleles in NARWs.

Activities Most Likely to Destroy Important Habitat

Ratelle and Vanderlaan *et al*. (2025) summarize the anthropogenic activities that are likely to destroy or damage NARW important habitat and which would result in the loss of NARW functions. The threats and associated activities, as well as the functions, features, and attributes affected are detailed in Table 3.

Table 3: Activities likely to destroy or damage to North Atlantic right whales (NARW) important habitat. Examples of activities that have, or have the potential to, affect functions, features, or attributes of habitats important to NARWs through an established or anticipated Pathway of Effect (PoE). The PoE describes, if possible, how an activity is likely to destroy the habitat (Brownscombe and Smokorowski 2021). A comprehensive list of activities and associated threats were identified and assessed in the NARW threat assessment (Vanderlaan et al. 2025.

Activity	Threat	Anticipated (A) or Established (E) Pathway of Effect	Function(s) Affected	Feature(s) Affected	Attribute(s) Affected
Fishing activity e.g., use of bottom-contact fixed fishing gear with associated vertical and/or groundline rope	Fishery interaction(s)	Reduction in space to complete movement (E)	Foraging/ Feeding Gestation/ Growth Rearing/ Nursing/ Socialization Social/ Reproduction Movement/ Migration	Physical space Corridor	Physical space, including the vertical and horizontal planes of the water column, to allow animals to move freely and unimpeded by physical obstructions and not alter behavioural functions at and below the surface. Habitat connectivity to successfully immigrate, emigrate, and facilitate seasonal movements in and out of known habitats.
Fishing activity e.g., plankton harvesting	Food supply reduction (direct)	Reduction in abundance and availability of prey (A)	Foraging/ Feeding Gestation/ Growth Rearing/ Nursing Social/ Reproduction Movement/ Migration	Marine environment Prey supply	Presence of a local or proximate source of prey. Prey availability at depths shallower than maximum NARW foraging depth. Abundant, sufficiently large and energy-rich prey with limited avoidance capabilities to meet NARW biological requirements. A minimum zooplankton energy density threshold for NARWs to feed. Persistent patches of prey that meet daily energy requirements of all life stages of NARWs, such as adult males and resting females (~1500-1900 MJ d^{-1}), pregnant females (~1855-2090 MJ d^{-1}), and including

Activity	Threat	Anticipated (A) or Established (E) Pathway of Effect	Function(s) Affected	Feature(s) Affected	Attribute(s) Affected
					the most energy demanding life stages—lactating females (~4120-4233 MJ d^{-1}), and developing juveniles. Dominance of large lipid rich copepods, especially *Calanus* spp. Other zooplankton prey include smaller copepods with less caloric value per individual (e.g., *Pseudocalanus* spp., *Centropages* spp.) and potentially euphausiids.
Vessel traffic in the marine environment e.g., shipping vessels, fishing vessels, cruise ships, whale watching vessels, ferries, offshore energy sector maintenance vessels, and supply vessels	Vessel presence	Reduction in space to complete movement (E)	Foraging/ Feeding Gestation/ Growth Rearing/ Nursing/ Socialization Social/ Reproduction Movement/ Migration	Physical space Corridor	Physical space, including the vertical and horizontal planes of the water column, to allow animals to move freely and unimpeded by physical obstructions and not alter behavioural functions at and below the surface. Habitat connectivity to successfully immigrate, emigrate, and facilitate seasonal movements in and out of known habitats.
Vessel traffic in the marine environment e.g., shipping vessels, fishing vessels, cruise	Vessel noise pollution	Reduction in communication space (E) e.g., masking, avoidance	Foraging/ Feeding Rearing/ Nursing/ Socialization Social/ Reproduction	Acoustic environment	Ambient sound levels ensuring integrity of acoustic space within the 20 Hz - 22 kHz frequency band. Ambient sound levels that allow efficient acoustic social communication and do not

Activity	Threat	Anticipated (A) or Established (E) Pathway of Effect	Function(s) Affected	Feature(s) Affected	Attribute(s) Affected
ships, whale watching vessels, ferries, offshore energy sector maintenance vessels, and supply vessels			Movement/ Migration		impede use of habitat for behavioural functions.
Introduction of underwater noise e.g., seismic surveys using airgun arrays, low and mid-frequency sonars, pile driving, production drilling	Noise pollution	Reduction in communication space (E) e.g., masking, avoidance	Foraging/ Feeding Rearing/ Nursing/ Socialization Social/ Reproduction Movement/ Migration	Acoustic environment	Ambient sound levels ensuring integrity of acoustic space within the 20 Hz - 22 kHz frequency band. Ambient sound levels that allow efficient acoustic social communication and do not impede use of habitat for behavioural functions.
Introduction of underwater noise e.g., seismic surveys using airgun arrays, low and mid-frequency sonars, pile driving, production drilling	Noise pollution	Reduction in space to complete movement (A) i.e., avoidance, habitat connectivity	Foraging/ Feeding Gestation/ Growth Rearing/ Nursing/ Socialization Social/ Reproduction Movement/ Migration	Physical space Corridor	Physical space, including the vertical and horizontal planes of the water column, to allow animals to move freely and unimpeded by physical obstructions and not alter behavioural functions at and below the surface. Habitat connectivity to successfully immigrate, emigrate, and facilitate seasonal movements in and out of known habitats.

