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Canadian Science Advisory Secretariat
Maritimes Region **Science Response 2017/014**

THREAT ASSESSMENT FOR LOGGERHEAD SEA TURTLE (*CARETTA CARETTA*), NORTHWEST ATLANTIC POPULATION

Context

The Loggerhead Sea Turtle (*Caretta caretta*) (assessed as endangered, COSEWIC 2010) was recommended for addition to Schedule 1 of the *Species at Risk Act* (SARA) on August 27, 2016 (Government of Canada 2016). If the decision is made to list the species under SARA, a proposed recovery strategy must be posted on the Species at Risk Public Registry within one year of listing (SARA, s. 42[1]).

For aquatic species, SARA recovery strategies require the inclusion of a threat assessment based on Fisheries and Oceans Canada's (DFO's) Guidance on Assessing Threats, Ecological Risk and Ecological Impacts for Species at Risk (DFO 2014a). Threat assessments inform species listing recommendations, recovery strategies, and action plans (DFO 2014a). Information on threats is needed to plan and prioritize recovery measures for the species, and to inform the regulatory and management decisions made by DFO regarding human activities that interact with the species. Threat assessments are normally completed as part of the Recovery Potential Assessment (RPA) for the species (DFO 2014b). At the Loggerhead Sea Turtle RPA, threats were described briefly (DFO 2010a); however, a threat table for the Loggerhead Sea Turtle was not completed. Since that time, new threat assessment guidance has become available (DFO 2014a).

Loggerhead Sea Turtles found in Atlantic Canadian waters belong to the Northwest Atlantic Ocean Designatable Unit (DU), which is referred to as the Northwest Atlantic Distinct Population Segment (DPS) in the United States (US) recovery documents. Because the US Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle (NMFS-USFWS 2008a) forms the basis for much of this assessment, this report refers to the Loggerhead Sea Turtle population as the "Northwest Atlantic population".

This report identifies the Threat Risks (see Table 1 for definition of "Threat Risk") for Loggerhead Sea Turtles when they are in Atlantic Canadian waters and also throughout their entire range in the Northwest Atlantic. Assessing the Threat Risk within the entire range of the population provides context for the recovery of this species within Atlantic Canadian waters and allows for a comparison of threats in Atlantic Canada relative to threats occurring throughout the Northwest Atlantic.

This Science Response Report results from the Science Response Process of December 12, 2016, on the Threat Assessment for Loggerhead Sea Turtle (*Caretta caretta*), Northwest Atlantic Population.

Background

Loggerhead Sea Turtles in Canada were assessed as endangered by COSEWIC (2010) due to declines in the Northwest Atlantic Ocean, shown by declining numbers of nests and nesting females dating to 2007-2008. Since the COSEWIC (2010) assessment, the trajectory for the Northwest Atlantic population has been uncertain, and may be increasing. Nest numbers from Florida's 27 core index beaches from 2007 to 2016 increased; however, more years of data are needed to determine trends (FFWCC 2016).

In Atlantic Canadian waters, Loggerhead Sea Turtle population estimates are not available. For the Northwest Atlantic population as a whole, some population estimates are available; however, there are limitations and uncertainties associated with these studies (DOI 2011) and therefore a reliable abundance estimate does not exist. Annual nest counts are the only reliable quantitative estimates available and are converted to annual numbers of nesting females. Mean annual numbers of nests in the Northwest Atlantic from 1989-2008 were used to calculate a mean number of 17,288 nesting females for all recovery units[1] in the Northwest Atlantic except the Greater Caribbean Recovery Unit for which data are not available (NMFS-USFWS 2008a).

Loggerhead Sea Turtles are vulnerable to threats through all of their life stages, from egg to adult, in a variety of habitat types both within and outside of Canada. The distribution of the Northwest Atlantic population includes Canadian, US, and Caribbean waters but also the Northeast Atlantic including the Mediterranean Sea where Northwest Atlantic Loggerhead Sea Turtles overlap with Loggerhead Sea Turtles from the Northeast Atlantic DPS and the Mediterranean DPS (DOI 2011).

The National Marine Fisheries Service and US Fish and Wildlife Service, herein referred to as NMFS-USFWS, identify Loggerhead Sea Turtle life stages[2] and the ecosystems in which they are found:

- Nesting female (terrestrial zone)
- Egg (terrestrial zone)
- Hatchling (terrestrial zone)
- Hatchling swim frenzy/transitional stage (neritic zone)
- Juvenile (neritic and oceanic zones)
- Adult (neritic and oceanic zones)

In the past, it was thought that Loggerhead Sea Turtles underwent an ontogenetic shift from oceanic zones as small juveniles to neritic zones as larger juveniles where they would remain until becoming reproductive adults. Satellite tagging studies such as those by McLellan and Read (2007) and Mansfield et al. (2009) found that juvenile Loggerhead Sea Turtle habitat use is more complex than this, with larger individuals sometimes moving back into oceanic habitats after spending time in the neritic zone.

[1] Recovery units are nesting assemblages defined by NMFS-USFWS (2008a) based on geographic isolation and geopolitical boundaries and are as follows: Northern Recovery Unit (Florida / Georgia border north to Virginia), Peninsular Florida Recovery Unit, Dry Tortugas Recovery Unit (West of Key West, FL), Northern Gulf of Mexico Recovery Unit, and the Greater Caribbean Recovery Unit.

[2] COSEWIC (2010) provides a different breakdown of life stages (based on TEWG 2009), which are defined primarily by size (straight carapace length). For the purpose of this report, the life stages identified by NMFS-USFWS (2008a) are used.

Within Atlantic Canada, small and large juveniles are present. Curved carapace lengths were measured from 119 Loggerhead Sea Turtles between 2010 to present ranging from 50.5 – 95 cm (Mike James pers. comm. 2016). Larger juveniles likely include individuals that may have re-entered the oceanic zone after shifting into neritic feeding grounds.

Threats to Loggerhead Sea Turtles within the broader Northwest Atlantic can affect the number of juveniles that come into Atlantic Canadian waters. Likewise, threats in Canada can affect the number of Loggerhead Sea Turtles that survive to reproductive ages, thereby influencing the recovery of the population. Studies referenced in COSEWIC (2010) suggest that improving the survival of juvenile Loggerhead Sea Turtles would be more effective in maintaining the population than earlier life stages, because the reproductive value of juveniles as they transition into adulthood is higher.

Recovery of Loggerhead Sea Turtle populations is complicated not only by a multitude of threats affecting them at all life stages, but also by biological limitations that include late maturity (16 – 34 years), nesting only every 2-3 years, and high egg and hatchling mortality (COSEWIC 2010).

DFO 2014a defines a threat as:

> "Any human activity or process that has caused, is causing, or may cause harm, death, or behavioural changes to a wildlife species at risk, or the destruction, degradation, and/or impairment of its habitat, to the extent that population-level effects occur. A human activity may exacerbate a natural process."

The RPA (DFO 2010a) provides information on sources of harm and mortality to Loggerhead Sea Turtles in Atlantic Canadian waters, noting that the only recorded source of human-induced harm or mortality is bycatch in the pelagic longline fishery. This is the only fishery in Atlantic Canada with observed Loggerhead Sea Turtle interactions. The RPA notes other potential threats, although provides little detail on them: vessel strikes, pollution, ingestion of marine debris, entanglement, noise and light from offshore activities, and climate change. The lack of documented mortalities from these threats may indicate a paucity of information, rather than that they have not occurred (DFO 2010a).

Analysis and Response

Methods

This threat assessment follows DFO 2014a guidance to the extent possible in the context of limited data and information on Loggerhead Sea Turtles within Atlantic Canadian waters and throughout the broader Northwest Atlantic[3]. DFO's guidance for assessing threats (DFO 2014a) provides quantitative definitions for characterizing threats (e.g. Likelihood of Occurrence, Level of Impact, and Threat Extent) that require abundance estimates; however, abundance estimates within Canada are not available and estimates for the Northwest Atlantic population are not reliable. As a result, application of DFO 2014a guidance was followed with modifications as described below.

This assessment includes threats identified in the RPA as well as major threats affecting the Northwest Atlantic population that occur outside of Canada, where Loggerhead Sea Turtles spend the majority of their time. Assessing threats outside of Canada is important in setting the

[3] It is possible that juveniles found in Atlantic Canada are part of the Northeast Atlantic population (e.g., nesting beaches primarily in Cape Verde) (DOI 2011). This threat assessment does not assess threats to the Northeast Atlantic population occurring outside of Canada, as the abundance of these individuals in Canada is not expected to be high.

context for recovery of the species in Atlantic Canada. Threats assessed for both the Northwest Atlantic population as a whole and Canada are:

- Bycatch in fisheries
- Entanglement (from debris such as ghost fishing gear)
- Underwater noise
- Marine pollution (contaminants and debris ingestion)
- Vessel strikes

Threats assessed that occur outside of Canada are:

- Harvesting (legal and illegal)
- Coastal development and beach use
- Artificial light

These threats are discussed in detail in COSEWIC (2010) and in NMFS-USFWS (2008a).

For each threat, several elements are examined, as defined in DFO 2014a: Likelihood of Occurrence, Level of Impact, Causal Certainty, Population Threat Risk, Threat Occurrence, Threat Frequency, and Threat Extent. Each element is characterized using the definitions provided in DFO 2014a to the extent possible. Detailed methods and interpretations of DFO guidance (DFO 2014a) for the purpose of this assessment are provided in Table 1.

