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# RECOVERY POTENTIAL ASSESSMENT FOR THE LEATHERBACK SEA TURTLE (*DERMOCHELYS CORIACEA*), NORTHWEST ATLANTIC SUBPOPULATION

*Leatherback Sea Turtle (*Dermochelys coriacea*) Photo credit: Canadian Sea Turtle Network. Not to be reproduced.*

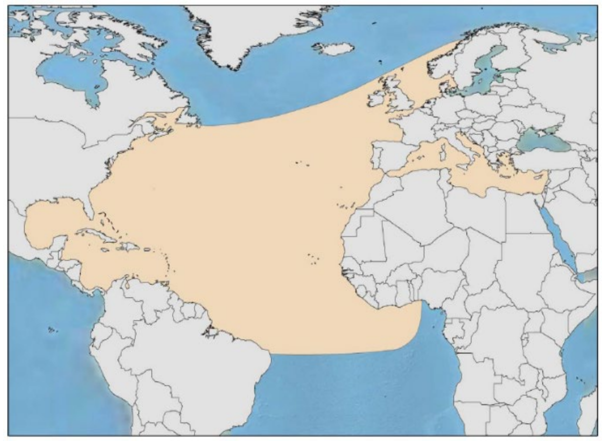

*Figure 1. Map of the Northwest Atlantic Ocean Leatherback subpopulation (source: Wallace et al. 2010).*

## Context:

*Leatherback Sea Turtles (*Dermochelys coriacea*) in Atlantic Canada belong to the Northwest Atlantic subpopulation. The Leatherback Sea Turtle was listed as Endangered under the Species a Risk Act (SARA) in 2003 and was re-listed as two populations (Pacific and Atlantic) in 2017, both Endangered.*

*Fisheries and Oceans Canada (DFO) Science Branch was asked to complete a Recovery Potential Assessment (RPA) based on the national guidance to provide scientific advice in support of ongoing recovery efforts. As required by the Species at Risk Act, a recovery strategy for the Leatherback Sea Turtle in Atlantic Canada was published in 2007 (Atlantic Leatherback Turtle Recovery Team 2006). An RPA according to current guidance was not completed for the Leatherback Sea Turtle prior to its listing. However, certain elements were addressed over time through separate CSAS processes, including the identification of important habitat (DFO 2020a) and a threat assessment (DFO 2020b). The advice in the RPA may be used to inform the development and revision of recovery documents and to support decision making with regards to the use of permits and their related conditions.*

*This Science Advisory Report is from the December 10–11, 2020 zonal advisory meeting on Recovery Potential Assessment (RPA) for Leatherback Sea Turtle, Northwest Atlantic Subpopulation. Additional publications from this meeting will be posted on the [Fisheries and Oceans Canada (DFO) Science Advisory Schedule](#) as they become available.*

# SUMMARY


- In 2017, Leatherback Sea Turtles were re-listed under the *Species at Risk Act* (SARA) as two populations (Atlantic and Pacific), both Endangered. Leatherback Sea Turtles in Atlantic Canada belong to the Northwest Atlantic (NWA) subpopulation, which is listed as Endangered through the International Union for Conservation of Nature (IUCN) Red List. A Recovery Potential Assessment according to current guidance was not completed for the Leatherback Sea Turtle prior to its listing under SARA.
- The NWA Leatherback subpopulation is in decline, with a recent index abundance estimate of 20,659 mature nesting females at consistently monitored beaches and a regional nesting abundance decrease of 9.32% (CI: -12.9% to -5.57%) annually from 2008–2017.
- In the Northwest Atlantic, Leatherbacks use Canadian waters seasonally in the summer months. High use areas of core foraging habitat have been identified throughout Atlantic Canadian waters.
- There is no existing evidence to suggest that Leatherbacks are habitat limited in Atlantic Canadian waters.
- In Atlantic Canada, Leatherbacks do not come ashore and are broadly distributed through coastal and offshore waters. As such, there is no current method to accurately determine the number of turtles using these waters. Efforts are underway to correct for biases in estimating abundance of various species in aerial survey areas, which may produce a minimum estimate of the number of Leatherbacks using these waters.
- Throughout their range, Leatherbacks encounter a variety of natural and anthropogenic threats, with incidental fishery interactions identified as a leading cause of mortality within this subpopulation.
- While interactions do occur between Leatherbacks and fisheries in Atlantic Canadian waters, available data suggest that fishery interactions occur most frequently outside of Canadian waters, especially in waters adjacent to some high-density nesting beaches.
- At-sea mortality in Canada, and elsewhere, may be reduced through adaptive fishing methods (i.e., ropeless fishing gear, time-area closures, reduction of ghost gear).
- A spatial-temporal analysis of the overlap between fishery and Leatherback distributions should occur prior to the establishment of any new fisheries or potential changes in the seasonality or spatial extent of existing fisheries are considered.
- There is some scope for harm to Leatherbacks in Atlantic Canadian waters; however, human-induced threats should be reduced to the fullest extent possible throughout the Northwest Atlantic and regular assessments should be conducted to evaluate the impact of Canadian fisheries on this subpopulation.
- A recovery goal is to increase the number of Leatherbacks in the broader NWA subpopulation by maintaining or increasing the number of adult and subadult Leatherbacks using Atlantic Canadian waters. Progress towards this goal may be achieved by reducing human-induced interactions and mortalities in Atlantic Canada, supporting Leatherback persistent use of Canadian waters as core foraging habitat, and continuing efforts to monitor Leatherback spatial and temporal distributions.
- The NWA Leatherback subpopulation is not currently on course to meet the recovery goal. International collaboration (through activities such as nesting beach monitoring and protection, increased survey efforts throughout foraging habitats, and reduction of fishery

interactions throughout the NWA Leatherback range) is necessary for the recovery of this subpopulation.

# BACKGROUND

The Leatherback Sea Turtle was assessed as Endangered by COSEWIC (Committee on the Status of Endangered Wildlife in Canada) in 1981, and then again in 2012 when it was separated into two populations, Atlantic and Pacific (COSEWIC 2012). The Leatherback Sea Turtle was listed as Endangered under SARA in 2003 and was re-listed as two populations (Pacific and Atlantic) in 2017, both Endangered. There are three subpopulations of Leatherback Sea Turtle recognized in the Atlantic, reflecting geographic separation of corresponding nesting areas. The Northwest Atlantic (NWA) subpopulation nests on tropical and subtropical beaches north of the equator on the western side of the Atlantic, but forages widely in both the Eastern and Western North Atlantic, including waters off Europe and the Mediterranean, the United States and Canada. The NWA subpopulation is listed as Endangered by the International Union for Conservation of Nature (IUCN) (Northwest Atlantic Leatherback Working Group 2019).