Activity	Threat	Anticipated (A) or Established (E) Pathway of Effect	Function(s) Affected	Feature(s) Affected	Attribute(s) Affected
Industrial activities e.g., ocean dumping, industrial development and operation, vessel discharge	Chemical contaminants e.g., heavy metal pollution, persistent organic pollutant pollution, petroleum spills, plastic and marine debris pollution	Reduction in environmental quality (E)	Foraging/ Feeding Gestation/ Growth Rearing/ Nursing/ Socialization Social/ Reproduction Movement/ Migration	Marine environment Prey supply Water quality Air quality	Presence of a local or proximate source of prey. Abundant, sufficiently large and energy-rich prey with limited avoidance capabilities to meet NARW biological requirements. A minimum zooplankton energy density threshold for NARWs to feed. Persistent patches of prey that meet daily energy requirements of all life stages of NARWs, such as adult males and resting females (~1500-1900 MJ d^{-1}), pregnant females (~1855-2090 MJ d^{-1}), and including the most energy demanding life stages—lactating females (~4120-4233 MJ d^{-1}), and developing juveniles. Dominance of large lipid rich copepods, especially *Calanus* spp. Other zooplankton prey include smaller copepods with less caloric value per individual (e.g., *Pseudocalanus* spp., *Centropages* spp.) and potentially euphausiids. Suitable chemical, physical, and biological water quality characteristics to sustain prey species. Water and air quality to not cause adverse health effects or result in loss of function.

Activity	Threat	Anticipated (A) or Established (E) Pathway of Effect	Function(s) Affected	Feature(s) Affected	Attribute(s) Affected
Industrial activities e.g., ocean dumping, industrial development and operation, vessel discharge	Chemical contaminants e.g., heavy metal pollution, persistent organic pollutant pollution, petroleum spills, plastic and marine debris pollution	Reduction in space to complete movement (A) e.g., avoidance	Foraging/ Feeding Gestation/ Growth Rearing/ Nursing/ Socialization Social/ Reproduction Movement/ Migration	Physical space Corridor	Physical space, including the vertical and horizontal planes of the water column, to allow animals to move freely and unimpeded by physical obstructions and not alter behavioural functions at and below the surface. Habitat connectivity to successfully immigrate, emigrate, and facilitate seasonal movements in and out of known habitats.
Energy development and production e.g., development of offshore wind farms	Coastal and marine offshore development i.e., construction of industrial platforms	Reduction in environmental quality (E) e.g., disruption of localized ocean properties, changes to food supply	Foraging/ Feeding Gestation/ Growth Rearing/ Nursing/ Socialization Social/ Reproduction Movement/ Migration	Marine environment Bathymetric features Prey supply Water column Water quality Air quality	Presence of a local or proximate source of prey. Environmental, oceanographic, and bathymetric conditions to supply, support and aggregate high concentrations of prey at depths shallower than maximum NARW foraging depth: upwelling or downwelling zones and localized interactions of ocean currents with coastline or bathymetric features. Environmental, oceanographic, and bathymetric cues for movement and migration Bathymetric features to retain and aggregate prey species at depths shallower than maximum NARW foraging depth: localized

Activity	Threat	Anticipated (A) or Established (E) Pathway of Effect	Function(s) Affected	Feature(s) Affected	Attribute(s) Affected
					interactions of ocean currents with coastline or bathymetric features and prey-retaining basins or valleys providing habitat stability. Prey availability at depths shallower than maximum NARW foraging depth. Abundant, sufficiently large and energy-rich prey with limited avoidance capabilities to meet NARW biological requirements. A minimum zooplankton energy density threshold for NARWs to feed. Persistent patches of prey that meet daily energy requirements of all life stages of NARWs, such as adult males and resting females (~1500-1900 MJ d^{-1}), pregnant females (~1855-2090 MJ d^{-1}), and including the most energy demanding life stages—lactating females (~4120-4233 MJ d^{-1}), and developing juveniles. Dominance of large lipid rich copepods, especially *Calanus* spp. Other zooplankton prey include smaller copepods with less caloric value per individual (e.g., *Pseudocalanus* spp., *Centropages* spp.) and potentially euphausiids. Chemical, physical, and biological characteristics of the water column to supply, support, and aggregate high concentrations of prey and not result in loss of function.

Activity	Threat	Anticipated (A) or Established (E) Pathway of Effect	Function(s) Affected	Feature(s) Affected	Attribute(s) Affected
					Water depth < 350 m to include recorded maximum NARW dive depth (i.e., 306 m). Suitable chemical, physical, and biological water quality characteristics to sustain prey species. Water and air quality to not cause adverse health effects or result in loss of function.
Energy development and production e.g., development of offshore wind farms, oil and gas platforms	Coastal and marine offshore development i.e., construction of industrial platforms	Reduction in space to complete movement (E)	Foraging/ Feeding Gestation/ Growth Rearing/ Nursing/ Socialization Social/ Reproduction Movement/ Migration	Physical space Corridor	Physical space, including the vertical and horizontal planes of the water column, to allow animals to move freely and unimpeded by physical obstructions and not alter behavioural functions at and below the surface. Habitat connectivity to successfully immigrate, emigrate, and facilitate seasonal movements in and out of known habitats.
Energy development and production e.g., operation and maintenance of offshore wind farms, petroleum drilling	Coastal and marine offshore energy production i.e., operation and maintenance	Reduction in environmental quality (A) e.g., disruption of localized ocean properties, changes to food supply	Foraging/ Feeding Gestation/ Growth Rearing/ Nursing/ Socialization Social/ Reproduction Movement/ Migration	Marine environment Bathymetric features Prey supply Water Column Water quality Air quality	Presence of a local or proximate source of prey. Environmental, oceanographic, and bathymetric conditions to supply, support and aggregate high concentrations of prey at depths shallower than maximum NARW foraging depth: upwelling or downwelling zones and localized interactions of ocean currents with coastline or bathymetric features. Environmental, oceanographic, and bathymetric cues for movement and migration