The precautionary approach was applied when characterizing threat elements for which limited or inconclusive information was available, or in cases of uncertainty. In these situations, higher characterizations were selected; for example, Threat Extent was characterized as “Broad” rather than “Narrow” for vessel strikes in the Northwest Atlantic (see the following section for rationale).

The rationales for the assignment of each characterization for Likelihood of Occurrence, Level of Impact, Causal Certainty, Threat Frequency, and Threat Extent are detailed in the Results sub-section titled “Rationalization for Threat Characterization”. Rationales are not provided for Threat Occurrence because all threats are characterized as current. Threat Risk does not require a rationale, as it is based on a formula in DFO 2014a that considers Likelihood of Occurrence and Level of Impact (refer to Table 1 for more information).

As per the threat assessment guidance (DFO 2014a), climate change and trophic changes are not characterized within the threat assessment table (Table 2). These threats to Loggerhead Sea Turtles and their habitat in Canadian waters have not been documented or quantified (DFO 2010a); however, they are likely to have implications for Loggerhead Sea Turtle distribution and/or abundance within Canadian waters. Climate change may affect the Northwest Atlantic population as a whole, with sea level rise reducing available nesting areas and warming temperatures affecting nest incubation success and influencing temperature-dependent sex ratios (Carthy et al. 2003; Witt et al. 2010). At sea, Loggerhead Sea Turtle distribution, foraging patterns and temperature tolerance could change due to rising temperatures and changing current patterns (Witt et al. 2010), which can also affect Loggerhead Sea Turtle prey availability (Conant et al. 2009).

The threat assessment does not take cumulative effects into account. With all threats combined, the overall Threat Risk for Loggerhead Sea Turtles in the Northwest Atlantic population would likely be high.

Table 1. Methodology for Loggerhead Sea Turtle Threat Assessment based on DFO 2014a

Threat Evaluation Criteria	Methods
Likelihood of Occurrence	*DFO 2014a Definition*: "The likelihood of occurrence applies to a specific threat occurring over 10 years or 3 generations, whichever is shorter. For Loggerheads, the shorter period is 10 years (one generation is approximately 46 years [COSEWIC 2010])." Categories: known or very likely to occur (known), likely to occur (likely), unlikely, remote, unknown. Likelihood of Occurrence was determined based on evidence of threat occurrence as noted in COSEWIC (2010), the National Marine Fisheries Service and US Fish and Wildlife Service threat assessment (NMFS-USFWS 2008a), and other studies. Expert opinion was used to determine the Likelihood of Occurrence in Canadian waters when information was absent. A precautionary approach was taken in these cases by using a high ranking of Likelihood of Occurrence (e.g., there have been no observed incidences of marine pollution having an effect on Loggerhead Sea Turtle populations; however, this threat was determined to be "Likely" rather than using a lower ranking such as "Remote").
Level of Impact	*DFO 2014a Definition*: "Level of impact: the magnitude of the impact caused by a given threat, and the level to which it affects the survival or recovery of the population." Categories: unknown, low, medium, high, extreme. There is no population estimate for the Northwest Atlantic population of Loggerhead Sea Turtles (all size classes), nor for the portion of the population using Canadian waters. Therefore, a quantitative assessment of effects on population (as per DFO 2014a) cannot be completed. As an alternative, the following methods were applied: **Northwest Atlantic Methods:** the NMFS-USFWS Threats Analysis for Loggerheads in the Northwest Atlantic (NMFS-USFWS 2008a, Appendix 1; Bolten et al. 2011) was used to determine the Level of Impact. • Annual mortalities identified by NMFS-USFWS for each threat were ranked as low, medium, high, or extreme (following with DFO [2014a] guidance) (see Appendix A). • Annual mortalities were estimated using the best available information[1] and were presented as a range (e.g., 1-300), with total mortality identified as the log midpoint (NMFS-USFWS 2008a)[2]. It is possible that mortalities are underestimated or possibly even overestimated due to data limitations and uncertainties. Annual nesting female mortalities should be considered an underestimate as a precautionary approach, unless information is provided to suggest otherwise. • Note that annual mortalities in the NMFS-USFWS (2008a) threat assessment were converted into mortalities of nesting females to account for different reproductive values at each life stage (e.g., the mortality of one nesting female is equivalent to 250 hatchlings, 34.5 oceanic juveniles, or 4.3 neritic juveniles). Annual mortalities do not represent the Level of Impact on the total population, as the total Northwest Atlantic population is not known[3]. However, these data demonstrate the relative severity of each threat and are therefore useful in estimating Level of Impact. Note that this method for estimating the Level of Impact is consistent with the Porbeagle (DFO 2015) and

Threat Evaluation Criteria	Methods
	Cusk (DFO 2014c) threat assessments. • Mortalities of Loggerhead Sea Turtles in the Mediterranean, particularly those juveniles that belong to the Northwest Atlantic population, were not incorporated in the NMFS-USFWS (2008a) threat assessment except for very limited information contributing to the assessment of bycatch. Mortality data for Northwest Atlantic Loggerhead Sea Turtles within the Mediterranean was sought from other available literature for inclusion in this assessment, with very limited information available. Some mortality information is available in Casale and Margaritoulis (2010). For each threat, assumptions are made as to how mortality estimates in the Mediterranean would change the Level of Impact characterization, if they were available. **Atlantic Canada methods:** In Canada, the only estimate of anthropogenic mortality is 200-500 oceanic/neritic juveniles per year associated with incidental capture in the pelagic longline fishery (DFO 2010a,b)[4]. As there are currently no other reported anthropogenic or natural threats associated with Loggerhead Sea Turtle mortality in Atlantic Canada, the Level of Impact for other threats is determined considering the mortalities that *could* occur in Canada relative to those throughout the entire range of the population. Based on available thermal habitat and that Loggerhead Sea Turtles are at the northern edge of their range when they are in Canada, it was assumed that fewer Loggerhead Sea Turtles are present in Canada compared to some other areas of the Northwest Atlantic. As a result, mortalities are expected to be lower in Canada versus elsewhere in the Northwest Atlantic for most threats.
Causal Certainty	*DFO 2014a Definition*: "Causal certainty: the strength of evidence linking the threat to the survival and recovery of the population." Categories: very low, low, medium, high, very high. Each category is defined by the amount of evidence linking the threat to population decline or jeopardy to the species survival or recovery. The first step in determining Causal Certainty was to determine whether or not there is evidence regarding effects to individual Loggerhead Sea Turtles. When mortality numbers were available, the limitations of the information were also considered in determining Causal Certainty. For example, bycatch data available for the Atlantic Canadian pelagic longline fishery may provide an underestimate due to limited observer coverage (DFO 2010a). Due to the inability to determine population decline caused by each threat, the number of mortalities caused by each threat is used to infer the degree to which the threat may jeopardize recovery or survival. In Atlantic Canada, there are no mortality data for threats other than fisheries, therefore the Causal Certainty of this threat is higher than other threats in Canada. Note that because there are no abundance estimates in Canada or the Northwest Atlantic, the category of "very high" was never selected as it requires quantitative data.

Threat Evaluation Criteria	Methods
Threat Risk	*DFO 2014a Definition*: "Threat risk: the product of likelihood and level of impact as determined using a risk matrix approach." Categories: low, medium, high, unknown. There is a standard formula provided in DFO 2014a to determine Threat Risk.
Threat Occurrence	*DFO 2014a Definition*: "Threat occurrence: refers to the timing of the occurrence of the threat and describes whether a threat is historical, current and/or anticipatory." Categories: historical, current, anticipatory. All threats to the Loggerhead Sea Turtle are current. Although the Level of Impact has likely changed for each threat over time (e.g., the level of harvesting in some countries is likely lower now than it was before legislation was enacted to protect the species). Apart from directed take of turtles in some countries that is now prohibited, there are no historic threats known to the authors of this document that are not still occurring today. Future (anticipatory) threats would include those that are difficult to predict (e.g., climate change) and are not represented in this table, as per DFO 2014a. Because all threats are current, detailed rationales for this element of the threat assessment are not provided in the section "Rationalization for Threat Characterization".
Threat Frequency	*DFO 2014a Definition*: "Threat frequency: the temporal extent of the threat over the next 10 years or three generations, whichever is shorter." Categories: single, recurrent, and continuous. Threat Frequency considers threats at the population level (the Northwest Atlantic, including that component in Canadian waters) operating at *any* given time and place. The assessment of Threat Frequency for Loggerhead Sea Turtles in Atlantic Canada only applies to turtles when they are within the Canadian Exclusive Economic Zone. For example, the entire time that Loggerhead Sea Turtles are in Canadian waters they are continuously exposed to underwater noise from activities such as shipping (engine noise) and, therefore, the Threat Frequency is categorized as continuous. In many cases, some threats can encompass elements that are continuous, recurrent, and single events (e.g., underwater noise). In these cases, "continuous" is the Threat Frequency selected as it encompasses recurrent and single events. In this assessment, this approach is taken for the threats of underwater noise, marine pollution, coastal development, and artificial light.
Threat Extent	*DFO 2014a Definition*: "Threat extent: the proportion of the population affected by the threat." Categories: restricted, narrow, broad, extensive. As there are no reliable abundance estimates for the Northwest Atlantic Loggerhead Sea Turtle population or for the species in Atlantic Canada, expert opinion was used. Threat Extent refers to the proportion of the population that could

Threat Evaluation Criteria	Methods
	potentially be affected, (i.e., overlap of Loggerhead Sea Turtle distribution overlap with threat), not the effect on the population from the threat (that is covered by the Level of Impact). Mortality numbers are considered when assessing the Threat Extent – a high number of mortalities indicates a greater Threat Extent.