This Recovery Potential Assessment contains information to support decision-making regarding the issuance of permits or agreements, recovery documents, and the formulation of exemptions and related conditions of SARA. Two other CSAS processes have been completed for the Leatherback Sea Turtle NWA subpopulation, including important habitat in Atlantic Canada (DFO 2020a) and the threat assessment (DFO 2020b). Elements directly referencing these processes have been omitted from this RPA (Elements 5 and 8).

# ASSESSMENT

## Elements 1 and 3: Biology and Life-history Parameters

The Leatherback Sea Turtle is the largest of the seven extant species of marine turtles, and it is the sole living member of the family Dermochelyidae. Most mature Leatherbacks measured in Canadian waters measure < 175 cm curved carapace length and < 640 kg (James et al. 2007). Leatherbacks have a functionally endothermic physiology, with the capacity of maintaining body temperature up to 18 ºC above ambient (Frair et al. 1972). Such endothermy is facilitated by a large body size, a thick layer of blubber, high volume-to-surface-area ratio, a countercurrent circulatory system, and the ability to elevate body temperature through increased metabolic activity.

Leatherbacks nest on land but spend the rest of their lives at sea, where they make long-distance pelagic migrations between their nesting beaches in low latitudes and foraging habitats at temperate latitudes, including Atlantic Canada. The diet of the Leatherback consists solely of gelatinous zooplankton that are seasonally abundant in temperate shelf and slope waters off eastern Canada.

*Table 1. Current life-history parameters for the Northwest Atlantic Leatherback Sea Turtle.*

| Parameter | Measure |
|---|---|
| Wild growth rate | Unknown |
| Age at maturity | The most recent estimate is 17–19 years (Avens et al. 2020). |
| Generation time | 30 years (NMFS-USFWS 2020). |
| Internesting interval | Average of 10 days; range: 7–15 days (Eckert et al. 2012, Eckert et al. 2015). |
| Clutch frequency | Average of 5.5, ranging between 3.6–8.3 clutches (NMFS-USFWS 2020). |
| Clutch size | 80–88 eggs (NMFS-USFWS 2020). |
| Remigration interval | Average of 2.7 years; range: 1–11 years (NMFS-USFWS 2020). |

Indications of productivity decreases have been documented by some researchers (e.g., declining hatching success and clutch frequency, increased remigration intervals; Chevallier et al. 2020). An overall decreasing nest trend (decline in nesting female abundance) has been observed using long-term monitoring data from seven countries (NMFS-USFWS 2020). Leatherbacks have the lowest hatching success among all sea turtles, at about 50% (as low as 8.9% in Costa Rica, Troëng et al. 2007; and as high as 93.4% in Florida, Perrault et al. 2012), and they also have the lowest emergence success at approximately 50% (COSEWIC 2012). Sea turtles have temperature-dependent sex determination, with warmer nest incubation temperatures associated with female biased hatchling production. Survival rates of hatchlings after they enter the ocean, and the life history of juveniles, are not known. Like many long-lived species, survival of hatchlings (and presumably small juveniles) is low, whereas the size of sub-adults and adults confers them a high degree of protection from natural predation. Survival estimates for nesting female Leatherbacks are 88.9% in Florida (Stewart et al. 2014), but only 78.9% in French Guiana (Chevallier et al. 2020).

For more information on the biology of the Leatherback Sea Turtle, please refer to COSEWIC (2012).

## Element 2: Abundance Trajectory and Number of Populations

Current estimates suggest there are 20,659 mature female leatherbacks in the NWA subpopulation, with a decreasing trend in abundance (NMFS-USFWS 2020). This estimate is based on the best available nesting data from recently and consistently monitored nesting beaches. Another abundance estimate of 20,000 mature individuals was recently published, capturing a decrease of 60% from historic nest trend data (IUCN Red List, as cited in Northwest Atlantic Leatherback Working Group 2019). Differences between these two abundance estimates may be attributed to the application of different remigration intervals (NMFS-USFWS 2020). Declines over short- and long-term trajectories are summarized in Table 2.

*Table 2. Adapted from Northwest Atlantic Leatherback Working Group (2018): summary of regional trends in annual nest abundance measured by annual mean percent changes (and confidence intervals) in nest abundance over short- and long-term trajectories.*

| Region | 1990–2017<br>(n = 23 nesting sites) | 1998–2017<br>(n = 22 nesting sites) | 2008–2017<br>(n = 18 nesting sites) |
|---|---|---|---|
| NW Atlantic | -4.21%<br>(CI: -6.66% to -2.23%) | -5.37%<br>(CI: -8.09% to -2.61%) | -9.32%<br>(CI: -12.9% to -5.57%) |

The NWA subpopulation is distributed throughout the North Atlantic Ocean, including the Caribbean Sea, Gulf of Mexico, and Mediterranean Sea (NMFS-USFWS 2020). Leatherbacks found in Atlantic Canada originate from nesting assemblages in the western North Atlantic, with the Guiana Shield representing the most southern nesting habitat. Adult and subadult Leatherbacks occur only at sea in Canada; population abundance and distribution throughout this region is not currently quantified. DFO has conducted broad-scale aerial surveys for marine megafauna (including Leatherbacks) in Atlantic Canadian waters: the 2007 Trans North Atlantic Sightings Survey and the 2016 Northwest Atlantic International Sightings Survey. However, aerial surveys such as these do not cover all continental shelf waters used by leatherbacks and rarely fly beyond the shelf break. There is no associated estimate of the Leatherback population in Atlantic Canada, but efforts are underway to correct for biases in estimating abundance of various species in survey areas. Deriving accurate estimates of turtle abundance from aerial surveys across the species' range in Atlantic Canada is impeded by multiple factors related to the species' broad distribution in shelf and offshore waters, as well as detectability issues related to turtle size (survey altitude is not always optimized for spotting turtles), turtle colour (contrast), atmospheric and sea conditions, and turtle diving behavior. Furthermore, sightability correction factors, which take into account factors that influence detection of turtles (e.g., aerial surveys only detect turtles at or very near to the surface) would be required to derive such estimates.