Activity	Threat	Anticipated (A) or Established (E) Pathway of Effect	Function(s) Affected	Feature(s) Affected	Attribute(s) Affected
					Bathymetric features to retain and aggregate prey species at depths shallower than maximum NARW foraging depth: localized interactions of ocean currents with coastline or bathymetric features and prey-retaining basins or valleys providing habitat stability. Prey availability at depths shallower than maximum NARW foraging depth. Abundant, sufficiently large and energy-rich prey with limited avoidance capabilities to meet NARW biological requirements. A minimum zooplankton energy density threshold for NARWs to feed. Persistent patches of prey that meet daily energy requirements of all life stages of NARWs, such as adult males and resting females (~1500-1900 MJ d^{-1}), pregnant females (~1855-2090 MJ d^{-1}), and including the most energy demanding life stages—lactating females (~4120-4233 MJ d^{-1}), and developing juveniles. Dominance of large lipid rich copepods, especially *Calanus* spp. Other zooplankton prey include smaller copepods with less caloric value per individual (e.g., *Pseudocalanus* spp., *Centropages* spp.) and potentially euphausiids.

Activity	Threat	Anticipated (A) or Established (E) Pathway of Effect	Function(s) Affected	Feature(s) Affected	Attribute(s) Affected
					Chemical, physical, and biological characteristics of the water column to supply, support, and aggregate high concentrations of prey and not result in loss of function. Water depth < 350 m to include recorded maximum NARW dive depth (i.e., 306 m). Suitable chemical, physical, and biological water quality characteristics to sustain prey species. Water and air quality to not cause adverse health effects or result in loss of function.
Energy development and production e.g., development of offshore wind farms, oil and gas platforms, operation and maintenance of offshore wind farms, petroleum drilling	Noise pollution	Reduction in communication space (E) e.g., masking	Foraging/ Feeding Rearing/ Nursing/ Socialization Social/ Reproduction Movement/ Migration	Acoustic environment	Ambient sound levels ensuring integrity of acoustic space within the 20 Hz - 22 kHz frequency band. Ambient sound levels that allow efficient acoustic social communication and do not impede use of habitat for behavioural functions.
Energy development and production	Noise pollution	Reduction in space to complete movement (A)	Foraging/ Feeding Gestation/ Growth	Physical space Corridor	Physical space, including the vertical and horizontal planes of the water column, to allow animals to move freely and unimpeded by

Activity	Threat	Anticipated (A) or Established (E) Pathway of Effect	Function(s) Affected	Feature(s) Affected	Attribute(s) Affected
e.g., development of offshore wind farms, oil and gas platforms, operation and maintenance of offshore wind farms, petroleum drilling		i.e., avoidance	Rearing/ Nursing/ Socialization Social/ Reproduction Movement/ Migration		physical obstructions and not alter behavioural functions at and below the surface. Habitat connectivity to successfully immigrate, emigrate, and facilitate seasonal movements in and out of known habitats.

Threats to Co-occurring Species

NARWs co-occur within the distribution range and habitat of several other marine mammal species, including those listed under the *Species at Risk Act* , such as the: blue whale (*Balaenoptera musculus*, Atlantic population - Endangered); fin whale (*B. physalus*, Atlantic population – Special Concern); St. Lawrence Estuary beluga (*Delphinapterus leucas*, Northwest Atlantic population - Endangered); northern bottlenose whale (*Hyperoodon ampullatus*, Scotian Shelf population - Endangered); and, Sowerby's beaked whale (*Mesoplodon bidens* – Special Concern). They also co-occur with other listed species, including the: white shark (Endangered); leatherback sea turtle (*Dermochelys coriacea - Endangered*); and, loggerhead sea turtle (*Caretta caretta - Endangered*). In addition, NARWs overlap with species assessed by COSEWIC as Special Concern, Threatened, or Endangered, such as the sei whale (*B. borealis*, Atlantic population – Endangered) and harbour porpoise (Special Concern). Many of the threats faced by NARWs also pose risks to these co-occurring species, although the impacts may vary.