Notes:

1. Annual mortalities used in the NMFS-USFWS (2008a) threat assessment are presented in a spreadsheet that is available online (see NMFS-USFWS 2008b).
2. For full details of the NMFS-USFWS (2008a) threat assessment, refer to Appendix 1 of that document (see References section for full citation).
3. Mean annual numbers of nests were calculated for most nesting beaches in the Northwest Atlantic from 1989-2008 (NMFS-USFWS 2008a). These data are used to determine a mean number of annual nesting females = 17,288 (COSEWIC 2010). Note that as mature female Loggerhead Sea Turtles do not nest annually, this is not the total number of nesting females.
4. This post-release mortality rate estimate is based on a literature review in other jurisdictions where a variety of hook types are used (see DFO 2010a,b). This number will be refined following a DFO / NOAA tagging study expected to be peer reviewed in 2017/18.

Results

The threat assessment is presented in Table 2 with a detailed rationale for each characterization provided in the section "Rationalization for Threat Characterization". Within Atlantic Canadian waters, the only threat with documented mortalities is bycatch in the pelagic longline fishery, which incidentally catches approximately 1,200 individuals annually and results in 200 – 500 annual juvenile mortalities (DFO 2010a). This equates to 5 – 15 adult female equivalent mortalities of oceanic juveniles or 47 – 118 nesting female equivalents of neritic juveniles (range of of 5 – 118 nesting female equivalent mortalities) using the relative reproductive value (RRV) for oceanic juveniles presented in NMFS-USFWS (2008a). This threat is given a Threat Risk of "medium", whereas most other threats are assessed as "low" in Atlantic Canadian waters. The Threat Risk of marine pollution (contaminants and debris) in Canada is "unknown" due to an "unknown" Level of Impact (see Table 1 for rationale).

The Causal Certainty of threats within Atlantic Canadian waters on the population is "medium" for bycatch in commercial fisheries (pelagic longline) and "very low" for all other threats. This reflects a lack of data on the effects of these threats within Canada and worldwide. For example, worldwide there are limited studies with small sample sizes on the effects of marine debris ingestion that have shown this is not the leading cause of death for Loggerhead Sea Turtles. The absence of a reliable abundance estimate for the population also contributes to "very low" Causal Certainty for most threats (see Table 1 for more details).

Threats ranked as "high" for the Northwest Atlantic population in order of highest to lowest annual mortalities[4] are as follows:

- Bycatch in fisheries (12,433 nesting female equivalent mortalities/year)
    - High Causal Certainty
- Artificial Light on nesting beaches (1,203 nesting female equivalent mortalities/year)
    - High Causal Certainty
- Legal and illegal harvesting (1,050 nesting female equivalent mortalities/year)
    - The Causal Certainty for this threat is medium, while others on this list have a "high" Causal Certainty. This threat is presumed to be less severe in recent years as a result of protection measures that many countries have put in place, meaning that legal harvesting mortalities may be overestimated. However, accurate mortality data is not easily obtained for illegal harvesting and therefore illegal mortality could be underestimated (Casale 2011).
- Coastal development and beach use (183 nesting female equivalent mortalities/year)
    - High Causal Certainty

In total, there are 15,676[5] annual mortalities (nesting female equivalents) in the Northwest Atlantic population of Loggerhead Sea Turtles. Mortalities in Atlantic Canada account for 0.8% of total mortalities (assuming 118 annual mortalities) and mortalities outside of Canada account for 99.2% of annual mortalities (15,558 annual mortalities). The threat of fishing in Atlantic Canadian waters accounts for fewer annual Loggerhead Sea Turtle mortalities (5 – 118 nesting female equivalents, or 0.8% of total annual mortalities assuming 118 annual mortalities)

[4] All mortalities are presented in nesting female equivalencies (see note 4 in Table 2).
[5] This is the sum of all mortalities presented in Table 1, including mortalities in Atlantic Canada.

compared to this threat throughout the Northwest Atlantic (12,433 nesting female equivalents, or 79.3% of total annual mortalities).

Following Table 2, the rationale for each characterization is presented in the section "Rationalization for Threat Characterization".

Table 2. Threat assessment for the Loggerhead Sea Turtle in the Broader Northwest Atlantic Population and in Atlantic Canadian waters based on DFO 2014a guidance (the last three rows in blue represent threats that occur only outside of Canada.)

Threat	Geographic Scale	Likelihood of Occurrence	Level of Impact (# Mortalities[5])	Causal Certainty	Threat Risk	Threat Occurrence	Threat Frequency	Threat Extent
Bycatch	NW Atlantic	Known	High (12,433)	High	High	Current	Continuous	Broad
	Atl. Canada[1]	Known	Medium (5-118)	Low	Medium	Current	Recurrent	Narrow
Entanglement[2]	NW Atlantic	Known	Medium (127)	Low	Medium	Current	Continuous	Broad
	Atl. Canada	Remote	Low	Very Low	Low	Current	Continuous	Unknown
Underwater Noise	NW Atlantic	Known	Low (0)	Very Low	Low	Current	Continuous	Extensive
	Atl. Canada	Known	Low	Very Low	Low	Current	Continuous	Extensive
Marine Pollution[3]	NW Atlantic	Known	Medium (254)	Medium	Medium	Current	Continuous	Extensive
	Atl. Canada	Likely	Unknown	Very Low	Unknown	Current	Continuous	Unknown
Vessel Strikes	NW Atlantic	Known	Medium (308)	Medium	Medium	Current	Continuous	Broad
	Atl. Canada	Unlikely	Low	Very Low	Low	Current	Continuous	Restricted
Harvesting (Legal / Illegal)	NW Atlantic	Known	High (1,050)	Medium	High	Current	Recurrent	Broad
Coastal Development[4]	NW Atlantic	Known	Medium (183)	High	Medium	Current	Continuous	Narrow
Artificial Light (Nesting Beaches)	NW Atlantic	Known	High (1,203)	High	High	Current	Continuous	Broad

Notes:

1. In Atlantic Canada, the only recorded incidental mortalities of Loggerhead Sea Turtle are attributed to the pelagic longline fishery targeting swordfish and tropical tunas (DFO 2010a). Comparatively in the US, gear types targeting a variety of species are known to cause incidental mortality to Loggerhead Sea Turtles including: bottom trawls, dredges, pelagic longlines, demersal longlines, gillnets and other gear types (NMFS-USFWS 2008a).
2. Entanglement caused by ghost fishing or marine debris is included here. Entanglement in active fishing gear is included in “bycatch”.
3. Marine pollution includes contaminants that Loggerhead Sea Turtles may be exposed to (including from oil pollution) and debris ingestion.
4. Coastal development also includes beach use (e.g., driving on beaches, human presence on beaches in general).
5. Annual mortality at all life stages determined by NMFS-USFWS (2008a) and equated to annual mortalities of nesting females. The NMFS-USFWS (2008a) Relative Reproductive Value (RRV) for oceanic juveniles was used to determine the equivalency of juvenile mortalities bycaught in Atlantic Canada to nesting females. RRVs for each life stage are presented in Table A1-5 in NMFS-USFWS (2008a). For example, a nesting female has an RRV of 1.0 and an oceanic juvenile has an RRV of 0.02 (i.e., one nesting female equates to 34.5 oceanic juveniles).

Rationalization for Threat Characterization

This section presents the rationale for characterizing each threat for the Northwest Atlantic population of Loggerhead Sea Turtles and for Loggerhead Sea Turtles found in Atlantic Canada. Two tables are provided for each threat, one for the Northwest Atlantic population and one for Loggerhead Sea Turtles in Atlantic Canadian waters. Note that rationales are not provided for the Threat Occurrence and Threat Risk, as explained in the Methods section and in Table 1.