## Elements 4, 5, 6, and 7: Distribution, Habitat, Constraints, and Residency

*Table 3. The functions, features, and attributes of Leatherback Sea Turtle habitats in Atlantic Canada.*

| Function | Feature | Attributes |
|---|---|---|
| **Foraging** | Adequate food supply | Presence of gelatinous prey species (jellyfish, salps, siphonophores) in adequate quantities to support foraging. |
| | | Seasonal primary production supporting growth of prey species (sea surface temperature, chlorophyll a, upwelling). |
| | | Oceanographic and bathymetric characteristics supporting seasonal productivity and presence of prey species (sea surface height, bottom slope, retention areas, oceanographic frontal systems, climatic stability). |
| | Space for foraging | Adequate space such that anthropogenic physical hazards (i.e., marine debris, vessel traffic, ghost gear, active commercial and food, social, or ceremonial fisheries) are at densities that do not impede foraging activity. |
| | Acoustic environment | Anthropogenic noise at levels that do not disrupt and/or displace foraging activity. |
| | Water quality | Water quality that supports sufficient quantity and quality of prey and that does not impede use of the habitat by Leatherback Sea Turtles. |
| **Migration** | Space for navigation | Adequate space such that anthropogenic physical hazards (i.e., marine debris, vessel traffic, ghost gear, active commercial and food, social, or ceremonial fisheries) are at densities that do not impede migration. |
| | Acoustic environment | Anthropogenic noise at levels that do not impede and/or displace migration. |
| | Water quality | Water quality that supports sufficient quantity and quality of prey and that does not impede use of the habitat by Leatherback Sea Turtles. |

Leatherback Sea Turtles do not have defined residences or structures that they habitually occupy. They are associated with important habitat areas (or broad areas of seasonal residency), defined in DFO (2020a). In Canadian waters, Leatherback habitat consists of foraging habitat and migratory range. Leatherback terrestrial habitat is outside of Atlantic Canada. The amount of time spent in Atlantic Canada is positively correlated with foraging habitat quality (DFO 2020a). Features of the foraging habitat include high seasonal primary production, upwelling, retention areas, and oceanographic frontal systems (Mosnier et al. 2018, DFO 2020a), all variables that influence the availability of food resources. Attributes that help predict the occurrence of Leatherbacks include sea surface temperature and chlorophyll-a for primary production, and bottom slope and sea surface height for oceanographic frontal systems (Mosnier et al. 2018). Telemetry data, surveys, and sightings can help explain Leatherback habitat use. For successful use of their foraging habitat, Leatherbacks need unimpeded space. Thermal regime influences the ecology of Leatherbacks (DFO 2020a). Additionally, prey availability may be affected by climate change, altering productivity in marine environments (NMFS-USFWS 2020). Information pertaining to the spatial extent of areas that have these habitat properties is presented in DFO (2020a).

To complete successful long-distance migrations, Leatherbacks need unimpeded space for navigation. Threats to this feature include fishing gear (which can result in entanglement), and vessels (which can interact with turtles, causing severe injury or mortality). Telemetry data, as well as sightings and survey data, are used to understand Leatherback use of migratory habitat. Habitat fragmentation is not a concern for the survival or recovery of the NWA subpopulation of Leatherback Sea Turtles, as there are no spatial constraints preventing them from moving between habitats.

## Element 8: Threats to Leatherback Sea Turtle Survival

Refer to DFO (2020b) for an assessment of threats to the NWA subpopulation segment of Leatherback Sea Turtle, as well as threats to individuals of that subpopulation segment that use Atlantic Canadian waters.

## Element 9: Threats to Leatherback Sea Turtle Habitat Properties

In Atlantic Canada, Leatherback Sea Turtle habitat supports turtle foraging and migration. Variables that negatively affect food availability, disrupt migration, or otherwise make Leatherback habitat unsuitable could threaten the function of this habitat.

Climate change impacts the distribution and seasonality of planktonic organisms (Edwards and Richardson 2004), including the gelatinous zooplankton Leatherbacks feed on (Purcell 2005, Smith et al. 2016), thereby affecting seasonal habitat use and potentially exposing them to additional threats. For example, a shift in the current temporal distribution of jellyfish prey in Atlantic Canada by only a few weeks could increase the overlap of Leatherbacks with fisheries that presently operate largely or entirely outside of the Leatherback foraging period in Canadian waters. This could result in enhanced entanglement rates. Additionally, climate change may directly impact the fisheries known to interact with Leatherbacks, prompting shifts in the timing and location of associated effort. Leatherback foraging habitat is expected to expand or shift with global warming, with a predicted increase in residency times at higher latitudes (McMahon and Hays 2006). This could prompt Leatherback Sea Turtles to migrate further to adapt to changing food distributions, requiring greater energy expenditure (Hawkes et al. 2009).

Marine pollution, including oil spills and contaminants, negatively impact the organisms Leatherbacks feed on. Oil spills and dispersants can cause tissue degradation in jellyfish (Echols et al. 2016). Jellyfish and oil concentrate in convergence zones, where Leatherbacks preferentially feed. Spills from offshore oil facilities and transportation networks could diminish the foraging habitat of Leatherbacks in Atlantic Canada. Likewise, contaminant loads in nearshore areas (e.g., harbours, ports, and inlets) poses a continuous threat to Atlantic Canadian waters. A major source of contaminant pollution is pollutant runoff from the St. Lawrence River into the Gulf of St. Lawrence, a high-use habitat for this species. However, there are few studies documenting impacts of contaminants on marine animal populations (e.g., St. Lawrence beluga (*Delphinapterus leucas)* population), despite concern surrounding impacts on the Gulf of St. Lawrence ecosystem, where additive effects with other contaminants and interactions with other environment stresses are a concern (Gilbert and Dufour 2008).

Although not under current consideration, if a commercial jellyfish fishery was implemented in parts of Atlantic Canada in the future, it could have devastating impacts on Leatherback foraging habitat. A jellyfish fishery, particularly one operating in Leatherback high-use areas, could diminish the available food supply and threaten the quality of foraging habitat.

Additionally, should a jellyfish fishery evolve, Leatherbacks might be especially vulnerable in areas of high jellyfish concentration, as the fishery might be expected to highly overlap with prime turtle foraging areas and pose an associated entanglement threat to turtles.

Leatherback foraging and migratory habitat is threatened by the presence of anthropogenic obstacles that inhibit safe and successful migration through Atlantic Canadian waters. Fishing gear in coastal and shelf habitats is a source of entanglement as Leatherbacks traverse these areas (DFO 2020b).