Vessel collisions with marine animals threaten species globally, affect both small and large marine animals, and involve vessels of various sizes (Laist *et al*. 2001, Ritter 2012, Schoeman *et al*. 2020, Kelley *et al*. 2021, Nisi *et al*. 2024). The risk of lethal vessel strike could be reduced either by reducing vessel speeds to decrease the probability of a lethal injury, or by reducing the spatiotemporal co-occurrence between whales and vessels (Vanderlaan *et al*. 2008). Speed reductions for large vessels will benefit all large whale species as the empirical models of probability of a lethal injury are based on vessel-strike records of large whale species (Vanderlaan and Taggart 2007, Conn and Silber 2013, Garrison *et al.* 2025). Advanced models of probability of a lethal injury (Kelley *et al.* 2021, Garrison *et al.* 2025) demonstrate higher rates of lethality across all speeds for large ocean-going vessels than previously estimated and speed restrictions may not achieve sufficient reductions in the probability of lethality. Vessel traffic routing amendments designed to protect the NARW could have negative consequences on species that are not sympatric with NARWs (Vanderlaan *et al*. 2008). For instance, the Area to Be Avoided on Roseway Basin was established to route vessel traffic away from NARWs initially reduced relative risk to NARWs by 82%; however, the relative risk of lethal vessel strikes increased by 7% for fin whales (Vanderlaan and Taggart 2009). In the USA seasonal management areas implemented spatiotemporal vessel speed restrictions to reduce vessel strike risk to NARWs. An examination of large whale mortalities pre- and post-implementation of the speed restrictions found comparable protection for humpback, minke, sei, and fin whales, however there was little evidence to suggest the speed restrictions were beneficial for blue and sperm whales (Laist *et al*. 2014, van der Hoop *et al*. 2015).There are two primary approaches to mitigating the risk of lethal fishing gear entanglements:

1. lowering the probability of entanglement; and
2. minimizing the chances of injury, or reduced fitness given an entanglement has occurred.

Preventing entanglements requires the reduction of the spatiotemporal co-occurrence of fishing gear and whales. This could be achieved through spatiotemporal fishing closures or the use of on-demand fishing gear (NEFSC 2025). A reduction of the co-occurrence of NARWs with fishing gear through a shift in the distribution of fishing effort could result in negative impacts on other species in these areas, including at-risk species. On-demand fishing gear would be beneficial to all species co-occurring with NARWs as it removes vertical buoy lines from the water column. This prevents whales from encountering vertical lines and could dramatically reduce fishing-gear entanglements (Myers *et al*. 2019).

Another conservation initiative that would benefit NARWs, as well as other co-occurring species at risk, is the recovery of abandoned, lost, or otherwise discarded fishing gear (ALDFG, i.e., “ghost gear”). Several such projects were funded in 2023-2024 under the Ghost Gear Fund to remove ALDFG gear in eastern Canadian waters (e.g., DFO 2024). This activity will reduce the probability of entanglement for all species where ALDFG is a concern.

Vanderlaan *et al*. 2025 presented 23 *Historical*, *Current*, and *Anticipatory* threats to NARWs. Many of the threats identified in that analysis are common across co-occurring species. Although spatiotemporal conservation initiatives implemented to protect NARWs from vessel strikes and fishing-gear entanglements have not always provided comparable threat reductions for other species, removing or reducing the occurrence of the other threats identified by Vanderlaan *et al*. 2025, has the potential to also reduce the threats to other species at risk.

ELEMENTS 12 THROUGH 15: RECOVERY TARGETS

Historical Abundance and Carrying Capacity (K)

Carrying capacity (K), corresponds to the maximum population size that could be sustained without anthropogenic sources of mortality. Generally, historical K can be defined as the pre-exploitation abundance for a given species. In the absence of such an estimation for the NARW, the historical or pre-whaling abundance for NARW has been estimated at 9,075 – 21,328 individuals based on extrapolation of spatially-explicit models of K developed for North Pacific right whales (Monsarrat *et al*. 2016). The uncertainty around this extrapolation, however, cautions against using this estimate as a management benchmark. Alternative approaches recognizing that the effective K for the species has fundamentally changed from historical levels, and which are more relevant to current dynamics, should be used instead. A more contemporary K could be estimated using density-dependent models where all threats would be removed.

Population Projections

Runge *et al.* (2023) developed a population viability analysis to evaluate the current status of NARWs, examine the contribution of various threats to population trend, and explore risk reductions required to achieve recovery of the species. The population viability analysis was also used to project the abundance of NARWs into the future, using scenarios meant to represent the current baseline conditions or scenarios meant to represent potential reductions in threats. Under the baseline scenario (Figure 17) that reflects the levels of threats estimated for 2019, the NARW population is expected to decrease steadily over the next 100 years, with a probability of quasi-extinction (probability that the number of mature females falls below 50 in 100 years) of 0.934. The median population growth rate over the next 35 years is estimated to be 0.985, with 90-percent confidence it will be greater than 0.973. As a growth rate of 1.0 indicates a stable population these values predict a continued gradual decline (Figure 17).

There are several limitations with this baseline projection. First, it does not account for the regulations and management actions that have been undertaken by Canada and the USA since 2019. Second, it only accounts for recent changes in *Calanus* population level indices; it does not account for potential long-term declines driven by climate change as predicted in the Gulf of St. Lawrence and on the Scotian Shelf by Lehoux *et al*. (2024). Third, an error has been found in v1.0 of the population viability analysis that over-estimates the reproductive rate for proven females; thus, the projections in Runge *et al*. (2023) are more optimistic than intended. The combined effect of all these caveats are unknown; however, the results in Runge *et al*. (2023) provide the best available baseline. Updates to the population viability analysis are expected in 2025.