BYCATCH

<table>
<tr><th colspan="2">Northwest Atlantic Population</th></tr>
<tr><td>Level of Impact: HIGH</td><td>Likelihood of Occurrence: KNOWN</td></tr>
<tr><td rowspan="2">The NMFS-USFSW (2008) threat assessment is broken down by gear type. The highest mortality rate was for bottom trawl (interactions regularly result in drowning) estimated to be 9,417 nesting females per year. For all gear types combined, the total nesting female mortalities were estimated at 12,433 individuals.
Bycatch data from Atlantic Canadian pelagic longline fleets was not included in the NMFS-USFWS (2008a) assessment. Pelagic longline data (the only fishery documented to catch Loggerhead Sea Turtles in Canada) was extrapolated from Lewison et al. (2004), which did not include Canadian data.
The NMFS-USFWS (2008a) threat assessment incorporates only limited information on Mediterranean mortalities (as indicated in NMFS-USFWS 2008b). In the demersal gillnet (large mesh) fishery, hundreds of Loggerhead Sea Turtles are killed annually. Data are available on numbers of Loggerhead Sea Turtles caught annually in Mediterranean pelagic longline fisheries, but not the number of mortalities. Demersal longline and small mesh demersal gillnet fisheries are expected to catch a significant amount of Loggerhead Sea Turtles, but no quantitative data were available at the time of the NMFS-USFWS (2008) analysis. Mediterranean mortality data were not included in the NMFS-USFWS (2008a) assessment of trawl, dredge, drift gillnets, pound nets and weirs, pots and traps, haul seines, channel nets, purse nets, and other hook and line fisheries (commercial and recreational). Some mortality information is available in Casale and Margaritoulis (2010); however, there are several countries with no data or catch numbers only (not mortalities). From available mortality data in the Mediterranean, the number of mortalities of Loggerhead Sea Turtles originating from the Northwest Atlantic population is not known, although Carreras et al. (2006) note that high</td><td>Pelagic longlines, gillnets, trawl gear and other fishing gear are known to incidentally catch turtles in US waters (e.g. Conant et al. 2009), with trawl gear having the greatest impact in US waters (NMFS-USFWS 2008a).</td></tr>
<tr><td>Causal Certainty: HIGH
Evidence exists that multiple fisheries incidentally catch Loggerhead Sea Turtles, as noted by mortalities identified in NMFS-USFWS (2008a). Fisheries constitute the greatest threat to Loggerhead Sea Turtles, compared to mortalities from other threats (see Table 1) and are therefore expected to jeopardize recovery.
Threat Frequency: CONTINUOUS
Fishing is widespread throughout the Northwest Atlantic in space and time; it is highly likely that one or more individuals within the global population are frequently exposed to this threat.
Although exposure is frequent, it is not expected to be continuous (occurring without interruption) in all areas of the Northwest Atlantic, but could be in areas where fishing effort is high (e.g., densely fished shrimp grounds in the US repeatedly capture Loggerhead Sea Turtles despite the use of turtle excluder devices [NMFS-USFWS 2008a]). The Threat Frequency was characterized as continuous, taking a precautionary approach.
Threat Extent: BROAD
Many fisheries occur in many regions that overlap with Loggerhead Sea Turtles; therefore, a large portion of the population has the potential to be affected.
As this threat causes the most mortalities of all threats (see Table 1), it is likely that a high proportion of the population is affected or has potential to be affected by this threat.
It is expected that interactions may be regular for this species.</td></tr>
</table>

Northwest Atlantic Population	
proportions of Atlantic Loggerhead Sea Turtles are found in Spanish waters and in the central Mediterranean and that half or more of the Loggerhead Sea Turtles captured by pelagic longliners in these waters are likely of Northwest Atlantic origin. In order to change the characterization of Level of Impact for this threat from "high" to "extreme" based on the characterizations used in this exercise, an additional 87,567 annual mortalities would have to occur and this is highly unlikely. • New evidence suggests that sea turtles can suffer from decompression sickness (DCS) when bycaught in gear that is operated at depths >10 meters, and post-release mortality may be high (García-Párraga et al. 2014).	

Atlantic Canada	
Likelihood of Occurrence: **KNOWN**	Causal Certainty: **MEDIUM**
• The pelagic longline fishery for swordfish and tunas (excluding Bluefin Tuna) is the only fishery in Atlantic Canada with records of incidentally captured Loggerhead Sea Turtles (DFO 2010a). • Although there is no known bycatch reported in other Canadian fisheries, it is possible that it exists. • Consistent with studies of epipelagic juvenile Loggerhead Sea Turtles in other areas of the Northwest Atlantic (Bolten 2003), telemetry data suggests that Loggerhead Sea Turtles in Canada are principally distributed in offshore waters and, like epipelagic Loggerhead Sea Turtles throughout the North Atlantic, spend most of their time within 5 m of the surface (James et al., unpublished data; NMFS-USFWS 2008a) and are therefore highly unlikely to interact with bottom fishing gear. For this reason, it is not likely that Loggerhead Sea Turtles in Canada would experience DCS as a result of bycatch in pelagic longline fisheries. In contrast, Loggerhead Sea Turtles in the US are more vulnerable to incidental capture by trawls and other bottom fishing gear because in their neritic stage they spend more time on the seabed, feeding on benthic organisms (e.g., mollusks, crabs, sea pens) (NMFS-USFWS 2008a).	• Mortalities from the pelagic longline fishery are known to occur, but the extent to which this is contributing to population decline in Atlantic Canada is not known mainly because the population estimates are not available. It is not likely that the number of nesting female mortality equivalents would result in jeopardy to survival or recovery of the population. • It is uncertain if previous levels of observer coverage for the pelagic longline fishery (5% minimum), from which mortality numbers were determined, were sufficient. The limited amount of coverage and poor or no coverage in certain areas could result in an underestimate of mortality estimates that were calculated at that time (DFO 2010a). In the fall of 2016, observer coverage requirements were increased to 25%, effective until the end of 2016 (Sweet, pers. comm. 2016). Observer requirements for 2017 are not yet known. • Rates of incidental capture as well as mortalities are calculated using outdated data (2002-2008). Since 2011, mandatory use of circle hooks in the pelagic longline fleet has been enforced. This is a mitigation measure that could result in fewer incidental captures, but further study is required to make this determination.

Atlantic Canada

Level of Impact: **MEDIUM**	Threat Frequency: **RECURRENT**
• Current post-release mortality estimates in the pelagic longline fishery suggest 200 – 500 juvenile mortalities/year (see Note 1, Table 2 and COSEWIC 2010) for the Canadian population (20-45% of approximately 1,200 caught annually). This equates to 5 – 15 or 47 – 118 nesting females if considering oceanic juveniles or neritic juvenile RRVs, respectively, using the NMFS-USFWS (2008a). Therefore, the overall range of annual nesting female equivalent mortalities in Atlantic Canadian waters is **5 – 118**. • As per DFO (2010a), mortalities from pelagic longline fisheries targeting tropical tunas are expected to be higher in Canada compared to the US. Canadian and US temperate Northwest Atlantic pelagic longline fisheries targeting swordfish are expected to have similar mortality rates. This is based on an analysis of bycatch data from 2005, 2006, and 2007, comparing US and Canadian observer data (Paul et al. 2010). Higher turtle-fishery interaction rates in the Canadian fishery are speculated to be the result of the Canadian fleet targeting tropical tunas and swordfish, whereas US fleets largely target swordfish only. Data show that Loggerheads Sea Turtles have a greater rate of bycatch in tropical tuna fisheries as relatively warmer waters are targeted (Paul et al. 2010). Observer coverage is not clearly broken down in accordance with the species targeted; therefore, interactions and mortalities in the Canadian pelagic longline fishery should be re-estimated taking into account the actual amount of observer coverage when targeting tropical tunas. • The abundance of Loggerhead Sea Turtles that use Canadian waters is unknown, but it is likely higher than the 1,200 estimated interactions per year. It is likely that the pelagic longline fishery incidentally captures only a proportion of Loggerhead Sea Turtles present in Atlantic Canadian waters. Although that proportion is unknown, it is expected to be narrow due to the dynamic nature of the fishery (see discussion under Threat Frequency and Threat Extent). A moderate population loss (11-30%) is, therefore, likely a conservative estimate. The population loss is expected to be closer to the low end of this range (closer to 11%).	• The pelagic longline fishery catches an estimated 1,200 Loggerhead Sea Turtles in Canadian waters each year (DFO 2010a). • Data on the frequency of Loggerhead Sea Turtle interactions in Canadian Atlantic pelagic longline fisheries are poor, limited to observer data that covered approximately 5% of fishing trip sea days annually (DFO 2010a) until fall 2016 when observer coverage requirements were increased to 25%. • Bycatch rates are higher when the fishery directs for tropical tuna rather than swordfish (DFO 2010a). • The fishery overlaps spatially and temporally with Loggerhead Sea Turtle presence in Atlantic Canada. Fishing effort occurs on and off the continental shelf, beginning as early as April, and persisting as late as December (DFO 2013), with most fishing taking place in the summer and fall (Marilyn Sweet, pers. comm. 2016). During this time, vessels typically move from the west at the beginning of the season to the east and then back again (DFO 2013) and fishing effort is patchily distributed. For these reasons, it is likely that Loggerhead Sea Turtles are not continuously exposed to this threat while in Atlantic Canadian waters, rather, this threat is considered recurrent (i.e., occurs repeatedly or periodically, DFO 2014a). **Threat Extent: NARROW** • There is co-occurrence of Loggerhead Sea Turtles in thermal transition zones with favourable pelagic longline fishing areas, particularly when targeting tropical tunas. • However, it is likely that a narrow proportion of the population (11-30%) is potentially affected by this threat, as the clustering of fishing effort is not likely to match the clustering of Loggerhead Sea Turtles. This is because the fishery is quite dynamic, moving throughout the season (DFO 2013). Overlap is also dependent on temperature and species targeted, with swordfish being the primary target of most of the fleet, rather than tropical tunas that prefer similar temperatures to Loggerhead Sea Turtles.

ENTANGLEMENT

Northwest Atlantic Population

Level of Impact: **MEDIUM**	Likelihood of Occurrence: **KNOWN**
• Based on the 2008 NMFS-USFWS assessment, entanglement is a greater risk for large sub-adult and adult Loggerhead Sea Turtles occupying the neritic zone (approximately 300 juvenile mortalities per year) than the oceanic zone where stage 3 and 4 size class juveniles typical of the Canadian population are most regularly distributed (approximately 1 juvenile mortality per year). Overall adjusted mortalities equate to **127** nesting females per year (includes mortalities resulting from derelict fishing gear and non-fishing gear entanglements). • However, juvenile Loggerhead Sea Turtles are often found in convergence zones where marine debris aggregates, making them vulnerable to entanglement and ingestion of marine debris (NMFS-USFWS 2008a). • Entanglement data in the Mediterranean was not found at the time of writing this assessment. Casale (2008) states that there are no data about interactions of ghost fishing gear with marine turtles and that this is likely an important threat. It is not likely that adding mortalities from entanglement in the Mediterranean would change the LI, as an additional 874 mortalities (nesting female equivalent) would need to occur to change the LI to "high", using the methods in this assessment.	• Loggerhead Sea Turtles have been found entangled in monofilament line, rope, discarded netting and other materials (Balazs 1985, Plotkin and Amos 1988, and NMFS unpublished data in NMFS-USFWS 2008a). Causal Certainty: **LOW** • There is no evidence that entanglement is contributing to population decline. Second only to underwater noise, entanglement has the lowest number of estimated mortalities of all threats. Therefore, it is unlikely that this threat alone is contributing to population decline. Threat Frequency: **CONTINUOUS** • Threat is always present (potential is there due to debris being widespread) for one or more individuals in the population at any given time to encounter marine debris and become entangled. Threat Extent: **BROAD** • Marine debris that could cause entanglement has the potential to affect most oceanic/neritic turtles throughout ocean basins in the Northwest Atlantic. • Convergence zones overlap with Loggerhead Sea Turtle distributions, increasing the Threat Extent.