Although less understood, underwater noise could displace Leatherbacks from their preferred habitat and represents a potential threat to habitat. However, while noise is a known issue with marine mammals (Erbe et al. 2019), its impact on Leatherbacks is unknown.

## Element 10: Natural Factors

In the absence of anthropogenic threats, Leatherback Sea Turtles are presumed to be long lived. The species' generation time, age of maturity, low emergence success, long remigration intervals, and poorly understood juvenile life stage (also known as the "lost years"; referencing the time between when hatchlings first enter the ocean through to the size when they are again regularly observed as sub-adults) are important traits when considering population survival and recovery. While information on the juvenile period of development for the NWA Leatherback subpopulation is scarce, it is assumed that juveniles and hatchlings are subject to many of the same threats impacting sub-adults and adults, and likely additional threats too.

Predation is prevalent on nesting beaches, targeting eggs and hatchlings (e.g., insects, crabs, vultures, dogs, cattle, armadillos, raccoons, herons, gulls, raptors; NMFS-USFWS 2020), and at sea targeting hatchlings, juveniles, sub adults, and adults (e.g., carnivorous fishes, marine mammals, and sharks). Beach erosion threatens nesting habitat by reducing available nesting area and, in the shorter-term, washing away nests. Extreme climatic events can cause nest temperature changes, sand loss, tidal inundation, and deposit marine debris (e.g., *Sargassum*) onto beaches, reducing the amount of habitat that Leatherbacks can occupy. Extreme temperature changes can impact the sex ratios of Leatherback hatchlings by affecting egg incubation temperatures. Moreover, extremely high incubation temperatures can result in embryonic mortality. Extreme precipitation, followed by rapid evaporation and high temperatures can create both very dry and very wet conditions affecting embryonic development, decreasing hatchling production and success (Patino-Martinez et al. 2014, Santidrián Tomillo et al. 2015). Tidal inundation also accounts for nest loss (e.g., 33–42% loss in Panama, Patino-Martinez et al. 2008). Native and non-native beach vegetation affects nesting beaches in multiple ways, including obstructing nesting activity; lowering moisture content of sand; trapping hatchlings as they emerge from nests; and shading nests, which can impact nest incubation temperatures, and hatchling sex ratios (Leatherbacks are subject to temperature-dependent sex determination).

## Element 11: Ecosystem Factors

Bycatch is a widespread, serious threat affecting multiple marine species. It is considered the most significant threat to NWA Leatherbacks and the primary driver of declines observed in this subpopulation. An assessment of available bycatch data from fisheries in DFO Maritimes Region (2002–2006) demonstrated that the Canadian Atlantic pelagic longline fleet incidentally captured approximately 22 different species, including several sharks, birds, marine mammals, turtles, and other pelagic fishes (Gavaris et al. 2010). In Atlantic Canada, the Leatherback Turtle foraging period (summer-fall) occurs when the highest number of commercial fisheries are active. There have been reports of Leatherback interactions in a variety of gear types used in commercial fisheries, including trawls, gillnets, longlines (benthic and pelagic), hook and line, traps, pots, barrels, and trap nets (DFO 2012, Hamelin et al. 2017, DFO 2020c). However, that the inshore lobster fishery, which is often considered to be especially dangerous to Leatherbacks (and other species) because of the entanglement hazard associated with vertical lines present, is currently time-area managed in Atlantic Canada in such a way that associated fishing effort is low when Leatherbacks are present. Therefore, a shift in the temporal distribution of the Leatherback foraging period due to climate change could result in increases in entanglement rates in lobster (and potentially other) fisheries, akin to that observed in other jurisdictions, impacting not only Leatherbacks but other species (e.g., cetaceans).

Current bycatch monitoring efforts include fishery observer programs and mandatory fishery-dependent SARA logbook reporting. However, observer coverage is low and SARA logbook reporting biases are numerous (Hurtubise et al. 2020). There is a gross underestimate of Leatherback mortality associated with bycatch in Atlantic Canada (Hamelin et al. 2017). If bycatch were abated, particularly in a suite of gear types with high impact, it would benefit the survival and recovery of Leatherbacks and other animals that present as bycatch.

Ghost gear is fishing gear that has been abandoned, lost or otherwise discarded, and may present a larger entanglement threat than bycatch because ghost gear is, by its very nature, unattended, removing the possibility of live release. It is also difficult to discern if gear attached to stranded Leatherbacks was actively fished or ghost gear. There are no reports of Leatherback interactions with ghost gear in Atlantic Canada. However, as ghost gear is considered to be an active threat, eliminating this threat in Atlantic Canada would be expected to benefit the NWA Leatherback subpopulation. Currently there are initiatives in place (e.g., Sustainable Fisheries Solutions and Retrieval Support Contribution Program) to prevent and mitigate abandoned, lost, or otherwise discarded fishing gear in Atlantic Canada through reporting and retrieval of ghost gear throughout Canadian waters, responsible disposal of ghost gear, and investments in technologies that may reduce ghost gear in the future (DFO 2020d,e). The continuation and expansion of initiatives such as these will reduce the risk of turtle entanglement in ghost gear.

Underwater noise is a well-documented threat to marine mammals, especially cetaceans. However, impacts of noise are less understood for Leatherbacks. There are no documented Leatherback mortalities associated with underwater noise, and the behavioural and/or physiological effects have not been empirically demonstrated. Regardless, some measures are currently being implemented to mitigate the sound associated with seismic surveys (DFO 2007). While they are anticipated, measurable benefits have not yet been shown for Leatherbacks.

Marine pollution directly impacts both the Leatherback Sea Turtle and its habitat. Leatherbacks regularly forage in convergence zones, where both jellyfish and pollutants concentrate, potentially exposing them to the threat of incidental ingestion of oil and contaminants, as well as a potentially contaminated food supply. Plastic pollution can be associated with entanglement (e.g., polypropylene rope) and can also be ingested (Mrosovsky et al. 2009). Ingestion of plastics can block the digestive tract causing death and serious injury (DFO 2020c). Although it is not considered a primary threat to the species' recovery, abating marine pollution would benefit Leatherback habitat and reduce associated death and injury for many species inhabiting Atlantic Canadian waters. Water quality would also be enhanced, benefiting all flora and fauna in the ecosystem.