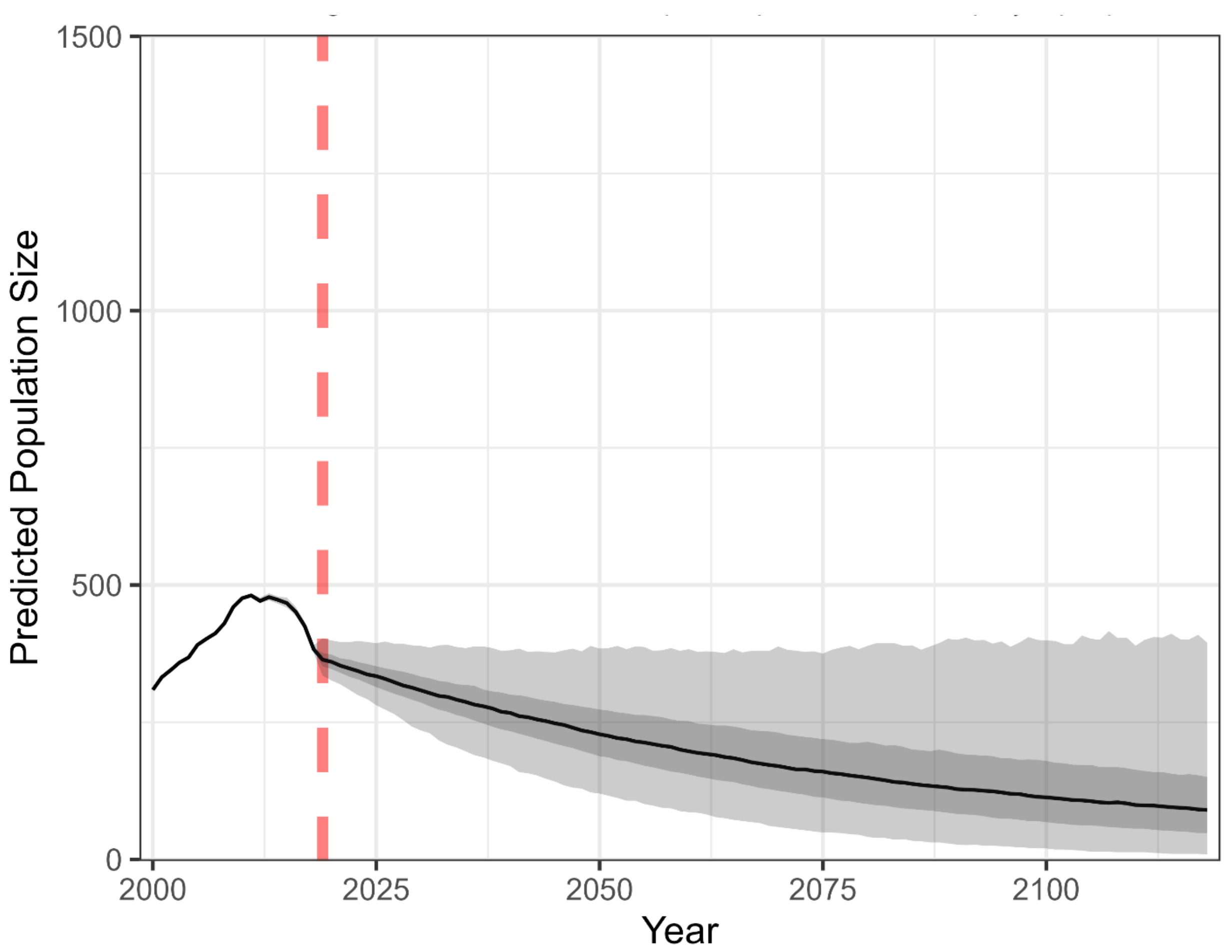

Figure 17: Historical and projected total North Atlantic right whale population size over time 2001-2119 illustrating baseline scenario (status quo) from Runge et al (2023). The bold line shows the median value; the light gray shaded area encompasses the 2.5% and 97.5% quantiles (thus the 95% projection interval) while the dark gray area encompasses the 25% and 75% quantiles (thus the 50% projection interval); and the red dashed line indicates the year 2019.

Proposed Abundance and Distribution Objectives

The proposed long-term (100 year) recovery target would be to reach more than 1000 mature individuals in the population as this would contribute to the possible re-evaluation of the COSEWIC listing status for NARWs from Endangered to Threatened. This would first require a sustained positive growth rate over at least one generation (35 years), and ideally a growth rate of 1.02 or more, to allow for doubling of the population over one generation (i.e., reach a population size of 756 by 2054).

Although not a specific population abundance recovery target, another proposed long-term recovery goal could would be to reduce the probability of a quasi-extinction (<50 mature females) of less than 0.1 over 100 years. Several scenarios (see following section) achieve this goal, however Scenario 5 that requires a risk reduction of 54% for both vessel strikes and entanglements, achieves this goal with the lowest risk reductions when considering both industries. It also achieves the long-term goal of 1000 mature individuals in the population in 94 years and there is assured stability in the population (80% CI for $\lambda > 1.0$).

More immediate proposed recovery targets would be to achieve: 1) stability in the population by halting the declining trend of population size that started in 2011. Since 2020 there are signs that this declining trend is slowing with the population increasing slightly between 2020 and 2023. However, the uncertainty around these estimates remains high. The associated 95% credible intervals around population estimates overlap across years, and the wide interval around the 2023 estimate (Linden 2024) encompasses the 2019 estimate that was clearly part of the decline. Further monitoring and modelling of the NARW population will determine whether this is a true reversal of the population's decline.