Atlantic Canada

Likelihood of Occurrence: **REMOTE**	Threat Frequency: **CONTINUOUS**
• There are no known occurrences of entanglement in Canadian waters.	• Refer to assessment of entanglement in the Northwest Atlantic population; the same applies in Canada.
Level of Impact: **LOW**	Threat Extent: **UNKNOWN**
• See Level of Impact assessment for entanglement to the Northwest Atlantic population. As a greater number and diversity of fisheries are conducted in the neritic zone in Atlantic Canada compared to the oceanic zone, where most Loggerhead Sea Turtles in Canada are found, entanglement in fishing gear is less likely in Canada compared to other parts of the Northwest Atlantic. If Loggerhead Sea Turtles become more frequent in neritic waters, this risk of entanglement in Canada could increase.	• The amount and distribution of debris in Canadian waters that could result in entanglement is not known. • Loggerhead Sea Turtles are found near oceanic convergence zones, the same areas where debris can accumulate. However, according to NMFS-USFWS (2008a), this threat mainly affects neritic Loggerhead Sea Turtles rather than oceanic Loggerhead Sea Turtles (the life stage most commonly found in Canada). • Derelict fishing gear is implicated in most

Atlantic Canada	
Causal Certainty: **VERY LOW**	entanglements, rather than other marine debris that is not associated with fishing activity (NMFS-USFWS 2008a). As most fisheries in Atlantic Canada occur in the neritic zone, it is possible that some associated gear will sink and remain in this zone, posing less of a threat to Loggerhead Sea Turtles. This is a highly uncertain assumption, therefore Threat Extent is considered "unknown".
• This could occur, but there is no evidence in Canada.	

UNDERWATER NOISE

Northwest Atlantic Population	
Likelihood of Occurrence: **KNOWN**	Threat Frequency: **CONTINUOUS**
• Loggerhead hearing range frequencies (greatest sensitivity 100-400 Hz, Martin et al. 2012) overlap with frequencies of anthropogenic noise sources such as shipping (i.e., engine noise), pile driving, seismic airgun arrays, offshore drilling, and low-frequency sonar (Dow Piniak et al. 2012). • Underwater noise is known to occur throughout the oceans globally, overlapping with Loggerhead Sea Turtle distribution. • The Likelihood of Occurrence for this threat is assessed as "known" because it is known to occur throughout the world's oceans, not because it has a "known" effect on Loggerhead Sea Turtle survival or fitness (see Causal Certainty and Level of Impact). Therefore, this characterization is precautionary.	• Chronic (non-impulsive) noise is continuous and is most often associated with commercial shipping (i.e., engine noise) but can be caused by recreational boating, drilling (including vibratory pile drivers) and construction (if over long durations), and renewable energy sources such as wind turbines (NOAA 2015). • Acute (impulsive) noise is short-lived and typically has a high peak pressure (NOAA 2015). It can be caused by blasting, seismic and military activities, and impulsive pile driving. Impulsive noise is recurrent, rather than continuous. Some impulsive noises may occur as a single event (e.g., blasting). • Shipping is likely the underwater noise source that is most frequent and widespread throughout the Northwest Atlantic. The other sources of underwater noise mentioned (continuous and recurrent) occur throughout the Northwest Atlantic.
Level of Impact: LOW	
• Noise pollution is assessed by NMFS-USFWS (2008a) as low for all life stages, and there are no recorded mortalities in the Northwest Atlantic or Mediterranean.	
Causal Certainty: **VERY LOW**	Threat Extent: **EXTENSIVE**
• There is no evidence that underwater noise causes mortality or jeopardizes recovery. • Most studies on underwater noise have been conducted with captive turtles (e.g., Martin et al. 2012, Lavender et al. 2014) and the results cannot be easily applied to wild populations. • One study of Loggerhead Sea Turtles in the wild demonstrated startle responses to and avoidance of seismic airgun arrays (DeRuiter and Doukara 2012). Another study involving the containment of Loggerhead Sea Turtles in a canal and exposing them to seismic airgun blasts also showed avoidance behavior (O'Hara and Wilcox 1990). • Behavioural changes from underwater noise (e.g., startle responses and area avoidance)	• As noted for Threat Occurrence, underwater noise occurs throughout the Northwest Atlantic and, therefore, has the potential to affect a large proportion of the Loggerhead Sea Turtle population. • In the Mediterranean, vessel traffic density is higher than anywhere else within the range of the Northwest Atlantic Loggerhead Sea Turtle population (Marine Traffic 2016) and, therefore, it is likely a noisier environment than other locations. In addition, the Mediterranean is a more populous region than the eastern seaboard of North America, likely producing more underwater noise associated with coastal construction activities.

Northwest Atlantic Population	
on Loggerhead Sea Turtles could affect fitness and cause displacement from feeding and other important areas (NMFS-USFWS 2008a). These effects on individuals, and on the population, are not well understood. • Noise thresholds causing hearing loss (temporary or permanent) are not established, nor are effects on Loggerhead Sea Turtle fitness from hearing loss (DeRuiter and Doukara 2012). • The sensitivity of Loggerhead Sea Turtles to underwater noise is not well understood, including among different life history stages (Lee et al. 2011).	

Atlantic Canada	
Likelihood of Occurrence: **KNOWN**	Threat Frequency: **CONTINUOUS**
• Although there are no observed effects on Loggerhead Sea Turtles from underwater noise in Canada, most of the above activities that cause underwater noise are occurring regularly in Canadian waters (mainly continuous shipping noise and also seismic programs that typically occur once every year, with each program lasting about 2-6 months). Other sources of underwater noise (e.g., pile driving or seismic profiling) are not regular activities within or near Loggerhead Sea Turtle habitat but could occur in the future.	• Refer to Threat Frequency for Northwest Atlantic population. The same noise sources are present in Atlantic Canadian waters, but likely to a lesser extent than the US as there is less shipping (Marine Traffic 2016). In Atlantic Canada, there are fewer offshore oil and gas activities compared to the US Gulf of Mexico. For example, in Nova Scotia there are only two existing oil and gas production projects (CNSOPB 2016) and three in Newfoundland (CNLOPB 2016) compared to 304 offshore rigs operating in the Gulf of Mexico as of August 2015 (EIA 2015). The eastern seaboard of the US is currently off-limits for offshore energy development, although a large area of offshore waters is being considered for seismic exploration (API 2016).
Level of Impact: **LOW**	
• There are no known mortalities of Loggerhead Sea Turtles caused by underwater noise in Canadian waters or elsewhere.	
Causal Certainty: **VERY LOW**	Threat Extent: **EXTENSIVE**
• Refer to rationale for the Northwest Atlantic population.	• Shipping noise is expected to affect most Loggerhead Sea Turtles when they are in Canadian waters, as shipping is continuous.