Vessel strikes are a threat affecting sea turtles (Foley et al. 2019), as well as marine mammals (Davies and Brillant 2019, Shoeman et al. 2020). Vessels can cause severe injury and death to the animals they contact. There has been evidence of vessels striking Leatherbacks in Atlantic

Canadian waters (DFO 2020c). If vessel strikes were reduced, there would be a decrease in corresponding injury and mortality rates among marine megafauna.

Climate change impacts the ecosystem widely, although the full extent and severity of associated changes cannot be predicted. In Atlantic Canada, climate change may alter the distribution of the Leatherback's gelatinous planktonic food supply, with accompanying changes in turtle distributions. Ocean warming may result in exploitation of new foraging areas by Leatherbacks or a temporal shift in their use of present-day foraging areas. Either result could potentially increase the overlap of Leatherback-fishery distributions, enhancing the species' vulnerability to present sources of entanglement, and/or expose Leatherbacks to a new suite of anthropogenic hazards (fisheries or otherwise) on their foraging grounds.

## Element 12: Abundance and Distribution Targets

While present in Canadian waters, adult and sub-adult Leatherback Sea Turtles pursue an entirely marine existence, are broadly distributed, and spend much of their time at depth; therefore, population abundance throughout this region has not yet been quantified. Aerial surveys targeting marine megafauna have been completed in Atlantic Canada; however, a standardized, accurate abundance estimate for Leatherbacks cannot yet be obtained from aerial data due to factors outlined in Element 2. Archibald and James (2016) analyzed relative leatherback abundance at a single site in coastal waters off Nova Scotia from 2002–2015 using haphazard, unmarked, linear transects. Sightings throughout these surveys (n = 564) suggested a mean density of 9.8 Leatherbacks per 100 $km^2$, with high inter-annual variability. These surveys corresponded to a small area, were subject to availability biases and employed opportunistic methods (Archibald and James 2016). For these reasons, this study cannot be used to generate a Leatherback abundance estimate for the greater Northwest Atlantic. In addition to opportunistic sightings, some inference may be drawn from reported interactions with Atlantic Canadian fisheries. Mandated SARA logbooks recorded 477 reports of leatherback interactions from 2006–2017 (Hurtubise et al. 2020), and 205 leatherback interactions with fixed gear fisheries were publicly reported from 1998–2014 (Hamelin et al. 2017). Due to a number of reporting biases, these results underestimate true interaction rates. Due to challenges associated with estimating in-water abundance of Leatherbacks in Atlantic Canadian waters, the use of recent index abundances for the broader NWA subpopulation, based on terrestrial counts of nesting turtles, is more appropriate for determining current abundance and future targets.

Currently, no method has been implemented to measure Leatherback abundance across the species' entire range in Atlantic Canada. Therefore, a quantitative abundance estimate cannot be proposed. However, to achieve the recovery goal of increasing the number of Leatherbacks in the broader NWA subpopulation by maintaining or increasing the number of adult and subadult Leatherbacks using Atlantic Canadian waters, effort must be directed to reduce human-induced interactions and mortalities, support the continued Leatherback use of Canadian waters as core foraging habitat, and continue efforts to monitor timing and movements of Leatherbacks directly (through surveys and bycatch reporting) and remotely (through biotelemetry).

## Element 13: Population Trajectories

There are limited data available to project population trajectories for Leatherbacks that use Atlantic Canadian waters. However, these Leatherbacks are part of the broader NWA subpopulation and, therefore, it is most relevant to assess the trajectory of this subpopulation, as indexed by nesting trends. In a recent review of the NWA Leatherback subpopulation, the U.S. National Marine Fisheries Service and U.S Fish and Wildlife Service estimated the amount of time it would take for nesting females in this subpopulation to decline by 50% in order to assess whether the subpopulation was at risk of extinction now or in the foreseeable future (NMFS-USFWS 2020). Parameters used in this estimation include mean time to maturation (approximately 19 years; Avens et al. 2020) as well as mean nesting longevity (approximately 11 years; Avens et al. 2020). The generation time for this subpopulation was approximated at 30 years (NMFS-USFWS 2020), which is a reasonable time frame to project population trajectories. Based on current abundance estimates (through counts of mature nesting females) and these life-history parameters, the NWA Leatherback subpopulation is projected to continue to decline. Current best available data estimate that the number of nesting females will decrease by 50% within 8–28 years, based on various scenarios (Table 4). All of these scenarios involve this subpopulation declining by 50% within one generation time (30 years) (NMFS-USFWS 2020).

*Table 4. Adapted from NMFS-USFWS (2020): summary of 3 scenarios used in an extinction risk analysis, and the projected decline of the subpopulation (assumptions: mean time to maturation = 19 years, mean nesting longevity = 11 years, generation time = 30 years).*

| Scenario | Population Index | Change in population | Projected NWA subpopulation decline |
|---|---|---|---|
| 1 | Incidental capture in Trinidad gillnet fishery adjacent to index nesting beaches | Annual mortality of 1,000 adults (assume 500 females) | Total nester abundance decrease by 50% in 28 years |
| 2 | Regional nest trend data from Northwest Atlantic Leatherback Working Group 2018 | 9.32% decline in nesting females from 2008–2017 (95% CI:12.9–5.5%); a 4.21% decline in nesting females from 1990–2017 (95% CI: 6.66–2.23%) | Total nester abundance decrease by 50% in 8 (95% CI: 6–13 years)–17 years (95% CI 11–31 years) |
| 3 | Nest trend data from highest abundance nesting beaches in the NWA (Trinidad) | 7.32% decline in nesting females annually (95% CI: 34–18%) | Total nester abundance decrease by 50% within 10 years (95% CI: 3 years to never[1]) |

*[1]"Never is highly unlikely, as there's a 75% chance that the true value is negative (f = 0.754; NMFS-USFWS 2020"*

The largest Leatherback nesting assemblages in the NWA occur in Trinidad, French Guiana, and Panama, where catastrophic events or declines could have a disproportionately large impact on the Norwest Atlantic subpopulation as a whole (NMFS-USFWS 2020). The threat of incidental capture of females nesting in Trinidad was included as extinction risk scenario 1 in Table 4, as this threat has been identified as a source of high mortality in coastal waters off index nesting beaches (NMFS-USFWS 2020). The Trinidad nesting assemblage holds particular importance to Canada's foraging population, as genetic analyses indicate it is a key source population for Leatherbacks found in Atlantic Canada (Stewart et al. 2013).