Other proximate proposed recovery targets would be to achieve: 2) a sustained positive growth rate for one generation (35 years); 3) a doubling of the population in one generation (35 years; ~2% annual growth rate) resulting in a population of 756 mature individuals by 2054; and, 4) a probability of quasi-extinction (i.e., < 50 of proven females) of less than 0.2 over 100 years. To achieve the second recovery target of positive growth rate with assured stability, i.e., an 80% credible interval for $\lambda > 1.0$, would result in 614 individuals in the population by 2054. Doubling of the population in one generation is an ambitious goal that would require substantial risk reductions however; there is a 51-57% chance of achieving this target. The fourth proposed recovery target is similar to the second proposed long-term recovery goal; however, it requires less risk reduction to achieve, resulting in a smaller impact on fishing and shipping industries compared to the more stringent long term goals of a 0.1 probability of quasi-extinction.

We also identified two potential distribution targets to aid in the survival and recovery of NARWs. The first includes maintaining the historical and contemporary distribution of NARWs in Canadian waters with unimpeded access to migratory corridors and aggregation areas. This would include all important habitat identified in Ratelle and Vanderlaan et al. (2025; Figure 15) to ensure the continued availability of habitat of necessary quality in Canadian waters to support NARWs. The spatial extent of the distribution of NARWs may also increase in Canadian waters in the future. There have been sporadic sightings and acoustic detections on the Newfoundland and Labrador Shelves (Lawson et al. 2025) that could indicate expansion of the northern limit. Therefore, the second distributional target is to maintain unimpeded access to identified potential feeding habitats (Ratelle and Vanderlaan et al. 2025) and migratory corridors that connect these potential feeding areas to identified important habitat.

ELEMENTS 16 THROUGH 21: SCENARIOS FOR MITIGATION OF THREATS AND ALTERNATIVES TO ACTIVITIES

Several conservation initiatives and management actions that have been implemented or proposed to reduce threats to NARWs, including achievements and performance indicators, have recently been reviewed (DFO 2018, DFO 2021, Vanderlaan *et al*. 2025). A current inventory of ongoing mitigation measures is included in the "Report on the Progress of Recovery Strategy Implementation for the North Atlantic Right Whale (*Eubalaena glacialis*) in Canada for the Period 2015 to 2020" (DFO 2025a). The report synthesizes progress made towards implementation of the Recovery Strategy objectives including a broad list of activities undertaken to increase survivorship and promote recovery of the NARW population. Generally, continued and additional actions to reduce vessel strikes and entanglements will be needed to achieve recovery targets and objectives.

Different scenarios of threat mitigation and future ecological change have been evaluated for their effects on population dynamics using a population viability analysis (Runge *et al*. 2023). Threat mitigation actions were not explicitly stated in the population model but were instead described as percent threat reductions in specific threats, regardless of the means to achieve the specified percent reduction. Threat reductions represent the percent reduction in the severe injury rate that in turn affects both probabilities of mortality and reproduction in the population viability analysis (Runge *et al*. 2023). Tables 4 and 5 describe scenarios that compare different levels of threat reduction relative to the baseline. Scenarios 1 through 8 are not explicitly described in Runge *et al*. (2023) but were run using the publicly available code (v1.0) for the population viability analysis.

Threat Reduction

The scenarios presented in Tables 4 and 5 consider the potential reduction in entanglement risk, vessel-strike risk, or both, at several levels of aspiration. The reductions in risk of various threats are stated relative to the baseline scenario (circa 2019 conditions) and the parameters related to vessel traffic were held constant through time in all projections. Reductions in risk, for both vessel strikes and fishing-gear entanglements threats, were realized via reductions in rates of severe injuries, which in turn affects both the probabilities of mortalities and reproduction, used in the estimation of population trajectories in the population viability analysis (Runge *et al.* 2023).

Table 4: Description of scenarios evaluated using forward projections of the best-fit model, with modifications to parameters as described. All model projections were run for 100 years and replicated 1,000 times to capture parametric uncertainty and temporal variance. Scenario 0 was taken directly from Runge et al. (2023). Scenarios 1-8 were generated using the publicly available computer code from Runge et al. (2023), with the parameters changed for entanglement threat (E) and vessel strike threat (V) as indicated.

Scenario	Description	Explanation
Scenario 0	Baseline model	Project model with threats at the levels estimated for 2019, without accounting for any management measures that have been taken since then.
Scenario 1	E 50 / V 0	Projection with entanglement threat (E) reduced by 50% compared to the baseline model.
Scenario 2	E 0 / V 90	Projection with vessel strike threat (V) reduced by 90% compared to the baseline model.
Scenario 3	E 28 / V 28	Projection with entanglement and vessel strike threats each reduced by 28% compared to the baseline model.
Scenario 4	E 90 / V 0	Projection with entanglement threat reduced by 90% compared to the baseline model.
Scenario 5	E 54 / V 54	Projection with entanglement and vessel strike threats each reduced by 54% compared to the baseline model.
Scenario 6	E 100 / V 0	Projection with entanglement threat reduced by 100% compared to the baseline model.
Scenario 7	E 64 / V 64	Projection with entanglement and vessel strike threats each reduced by 64% compared to the baseline model.
Scenario 8	E 94 / V 94	Projection with entanglement and vessel strike threats each reduced by 94% compared to the baseline model.