MARINE POLLUTION

Northwest Atlantic Population

Likelihood of Occurrence: **KNOWN**	Causal Certainty: **MEDIUM**
• Because Loggerhead Sea Turtles are generalist feeders, they may ingest more debris in all life stages compared to other sea turtle species (Lutcavage et al. 1997). • Sea turtles are sensitive to oil spills; they do not demonstrate oil spill avoidance behavior, they feed indiscriminately, and inhale air at the surface thereby exposing them to chemical ingestion and inhalation (NOAA 2010). Eggs are particularly vulnerable; chemical exposure can cause developmental problems in hatchlings and decrease survival rates (NOAA 2010). Sea turtles may experience a variety of other health effects due to ingestion of chemicals from oil or dispersants, including ulcers, damage to the liver or kidneys, reproductive failure, or death (NOAA 2010). • Loggerhead Sea Turtles may follow prey that can be attracted to platform or vessel lighting (e.g., squid), potentially increasing their likelihood of exposure to petroleum products (NMFS-USFWS 2008a).	• There is evidence that exposure to petroleum products can be fatal to Loggerhead Sea Turtles, as with many other marine species (NMFS-USFWS 2008a). • Marine pollution is not expected to jeopardize recovery to the same extent as other threats, as there are fewer documented mortalities. However, major acute events such as the Deepwater Horizon oil spill could have a more profound effect on recovery. • NOAA rehabilitated 450 oiled sea turtles (approximately 75% Loggerhead Sea Turtles) and relocated 275 sea turtle nests (approximately 95% Loggerhead Sea Turtle nests) following the Deepwater Horizon oil spill in the Gulf of Mexico (NOAA 2014a). There were 600 observed sea turtle deaths caused by the spill, 75% of which were Kemp's Ridley Sea Turtles (NOAA 2014a). • Effects of platform and vessel lighting on individuals and populations are not known (NMFSNMFS-USFWS 2008a)
Level of Impact: **MEDIUM**	Threat Frequency: **CONTINUOUS**
• The NMFS-USFWS (2008a) notes that there are approximately 1 to 30 annual mortalities for most life stages from this threat except during the swim frenzy stage where mortalities from oil pollution and debris ingestion are each estimated at 30,000. Annual mortalities from all pollution sources except for pollution causing entanglement (see above) have been equated to **254** nesting females. This number is heavily influenced by a high number of mortalities at the swim frenzy stage. • Nelms et al. (2016) note that adults and subadults are often able to defecate marine debris due to having a wide digestive tract, and, therefore, they may have some tolerance to debris ingestion. A study by Nicolau et al. (2016) that examined the stomach contents of 95 stranded Loggerhead Sea Turtles on the Portuguese coast found that 59% of turtles had debris in their gastrointestinal tract; however, this was identified as the cause of death for only one turtle. Other studies in the Mediterranean indicate that Loggerhead Sea Turtles are often able to pass marine litter through their digestive tracts (e.g., Camedda et al 2014; Campani et al. 2013). • Juvenile Loggerhead Sea Turtles are often found in convergent zones where marine debris aggregates, making them vulnerable to	• Marine pollution is ubiquitous throughout the oceans globally (Barnes et al. 2009), including in the Northwest Atlantic (this includes debris and contaminants). Contaminants and debris are present in the ocean continuously. • Some events are recurrent or single, including large-scale events (e.g., oil spills) or small scale events (e.g., fishing vessel leaking fluid, agrochemical run-off into the ocean). These events are unpredictable and could occur many times in 10 years or 3 generations. Threat Extent: **EXTENSIVE** • A map in Cozar et al. (2014) shows that surface marine plastic debris is concentrated in the North Atlantic Gyre, south of Canadian waters, and extends outward toward coastal areas. Plastic debris is more extensive in the Pacific than in other oceans. • It is expected that Loggerhead Sea Turtles will encounter pollution at some stage in their life cycle, as it is ubiquitous (Barnes et al. 2009). • Marine debris is quite concentrated on some nesting beaches in the Mediterranean, as documented by Casale and Margaritoulis (2010); indicating a large amount of marine debris is likely found in oceanic environments of the Mediterranean as well.

Northwest Atlantic Population	
entanglement and ingestion of marine debris (NMFSNMFS-USFWS 2008a).	

Atlantic Canada	
Likelihood of Occurrence**: LIKELY**	Causal Certainty: **VERY LOW**
• There are no known cases of mortality or injury from marine pollution in Canada; however, Loggerheads could be affected by marine debris, oil spills, and offshore oil and gas activities that occur in Atlantic Canadian waters. • Juvenile Loggerhead Sea Turtles are often found in convergence zones where marine debris aggregates (Carr 1986; NMFS-USFWS 2008a), making them vulnerable to entanglement and ingestion of marine debris (NMFSNMFS-USFWS 2008a). In Atlantic Canada, Loggerhead Sea Turtles are regularly found in warmer waters around the Scotian Shelf break and the Grand Banks in summer months (COSEWIC 2010). These areas are often characterized by current convergence, which can concentrate marine debris.	• There is high certainty that contaminants exist in Atlantic Canadian waters (including from oil and gas activities), just as they do globally; however, the effects of contaminants from Atlantic Canadian waters on Loggerhead Sea Turtles relative to other areas of the Northwest Atlantic are unknown. • It is likely that Loggerhead Sea Turtles are ingesting marine debris, but there is no knowledge or information on what effect this is having on the heath of individual turtles. Necropsy data are too sparse to provide certainty regarding the impacts from debris ingestion.
Level of Impact: **UNKNOWN**	Threat Frequency: **CONTINUOUS**
• According to necropsy data in Atlantic Canada, no plastics have been recorded in the guts of Loggerhead Sea Turtles to date; however, this finding is based on only a small number of carcasses, and, as sample size increases, it is expected that some evidence of debris ingestion will be documented (Mike James, pers. comm. 2016). • Juvenile sea turtles do not have fully developed digestive tracts and although they are likely able to pass small pieces of marine debris, they are vulnerable to the effects of ingesting large debris (Nelms et al. 2016). • Because the occurrence of this threat and effects on Loggerhead Sea Turtles in Atlantic Canada are not well understood, the Level of Impact is unknown.	• As noted previously, marine pollution is ubiquitous in the oceans globally (Barnes et al. 2009), and Canada is no exception. However, there is less land and ocean-based development in Canada compared to the US (Pesch and Wells 2004). Therefore, recurrent / single events releasing contaminants into the ocean are likely to be less frequent in Canada compared to the US.
	Threat Extent: **UNKNOWN**
	• The map in Cozar et al. (2014) shows that the most dense areas of surface plastic accumulation are not in Atlantic Canadian waters. This does not imply that plastics are not found in Atlantic Canadian waters. The amount of marine debris within Canada and how it overlaps with Loggerhead Sea Turtle distribution is not known.

VESSEL STRIKES

Northwest Atlantic Population	
Likelihood of Occurrence: **KNOWN**	Causal Certainty: **MEDIUM**
• Collisions and propeller injuries from boats are more commonly documented in the neritic zone where recreational vessel activities are most concentrated (NMFS-USFWS 2008a).	• Effects on individuals are known and this threat may jeopardize recovery.
	Threat Frequency: **CONTINUOUS**
	• Large commercial vessels (e.g. tankers and cargo ships), fishing boats, and recreational vessels traverse the waters of the Northwest

Northwest Atlantic Population

Level of Impact: **MEDIUM**

- The NMFS-USFWS (2008a) threat assessment calculated 300 neritic juvenile and 300 adult mortalities per year from vessel strikes, which equates to **308** nesting female mortalities.
- The NMFS-USFWS (2008a) assessment does not take into account vessel strike mortalities in the Mediterranean.
- Vessel traffic density in the Mediterranean is higher than anywhere else within the range of the Northwest Atlantic Loggerhead Sea Turtle population (Marine Traffic 2016) and, therefore, vessel strikes may be more likely in this area, particularly through the narrow passage of the Strait of Gibraltar (as narrow as approximately 15 km). IUCN (2012) states that vessel strikes with marine turtles and other marine species are common; however, mortality data are lacking. At least 692 nesting female equivalent mortalities per year would have to occur to change the Level of Impact ranking from medium to high, based on the methods of this assessment.

Atlantic on a continuous basis (Marine Traffic 2016).

- Recreational boating is common in most coastal areas, particularly those in warmer climate where coastal use occurs year-round (NMFS-USFWS 2008a); therefore, the potential for vessel strikes is likely continuous in these locations.

Threat Extent: **BROAD**

- There is potential for this to occur throughout Loggerhead Sea Turtle range in the Northwest Atlantic, with greater overlap in coastal waters where vessels (recreational and/or commercial) are highly concentrated (e.g. near human population centres, productive fishing areas, etc.).
- This threat has the potential to affect a broad range of Loggerhead Sea Turtles. NMFS-USFWS (2008a) mortality data place this threat in the middle of all threats (Threat Risk of medium). Because of this and the associated high potential for mortality, a precautionary approach is taken and the Threat Extent is determined to be broad.

Atlantic Canada

Likelihood of Occurrence: **UNLIKELY**

- There are no known cases of vessel strikes in Canada. Loggerhead Sea Turtles may encounter this threat from recreational and non-recreational vessels (shipping, fishing, seismic, etc.), but there is no evidence of this to date.
- The potential for regular recreational vessel encounters in Atlantic Canadian waters is low primarily because Loggerhead Sea Turtles are found offshore in Atlantic Canada where encounters with recreational boaters are unlikely).

Level of Impact: **LOW**

- There is no evidence of encounters in Canada, likely due to the offshore distribution of Loggerhead Sea Turtles in Atlantic Canada and fewer recreational vessels in Canada compared to the US and other high-use areas of the Caribbean.

Causal Certainty: **VERY LOW**

- There is no evidence that vessel strikes have occurred in Canada.

Threat Frequency: **CONTINUOUS**

- There are fewer vessels in Atlantic Canada compared to the rest of the Northwest Atlantic; however, vessel movement throughout Atlantic Canadian waters is continuous (MarineTraffic 2016).

Threat Extent: **RESTRICTED**

- In Atlantic Canada, vessel strikes are less likely to occur compared to in US waters. Most vessel strikes with Loggerhead Sea Turtles are associated with recreational vessels that are present in much lower numbers in Atlantic Canadian waters compared to US waters.
- Loggerhead Sea Turtle distribution in Atlantic Canada overlaps with shipping routes that cross the Atlantic (DFO 2005); however, the highest densities of ship traffic in Atlantic Canada occur close to the coastline, distant from most observations of Loggerhead Sea Turtles (DFO 2005).
- In addition, Loggerhead Sea Turtles may avoid vessels, as observed in a study by Weir (2007), further decreasing their vulnerability to this threat.