All Leatherback population abundance indices, and associated population trajectories, are based on mature female nesting abundance. To calculate regional decline over recent and long-term time scales (scenario 2), beaches with long-term (over 10 years) nesting data were considered (Northwest Atlantic Leatherback Working Group 2018). To derive the nest trend data from index beaches (scenario 3), data from high abundance nesting beaches were considered over the previous 3 years (NMFS-USFWS 2020). Based on the current available data from recent abundance and population trajectory analyses, the NWA subpopulation is not anticipated to meet recovery targets identified in Element 12.

## Element 14: Suitable Habitat

Habitat availability is not considered a limiting factor for Leatherback population growth in Atlantic Canada. Satellite telemetry data from 128 Leatherback Sea Turtles confirmed annual seasonal use of Atlantic Canadian waters over 19 years, with tracked turtles indicating consistent use of several areas (DFO 2020a). Atlantic Canadian waters represent an important foraging site for Leatherbacks, with high foraging activity occurring in three areas: (1) waters east and southeast of Georges Bank, including the Northeast Channel near the southwestern boundary of the Canadian EEZ; (2) the southeastern Gulf of St. Lawrence and waters off eastern Cape Breton Island, including Sydney Bight, the Cabot Strait, portions of the Magdalen Shallows and adjacent portions of the Laurentian Channel; and (3) waters south and east of the Burin Peninsula, Newfoundland, including parts of Placentia Bay (DFO 2020a). Beyond these high use foraging areas, Leatherbacks use waters throughout the Canadian NWA for foraging and migration, and they broadly distribute themselves throughout this region each summer. If the NWA Leatherback Sea Turtle subpopulation numbers were to increase, there is no current evidence to suggest that foraging habitat in Atlantic Canadian waters would be limiting. However, foraging habitat is primarily driven by prey availability, and changing climates can alter productivity in marine environments, which, in turn, could affect Leatherback prey availability and distribution (NMFS-USFWS 2020, Nordstrom et al. 2020). To identify potential changes in the seasonal distribution of these turtles, continued monitoring of Leatherback Sea Turtle distribution throughout Canadian waters is recommended.

## Element 15: Population Projections

Considering current best available data for nesting females within the Northwest Atlantic subpopulation, Leatherbacks are facing a steep population decline. Productivity parameters, such as clutch frequency and hatchling success, have decreased at highly-monitored nesting beaches (NMFS-USFWS 2020) and, in recent assessment, most nesting beaches in the NWA displayed negative trends in annual nesting abundance from 2008–2017 (Northwest Atlantic Leatherback Working Group 2018). The recovery goal is to increase the number of Leatherbacks in the broader NWA subpopulation by maintaining or increasing the number of adult and subadult Leatherbacks using Atlantic Canadian waters as foraging habitat Given the present population trajectory combined with the species' life history characteristics, the NWA Leatherback subpopulation is not currently on track to meet this recovery goal.

Mortality rates affecting Leatherbacks at different life-history stages remain unknown. Due to their highly migratory nature, natural mortality rates for juvenile, sub-adult, and adult Leatherbacks are unclear. In Canadian waters, anthropogenic threats have been identified (namely incidental entanglement in commercial fisheries); however, the level of impact these threats have on population abundance remain unknown. A low level of observer coverage exists across most Canadian Atlantic commercial fisheries, with some fisheries receiving little-to-no coverage (e.g., pot and trap net fisheries). Additionally, post-release mortality remains unknown for Leatherbacks interacting with Atlantic Canadian fisheries. Due to these factors, the extent of Leatherback mortality within Atlantic Canadian waters cannot be accurately estimated, and, therefore, projections cannot be made about the rate at which changes in anthropogenic mortality would affect the probability of population recovery. However, it is reasonable to predict that reducing mortality in Canadian waters will contribute to supporting an increase in the number of Leatherbacks using Atlantic Canadian waters (recovery target).

## Element 16: Mitigation Measures

Incidental interactions with fisheries have been identified as a principal threat to Leatherbacks in their foraging habitat (NMFS-USFWS 2020, Hamelin et al. 2017, Archibald and James 2018). Measures to reduce turtle bycatch in gillnets have been identified for potential application in nearshore waters of Trinidad, currently considered to be an area of high Leatherback Sea Turtle-fishery interactions. Eckert and Gearhart (2009) identified a plan to reduce Leatherback bycatch specifically on the North and East coasts of Trinidad, which are adjacent to what are currently the highest density nesting beaches in the Guiana Shield region. Mitigation measures included the creation of turtle-safe nets (with a reduced length of no more than 20 m and a reduced mesh depth of no more than 50 meshes) and use of hook and line fishing methods. These methods have not been mandated by the Fishery Division and few fishers have voluntarily adopted them (Eckert and Gearhart 2009).

Efforts to reduce the amount of pot and trap fishing gear using vertical lines in the water column may reduce fisheries impacts on the NWA Leatherback subpopulation (NMFS-USFWS 2020). For these fisheries, mandating intervals for checking gear could reduce their impact, as severity of injuries and risk of mortality to entangled Leatherbacks increases with time (Hamelin et al. 2017). The use of ropeless, vertical line-free fishing gear (or pop-up gear systems) incorporating acoustic marking and retrieval or GPS marking and grappling have been identified as a potential tool for reducing North Atlantic Right Whale interactions (Myers et al. 2019); however, implementation of ropeless fishing gear would likely reduce Leatherback entanglement rates too. Testing of associated technologies is ongoing, and ropeless gear has yet to be mandated in the Northwest Atlantic.

Time-area management of fishing activities when Leatherback Sea Turtles are present could afford some level of protection (NMFS-USFWS 2020). For example, seasonal closures have been implemented in specific areas of the Mid-Atlantic Exclusive Economic Zone of the United States, with closures pertaining to any gillnets equal to or larger than 7-inch mesh to reduce bycatch of Bottlenose Dolphin as well as all sea turtle species (NMFS 2006). Leatherback Conservation Areas have been proposed directly off nesting beaches on the East and North coasts of Trinidad, where the majority of Leatherback nesting occurs. If established, these areas would prohibit use of all surface drift gillnets from February through October to reduce Leatherback bycatch and mortality during the nesting season (Eckert 2013). Seasonal closures to protect sea turtles have been implemented in other nesting countries, including Suriname, where a seasonal no fishing zone was initiated in 2001 to protect turtles from incidental capture during the nesting season. However, increased public education about these closed areas is required to improve fisher compliance (Madarie 2006). To date, seasonal closures have not been implemented off high-density index nesting beaches such as Grande Riviere and Matura, Trinidad. Additional time-area closures in regions with localized high rates of bycatch may be beneficial to the NWA Leatherback subpopulation.