Table 5: A summary of results from future simulations generated using range wide population viability analysis for North Atlantic right whales (Runge et al. 2023). Model projections were run for 100 years and replicated 1,000 times to capture parametric uncertainty and temporal variance (refer to Table 4 for details of each simulation). The median and lower 10% quantile for the annual population growth rate over the first 35 years of the simulation is shown. The probability of quasi-extinction is defined as the probability of the number of mature females falling below 50 over the next 100 years. The average time for the population to reach 1,000 mature animals and the probability of the population doubling within one generation (35 years) are also shown.

Scenario	Risk reduction: Entanglement	Risk reduction: Vessel strike	Growth rate (λ) over first 35 years Median	Growth rate (λ) over first 35 years Lower 10%	Probability of quasi-extinction	Average time to reach 1,000 mature animals (years)	Probability of population doubling in 35 years
0	--	--	0.985	0.973	0.934	>100	<0.001
1	50%	--	1.003	0.990	0.352	>100	0.018
2	--	90%	1.001	0.989	0.415	>100	0.035
3	28%	28%	1.000	0.990	0.444	>100	0.003
4	90%	--	1.018	1.003	0.080	75	0.453
5	54%	54%	1.014	1.006	0.042	94	0.197
6	100%	--	1.022	1.005	0.050	63	0.586
7	64%	64%	1.020	1.012	0.005	70	0.511
8	94%	94%	1.037	1.030	<0.001	39	1.000

Scenarios 1 through 3 all achieve roughly the same recovery target: raising the median population growth rate (λ) to 1.0 (stability) over the next generation (35 years). The population viability analysis estimates that this would require a 50% reduction in the entanglement risk alone, a 90% reduction in the vessel-strike risk alone, or a simultaneous 28% reduction in both (Figure 18A). Such an improvement would, indeed, raise the median growth rate to 1.0, with 90% confidence that the growth rate would be at least above 0.99. In addition, such a risk reduction would reduce the probability of quasi-extinction to approximately 0.4 (from 0.934). The probability of the population doubling within 35 years would increase, but still remains quite small (less than 0.04).

Scenarios 4 and 5 achieve 90% confidence that the median growth rate over the next generation (35 years) would be greater than one, and seek assurance of stability. The population viability analysis model estimates this would require a 90% reduction in entanglement risk alone, or a simultaneous 54% reduction in both the entanglement and vessel-strike risk (Figure 18B). A 100% reduction in the vessel-strike risk *alone* would not achieve this recovery target (not shown). Under these risk reductions, the median growth rate over one generation increases to about 1.014-1.018, the risk of quasi-extinction drops to 0.042-0.080, and the probability of doubling in one generation rises to 0.20-0.45.

Scenarios 6 and 7 achieve a median growth rate such that the population is likely to double over one generation (this is a growth rate of about 1.02). The population viability analysis estimates a 0.59 probability of achieving this goal with 100% reduction in the entanglement threat alone, or a 0.51 probability with simultaneous 64% reduction in both threats (*Figure* 18C). Reduction in these threats to this degree is estimated to reduce the risk of quasi-extinction below 5% and achieve a population size of 1,000 within approximately 70 years.

The last scenario, Scenario 8 (Figure 18D), assesses the effect of a simultaneous 94% reduction in both entanglement and vessel-strike threats. This scenario would achieve a median growth rate of 1.037 over the next 35 years, reduce the probability of quasi-extinction to below 0.001, and double the population size with near certainty in one generation.

A comparison of the scenarios in Table 5 demonstrates that the required reduction of fishing-gear entanglement and vessel strike risk to achieve recovery depends on the threshold target. However, the results suggest that there are potential pathways to recovery regardless of which target is chosen. We did not assess the technical, economic, or political feasibility of these pathways.

As noted above, there are caveats associated with the results from v1.0 of the population viability analysis described in Runge *et al*. (2023). Nevertheless, the comparative results in Table 5 provide insights about the levels of risk reduction that would be required to achieve different target thresholds for populations growth and quasi-extinction probabilities.