Threats Occurring Outside of Canada Only

HARVESTING (Legal and Illegal)	
Level of Impact: **HIGH**	Likelihood of Occurrence: **KNOWN**
• Illegal harvesting is mainly focussed on poaching eggs, although juveniles and adults are also taken. The total amount of *illegal harvesting* equates to **107** nesting females, although it is suspected that this is an underestimate (NMFS-USFWS 2008a). This is supported by Humber et al. (2014) who state that "illegal take, along with bycatch, is likely significantly under-recorded and far greater than the levels of directed take." The NMFS-USFWS (2008a) assessment calculates that the equivalent of **943** nesting female Loggerhead Sea Turtles are taken *legally* each year; however, this estimate does not reflect that Cuba (TEWG 2009) and the Bahamas (Bjorndal and Bolten 2009) ceased such activities in 2009. • Humber et al. (2014) provide a more current estimate of legal take (as of January 1, 2013) in the Northwest Atlantic at 1,005.3 (121 in the Mediterranean). Colombia and Haiti have the greatest take numbers at 645.8 and 328.0, respectively (Humber et al. 2014). The life stage breakdown of these mortalities is not presented and, therefore, the nesting female equivalent mortalities cannot be calculated. It is unlikely that all of these mortalities are adults – in the NMFS-USFWS (2008a) assessment, most mortalities occur at the juvenile neritic stage (3,000 annual mortalities compared to 300 at adult neritic stage). • The total adjusted mortality for *illegal and legal* harvest provided by NMFS-USFWS (2008a) is **1,050** nesting females (943 legal + 107 illegal). • Although the NMFS-USFWS (2008a) mortality estimates are not current, they are the only available mortality data that are converted to nesting female mortalities. It is possible that mortalities associated with legal harvesting are over-estimated considering the more recent compilation by Humber et al. (2014), and illegal harvesting mortalities are likely underestimated. • In the Mediterranean, harvesting is not considered to be a current conservation issue (Casale 2008). As noted by Humber et al. (2014), legal mortalities in the Mediterranean are 121 annually (life stage not specified) and illegal harvest numbers are not known. If nesting female equivalent mortalities of Northwest Atlantic Loggerhead Sea Turtles due to harvesting were available, it would not	• Illegal harvest of Loggerhead Sea Turtles and eggs in the US, where the majority of Northwest Atlantic population nesting beaches are located and nest density is highest, is uncommon (NMFS-USFWS 2008a). Illegal and legal harvests are concentrated in the Caribbean region and present a serious management challenge, as the extent of exploitation is unknown (NMFS-USFWS 2008a). • Legal harvesting ceased in the Bahamas in 2009 when full protection was afforded to all sea turtles under Fisheries Regulations (Bjorndal and Bolten 2009). According to the Turtle Expert Working Group (TEWG 2009), a NOAA-chaired group of marine turtle biology and conservation authorities, all legal harvesting in Cuba has also ceased, (significant, as Cuba was formerly the only country in the Northwest Atlantic to harvest substantial numbers of Loggerhead Sea Turtles [TEWG 2009]). Legal harvest in other countries occurs at present, but at low levels, as most of these countries are found in the Caribbean where Loggerhead Sea Turtle density is relatively low (Ehrhart et al. 2007 in TEWG 2009). Richardson et al. (2006) summarize sea turtle harvest and import/export legislation in UK territories in the Caribbean: for some territories, harvesting is allowed with specific conditions (Cayman Islands, Monteserrat, and Turks and Caicos). • The only countries with active legal harvests (as of January 1, 2013) in the Northwest Atlantic are Colombia, Grenada, Haiti, and St. Vincent and the Grenadines (Humber et al. 2014). In the Mediterranean, Albania and Algeria have active legal harvests (Humber et al. 2014).

HARVESTING (Legal and Illegal)	
change the result of this assessment, as there would have to be an additional 98,951 mortalities (equated to nesting females) to reach a Level of Impact of extreme.	
Causal Certainty: **MEDIUM**	Threat Frequency: **RECURRENT**
• Population trends may be linked to rates of legal and illegal harvesting. • The TEWG (2009) notes that when legal harvesting in Cuba ended in 1996, the annual number of nests in Florida began to increase. During the 1960s, through to the 1990s, when the Cuba harvest was active, the number of Loggerhead Sea Turtle nests in Florida was declining (TEWG 2009). It is not clear if these events are linked (TEWG 2009); however, it is likely that the population would be affected by excessive harvesting. • The Causal Certainty that this threat has the *potential* to affect the population or jeopardize recovery is high, but the Causal Certainty that it is in fact affecting the Northwest Atlantic Loggerhead Sea Turtle population is medium.	• Illegal and legal harvest of eggs and turtles is not likely occurring on a continuous basis, nor is it a single event within one generation or ten years. • Poaching of eggs occurs repeatedly (recurrently) during the nesting season. Nesting females, adult males, and juveniles turtles experience poaching repeatedly at varying times, although likely at lower frequencies compared to eggs; however, the reproductive value of eggs is lower than at other life stages (e.g., 1 nesting female is equivalent to 250 eggs, NMFS-USFWS 2008a). Threat Extent: **BROAD** • Egg harvesting is limited to terrestrial nesting areas and it is expected that harvesting of adults and juveniles largely occurs in coastal waters. Combined, these areas represent only part of the Loggerhead Sea Turtle's range, thus the Threat Extent is expected to be narrow (affecting 11-30% of the population). • In addition, legal harvesting has nearly ceased in formerly heavily harvested areas, which may have reduced pressure on the population. • This is not currently a significant threat to Northwest Atlantic juveniles found in the Mediterranean (Casale 2008). • Nesting female mortality equivalents from harvesting are the third highest of all threats. Because of this, it is expected that this threat has broad implications on the population.

COASTAL DEVELOPMENT (Included Beach Use)	
Likelihood of Occurrence: **KNOWN**	Threat Frequency: **CONTINUOUS**
• Coastal development can threaten nesting females, eggs, and hatchlings. Threats include beach restoration and nourishment, beach armouring, other shoreline stabilization infrastructure, sand compaction from vehicles and machinery, and coastal construction (NMFS-USFWS 2008a). • These threats cause habitat loss and degradation, loss of nests (e.g., from erosion and direct destruction), entrapment of hatchlings (e.g., under compacted sand,	• Coastal development activities (e.g., construction and beach nourishment) are not continuous while turtles are present, although development may occur continuously over a nesting season in a specific area. • The presence of structures on nesting beaches is continuous, as is the beach use associated with them. • Beach use is continuous during the nesting season in the day and can be recurrent at night, especially in resort / tourist areas.

COASTAL DEVELOPMENT (Included Beach Use)

behind breakwaters) leading to death and/or increased predation, and direct injury or death (e.g., dredging) (NMFS-USFWS 2008a).

- A study by Witherington et al. (2011) indicated that barriers on beaches (e.g., seawalls, buildings, temporary recreational structures) may result in nesting closer to the surf, making nests more vulnerable to storm surges and persistent high waves.
- Important nesting beaches are being acquired for long-term protection and the US Fish and Wildlife Service designated 685 miles (1,102 km) of beach habitat as critical habitat for Loggerhead Sea Turtles as per the *Endangered Species Act* (USFWS 2014; 2015a). This represents 48% of coastal beach shoreline in North and South Carolina, Georgia, Florida, Alabama, and Mississippi and approximately 84% of observed nesting occurs on beaches designated as critical habitat (USFWS 2015a). Critical habitat in nearshore waters near these beaches has been designated by NMFS (NOAA 2014b).

Level of Impact: **MEDIUM**

- According to NMFS-USFWS (2008a), beach armouring causes the most mortalities at 30,000 eggs and 3 nesting females per year. Beach nourishment causes the mortality of approximately 3,000 eggs and 3,000 hatchlings per year and coastal construction is estimated to destroy 3,000 eggs. The calculated number of nesting female mortalities for all coastal development is **183**.

Causal Certainty: **HIGH**

- There is high certainty that this threat is resulting in appreciable Loggerhead Sea Turtle mortality; however, total estimated annual mortality is low compared to other threats.
- The *potential* for this threat to jeopardize recovery is high if not managed properly as coastal development is recurrent throughout the US and the Caribbean where Loggerhead Sea Turtles nest.
- Although many nesting beaches have been designated as critical habitat in the US, development is not fully restricted (USFWS 2015b). Federal agencies must work with developers and others to ensure that proposed development does not negatively affect critical habitat (USFWS 2015b).

Threat Extent: **NARROW**

- Coastal development and beach use primarily affect eggs, hatchlings, and nesting females, and, to a lesser extent, juvenile and adult neritic Loggerhead Sea Turtles (e.g., impacts from dredging)
- This threat is largely confined to the beach, which is a small but critical part of Loggerhead Sea Turtle habitat in the Northwest Atlantic, thereby affecting a small but important proportion of their total life history.
- Development activities (e.g., construction) and beach use primarily occur in the day, outside of normal nesting times, and although hatchlings normally emerge after nightfall (NMFS-USFWS 2008a; Salmon and Reising 2014), they may also emerge in the day when temperatures are cooler (Sea Turtle Conservancy 2015).
- Few nesting beaches offer full protection for Loggerhead Sea Turtles; however, critical habitat designations in the US may result in additional protection.
- Due to US *Endangered Species Act* critical habitat designations, it is expected that future development will not continue on nesting beaches in the US without first ensuring that protection and mitigation measures are in place. For this reason, this threat is expected to have a limited impact (narrow extent) on the population. If development were uncontrolled, the threat would have a broad extent.