Pelagic longline fisheries have been extensively monitored in the NWA, in part because corresponding vessels provide a good platform for broad, multi-species scientific sampling and associated countries have trade-related commitments in place to meet data-reporting requirements of international management organizations (e.g., International Commission for the Conservation of Atlantic Tunas). A result has been long-term data collection on fishing effort, target species catch, and bycatch in these fisheries. Both Canada and the United States have implemented modifications to reduce bycatch and post-release mortality of various sea turtle species in pelagic longline fisheries. These modifications include mandating hook sizes and/or types (i.e., circle hook). Continued monitoring of these fisheries, and increased monitoring effort in fixed gear fisheries, would identify patterns of turtle bycatch (and changes in these patterns).

Such data can help assess patterns of bycatch over time, evaluate the efficacy of current bycatch mitigation measures, and/or highlight the need for additional conservation interventions.

As marine waste, abandoned or discarded fishing gear (ghost gear) poses an entanglement risk to a variety of marine species, including whales and sea turtles. While reporting of lost fishing gear has been previously mandated in Canadian fisheries, additional efforts to reduce ghost gear in Atlantic Canadian waters have recently been implemented. In 2020, DFO implemented the Sustainable Fisheries Solutions and Retrieval Support Contribution Program, which involves a variety of activities to reduce ghost gear in Atlantic Canada (DFO 2020d). These activities include the retrieval of ghost gear throughout Canadian waters, responsible disposal of ghost gear, and investments in technologies that may reduce ghost gear in the future. The continuation and expansion of initiatives such as these will reduce the risk of turtle entanglement.

In addition to fisheries interactions, Leatherbacks may face additional anthropogenic threats while in Canadian waters, though associated impacts on this subpopulation are often less clear. Dow Piniak et al. (2012) studied auditory sensitivity in Leatherback Sea Turtle hatchlings and determined that hatchling auditory sensitivity ranges overlap with frequencies produced by sources of marine noise, including drilling, shipping, pile driving, and wind turbines. Comparable studies have not been completed on adult Leatherbacks, but it is possible that underwater sound may impact Leatherbacks within their foraging habitat. Additional research is required to understand this threat and develop mitigation measures, if necessary.

## Element 17: Productivity or Survivorship Parameters

Quality of foraging habitat and individual foraging success are linked to the productivity of sea turtle populations, with impacts on remigration intervals and annual numbers of nesting females (Hays 2000, Garner et al. 2017). Nordstrom et al. (2020) used Generalized Linear Modelling (GLM) to conclude that jellyfish presence and biomass increased with increased Sea Surface Temperature (SST), and that both factors increased over time in Atlantic Canadian waters from 2006–2017. As waters continue to warm, it is predicted that Leatherback prey fields may be altered, either by a change in the seasonality of jellyfish growth and senescence or in a northward shift of jellyfish abundance, which may affect the distribution of Leatherbacks in Atlantic Canada (Nordstrom et al. 2020, Sherrill-Mix et al. 2007). Continued monitoring of the distribution of Leatherback Sea Turtle prey fields is recommended to discern changes in foraging opportunities and, therefore, potential changes in NWA Leatherback subpopulation productivity.

Leatherbacks normally nest on high-energy coastlines, including those corresponding to portions of eastern Florida, the northern Caribbean, the western Caribbean, the Guianas and Trinidad (Northwest Atlantic Leatherback Working Group 2018). In addition to shifting beach dynamics, many Leatherback nesting beaches have been threatened by anthropogenic activities including beach stabilization and placement of erosion reduction structures, beach development, and construction (Dow et al. 2007, Flores and Diez 2016). In addition to reducing any activities that may artificially cause nesting habitat loss, regional monitoring of beach loss and deposition patterns could help distinguish between shifting beach dynamics and true habitat loss.

## Element 18: Feasibility of Restoring Habitat

Currently, there are no data that suggest suitable Leatherback Sea Turtle foraging habitat in Atlantic Canadian waters is limited. Analyses of Leatherback Sea Turtle foraging behaviour in shelf waters off Nova Scotia indicates Leatherbacks can consume enough prey within a foraging season to account for 59% of a non-breeding turtle's annual energy budget, and 29% of a breeding female turtle's energy budget (Wallace et al. 2018).

## Elements 19, 20, and 21: Mortality Rate, Population Trajectory and Parameter Values

Elements 19–21 are not addressed in this document, as interaction rates, mortality rates, and post-release survival of Leatherbacks interacting with fisheries in Atlantic Canadian waters are unknown. If implemented successfully, and monitored diligently, it is anticipated that mitigation measures in commercial fisheries could reduce incidental bycatch and anthropogenic mortality. However, due to insufficient data, it is not possible to quantify changes in NWA Leatherback productivity or population recovery. The NWA Leatherback subpopulation is projected to continue to decline, with mature nesting female abundance predicted to decrease by 50% in the next 8–22 years (NMFS-USFWS 2020). As mortality rates are unknown, predictions cannot be made as to how this subpopulation would respond to mitigation measures and how these measures may alter the current projections.

## Element 22: Allowable Harm Assessment

Previous estimates of trends in the NWA Leatherback subpopulation concluded that it was generally stable or potentially increasing in certain areas (TEWG 2007, DFO 2004). However, recent nesting data from most nesting sites in the Northwest Atlantic have shown that the opposite trend is occurring and predicted to continue. Regionally, nest abundance in the NWA Leatherback Sea Turtle subpopulation has declined by 4.21% (CI: -6.66% to -2.23%) annually since 1990, with a decline of 9.32% (CI: -12.9% to -5.57%) annually from 2008–2017 (Northwest Atlantic Leatherback Working Group 2018). The average number of total nests per year have declined by 60% between past (approximately 58,000; approximately 3 generations ago) and current (approximately 23,000; 2013–2017) estimates (Northwest Atlantic Leatherback Working Group 2019). Based on currently available data, the NWA Leatherback subpopulation is indisputably in decline.

Fisheries interactions have been identified as the principal threat to Leatherbacks throughout their range, with interactions documented at the juvenile, sub-adult, and adult life stages (NMFS-USFWS 2020, DFO 2020b, Dow et al. 2007, Hamelin et al. 2017). Interactions between Leatherbacks and fisheries are believed to be especially frequent and impacting off nesting beaches, where artisanal gillnet and trawl fisheries operate in nearshore and offshore waters. For example, in Trinidad, it is estimated that approximately 3000 Leatherbacks are captured in coastal gillnets each nesting season, with an estimated mortality rate of 30% (Lee Lum 2006).