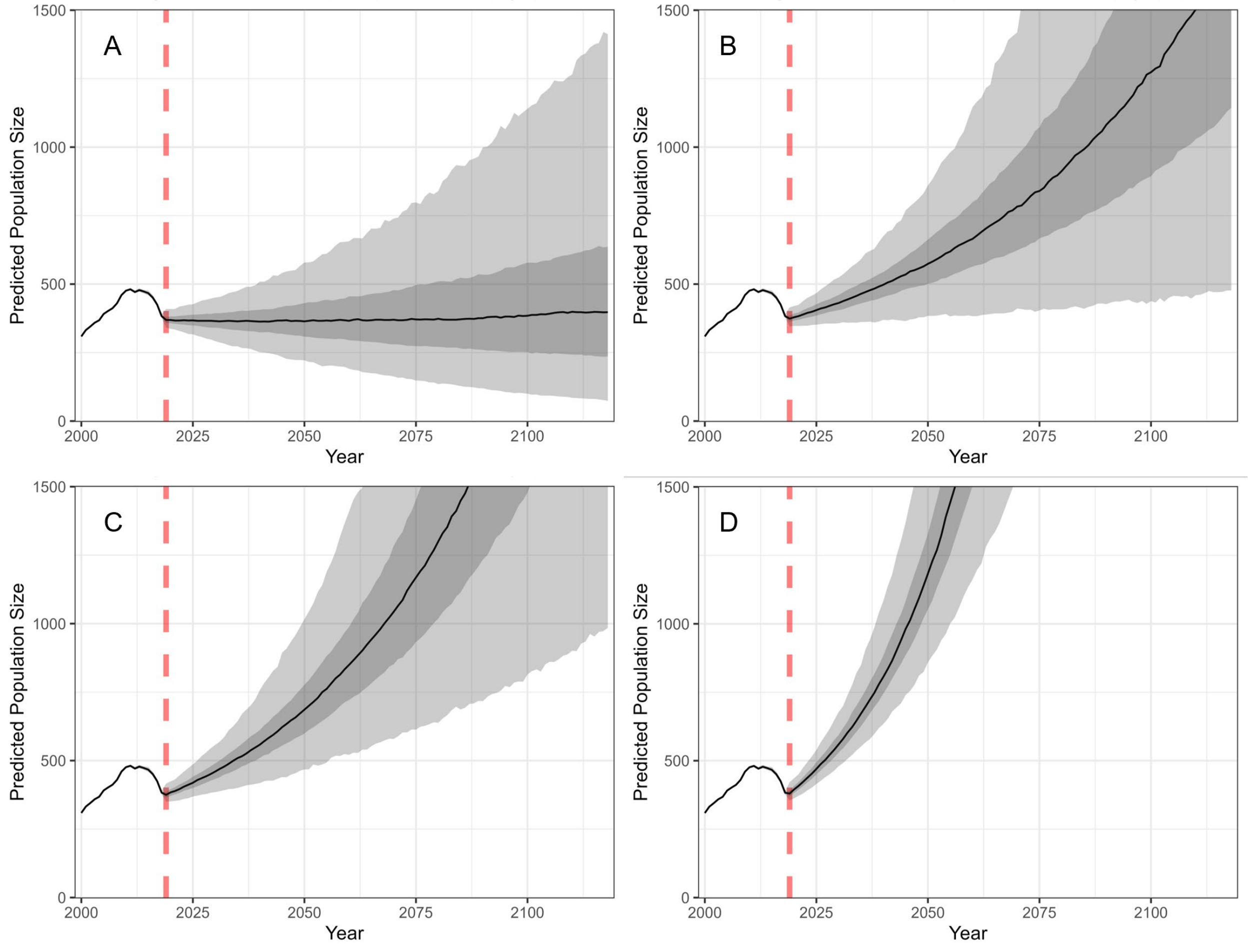

Figure 18: Historical and projected total North Atlantic right whale population size over time 2001-2119 illustrating scenarios: A) projection with entanglement and vessel strike threats each reduced by 28% compared to the baseline model; B) projection with entanglement and vessel strike threats each reduced by 54% compared to the baseline model; C) projection with entanglement and vessel strike threats each reduced by 64% compared to the baseline model, and D) projection with entanglement and vessel strike threats each reduced by 94% compared to the baseline model. The bold line shows the median value; the light gray shaded area encompasses the 2.5% and 97.5% quantiles (thus the 95% projection interval) while the dark gray area encompasses the 25% and 75% quantiles (thus the 50% projection interval); and the red dashed line indicates the year 2019.

ELEMENT 22: ALLOWABLE HARM ASSESSMENT

The *Species at Risk Act* prohibits activities that kill, harm, harass, capture, take, possess, collect, buy, sell, or trade an individual, or any part or derivative of an individual, of a species listed as extirpated, endangered, or threatened. Furthermore, the *Species at Risk Act* prohibits activities that damage or destroy designated critical habitat of the listed species, as defined under the regulations. However, the *Species at Risk Act* also provides a regulatory mechanism for permitting certain activities under specific conditions where it can be demonstrated that the activities will not jeopardize the survival or recovery of the species. This introduces the concept of “allowable harm”, a threshold of human-induced impact that may be tolerated under specific conditions, provided it does not compromise the species’ long-term viability. The Government of Canada has not adopted a standardized, quantitative definition for allowable harm to a species (Gavrilchuk and Doniol-Valcroze 2021), and several different methods have been used to assess allowable harm (DFO 2022). A conceptual framework was developed to evaluate how a proposed project may affect the survival and recovery of an endangered species under the *Species at Risk Act* permitting process (DFO 2022). While this framework provides a structured approach, it should not replace more robust methodologies such as those developed specifically for marine mammals (DFO 2022). One such methodology is the Potential Biological Removal (PBR) method, a standard for generating such estimates for cetaceans (Wade 1998). PBR allows for a calculation of the "maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population" (MMPA Sec. 3. 16 U.S.C. 1362). PBR is calculated annually for NARWs by NOAA and was estimated at 0.7 individuals in 2022 using a recovery factor of 0.1, a maximum growth rate of 0.04 and a minimum population size (N_{min}) of 332 individuals (Hayes *et al*. 2023). This means that any human-induced mortality of a NARW would exceed PBR. The PBR for the NARW has been less than or equal to one since 1995 (Vanderlaan *et al.* 2025 and references therein) and with the exception of just three years - 1998, 2015, and 2022, PBR has been exceeded (van der Hoop *et al.* 2013, Sharp *et al*. 2019, NOAA 2025). New guidelines for selecting the recovery factor for estimating the PBR in Canada have been developed. For a species that meets the IUCN criteria for Critically Endangered, such as the NARW, the recovery factor should be set to zero, resulting in a PBR of zero (DFO 2025b). Both of these PBR estimates indicate that there is no allowable harm to NARWs at this time. Reductions in anthropogenic mortalities would contribute directly towards both the long-term and proximate recovery targets.

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