ARTIFICIAL LIGHTING (on Nesting Beaches)	
Likelihood of Occurrence: **KNOWN**	Threat Frequency: **CONTINUOUS**
• Dense coastal development along nesting beaches, especially those in Florida, have accompanying light pollution that affects nesting Loggerhead Sea Turtles (NMFS-USFWS 2008a). • Nesting females can be deterred from nesting on beaches with artificial lighting and can become dis(mis)oriented (Witherington and Martin 1996). • Hatchlings are particularly vulnerable as they make their way to sea based on visual cues. Artificial light can override natural lighting, directing hatchlings inland instead of towards the ocean. This increases their vulnerability to predation, desiccation by the sun, and mortality by vehicles (Witherington and Martin 1996).	• In areas where beach lighting is an issue, this problem is continuous at night (lights are on all night) when it can affect nesting females and hatchlings.
Level of Impact: **HIGH**	Threat Extent: **BROAD**
• According to NMFS-USFWS (2008a), light pollution has severe consequences for hatchlings (approximately 300,000 mortalities). Hatchling disorientation events in Florida affect several hundred nests and tens of thousands of hatchlings each year (Nelson et al. 2002). Total estimated mortalities are equal to **1,203** nesting females	• This threat affects hatchlings primarily, but it can also affect nesting females. The rest of the Loggerhead Sea Turtle population is unaffected by artificial light on nesting beaches. • Many local governments in Florida have lighting ordinances in place to mitigate this threat (NMFS-USFWS 2008a). Ordinances exist in South Carolina as well (SCDNR 2013), and in other areas. In Florida, the highest compliance with mandatory ordinances is in areas with highest Loggerhead Sea Turtle nesting densities (NMFS-USFWS 2008a). • Data from NMFS-USFWS (2008a) identifies the magnitude of this threat second only to fisheries interactions in terms of total estimated mortalities, even when converted to nesting females. Because of this, it is expected that this threat has broad implications on the population.
Causal Certainty: **HIGH**	
• Second only to bycatch in fisheries as the threat with the highest number of estimated mortalities, light pollution is highly likely to jeopardize recovery. • Light pollution-associated mortalities estimated by NMFS-USFWS (2008a) are based on published literature, unpublished data from state departments, and personal communications (NMFS-USFWS 2008b).	

Data Limitations and Uncertainties

This assessment process identified several data limitations that may affect the results. These include:

- There is no reliable population abundance estimate for the Northwest Atlantic population and there is no estimate at all for Loggerhead Sea Turtles in Atlantic Canadian waters.
- A reassessment of Loggerhead Sea Turtle incidental catch and mortalities in Atlantic Canada may be required as more information becomes available:
    - Catch data used to calculate mortalities from the pelagic longline fishery in Canada is outdated (2002-2008) and is based on rates of post-hooking mortality (20-45%) that may also be outdated. Rates of incidental capture, and perhaps mortality rates, may be different following the implementation of mandatory use of 16-gauge circle hooks in 2011

(DFO 2010b). This is a mitigation measure intended to reduce the bycatch of Loggerhead Sea Turtles and other species compared to the use of traditional J-hooks.
  - Observer coverage requirements were low until October 2016, at a mean of 5% observer coverage annually for the fishery, and the geographic distribution of observer coverage may not have been sufficient to accurately record Loggerhead Sea Turtle bycatch (DFO 2010a). The increase in observer coverage that occurred in the fall of 2016 (Marilyn Sweet, pers. comm. 2016) may result in better bycatch estimates in the future, if this level of observer coverage remains a requirement in future years.
  - Because levels of observer coverage vary depending on species targeted, re-evaluation of Loggerhead Sea Turtle interactions and mortalities in the Canadian pelagic longline fishery should take into account the actual amount of observer coverage during trips targeting tropical tunas.

- Outside of Canada, legal and illegal harvest estimates are uncertain. A recent compilation by Humber et al. (2014) provides updated information on legal harvesting that may indicate an overestimate of legal harvest mortalities as calculated by NMFS-USFWS (2008a); however, there was difficulty obtaining accurate data from some countries. Illegally harvesting estimates are highly uncertain and are likely far greater than levels of legal take (Humber et al. 2014).
- Mortality data in the Mediterranean were not available for this assessment, and mortality data on Loggerhead Sea Turtles originating from the Northwest Atlantic population that are found in the Mediterranean is lacking. Incorporation of Mediterranean data, if it were available, is not expected to affect the results of this assessment (see Table 1 and Table 2).
- Conclusive evidence that some threats are having an effect on the population is lacking. For example, the ingestion of marine debris is not known to cause death in necropsied Loggerhead Sea Turtles; however the sample size is small.
- It is uncertain what effects underwater noise may have (if any) on Loggerhead Sea Turtle fitness.

Recommendations to Address Data Limitations and Uncertainties

A post-release survival study is underway that uses satellite telemetry to determine the survival of Loggerhead Sea Turtles in Atlantic Canadian waters following incidental capture in pelagic longline gear. This work is expected to help identify mitigations that could be used to reduce incidental capture and/or mortality from incidental capture in the pelagic longline fishery and is expected to be completed in 2018 (Mike James, pers. comm. 2016).

In the short term, a new analysis of observer data would be useful to recalculate annual incidental capture and mortality of Loggerhead Sea Turtles in Atlantic Canadian waters, taking into account the change from J-hooks to circle-hooks and the varying levels of observer coverage depending on the target species (tropical tunas vs. swordfish) given additional data sources.

A habitat use study involving fishery-independent sampling is currently underway (Mike James, pers. comm. 2016). This may better inform the likelihood of encounters (Threat Extent and Threat Frequency) with the pelagic longline fishery in Atlantic Canada.

Addressing the other data limitations will be a long-term and challenging endeavour requiring international collaboration (e.g., determining population abundance). Recovery strategies are high-level planning documents that set the strategic direction for a species recovery, whereas action plans are more detailed and can specifically identify research projects that could address data limitations and uncertainties.

Conclusions

This assessment identifies the threat of bycatch in the pelagic longline fishery, the only threat with documented mortalities in Atlantic Canadian waters, as a having a medium Threat Risk whereas all other threats that may occur in Canada (entanglement, underwater noise, marine pollution, and vessel strikes) are considered to be low risk. This assessment also highlights the data limitations and uncertainties that exist in determining the Level of Impact from this threat. In the short term, a new analysis of incidental catch data taking into account observer coverage variability and recent gear modification is recommended to refine incidental catch rates and mortalities in Canadian waters. In the long term, a post-release survival study will further inform our understanding of mortality rates and help to identify new mitigation measures for the pelagic longline fishery. This report also highlights the paucity of information on other threats to Loggerhead Sea Turtles in the Northwest Atlantic, especially in Atlantic Canadian waters.

The Threat Risk for all threats to Loggerhead Sea Turtles in Canada is expected to be lower than threats to the population throughout the broader Northwest Atlantic. This is a result of fewer Loggerhead Sea Turtles in Atlantic Canadian waters and fewer activities that threaten the species compared to in the broader Northwest Atlantic (i.e., Loggerhead Sea Turtles are faced with multiple threats on nesting beaches and in coastal environments which are not habitat types found in Canada). This is also shown by the very high annual mortalities that occur outside of Canada (15,558 nesting female equivalents, or 99.2% of total annual mortalities) compared to within Canada (between 5 and 118 nesting female equivalents, or 0.8% of total annual mortalities). Total annual mortalities in the Northwest Atlantic Loggerhead Sea Turtle population are calculated at 15,676 nesting female equivalents.

Canadian recovery measures alone will not recover the Northwest Atlantic population of Loggerhead Sea Turtles; recovery requires international collaboration. However, recovery efforts within Canada are needed to increase survivorship of juveniles that occur in Atlantic Canada into the reproductive stage; which would contribute to the recovery of this population. As the COSEWIC assessment states: “Bycatch of juvenile-stage turtles is particularly significant because changes in survivorship of this life-history stage have the largest impact on population growth” (COSEWIC 2010). This is especially true for larger juveniles that are present in Atlantic Canadian waters, as they have a higher reproductive value than smaller juveniles. Therefore, mitigations in Atlantic Canada to reduce bycatch and post-release mortality are important for the recovery of the population. In addition, juvenile survival in Atlantic Canada may also affect the Northeast Atlantic population of Loggerhead Sea Turtles, as it is possible that the two populations mix in Atlantic Canadian waters.

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Date: January 27, 2017

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Appendix 1

NMFS-USFWS (2008a) annual mortalities ranked in accordance with DFO 2014a characterizations for Level of Impact (low, medium, high, and extreme).

NMFS-USFWS (2008a) Threat Assessment Key			DFO 2014a Threat Assessment	
Estimated Annual Mortality	**Color Code**	**Value**	**Level of Impact**	**% population loss**
No evidence of mortality, based on best available information				
Sub-lethal effects occur at this stage and may result in reduced fitness (e.g., reduced somatic growth rates, reduced hatchling production, reduced prey abundance, reduced quality of nesting and/or foraging habitats)				
> 0 Mortality has been documented or is likely to occur; however, data are insufficient to estimate mortality		**1**	Low	1-10%
1-10		**3**	Low	1-10%
11-100		**30**	Medium	11-30%
101-1000		**300**	Medium	11-30%
1001-10,000		**3,000**	High	31-70%
10,001-100,000		**30,000**	High	31-70%
100,001-1,000,000		**300,000**	Extreme	71-100%

This Report is Available from the

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ISSN 1919-3769

Correct Citation for this Publication:

DFO. 2017. Threat Assessment for Loggerhead Sea Turtle (*Caretta caretta*), Northwest Atlantic Population. DFO Can. Sci. Advis. Sec. Sci. Resp. 2017/014.

Aussi disponible en français :

MPO. 2017. Évaluation des menaces pour la tortue caouanne (Caretta caretta), population du nord-ouest de l'Atlantique. Secr. can. de consult. sci. du MPO, Rép. des Sci. 2017/014.