In Atlantic Canada, pelagic longline fisheries account for the largest number of observed Leatherback interactions with 477 reports through SARA logbooks from 2006–2017 (Hurtubise et al. 2020). The majority of these interactions are reported from pelagic longline fisheries. However, the relatively high number of interactions reported from this fishery versus other fisheries is principally due to the enhanced availability of corresponding data rather than true interaction rates (Hurtubise et al. 2020). In fixed gear fisheries, 205 Leatherback interactions were publicly reported from 1998–2014. Due to inherent biases associate with self-reporting, this is considered a gross underestimate of true interaction rates with these fisheries (Hamelin et al. 2017).

Though interactions between Leatherbacks and Canadian Atlantic fisheries occur regularly, these interactions are not expected to represent a significant contribution to the decline of the NWA Leatherback subpopulation. Therefore, some scope for allowable harm exists at this time in Atlantic Canadian fisheries. As data are limited related to interactions between Leatherbacks and fisheries in Canadian waters, an increase in monitoring is required to quantify the extent of Leatherback bycatch. Evaluating the relative threat Canadian fisheries pose to Leatherbacks should include consideration of the spatial and temporal overlap of various fisheries (especially those deploying gear most likely to interact with Leatherbacks) with patterns of Leatherback foraging activity. For example, the inshore lobster fishery deploys more vertical lines (a key entanglement hazard for Leatherbacks) than any other fishery in Atlantic Canada. However, Lobster Fishing Areas (LFAs) along much of the Scotian Shelf are closed to fishing by June 30, and more northerly LFAs off Cape Breton Island are closed by mid-July, before most Leatherbacks arrive in these areas. Similarly, by the time lobster fishing resumes in the fall, most Leatherbacks have departed shelf foraging areas. Therefore, there is currently relatively low spatial-temporal overlap of the inshore lobster fishery with Leatherbacks in Atlantic Canada, diminishing the entanglement risk this fishery poses to the NWA subpopulation. While the minimal overlap of this fishery with Leatherbacks in Atlantic Canada is coincidental rather than deliberate, this case reinforces the need for careful consideration of potential entanglement impact before changing the timing or spatial extent of any existing fisheries in Atlantic Canada.

Satellite telemetry can provide insight into the survival of Leatherbacks post-tagging, including where tagged individuals may be less vulnerable to fisheries interactions. Of 133 Leatherbacks tracked in Canadian waters from 1995 to 2019, only 6.02% (n = 8) of deployments have ceased transmissions while in Canadian waters (Figure 2), and, of these, 4 deployments represented turtles tracked for more than a year, when battery depletion becomes increasingly probable. There are a number of reasons satellite tag transmissions cease, including battery depletion, detachment failure, instrument failure, tag damage, or death of the turtle (Hays et al. 2007, Hamelin and James 2018). While inference cannot be made to explain why the small number of satellite tags stopped transmitting in Canadian waters, this dataset suggests the majority of Leatherbacks survived their foraging season in Atlantic.

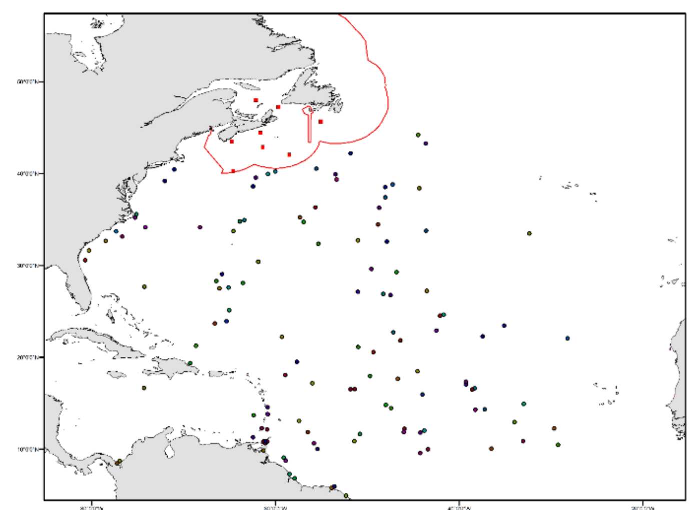

*Figure 2. Locations of last satellite tag transmissions from 133 Leatherback Sea Turtles tracked into Canadian waters.*

While a previous allowable harm assessment (DFO 2004) suggested that the NWA Leatherback population numbered in the hundreds of thousands of individuals, recent studies using quantitative data from index nesting beaches indicate that the current population is only a small fraction of that, and it is continuing to decline. Human-induced harm should be reduced to the fullest extent possible throughout the NWA Leatherback Sea Turtle's range, and all life stages, to assist with population recovery. In Canadian Atlantic fisheries, every feasible effort should be made to monitor interactions with Leatherbacks, including continued emphasis on mandatory reporting of interactions, increased fishery observer effort, and promotion of programs to collect volunteered data. Available data on these interactions should be reviewed and re-assessed regularly (at least every 5 years) in Atlantic Canada and the NWA more broadly, to evaluate the impact of Canadian and international fisheries on population recovery. These reassessments will be critical to determining if, and to what level, allowable harm should continue in Canadian Atlantic fisheries.

### Sources of Uncertainty

This assessment highlights numerous sources of uncertainty, including the extent of current natural and anthropogenic threats to Leatherback Sea Turtles. Biases in current monitoring methods (including fisheries observer data and SARA logbooks) preclude accurate estimation of fisheries interactions, as well as accompanying mortality, and likely underestimate bycatch rates. There remains limited information on the vulnerability of Leatherback Sea Turtles to marine noise, vessels strikes, and ingestion of marine debris in Canadian waters.

Certain key Leatherback life-history parameters remain unconfirmed, including wild growth rates, life expectancy, and natural mortality rates at all life stages. Recent NWA population estimates differ based on data sources and methods of calculation they employ, and numerous caveats surround the use of nesting data to derive population estimates and trajectories (NMFS-USFWS 2020).

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## SOURCES OF INFORMATION

This Science Advisory Report is from the December 10–11, 2020 zonal advisory meeting on Recovery Potential Assessment (RPA) for Leatherback Sea Turtle, Northwest Atlantic Subpopulation. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.


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